# Manual of Instructions SERIES 6780

## Frequency-Shift Power-Line Carrier Relaying System

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Book MA-95500D

# Warranty

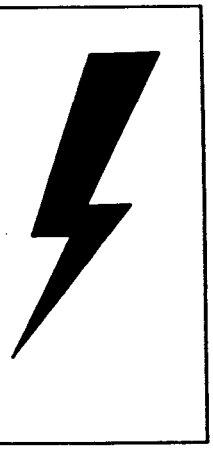
The Series 6780 Frequency-Shift Power-Line Carrier Relaying System carries a warranty of 12 months from date of delivery for replacement of any part which fails during normal operation or service. A defective part should be returned to the factory, shipping charges prepaid, for replacement f.o.b. Boonton, N. J.

**RFL Electronics Inc.**
Boonton, New Jersey USA

# CAUTION

**FOR YOUR SAFETY**

THE INSTALLATION, OPERATION, AND MAINTENANCE OF THIS EQUIPMENT SHOULD ONLY BE PERFORMED BY QUALIFIED PERSONS.



# WARNING:

**The equipment described in this manual contains high voltage. Exercise due care during operation and servicing. Read the safety summary on the reverse of this page.**

# SAFETY SUMMARY

The following safety precautions must be observed at all times during operation, service, and repair of this equipment. Failure to comply with these precautions, or with specific warnings elsewhere in this manual, violates safety standards of design, manufacture, and intended use of this product. Dowty Control Technologies assumes no liability for failure to comply with these requirements.

## GROUND THE CHASSIS

The chassis must be grounded to reduce shock hazard and allow the equipment to perform properly. Equipment supplied with three-wire ac power cables must be plugged into an approved three-contact electrical output. All other equipment is provided with a rear-panel ground terminal, which must be connected to a proper electrical ground by suitable cabling. Refer to the wiring diagram for the chassis or cabinet for the location of the ground terminal.

## DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE OR IN WET OR DAMP AREAS

Do not operate the product in the presence of flammable gases or fumes, or in any area that is wet or damp. Operating any electrical equipment under these conditions can result in a definite safety hazard.

## KEEP AWAY FROM LIVE CIRCUITS

Operating personnel should never remove covers. Component replacement and internal adjustments must be done by qualified service personnel. Before attempting any work inside the product, disconnect it from the power source and discharge the circuit being worked on by temporarily grounding it. This will remove any dangerous voltages that may still be present after power is removed.

## DO NOT SUBSTITUTE PARTS OR MODIFY EQUIPMENT

Because of the danger of introducing additional hazards, do not install substitute parts or make unauthorized modifications to the equipment. The product may be returned to Dowty for service and repair to ensure that all safety features are maintained.

## READ THE MANUAL

Operators should read this manual before attempting to use the equipment, to learn how to use it properly and safely. Service personnel must be properly trained and have the proper tools and equipment before attempting to make adjustments or repairs.

Service personnel must recognize that whenever work is being done on the product, there is a potential electrical shock hazard and appropriate protective measures must be taken. Electrical shock can result in serious injury, because it can cause unconsciousness, cardiac arrest, and brain damage.

Throughout this manual, warnings appear before procedures that are potentially dangerous, and cautions appear before procedures that may result in equipment damage if not performed properly. The instructions contained in these warnings and cautions must be followed exactly.

**Dowty Control Technologies**

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# INTRODUCTION

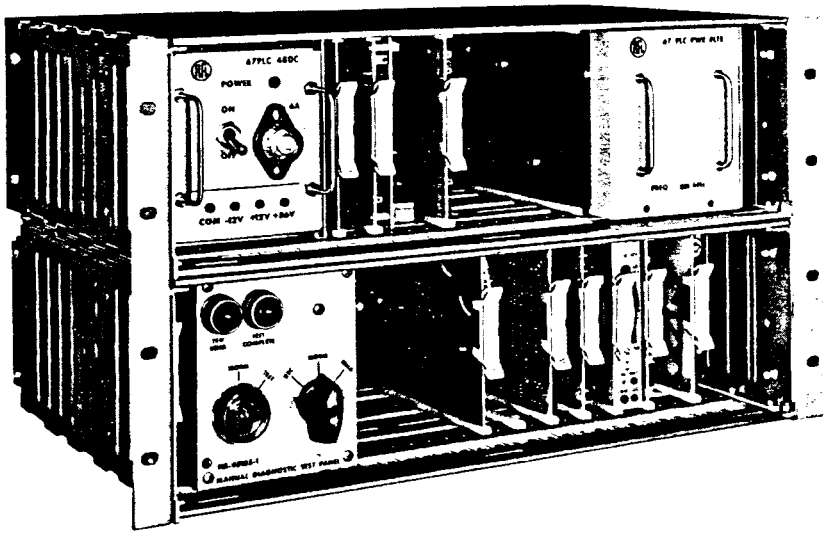


Figure 1.1. Typical terminal, Series 6780

The Series 6780 System is a frequency-shift-keyed (FSK) transmitting and receiving system that provides a communication system for protective relaying while using signals of powerline-carrier frequency in the range between 30 and 500 kHz. It transmits guard and trip commands from one point to another over a powerline system, either alone or in multiplex with other communication channels.

The equipment is capable of two-frequency (2-F) or three-frequency (3-F) FSK modes, so that either a single guard or a single trip command can be transmitted, or the 3-F mode may be used for transmission of three-state information.

The Series 6780 can be arranged to form many different systems, so that security, dependability, speed of response, or some preferred combination of all three can be emphasized at the designer's choice.

The equipment exhibits a high degree of dependability, and it can detect a valid trip during an instantaneous drop in signal level as great as 20 dB, while it simultaneously maintains relatively high security.

## DESCRIPTION

The general arrangement of the Series 6780 System is shown as Figure 1.2, which is a condensed block diagram of the system. More detailed block diagrams of the transmitting and receiving sections will be found, respectively, in the chapters on transmitters and receivers, which follow.

A typical two-frequency system may use a channel (center) frequency of 165 kHz. With a frequency shift of ±100 Hz, the guard, or monitoring, signal will be transmitted at 165.1 kHz. Then, at the command of a fault-detecting relay the transmitter will shift from guard frequency to trip frequency at 164.9 kHz. The transmitter's output is fed through coaxial cable, a line-tuning unit, and a coupling capacitor to the transmission line.

At the receiving point, the receiver will detect and identify either guard or trip frequency. Frequency-shift signals and noise information are then combined in a logic circuit where level detectors, timers, and a bipolar-noise detector test for a valid trip condition. The trip output is through either optically isolated, high-current transistors, output relays, or both. An ASEA RXMS-1 relay or a Westinghouse AR relay can be supplied mounted and wired inside the receiver chassis.

The Series 6780 will provide for direct-transfer trip (DTT), and for directional-comparison relaying (DCR) using either blocking or unblocking techniques. The standard single channel may be expanded to dual channel for DTT.

A dual-function 3-F channel is also available. This provides two relaying channels, such as combined DTT and DCR, in less bandwidth than that needed for two separate channels. The system is outlined in Figure 1.7. The dual-function channel uses only one transmitter chassis, and this economizes on cost of equipment. Other advantages include better utilization of the carrier-frequency spectrum because there is only one channel in either direction, rather than two. Reliability is improved because less equipment is used.

An optional voice-adapter module can be added to either a 2-F or a 3-F system. It includes a telephone handset, telephone jack, and a pushbutton-controlled in-band signaling system. The carrier for the voice signal is the guard frequency. During trip, the voice signal may be automatically cancelled so that the full output-power capability of the system is pre-empted when a trip is signaled.

An optional, diagnostic test panel mounts within the receiver chassis and allows an operator to test the continuity of the channel up to the trip-output relay.

## ORGANIZATION OF THE SYSTEM

The Series 6780 System (Figure 1.2) has separate chassis for the transmitter and the receiver, each of which contains several circuit card modules.

At a terminal at which both transmitting and receiving functions are used, the transmitter chassis contains:

(a) 67 PLC DC-DC Converter Power Supply, either Assembly HB-98515-1 (48 Vdc Input) or Assembly HB-98515-2 (129 Vdc Input)

(b) 67 PLC INPUT, Assembly HB-95545

(c) 67 PLC TRANS, Assembly HB-95500

(d) 67 PLC PWR AMP, Assembly HB-95565 or 67 PLC 1W AMP, Assembly HB-97010

(e) 67 PLC PWR FLT, Assembly HB-79650

The receiving chassis of such a terminal contains:

(a) 67 PLC FLT, Assembly HB-79640

(b) 67 PLC IF/BF, Assembly HB-95530

(c) 67 PLC DISC/CLI, Assembly HB-95560

(d) 67 PLC LM/SL, Assembly HB-95525

(e) 67 PLC LOGIC, Assembly HB-95535

(f) 67 PLC OUT, Assembly HB-95550

(g) Space for optional diagnostic unit, trip relay, and/or voice adapter

When a receiver chassis is used alone, a dc-dc converter must be added to power the chassis.

The arrangement of circuit cards in a standard bidirectional terminal is shown in Figure 1.3

## TRANSMITTER CHASSIS

### Input Card

The Model 67 PLC INPUT card carries circuits for the following functions:

(a) two optical isolators for two trip inputs,

(b) logic circuits controlling output frequency according to the input signals received,

(c) logic circuits controlling the output-power level and the trip-boost function,

(d) controls for the voice-enabling logic signal to the transmitter.

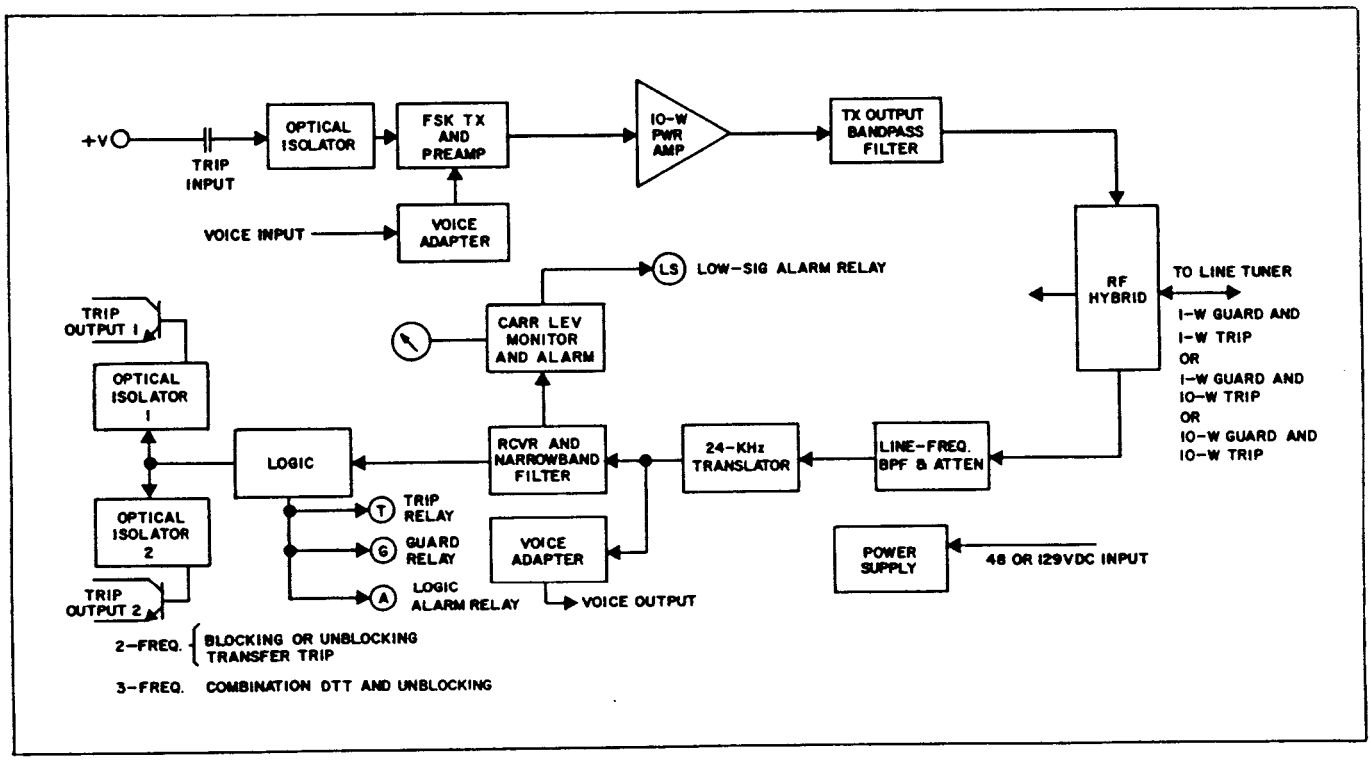



Figure 1.2. Condensed block diagram of system

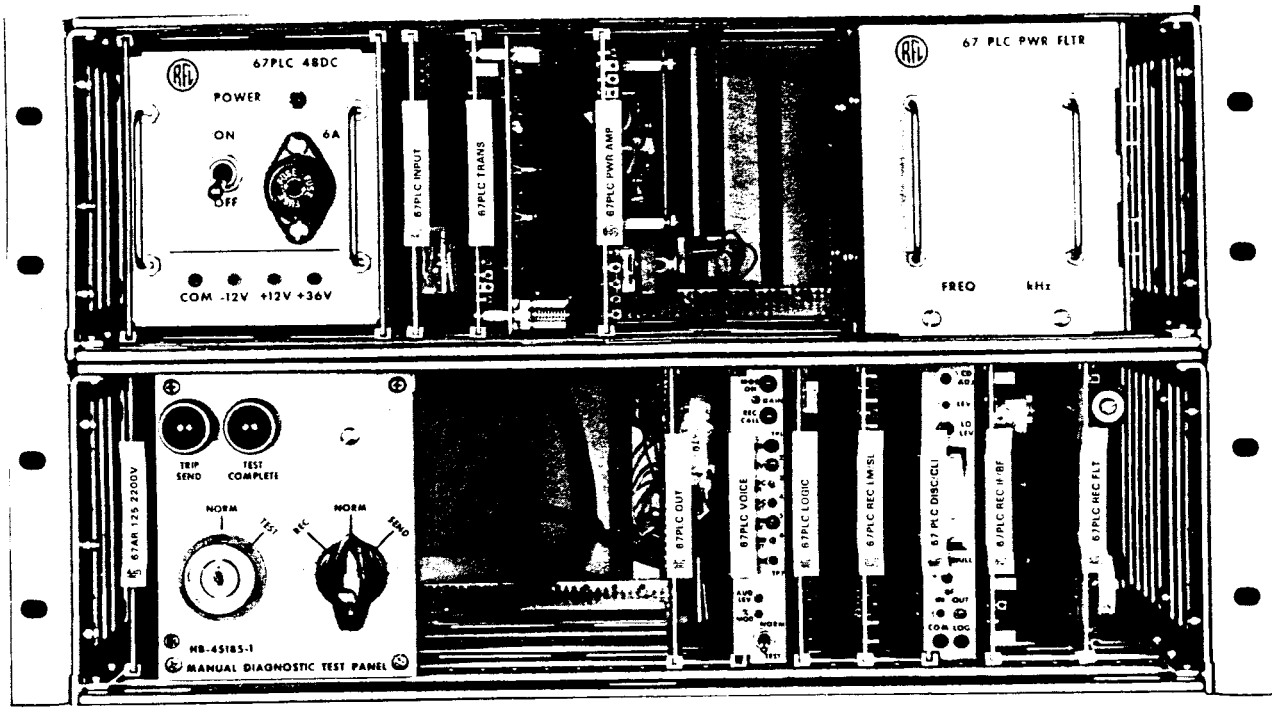



Figure 1.3. Arrangement of circuit cards in a standard bidirectional terminal

Though not directly associated with the input function, the input card also supports an alarm relay controlled by the output amplifier. This operates when the output-signal level falls below a predetermined value. Three supervisory lamps monitor Trip 1, Trip 2, and the alarm relay.

## Transmitter Card

The Model 67 PLC TRANS card carries a separate crystal-controlled oscillator for each frequency to be transmitted, an amplitude modulator for the voice signal, carrier-control circuits, a detector to monitor for low power-supply voltage, a preamplifier, and a plug-on bandpass filter.

The number of crystal oscillators needed is determined by whether two- or three-frequency FSK is used. The output of the high-frequency crystals is divided to the carrier frequency, and the crystal frequency is determined by the divisor chosen and by the output frequency desired, as described in Section 3 of this Manual. An optional crystal oven is available.

The output level of the transmitter's preamplifier, controlled by jumpers on the input card, determines whether the signal delivered by the output amplifier to the line-tuning unit is at a level of 1, 3, or 10 watts.

A low-voltage monitor on the transmitter card automatically turns off the carrier when the power-supply voltage drops below a predetermined limit.

## Power Amplifier

Two different power amplifier modules are available for the transmitter chassis; the Model 67 PLC 1W AMP (for low-power applications of up to 1 watt) and the Model 67 PLC PWR AMP (for higher-power applications of 1, 3, or 10 watts). For higher power requirements, the transmitter chassis may be connected to a Series 6515 Power Amplifier, for outputs of 40, 80, or 120 watts.

Both power amplifier modules contain a signal level monitor which activates the alarm relay on the Model 67 PLC INPUT card if the amplifier output level is too low.

Inputs and outputs are transformer coupled for isolation and held at 50 ohms impedance by a combination of voltage and current feedback.

A Model 67 PLC PWR FLT bandpass filter module is used to filter the amplifier output. This output can be connected directly to a line tuning unit or through a hybrid transformer for bidirectional applications.

## DC-DC Converters

The Models 67 PLC 129DC and 67 PLC 48DC are dc-dc converters used to generate the required operating voltages for the Series 6780 equipment from either a 129-volt or a 48-volt station battery.

The input circuit contains fuse protection and a power switch. A supervisory lamp indicates input-power status. One 36-Vdc and two 12-Vdc outputs provide operating power for a complete transmitting and receiving terminal. Overvoltage protection and a power-failure alarm are included.

Either of these two power supplies will power a complete bidirectional terminal, including both transmitter and receiver chassis. At a terminal where receivers only are used, the 36-volt power is not needed, and the receivers can be powered from any of the DRFL Series 6000 DC-DC Converters. These have dual, 12-volt 1-ampere outputs, and are available for for operation from dc sources with nominal voltages of 12, 24, 48, and 129 Vdc. Detailed data sheets are available.

# RECEIVER CHASSIS

## Input Filter

The Model 67 PLC REC FLT is a bandpass filter-used for rejecting out-of-band signals and for accepting the desired signal. It contains an input attenuator, adjusted at the time of installation according to the signal loss in the transmission medium, to bring the level of the input signal near the center of the dynamic range of the receiver.

## Intermediate- and Base-Frequency Card

The Model 67 PLC IF/BF contains an oscillator and demodulator to translate the input signal to an intermediate-frequency (IF) signal centered at 24 kHz. This signal is then filtered in a 24-kHz bandpass filter.

A second frequency translation on this circuit card moves this 24-kHz signal to a baseband frequency (BF) centered at 4 kHz. This signal is the input to the discriminator card.

The procedure for determining the fundamental frequencies of crystals on this circuit card is outlined in the succeeding chapter on the receiving system.

## Discriminator and Monitor

The 4-kHz signal from the IF/BF card is passed through a 4-kHz filter on the Model 67 PLC DISC/CLI card. This filter sets the basic bandwidth of the protective-relaying system, except for voice signals. The standard bandwidth of 200 Hz is shown on Figure 1.6, though this bandwidth may change with the application of the system.

This circuit card also carries a level detector which monitors signal level and displays it on a front-panel meter. The meter-driving signal is available for use externally. The level detector also controls a driver transistor for the low-level alarm relay on the output card.

## Limiter and Slicer

The signal at the output of the 4-kHz bandpass filter is also fed to the Model 67 PLC LM/SL card. This circuit card limits the level of the received signal and returns the signal to a frequency discriminator located on the discriminator card, the output of which is a squarewave with duty cycle controlled by the frequency (trip, center, or guard) of the input signal. Signal processing in a slicer determines whether the signal is high or low. The signals are then delivered to the logic card.

The 4-kHz signal also passes through an AM level detector where it is filtered by a lowpass filter to give an envelope of the 4-kHz FSK signal. This is fed to the logic card, where it is used to detect noise by rapid comparison of average and instantaneous signal levels.

## Logic Card

The Model 67 PLC LOGIC accepts output signals from the receiver cards, and signals from other sources, to analyze guard, trip, and noise information to build security and dependability into the system. Noise detection uses both a bipolar-noise detector and an analog noise detector. These compare average levels of signal against instantaneous change to test for excessive noise. A clear-channel pre-trip timer, with a 6-ms period, is arranged so that its period is extended to 18 ms during excessive-noise conditions. An undervoltage detector adds security to the trip-output circuit.

Guard-before-trip and trip-after-guard timers are provided for direct-transfer trip. These can be disabled for permissive-trip and for blocking applications.

Relay outputs are provided for guard, trip, low signal, and alarm; solid-state outputs are included for trip and guard signals. Supervisory lamps for trip, guard, high signal, low signal, and alarm are used to indicate the status of the system.

A detailed discussion of the functions provided on the logic card is given in Section 6 of this Manual.

## Output Card

The Model 67 PLC OUT contains four electromechanical-relay outputs, and two solid-state outputs. The trip relay is driven through a speed-up network.

The two solid-state outputs are implemented with floating power supply and optical isolators so that they are completely isolated from ground and from each other. These outputs may be used to drive a Westinghouse AR relay or an ASEA RXMS-1 relay, either of which can be mounted in the chassis.

## Voice Card

The optional Model 67 PLC VOICE card carries voice-input circuits for transmitting, voice-output circuits for receiving, a signaling-tone oscillator for transmitting, and a signaling-tone detector for receiving. A current supply for a carbon microphone is supplied, and the card will drive an audible alarm used to denote receipt of a call. A limiter on the voice card limits voice-signal level to the transmitter so that full modulation will not occur and, thus, the guard signal which usually is used as a carrier is not interrupted.

# CHASSIS, CABINETS, and ENCLOSURES

## Basic Chassis

The basic housing for the Series 6780 equipment is the Model 68 Chassis. This chassis accepts circuit cards in a plug-in, bookshelf-style assembly. A front door which drops below the horizontal plane provides easy access for installing, removing, or testing circuit cards. The chassis requires three standard EIA 1-¾-inch rack units, when used in a unidirectional application, so that the total panel height is 5-¼ inches (134 mm). A bidirectional terminal uses two such chassis. Mounting ears holding the chassis to the rack are adjustable so that the front panel may be mounted either flush in the plane of the relay-rack rails or set forward at three different positions. An enclosure for a complete bidirectional terminal is shown in Figure 1.5. Dimensions of the chassis appear in Figure 1.4.

Model 68 Chassis may be supplied singly, or mounted and wired as a group supported in an open-frame relay rack, in an enclosed-cabinet rack, or in a weatherproof enclosure.

Interconnection between circuit cards in a chassis is effected by wiring across a backplane which carries the edge-connector sockets for the circuit cards. Connections between the chassis and all external circuits are made through barrier-type terminal strips, or other connectors, mounted on the back panel of the chassis.

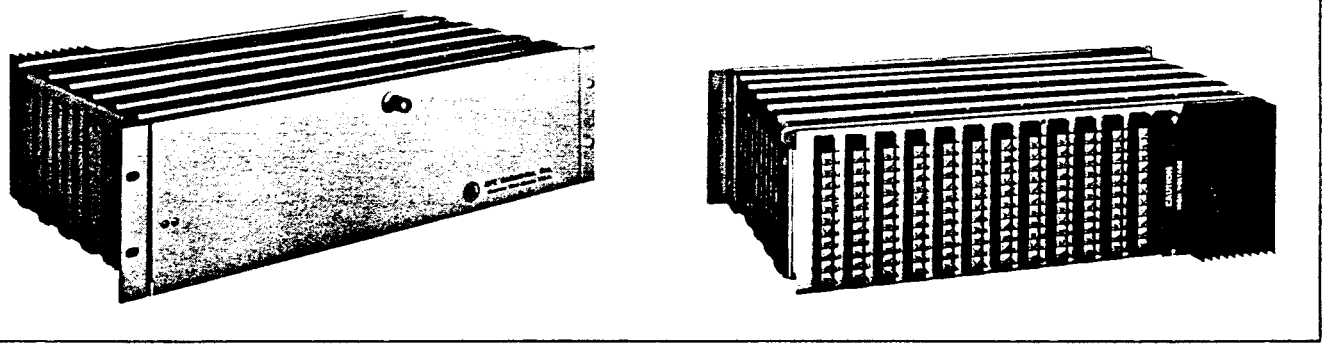
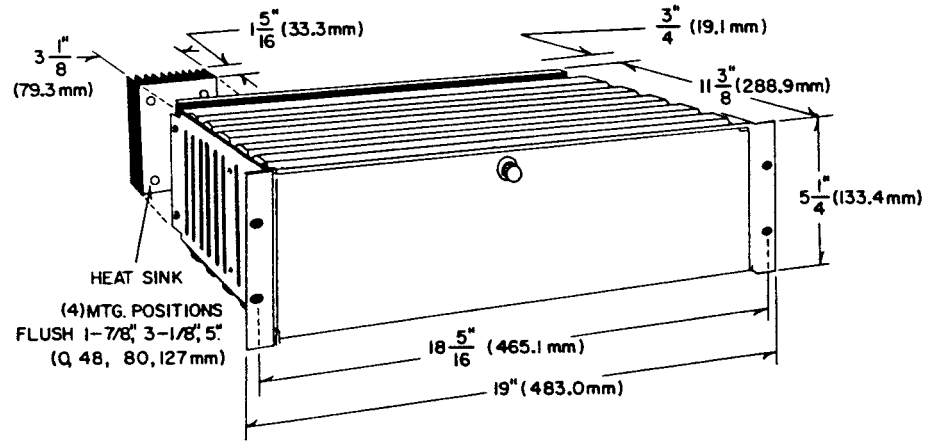


Figure 1.4. Model 68 Chassis




Chassis-mounting ears can be positioned so that the front panel is either flush or forward-mounted with respect to the vertical supporting channels of the rack. Two sets of mounting holes for these ears are provided. By reversing the mounting ears in either set of holes, four choices of position are available.

Figure 1.5. Dimensions, Model 68 Chassis

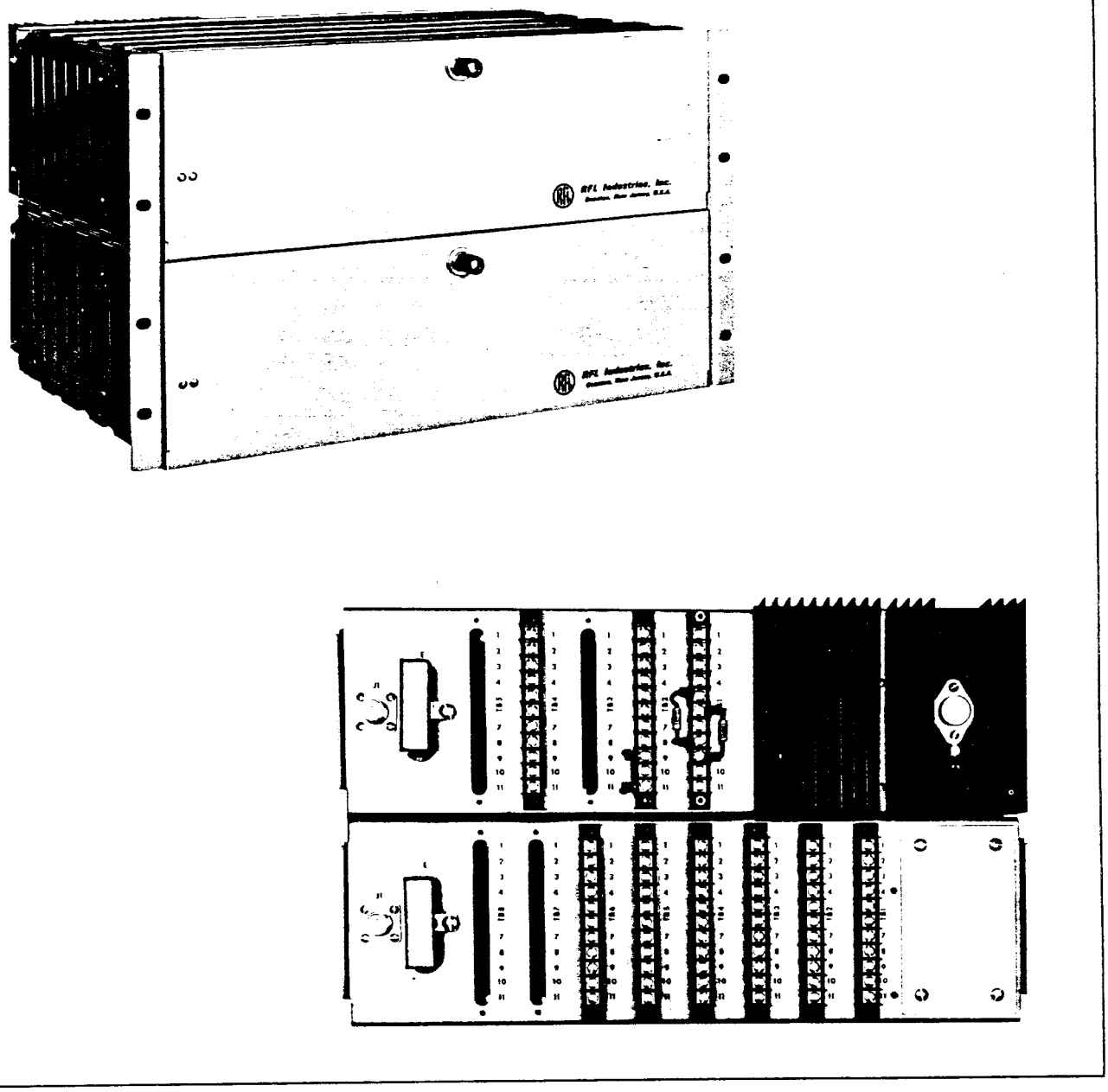


Figure 1.6. Front and rear views of bidirectional terminal

# SPECIFICATIONS

## TRANSMITTER

**Frequency Range**
30 to 500 kHz in 500-Hz steps.

**Modulation**
Either two-frequency or three-frequency FSK, with frequency shift selectable between ±100 and ±500 Hz.

**Frequency Stability**
±10 Hz, crystal-controlled.

**Output Power**
Adjustable to 1, 3, or 10 watts. Trip boost is optional. Up to 120 watts available when used with Series 6515 Power Amplifier.

**Harmonic Content**
—55 dBmo, or better.

**Keying**
15 to 30 mA from station battery, through limiting resistor to opto-isolator.

## RECEIVER

**Sensitivity**
10 mVrms, minimum signal.

**Dynamic Range**
30 dB.

**Input Impedance**
50, 75, or > 1000 ohms for bridging.

**Signal-to-Noise Detector**
Operational to in-band S/N ratio of 10 dB.

**Response Time**
With transmitter and receiver connected back-to-back, with solid-state output, the response time is 5-15 ms, depending on choice of bandwidth and logic.

**Trip Output**
(a) Either Schrack, Westinghouse AR, or ASEA RXMS-1 relay, mounted within chassis.

(b) Isolated, open-collector transistor with one-ampere, 145-Vdc capacity.

## LOGIC

(a) Direct-transfer trip, permissive-transfer trip, and directional comparison blocking or unblocking.

(b) Guard-before-trip function for direct-transfer trip can be disabled for permissive and blocking applications.

Logic is similar to that used in the DRFL Series 6745 audio-tone protective-relaying system.

## ALARMS

(a) Transmitter output-level alarm.

(b) Low received-signal level.

(c) Channel-failure alarm.

(d) Optional power-supply failure.

(e) Guard relay.

## AMBIENT OPERATING TEMPERATURE

—20 to 60°C.

## INTERFACE DIELECTRIC STRENGTH

Trip input, solid-state or relay trip output, and power-supply input are isolated from ground and from all other circuits. Breakdown is 1500 Vrms, 50-60 Hz, or 2200 Vdc and 2500 volts at 1.5 MHz, in accordance with ANSI/IEEE Standard C37.90-1978.

## PRIMARY POWER

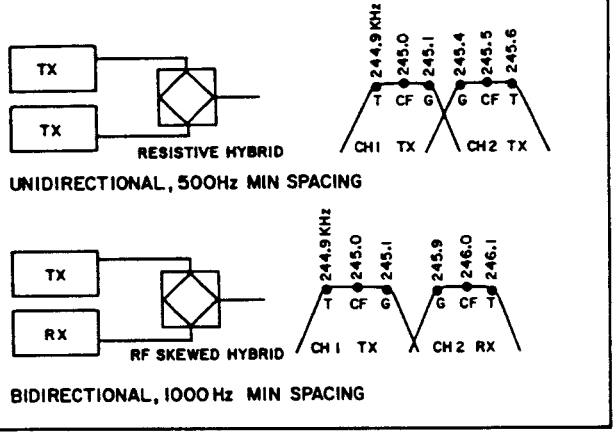
The equipment is powered with an isolated dc-dc converter. Models are available for operation from either 42-56 Vdc or 105-140 Vdc. Power consumption is less than 75 watts. For operation from 250-Vdc sources, a voltage-dropping and battery-transient-protection panel is available.

TABLE 1.1
CHANNEL SPACING AND DELAY TIME (1)

| Frequency Shift ±Hz | Nominal Bandwidth Hz | Delay Time ms (2) | Minimum Permissible Channel Spacing, Hz (3) | |
|---|---|---|---|---|
| | | | Unidirectional | Bidirectional (4) |
| 100 | 200 | 12 | 500 | 1000 |
| 250 | 500 | 7 | 1000 | 1500 |
| 500 | 1000 | 5 | 2000 | 3000 |

(1) Though not specifically shown, other frequency shifts, and spacings are available.
(2) Delay times shown include the period of the pre-trip timer.
(3) When the relaying channel is used also for voice the minimum spacing is 5.0 kHz to accommodate the voice sidebands.
(4) Minimum spacings for bidirectional channels may not apply where loss between terminals is unusually high.

TYPICAL CHANNEL SPACINGS




## PACKAGING and WEIGHT

Transmitter and receiver each occupy one Model 68 relay-rack-mounted chassis, each of which is 5¼ inches (133 mm) high. Space is available within the chassis for trip and guard relays and for a manual diagnostic test panel. Weight is less than 30 lbs. (13.6 kg).

# APPLICATION

## Operating Frequencies

Two choices must be made concerning operating frequencies. The first is the magnitude of frequency shift to be used. This sets the operating time and bandwidth of the channel. The second is the choice of center frequency. This is determined in multiplexed systems by (a) the minimum permissible spacing between channels, shown in Table 1.1, and (b) by prior frequency assignments which may have been made on the powerline.

The procedures for determining the fundamental frequency of crystals used in transmitters and receivers to obtain the desired center frequency are described in Section 3 and 5 of this Manual.

The operating or delay time of a channel is defined as the total time that elapses between the application of a trip-command pulse at the sending end and the appearance of the corresponding trip pulse at the output of the receiver. It does not include the opera-

ting time of relays, for they may not be used. It is measured by connecting the output of the transmitter directly to the input of the receiver (the so-called back-to-back connection), and so it does not include the transmission time of the communication system, which will differ for each application.

Operating time decreases as bandwidth is increased. In the Series 6780, the frequency shift used is selectable between ±100 and ±500 Hz from center frequency. The bandwidth, therefore, of the 4-kHz baseband-frequency filter used in the receiver, which defines the bandwidth of the system, is chosen between 200 and 1000 Hz, according to the frequency shift desired. Note that reduced operating time is obtained at the expense of carrier-frequency spectrum used.

Table 1.1 shows the delay time of a channel as a function of frequency shift. Linear interpolation may be used, if needed. It also lists the minimum permissible channel spacing for unidirectional and bidirectional systems, and it shows two examples of application of the data given. This table applies to two-frequency systems, and to three-frequency systems in which the frequency shifts for guard and trip are equal. Figure 1.7 shows how trip and guard signals appear in the passband of a typical filter in the receiver when the frequency shift is ±100 Hz.

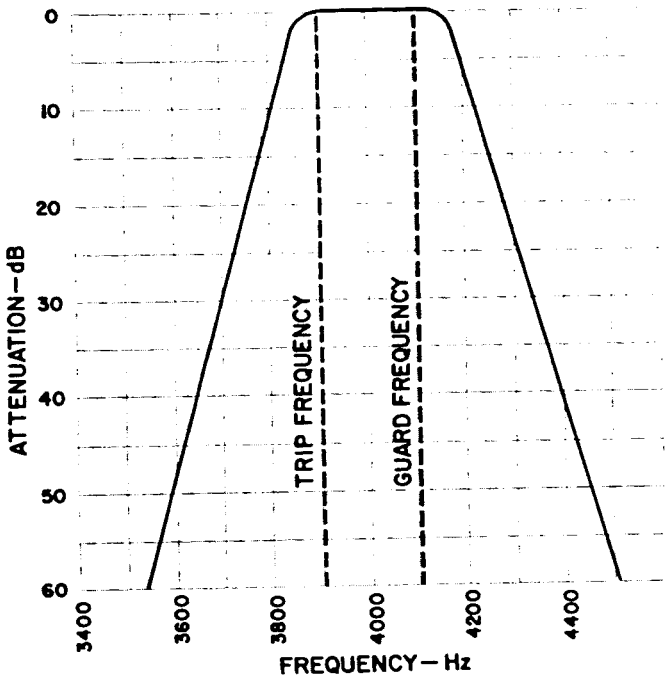



Figure 1.7. Location of trip and guard frequencies in passband of typical final receiving filter

## Dual-Function, Three-Frequency System

In a three-frequency system, more flexibility is available. For example, the center frequency may be designated as the guard and blocking signal in a system in which a downward shift in frequency is used for transfer trip and an upward shift is used for unblocking. The relatively narrowband requirement for transfer trip may be met with a shift of only 100 Hz from center frequency. The operating time for this function then would be 12 ms, as noted in Table 1.1. The need for faster, wideband response for unblocking, however, may be met with a frequency shift of 200 Hz from the guard and blocking frequency. This would give an operating time of only 8.7 ms. In this case a combined narrowband and wideband system is created with a total bandwidth of only 300 Hz.

The foregoing arrangement is outlined in Figure 1.8. It will be noted that the bandwidth of the filter in the trip receiver is less than that of the filter in the unblocking receiver, which has a faster response. Passbands of the two filters overlap at guard frequency, and the discriminators may be offset to favor guard. Frequency shifts may or may not equal, depending upon the particular application.

Circuits are arranged in the Series 6780 so that if the two trip inputs are energized simultaneously, overriding priority can be assigned to one of them.

## Dual Channel Bidirectional System

A dual channel configuration is shown which is shown which is recommended for direct transfer trip applications. The dual channel shown here is similar to the Series 6745 dual sub channel system. Two channels are combined with the advantage of 10 watts per channel at the line tuning unit. Also full redundancy is maintained to the extent that no single component failure can generate a false trip output. The dual channel approach saves interwiring, interconnections, and 1/3 the cost of a conventional dual channel system. Individual subchannel test keying is possible as well as automatic transfer to single channel operation.

## Space and Current Requirements

Circuit cards may be stacked in the chassis in any quantity up to the 32 one-half-inch module spaces available in each chassis. The number of module spaces required by each card, their current requirements, and the current capacities of various available power supplies are listed in Table 1.2.

## TABLE 1.2
## SPACE AND POWER REQUIREMENTS FOR CIRCUIT CARDS

| MODEL | ASSEMBLY | DESCRIPTION | CURRENT REQUIRED -mA | | | MODULE SPACES REQ'D | NOTE |
|---|---|---|---|---|---|---|---|
| | | | 12 VDC | -12 VDC | 36 VDC | | |
| 67 PLC 48 DC | HB-95515-1 | Power Supply, current capacity | 1000 | 1000 | 1000 | 9 | 1 |
| 67 PLC 129 DC | HB-95515-2 | Power Supply, current capacity | 1000 | 1000 | 1000 | 9 | 1 |
| 68 HPS 48 DC-1 | HB-41515 | Power Supply, current capacity | 1000 | 1000 | ----- | 3 | 2 |
| 68 HPS 129 DC-1 | HB-41505 | Power Supply, current capacity | 1000 | 1000 | ----- | 3 | 2 |
| 67 PLC INPUT | HB-95545 | Input Circuit | 38 | 0 | 0 | 2 | 3 |
| 67 PLC TRANS | HB-95500 | Transmitter | 215 | 190 | 0 | 3 | 4, 10 |
| 67 PLC PWR AMP | HB-95565 | 10-Watt Output Amplifier | 0 | 0 | 850 | 3 | 4 |
| 67 PLC PWR FLT | HB-79650 | Output Bandpass Filter | 0 | 0 | 0 | 10 | 11 |
| 67 PLC REC FLT | HB-79640 | Input Bandpass Filter | 0 | 0 | 0 | 2 | ----- |
| 67 PLC IF/BF | HB-95330 | IF and Baseband Circuits | 45 | 50 | 0 | 2 | 10 |
| 67 PLC DISC/CLI | HB-95560 | Discriminator and Level Indicator | 100 | 100 | 0 | 2 | 5 |
| 67 PLC LM/SL | HB-95525 | Limiter and Slicer | 40 | 40 | 0 | 2 | 6 |
| 67 PLC LOGIC | HB-95535 | Logic Circuit | 60 | 35 | 0 | 2 | 7 |
| 67 PLC VOICE | HB-95555 | Voice Input and Control | 91 | 58 | 0 | 2 | 8 |
| 67 PLC OUT | HB-95550 | Output Circuit | 0 | 0 | 0 | 2 | 9 |
| 67 PLC 1W AMP | HB-97010 | 1-Watt Amplifier | 500 | 500 | 0 | 3 | 4 |
| 67 PLC 1W FLT | HB-79700 | 1-Watt Bandpass Filter | 0 | 0 | 0 | 3 | ----- |
| 67 PLC SK HYB | HB-79715-1 | Skewed Hybrid | 0 | 0 | 0 | 3 | ----- |
| 67 PLC X HYB | HB-79710-1 | Transformer Hybrid | 0 | 0 | 0 | 3 | ----- |

**NOTES:**

(1) Requires also Regulator HB-46580 mounted on back of chassis, and also 36-V-regulator pass-transistor assembly mounted on back of chassis.
(2) Requires also Regulator HB-46580 mounted on back of chassis.
(3) Current drawn includes illumination of both DS1 and DS2.
(4) Current at full output.
(5) Current with low-level alarm relay energized, DS1 off.
(6) Current with DS2, GUARD, illuminated.
(7) Add to listed current as applicable: (a) trip relay, 85 mA; (b) guard relay, 30 mA; (c) alarm relay normally energized, 50 mA.
(8) Microphone connected to input.
(9) Relay currents are listed with sourcing card. Each isolated solid-state output circuit draws 19 mArms from power transformer.
(10) Add one more module space when using crystal oven.
(11) If mounted in extreme right side of chassis, only 9 spaces are required.

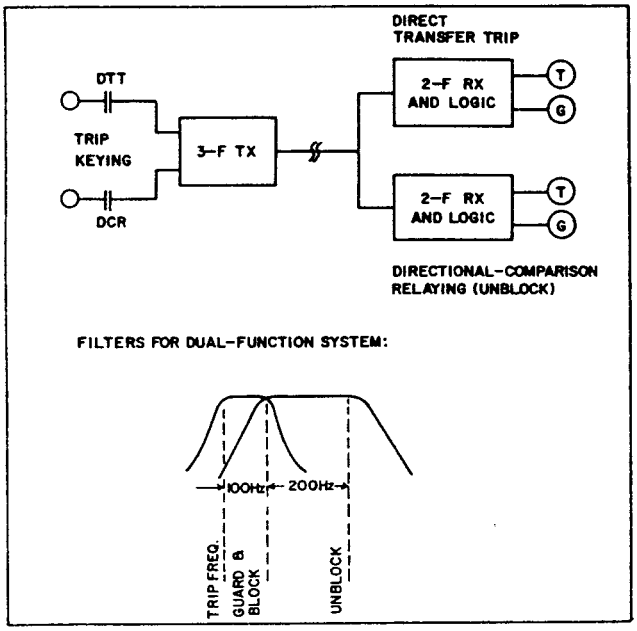



Figure 1.8. Block diagram- dual function, three frequency system

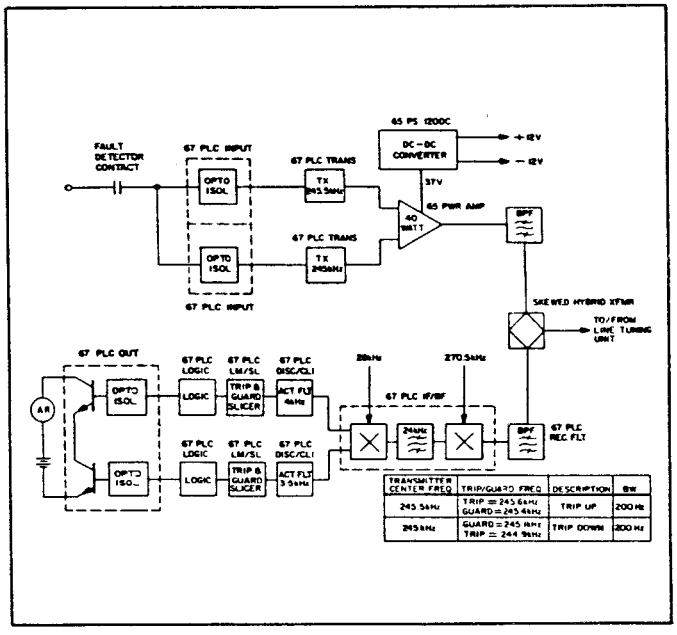



Figure 1.9. Block diagram- dual channel bidirectional system for direct transfer trip applications.

# INSTALLATION

All circuit modules of the Series 6780 System are mounted in the Model 68 Chassis, shown in Figures 1.3, 1.4, and 1.5. Each chassis contains the complement of modules needed for the specified application, and each is individually wired for that application. Specific interconnection diagrams are supplied with each system. A generalized interconnection diagram is shown in Figure 1.18.

## Unpacking

Individual chassis are shipped in commercial packing cartons, one per carton. Care should be taken when opening to ensure that the equipment is not damaged or scratched. Systems housed in more than one chassis may be ordered as assemblies mounted in relay-rack cabinets. In such cases, the assembly is shipped as a unit, mounted horizontally in a wood crate, or by air-ride van.

Examine all packing material carefully so that items of value are not discarded. Packing materials used in the chassis to keep modules in place during transportation should be removed carefully.

## Mounting

Each chassis is fitted with a hinged front door. Access is gained by turning the central locking screw counterclockwise until the door can be opened.

Chassis mounting ears can be positioned so that the front panel is either flush or mounted forward with respect to the plane of the vertical supporting channels of the rack. Two sets of mounting holes for these ears are provided. By reversing the mounting ears in either set of holes, four choices of position are available.

Relay racks and cabinets used to support equipment should be bolted to the floor or wall, as appropriate, to secure the equipment in place. It is absolutely essential that installations using an enclosed cabinet with swing-out relay rack be securely fastened to the floor. If this is not done, the cabinet will fall forward under the load of the swing-out rack when the rack is moved outward.

## Ventilation

To enhance reliability, the equipment should be operated within the specified range of ambient temperature. Ventilation should be provided to ensure that temperature limits are not exceeded within the enclosure for the equipment.

## Frequency-Dependent Components

Table 1.3 lists all components whose design is a function of the communication frequency chosen for use on the powerline.

## Electrical Connections

Connections to the chassis are made through barrier-type terminal blocks mounted on the rear.

TABLE 1.3
OPERATING-FREQUENCY-DEPENDENT COMPONENTS

| Module | Component |
|---|---|
| 67 PLC TRANS | Either crystal HB-46544-(X), or crystal HB-90303-(X) with oven assy. HB-46928. One required per oscillator. See Table 3.1 |
| | Model HB-79635-(X) plug on bandpass filter centered on output frequency. |
| 67 PLC PWR FLT | This bandpass filter is a separate plug-in module centered on the output frequency. |
| 67 PLC REC FLT | This bandpass filter is a separate plug-in module centered on the received frequency. |
| 67 PLC IF/BF | Piezoelectric crystal Y101. |

Details of typical input and output connections are shown in Figure 1.10 through 1.15.

When running trip-input leads, care should be taken to reduce the possibility of a false trip caused by currents induced in the leads. Trip-input leads should be assembled from shielded twisted pair, with the shield grounded only at the chassis of the Series 6780. It is also recommended that these leads by physically separated from wires that carry either high current or high voltage, so that the possibility of spurious magnetic and electric coupling is minimized.

## Setup Procedure

This procedure should be followed after the equipment has been checked and aligned, is wired in a system, and is ready for connection to a communication channel. Before proceeding, make sure all jumpers are positioned properly to obtain the performance specified. Details on placing jumpers are contained in Sections 2, 3, 5, and 6 of this Manual. The transmitter-output level and the receiver-input level may be set as follows:

### Transmitter

(1) Connect a 50-ohm dummy load to the UHF connector at the rear of the chassis.

(2) Connect a high-impedance, true-rms voltmeter across the load. If the measurement is made at the composite output of multiplexed transmitters, a frequency- selective voltmeter should be used if more than one transmitter is operated simultaneously.

(3) Adjust the transmitter's output to the desired level by adjusting LEV ADJ potentiometer R15 on Model 67 PLC TRANS module. (See Figure 3.2 for location).

**Receiver**

(1) Loosen locknut on attenuator R7 on Model 67 PLC REC FLT module. (See Figure 5.2 for location).

(2) While a guard signal is being received at normal level, note meter indication on Model 67 PLC DISC/CLI module.

(3) Adjust attenuator R7 on Model 67 PLC REC FLT module as needed until meter on Model 67 PLC DISC/CLI module indicates 0 dB.

(4) Tighten locknut R7 on attenuator.

This completes the adjustment of a standard chassis to the system. If additional optional equipment has been supplied, supplemental instructions for further adjustments will be supplied if needed.

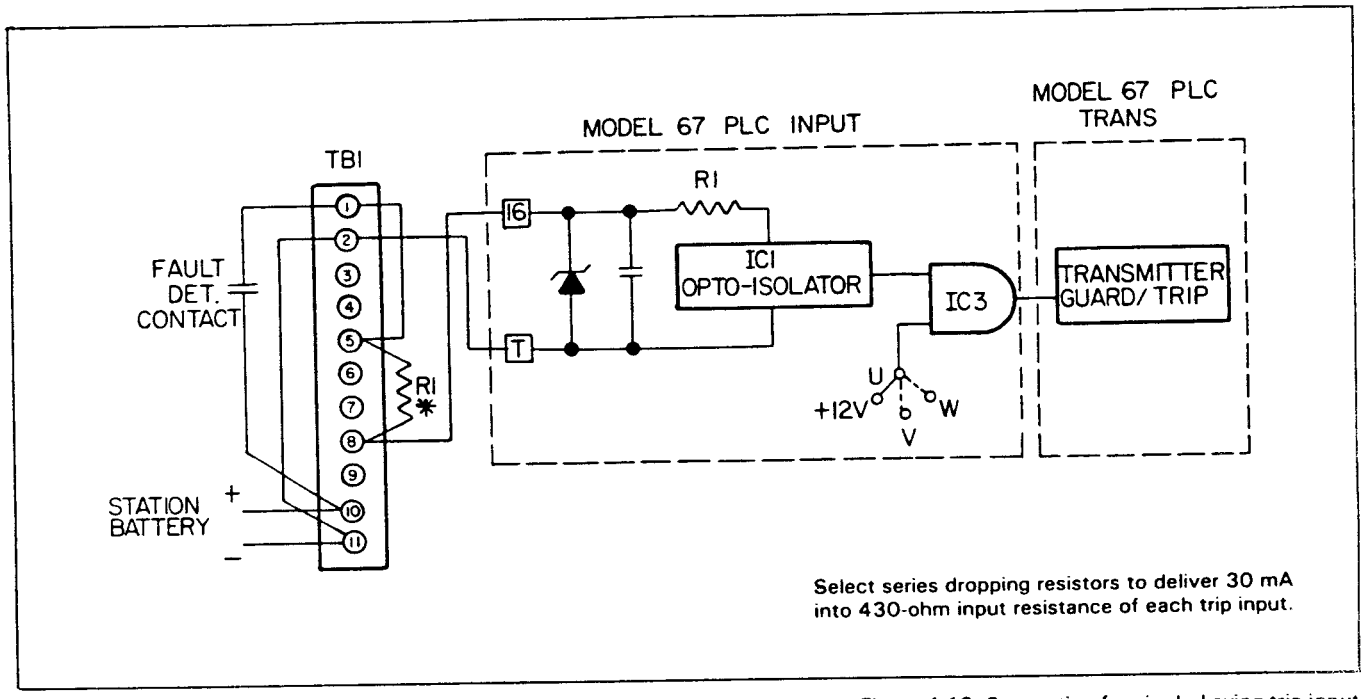



Figure 1.10. Connection for single-keying trip input

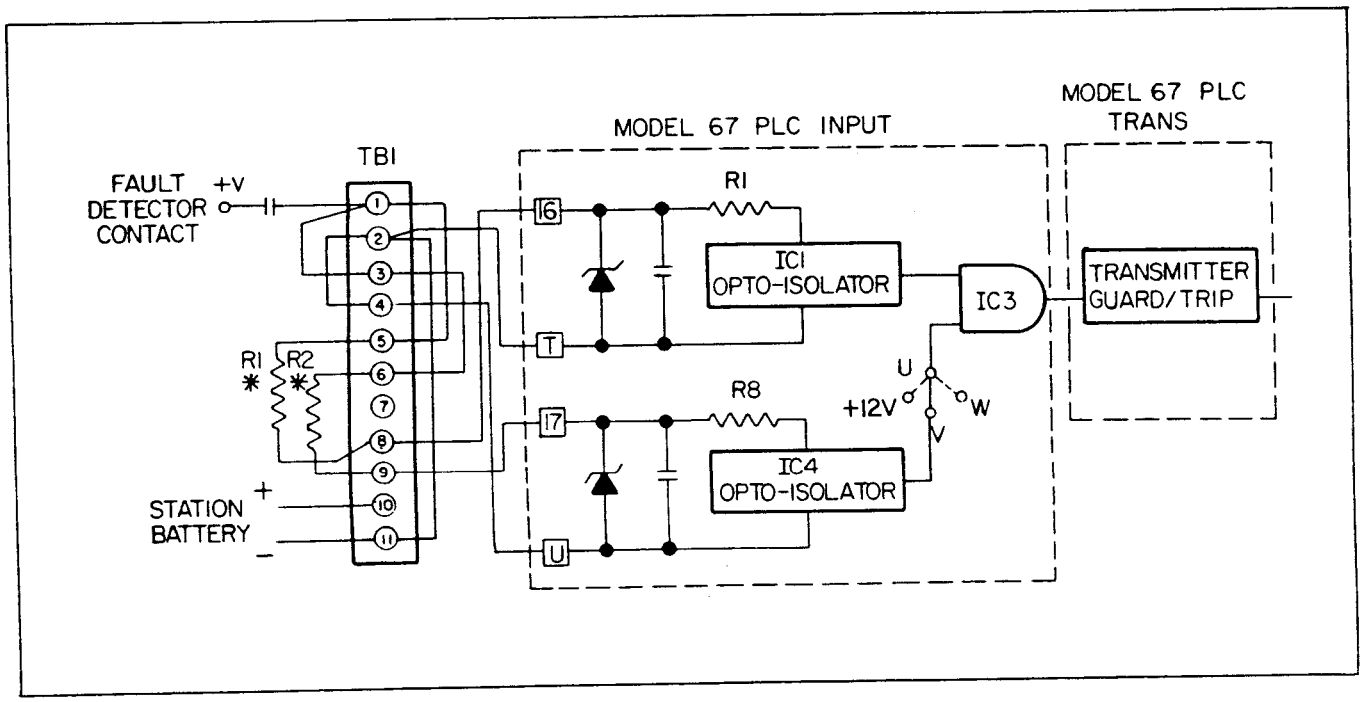



Figure 1.11. Connection for dual-keying trip input

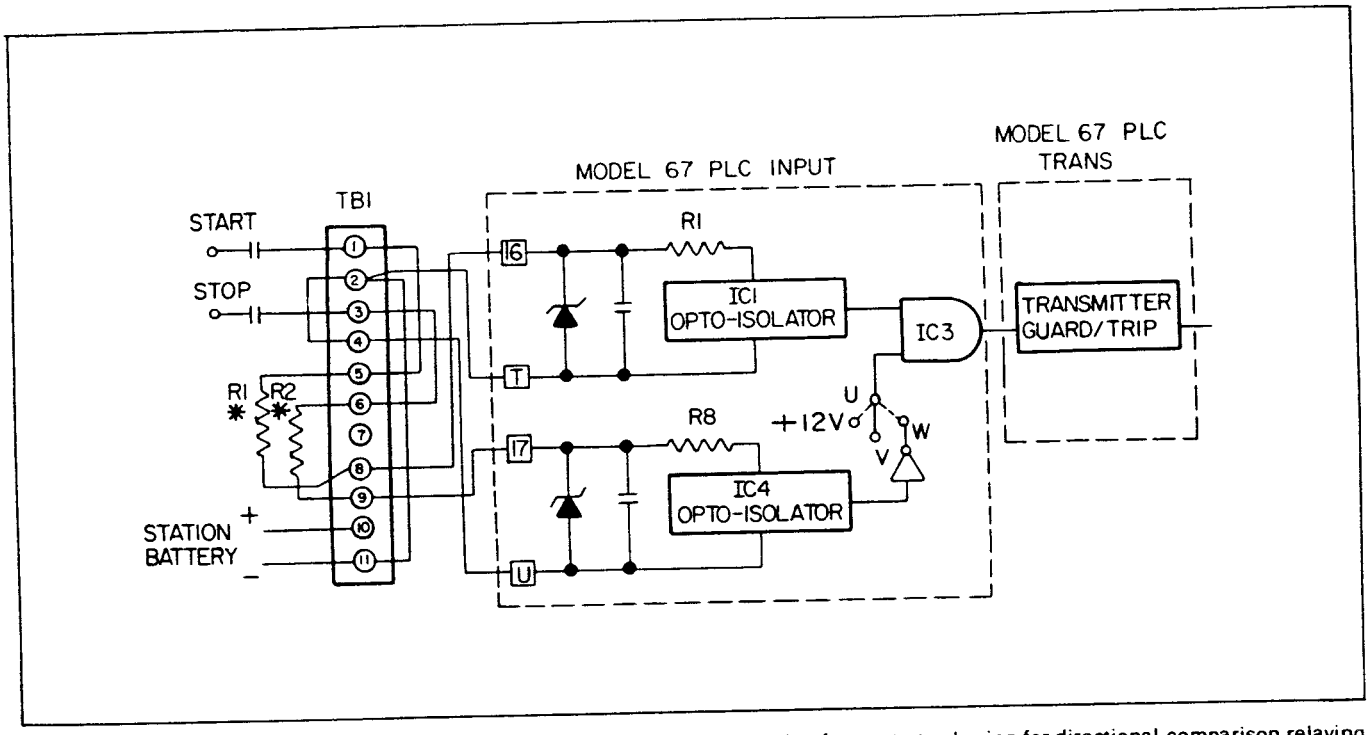



Figure 1.12. Connection for start-stop keying for directional-comparison relaying

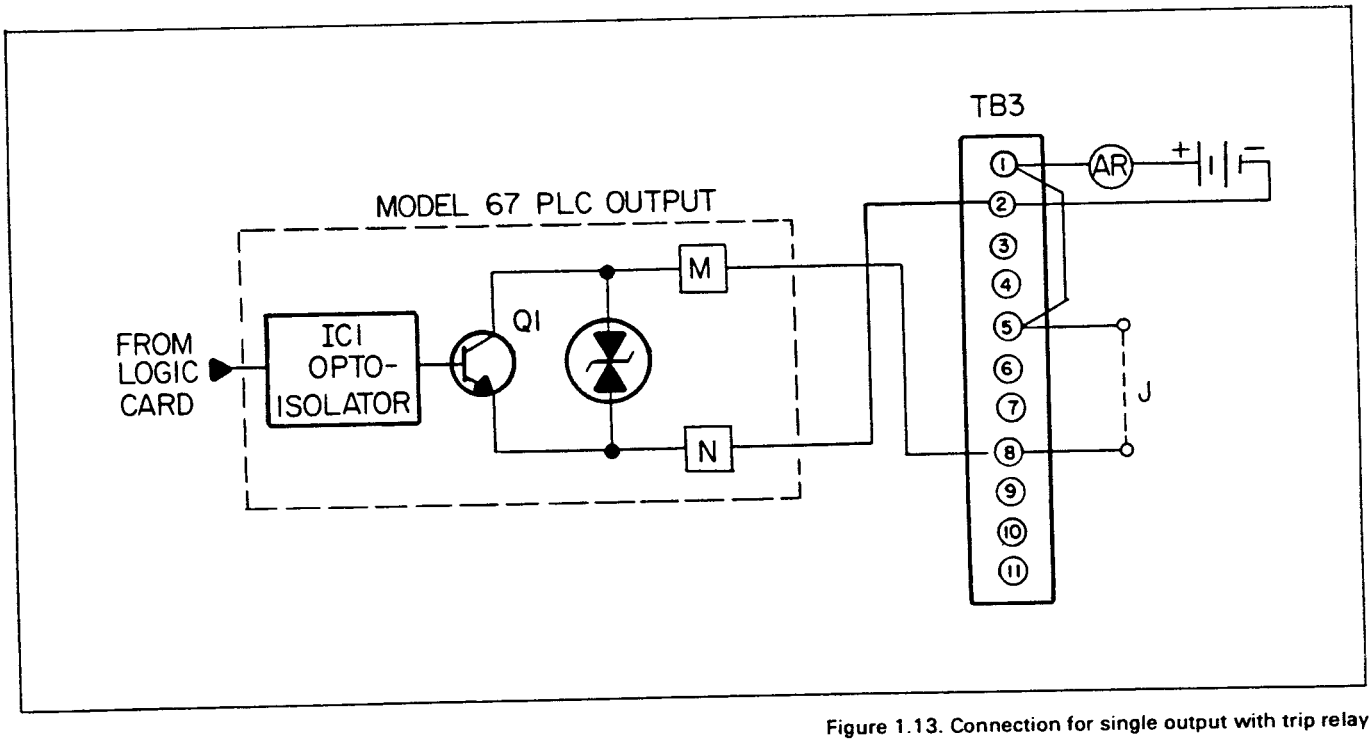



Figure 1.13. Connection for single output with trip relay

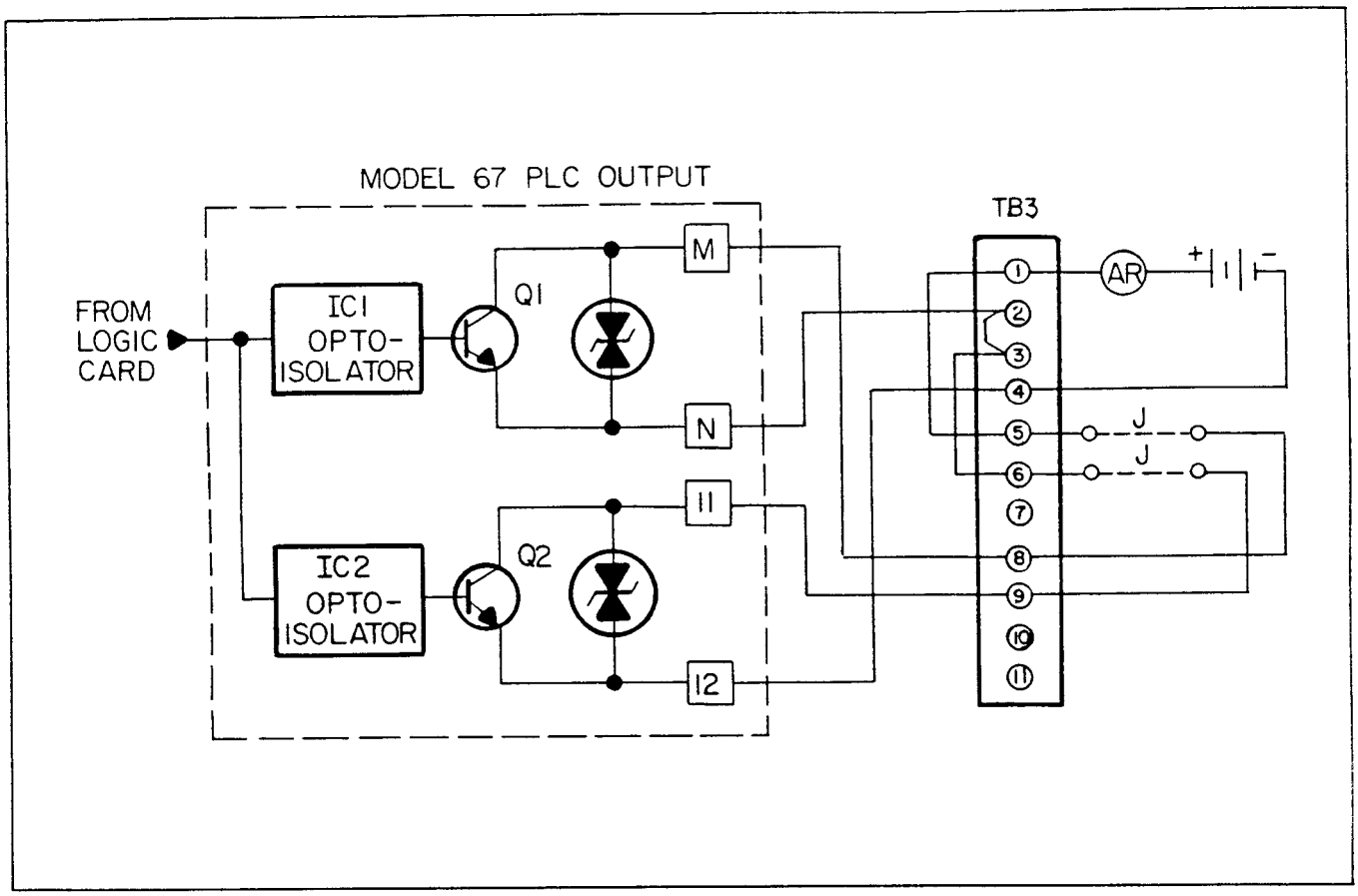



Figure 1.14. Connection for dual outputs in series with trip relay

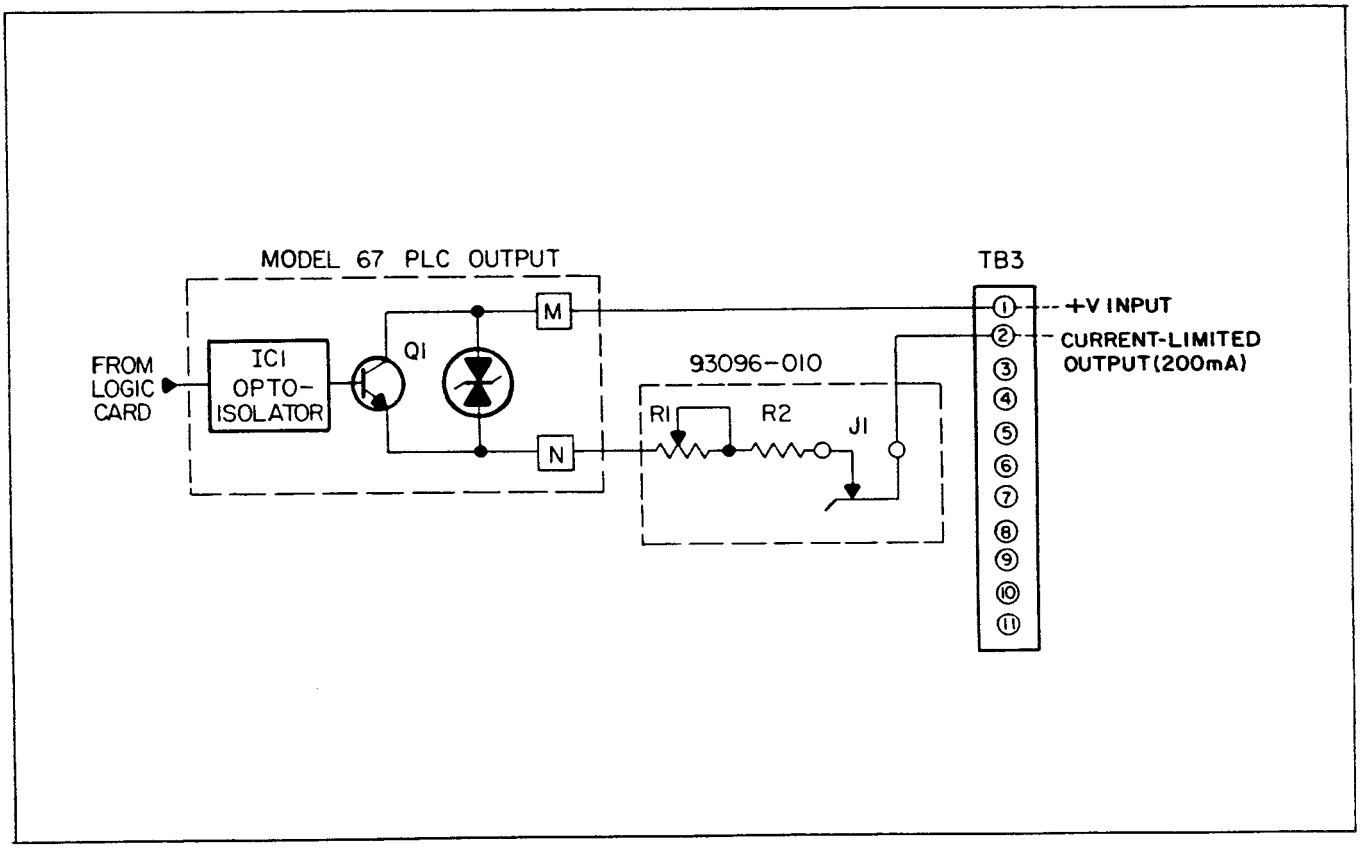



Figure 1.15. Connection for blocking output with 200 mA adjustable current drive

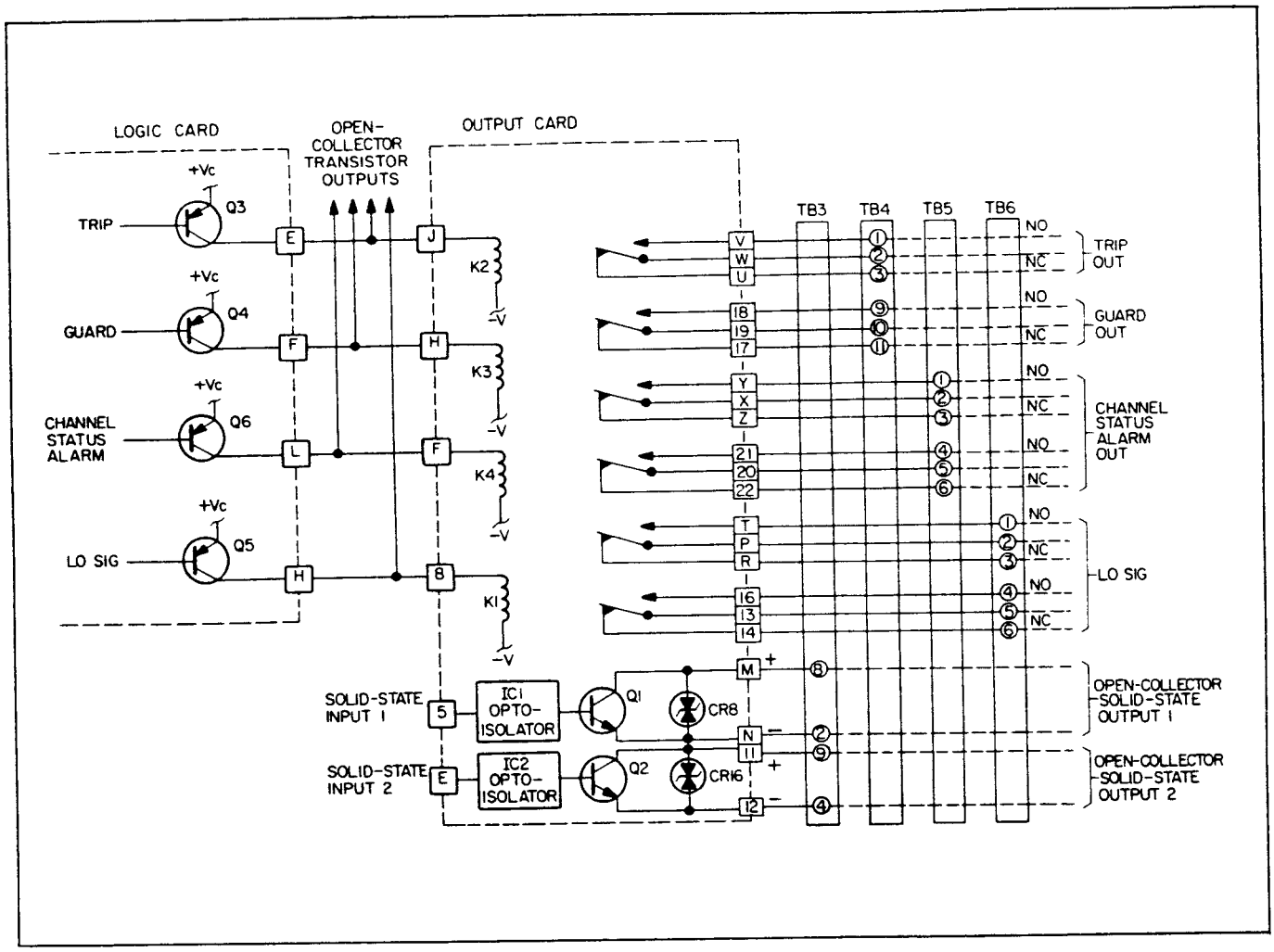



Figure 1.16. Typical output connections

# SYSTEM ALIGNMENT

The following procedures may be followed for setting up the equipment and preparing it for operation.

## Test Equipment Required

The following equipment will be needed to perform the required tests and adjustments for installation:

(a) A multimeter such as the Simpson 260, or equal.

(b) An oscilloscope with flat response to at least 1 MHz.

(c) An audio oscillator with 600-ohm output impedance.

(d) A frequency counter with range at least as high as the highest frequency of interest.

(e) A sensitive ac voltmeter with a dB scale based on 1 mW into 600 ohms.

(f) A 50-ohm, 25-watt non-inductive load resistor.

(g) A frequency-selective voltmeter such as the Rycom 6021A, or equal.

(h) A DRFL Model 68 EXT card extender for access to the side of a circuit card while connected in the circuit.

(i) A suitable source of line-frequency signal for the receiver. This may be either an accompanying transmitter from the system or a frequency-stable signal generator such as a synthesizer. In either case, frequency must be accurate and stable within ±2 Hz, and the input to the receiver should be adjustable from at least 0.1 to 100 mV.

## DC-DC Converter Check

(1) Make sure the proper station battery voltage is available for the dc-dc converter being used:

| | |
|---|---|
| 67 PLC 129 DC, 68 HPS 129 DC-1 | 105 to 145 Vdc |
| 67 PLC 48 DC, 68 HPS 48 DC-1 | 42 to 56 Vdc |
| 68 HPS 24 DC-1 | 21 to 28 Vdc |

(2) Place dc-dc converter POWER switch in ON position.

(3) Set multimeter for dc voltage measurements.

(4) Check Model 67 PLC 129 DC and 67 PLC 48 DC converters as follows:

(a) Connect negative multimeter lead to COM test jack.

(b) Connect positive multimeter lead to +12V test jack. Multimeter must indicate between +11.4 and +12.6 Vdc.

(c) Move positive multimeter lead to -12V test jack. Multimeter must indicate between -11.4 and -12.6 Vdc.

(d) Move positive multimeter lead to +36V test jack. Multimeter must indicate between +32 and +38 Vdc.

(5) Check Model 68 HPS 129 DC-1, 68 HPS 48 DC-1, and 68 HPS 24 DC-1 converters as follows:

(a) Connect positive multimeter lead to test point TP1 and negative lead to TP2.

(b) Note multimeter indication; it must be between +11.4 and +12.6 Vdc.

(c) Connect positive multimeter lead to test point TP3 and negative lead to TP4.

(d) Note multimeter indication; it must be between +11.4 and +12.6 Vdc.

## Transmitter

(1) Ensure that suitable series dropping resistors for trip input and output (if required) are installed. (See Figures 1.9 through 1.15).

(2) With the aid of Tables 2.1, 2.2, and 2.3 set all jumpers on the Model 67 PLC INPUT card so that its performance will conform to the requirements of the purchase specification.

(3) Energize inputs for TRIP 1, TRIP 2, or both, as appropriate, and observe that their supervisory lamps glow accordingly.

(4) Refer to Tables 3.1, 3.2, and 3.3. Ensure that appropriate oscillator crystals and frequency-divider jumpers are in proper position, and check the bandpass filter to be sure it is firmly mounted. Note which oscillator operates at each frequency, as required by the purchase specification.

(5) Check the bias currents in power amplifier as follows:

(a) Turn off power.

(b) Remove transmitter card.

(c) Install power amplifier on extender card and return the assembly to the chassis.

(d) Turn on power.

(e) Using an ungrounded voltmeter, measure voltage between test points TP3 and TP4. Adjust potentiometer R14 as needed to obtain a meter indication between +0.275 and +0.325 Vdc.

(f) Connect voltmeter across test points TP7 and TP8. Adjust potentiometer R27 as needed to obtain a meter indication between +0.275 and +0.325 Vdc.

(g) Turn off power, remove extender card, return both circuit modules to their proper slot in the chassis, and turn on power.

(6) Connect the frequency counter between TP4 (GRN) on the transmitter, and ground, to check for proper output frequency from each oscillator. Each frequency should be correct within ±2 Hz. If not, mount the transmitter on an extender card and adjust C3, on the appropriate oscillator, for the desired frequency.

(7) To check operation of the low-level alarm relay, the transmitter must be operated at the one-watt level. If Jumpers A and K on the input card are not already in place, then note and record their positions, and then set these jumpers to A and K.

Load the system with a 50-ohm non-inductive resistor and connect the ac voltmeter across the load. Check operation of the low-level alarm relay by lowering the power output with R15, LEV ADJ, on the transmitter card, until the alarm relay on the input card de-energizes. Relay contacts may be checked for continuity through 1TB4, (Figure 1.18). Then raise the output level until the relay again is energized. Restore jumpers on the input card to their original position.

(8) For the three output levels of the system, the proper voltages across the output load are as listed:

| Power Watts | Voltage Across 50 Ohms |
|---|---|
| 1 | 7.07 |
| 3 | 12.25 |
| 10 | 22.36 |

If the system has several power levels, check each for the proper level, and adjust the highest power level with R15, LEV ADJ, on the transmitter. Lower levels should be correct within ±1.5 dB.

Briefly check the transmitter, using an oscilloscope connected between TP3 (YEL) and TP4 (GRN) by observing the waveshape, to be sure that the driver is not limited or saturated.

This completes the test of the transmitter chassis.

## Receiver

The nominal receiving level of the system, as measured at TP2 (RED) and TP1 (BLK) on the Model 67 PLC IF/BF, is 27 mv. If jumpers B and D (Figure 5.3)

are used, a bridging input transformer with 18-dB attenuation is in the signal path. If jumpers A and C are installed, a resistive divider, with 28-dB attenuation is in the signal path in lieu of the transformer.

Either input is followed by a variable attenuator, accessible from the front panel, with a maximum attenuation of 30 dB. The loss of the communication path should be included in the purchase specification, so the appropriate attenuation may be selected. The resistive divider may be modified, if necessary.

## Receiver

The nominal receiving level of the system, as measured at TP2 (RED) and TP1 (BLK) on the Model 67 PLC IF/BF, is 27 mv. If jumpers B and D (Figure 5.3) are used, a bridging input transformer with 18-dB attenuation is in the signal path. If jumpers A and C are installed, a resistive divider, with 28-dB attenuation is in the signal path in lieu of the transformer.

Either input is followed by a variable attenuator, accessible from the front panel, with a maximum attenuation of 30 dB. The loss of the communication path should be included in the purchase specification, so the appropriate attenuation may be selected. The resistive divider may be modified, if necessary.

### IF/BF Card

(1) Examine the Model 67 PLC IF/BF to be sure that the crystal, Y101, and the divider near IC101 (Figure 5.7) are in accordance with the purchase specification. Table 5.3 gives the data needed. The jumper near IC5 should be at Position P. Make sure that the bandpass filter is firmly in place.

(2) Turn power off, install this card on a card extender, replace in chassis, and restore power. With a frequency counter at TP3 (turret terminal) adjust C103 so that the oscillator's output frequency is at precisely 24 kHz plus the channel frequency.

(3) Connect a frequency counter between test turret TP3 and test point TP1 (COM - black). Adjust capacitor C103 until the counter indicates the channel frequency plus 24 kHz; this is the oscillator frequency.

(4) Connect a frequency-selective voltmeter between test turret TP3 and ground, and adjust the voltmeter's frequency controls for maximum sensitivity to the oscillator frequency.

(5) Move the frequency-selective voltmeter lead from TP3 to test turret TP5. Adjust potentiometer R9 for the lowest possible voltmeter indication, which should be less than 10 mVrms.

(6) Move the frequency-selective voltmeter lead from TP5 to test turret TP11, and adjust the voltmeter's frequency controls for maximum sensitivity to the baseband frequency, which is 28 kHz.

(7) Move the frequency-selective voltmeter lead from TP11 to test turret TP7. Adjust potentiometer R28 for the lowest possible voltmeter indication, which should be less than 10 mVrms.

(8) Move the frequency-selective voltmeter lead from TP7 to test point TP2 (HF - red), and adjust the voltmeter's frequency controls for maximum sensitivity to the input carrier signal.

(9) Note the indication on the frequency-selective voltmeter; it should be 27 mVrms. If not, adjust attenuator R7 on the Model 67 PLC REC FLT card for a 27-mV indication.

(10) Move the frequency-selective voltmeter lead from TP2 to test point TP4 (BF - brown), and adjust the voltmeter's frequency controls for maximum sensitivity to a 4-kHz signal.

(11) Adjust potentiometer R4 for a voltmeter indication of 20 mVrms.

(12) Turn off power, remove card from the extender, and reinsert into chassis. Restore power.

### DISC/CLI Card

(1) Turn off power, assemble DISC/CLI card on extender, return to chassis, and restore power.

(2) Adjust FILT LEV potentiometer R73 to obtain 1.0 $\pm$0.05 Vdc at TP5 (YEL). This should correspond to 0 dBmO on the front-panel meter. If not, the adjust NOM potentiometer R30 for desired reading.

(3) The purchase specification will state a limit for input-signal level below which the low-level indicator lamp, DS1, should glow. Reduce the input to that level, then adjust potentiometer R58 until DS1 just begins to glow.

(4) Check that the indicating meter correctly shows changes of 10 and -10 dBmO in response to corresponding input-signal-level changes. With 0 dBmO = 27 mV at TP3 (GRN) on the Model 67 PLC REC FLT, 10 dBmO corresponds to 86 mV at that point, and -10 dBmO corresponds to 8.4 mV at TP3.

(5) Check the input-signal frequency to be sure it is at the specified value $\pm$2 Hz and at the nominal level of 27 mV. Then with an ac voltmeter check TP3 (turret) for a voltage level in the range from 0.80 to 1.2 Vrms.

(6) Trun off power, remove circuit card from extender and reinsert in chassis. Restore power.

### LM/SL Card

(1) Turn off power, remove circuit card from chassis and assemble on extender, reinsert in chassis, and restore power.

(2) Check that the position of the jumper at the input of IC7 is as specified.

(3) Adjust slicing levels as follows:
   (a) With a dc voltmeter connected at TP2 (BRN), key the input signal between trip and guard. The change of input frequency should cause a 16-volt change in voltage at TP2. Adjust SCALE potentiometer R29 to obtain this. Center this to plus and minus 8 ±0.5 Vdc with BIAS potentiometer R25.
   (b) Connect a dc voltmeter to TP6, TRIP SLICE, (turret terminal) and adjust R33 for a reading of 4 ±0.1 Vdc.
   (c) Connect a dc voltmeter to TP5 (turret terminal) and adjust R38, GUARD SLICE, for a reading of -4 ±0.1 Vdc.

(4) Check that DS1 illuminates for a trip signal, and that DS2 glows for a guard signal.

(5) Turn off power. Remove card from extender and replace in chassis. Restore power.

### Logic Card

(1) Turn off power, remove card and examine carefully for proper placement of jumpers while referring to purchase specification and Table 6.1. Install on extender, replace in chassis, and restore power.

(2) While keying between trip and guard, check for the following input voltages:
   (a) With trip input, edge-connector terminal 7 should be at 11 ±1 Vdc. With trip signal absent, Terminal 7 should be at —11 ±1 Vdc.
   (b) With guard input, edge-connector terminal 9 should be at 11 ±1 Vdc. With guard absent, this terminal should be at —11 ±1 Vdc.
   (c) With nominal signal-input level to the receiver, the voltage at edge-connector terminal 16 should be 1.0 ±0.15 Vdc.

(3) While keying between trip and guard, check for the following output voltages:
   (a) Check terminal E for 10 ±1 Vdc with trip present, and for —12 ±1 Vdc with trip absent.
   (b) Check terminal F for 10 ±1 Vdc with guard present, and for —12 ±1 Vdc with guard absent.

(4) Turn off power, remove card from extender and replace in chassis. Restore power.

### Output Card

Refer to the purchase specification for the desired wiring for output relays and check outputs accordingly.

### Voice Card

When supplied in a system, this optional card should be checked as follows:

(1) Turn off power, remove card from chassis and install on extender, replace assembly in chassis and restore power. Set AGC switch S1 to TEST position.

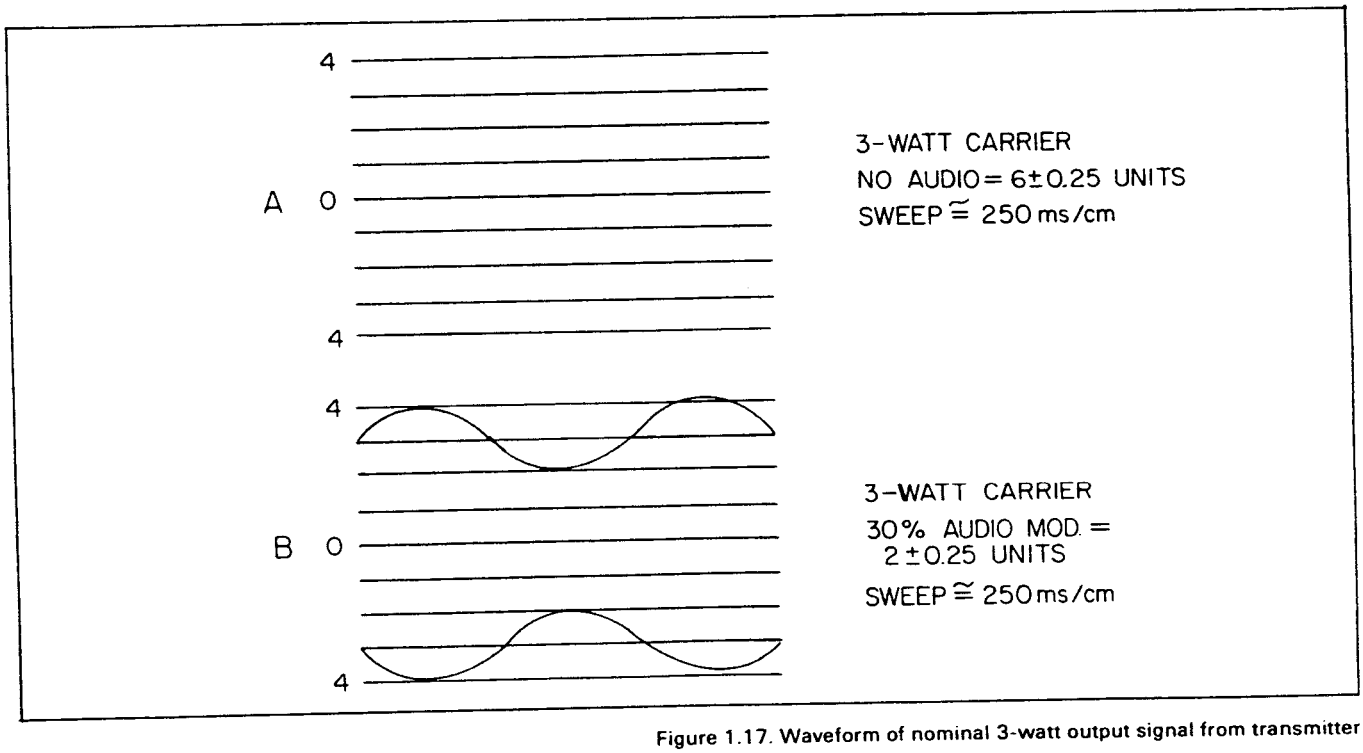



Figure 1.17. Waveform of nominal 3-watt output signal from transmitter

(2) At edge-connector terminal 16 introduce a 0.3-Vrms, 1-kHz signal from the audio oscillator with 300 ohms connected across its output terminals. This signal should produce a sine-wave signal which, as viewed with an oscilloscope connected at TP8 (turret terminal), will appear as just beginning to clip.

(3) Reduce audio-signal input to zero and measure output power from transmitter by measuring voltage across 50-ohm load resistor. This should be between 14.58 and 0.95 Vrms. The specified 3-watt output level would be 12.25 volts.

(4) While monitoring the level with the voltmeter, connect an oscilloscope across the load resistor and adjust to obtain the pattern shown in Figure 1.17(A).

(5) Restore audio signal of 0.3 Vrms, 1 kHz and adjust R63, %MOD, to produce levels shown in Figure 1.17(B).

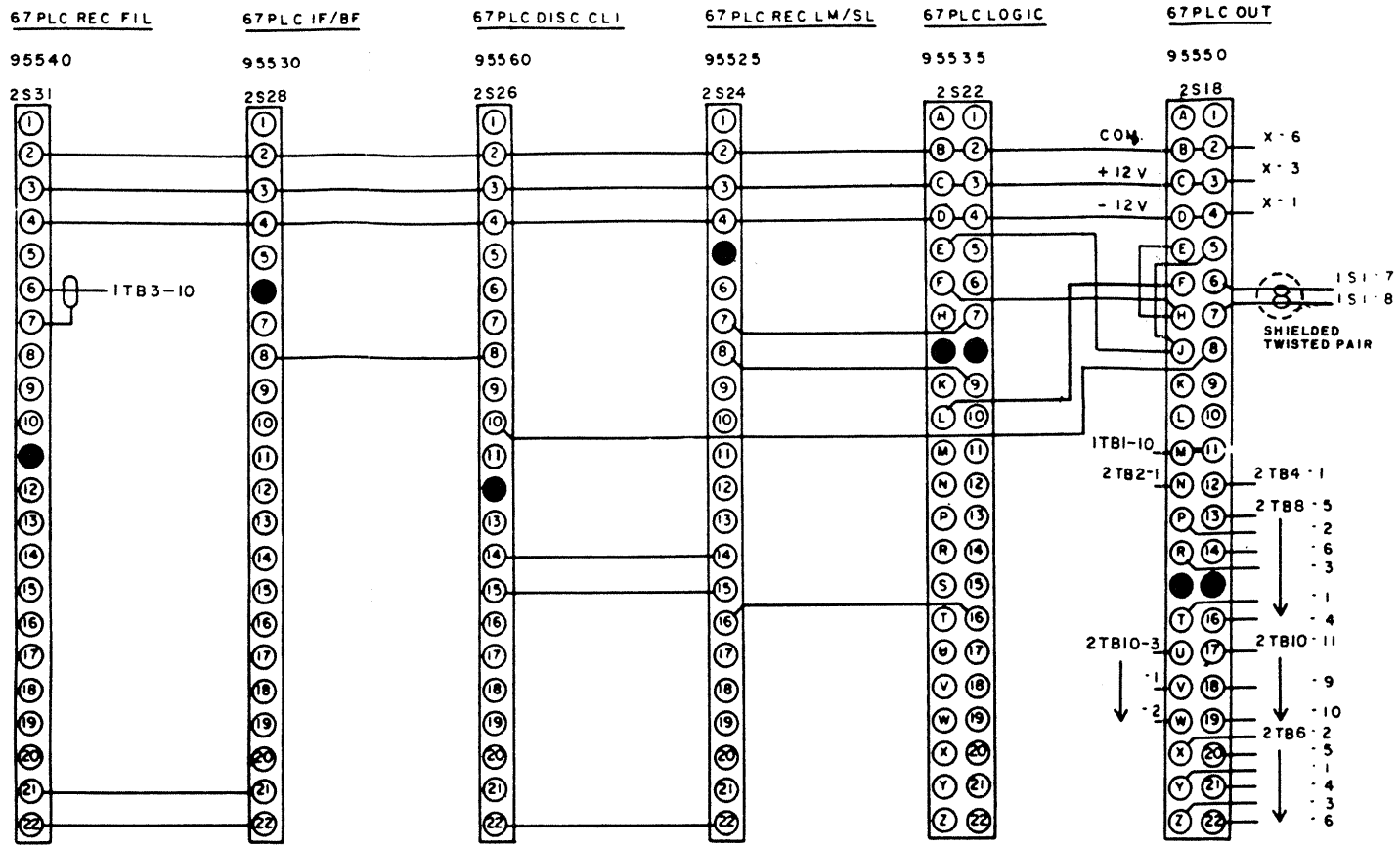
(6) Remove audio oscillator and shunt resistor.

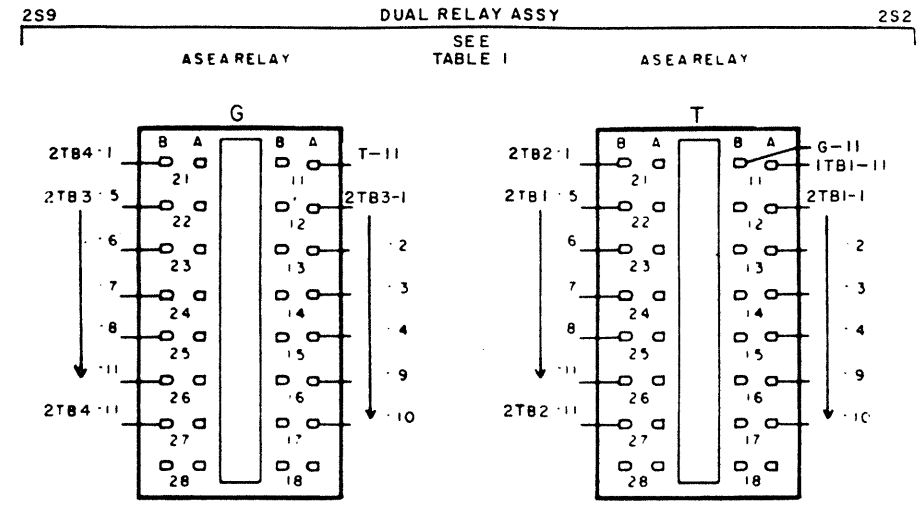
(7) Apply 12-Vdc source across edge-connector terminals 21 and 22, with terminal 21 positive, to activate the call tone. With oscilloscope, observe signal across load resistor. The waveform will be similar to that shown in Figure 1.11 (B) except that the modulating frequency will be 1800 $\pm$15 Hz. With a frequency counter, check this frequency at TP5 (BRN), MOD LEVEL.

(8) Connect an ac voltmeter to TP6 (YEL), activate the remote call tone from the opposite terminals and adjust AUD LEV potentiometer R71 for a reading of 0.8 Vrms. While receiving the remote call tone, observe TP7 (BLU), which should read 4 Vrms $\pm$20%.

(9) Connect an ac voltmeter to TP2 (GRN) and adjust GAIN potentiometer R7 for a reading of 1.0 Vrms. While monitoring TP2, move S1 from TEST to NORM and note, after several seconds, that TP2 returns to between 0.8 and 1.26 Vrms with 1.0 Vrms as the nominal value.

This completes the test of the receiver chassis.



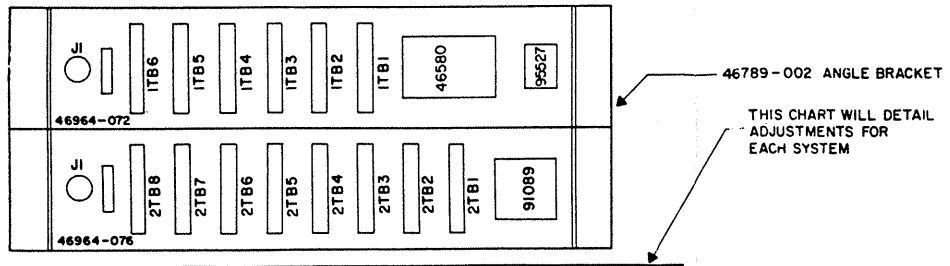

NOTES (WHERE APPLICABLE)

1. S - INDICATES PRINTED CIRCUIT BOARD SOCKETS
2. TB- INDICATES BARRIER STRIPS
3. ● - INDICATES KEY LOCATION
4. WIRING IS NO 22 STRANDED OF COLOR MARKED UNMARKED WIRE IS BUS WIRING
5. RELAY CONTACTS ARE SHOWN UNENERGIZED
6. IF DC GROUND IS NOT DESIRED A SUITABLE CAPACITOR (.5uF OR GREATER) MUST BE INSTALLED IN PLACE OF JUMPER
7. WIRING TO BE H V WIRE
8. WIRING TO BE ROUTED IN A SEPARATE HARNESS
9. ⓪ - INDICATES SHIELDED CABLE RG174 38479
10. BUSS ACROSS TERMINAL BLOCKS EXTERNALLY.

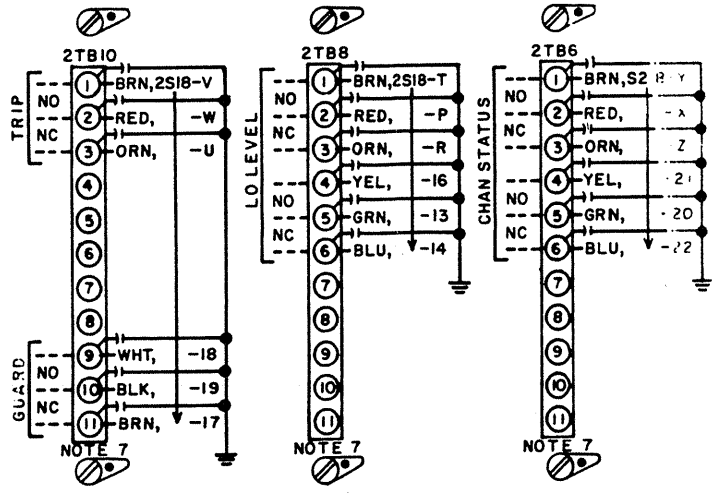
PARTS LIST

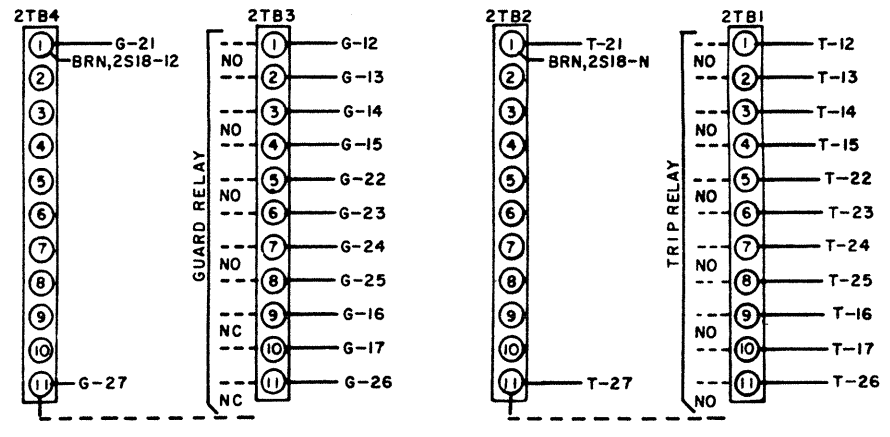
(2) 46950 CHASSIS
(2) 46963-001 FRONT PANEL
(2) 46964-072 REAR PANEL ASSY.
(1) 46964-001 REAR PANEL ASSY.

(1) 46580 REGULATOR
(1) 95527 "
(1) 44880 RLY MTG ASSY
(2) 46789-002 BRACKET, ANGLE
(2) 38576 SHIELDS
(30) 1007-1264 CAPACITOR .005uF, 20%, 3kV
(1) 98293 AUTO TXFR ASSY.




| 6780 PLC | | | | | | |
|---|---|---|---|---|---|---|
| APPLICATION | | | | | | |
| | | | | | | TRIP____KHz |
| | | | | | | GUARD____KHz |
| INPUT | TRANS | TX FIL | RX FIL | IF/BF | LIM/SL | LOGIC |
| | "G" OSC | | | | | |
| | "T" OSC | | | | | |



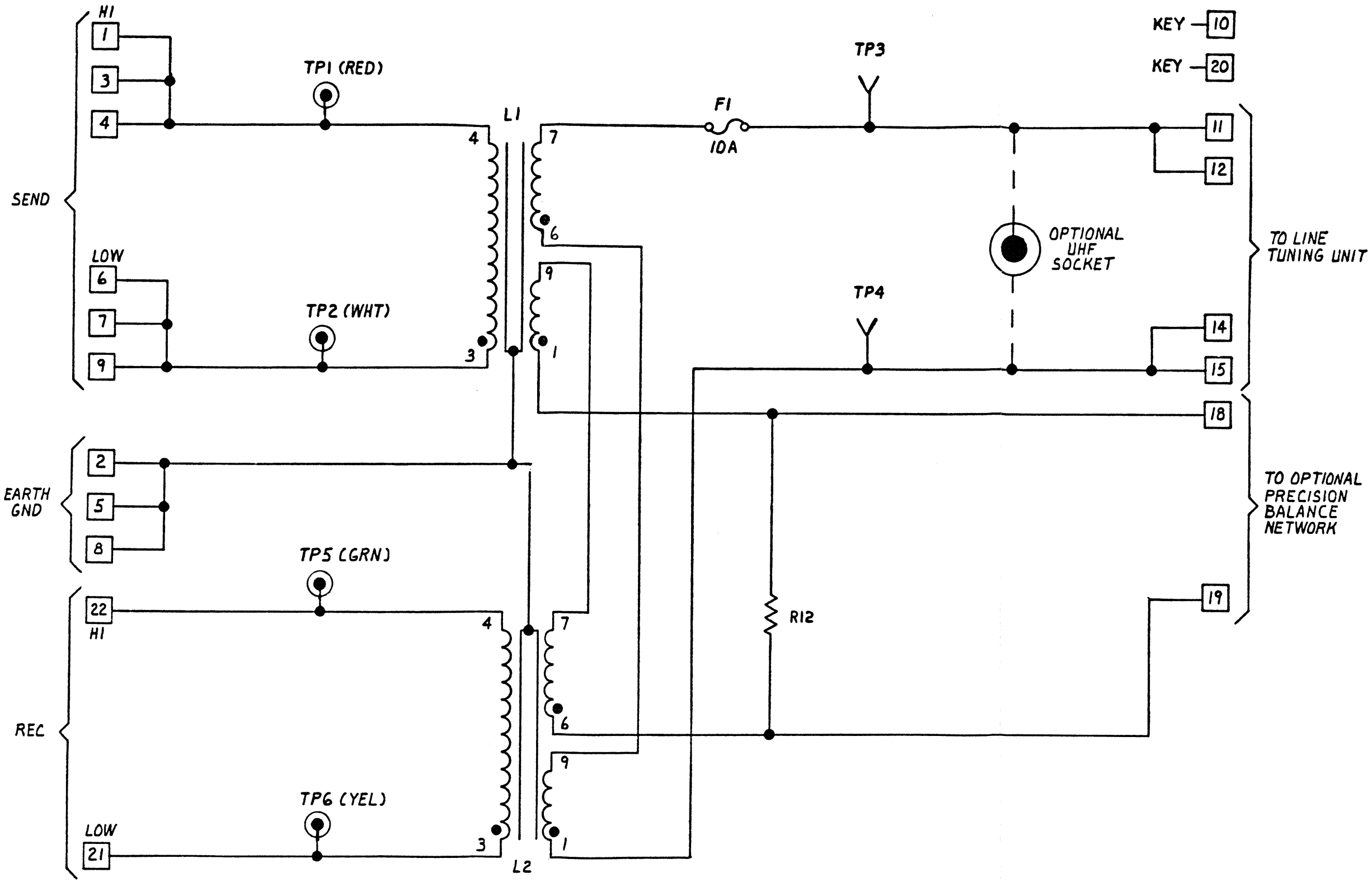



Figure 10.3. Schematic- Model 67 PLC X HYB

# Section 2
# INPUT

## MODEL 67 PLC INPUT
## DESCRIPTION

The Model 67 PLC INPUT is the interface between trip-input signals and the Series 6780 System. Two isolated trip-input circuts are provided, Trip 1 and Trip 2, and transmission of guard or block conditions is caused by the absense of any trip-signal input to the card.

A VOICE ENABLE input receives a logic 1 whenever a voice signal appears at the input to the Model 67 PLC VOICE circuit card.

The logic circuits on the input card are under control of the two trip signals and the voice-enable signal. Using these signals, and under the control of preset jumpers, the logic circuits control the output power level of the transmitter according to output frequency commanded, whenever voice signal is present or absent, whether voice muting is required during trip condition, and whether an increase of output power during trip (trip boost) is called for.

An alarm relay, mounted on the input card, is energized from the Model 67 PLC PWR AMP card. The relay is normally energized above a preset carrier level. If the output power level falls below that level, the relay is deenergized, supervisory lamp DS3 on the input card extinguishes, and two sets of Form-C contacts on the relay change their position. The relay is energized again when the power level is somewhat higher.

At terminal M, a logic low appears when a trip signal is transmitted to signify the "has-tripped" status of the transmitter. This signal may be connected to an alarm relay, located elsewhere in the chassis.

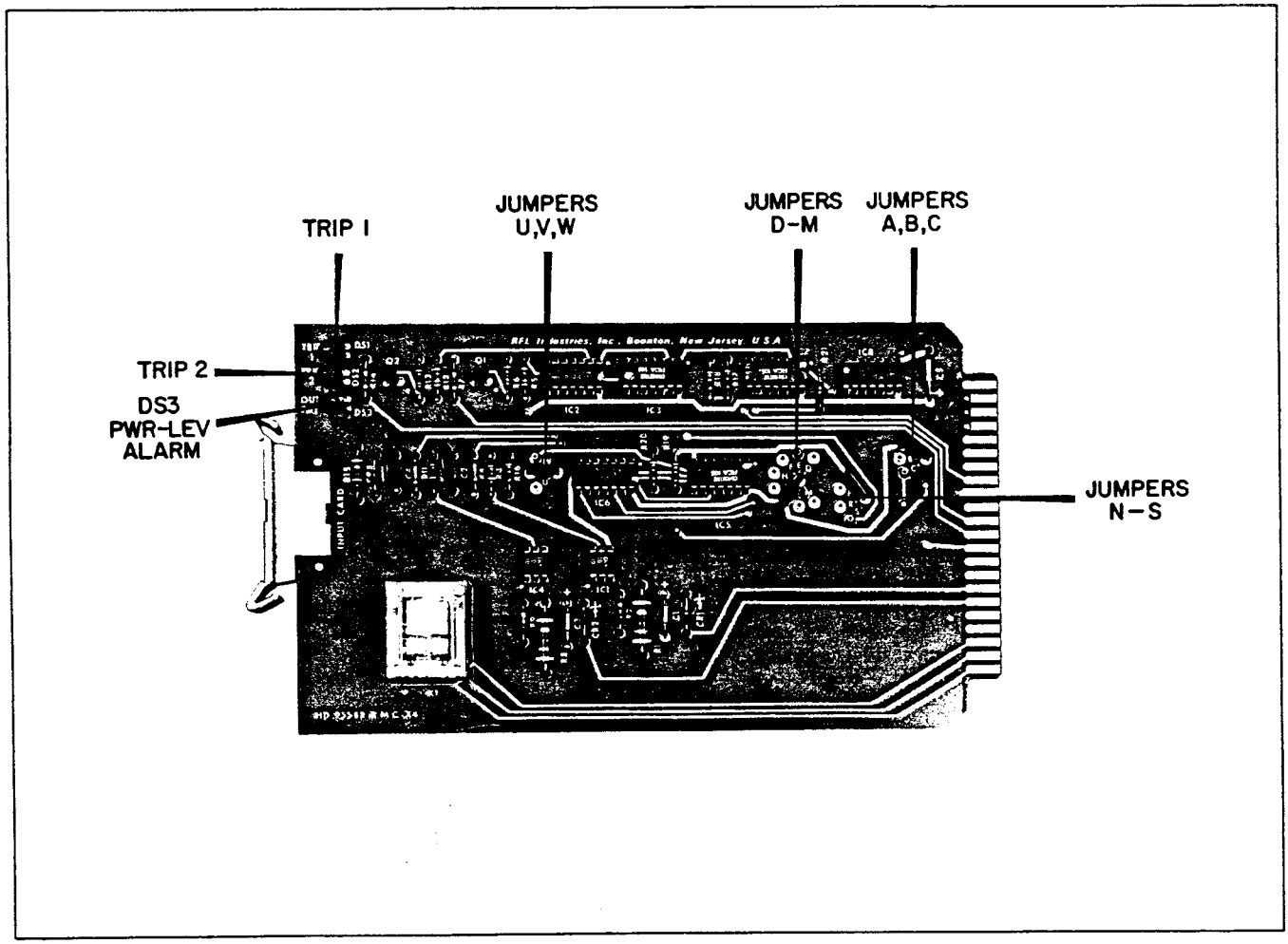



Figure 2.1. Location of controls and adjustments, Model 67 PLC INPUT

# CIRCUIT DETAILS

A schematic of the circuit of the Model 67 PLC INPUT appears as Figure 2.2. It will be the primary reference for the following discussion.

## Trip Input

A trip-input command requires a logic high (12 Vdc) between either terminals 16 and T, terminals 17 and U, or both for two simultaneous inputs. The trip circuit is closed through the contacts of the trip-command relay, and the voltage is usually taken from the station battery through a dropping resistor mounted on a barrier strip at the back of the chassis. Supervisory lamps DS1 and DS2 glow respectively in response to inputs at Trip 1 and Trip 2.

The condition of input logic at Trip 1 and Trip 2, and the setting of jumpers U, V, and W determine which output frequency, chosen from among the oscillators on the transmitter card, will be transmitted. The choice is made, under control of logic levels at terminals 11 and 12, in logic gates located on the transmitter card. (See Table 2.2).

The condition of the two trip inputs, and the status of the voice card if used, control two switches on the transmitter card which choose among 1, 3, and 10 watts for the output-power level. These switches are controlled by logic levels from the input card at terminals 6 and 7. The choice is made in gates IC5, IC6, and IC7 in accordance with the placement of jumpers A through M. (See Table 2.3).

## Force Boost

A signal to force the transmitter's output level to 10 watts may be introduced as a logic 1 at terminal 8. This output level will prevail irrespective of the input status at Trip 1 and Trip 2. This function may not be used in systems carrying voice signals, for the level must be held at 3 watts in such system while voice is transmitted.

## Voice Control

A voice-enable logic signal is received at terminal J from the Model 67 PLC VOICE card. When a voice voltage is present at the input of that card, a logic 1 appears at terminal J. This signal, combined with logic signals from Trip 1 and Trip 2, controls the transmitter's modulator through terminal 10. In general, when output level is 1 watt and voice is not muted, the output level is raised to 3 watts when the modulator is enabled. If the output level is 3 watts and voice is not muted, the modulator is enabled. And if the output level is 10 watts the modulator is not enabled. (See Table 2.3).

## Jumper Settings

Table 2.1 summarizes jumper settings for many desired input conditions and output functions.

**TABLE 2.1**
**JUMPER SETTINGS, MODEL 67 PLC INPUT**

| TRIP KEYING INPUT SELECTION | | | | POWER OUTPUT LEVEL SELECTION | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FUNCTION | U | V | W | 2-F | A | B | C | D | E | F | H | J | K | L | M | N | P | R | S |
| Single Optical Isolator Keying Input | X | | | NO VOICE 1W – 1W | X | | | | | | | | X | | | X | | | |
| | | | | 1W – 10W | X | | | | | X | | | | | | X | | | |
| Dual Optical Isolator Keying Input (Redundant) | | X | | 10W – 10W | X | | | | X | | | | | | | X | | | |
| Start/Stop Keying For Directional Comparison Relaying | | | X | VOICE (No Trip Override) 1W – 1W | | | X | | | | | | X | | | | X | | |
| | | | | 1W – 10W | | | X | | | | X | | | | | | X | | |
| 3F Dual Function Keying Input DTT/Unblk | X | | | 10W – 10W | | X | | | | | | X | | | | | X | | |
| | | | | VOICE (Trip Override) 1W – 1W | | | X | | | | | | X | | | | | X | | |
| | | | | 1W – 10W | | | X | | | X | | | | | | | | X | | |
| | | | | 10W – 10W | | X | | X | | | | | | | | | | X | | |
| | | | | 3-F Dual Function 1W – 1W | | | X | | | | | | X | | | | | | X | |
| | | | | 1W – 10W | | | X | | | | | | | X | | | | | X | |
| | | | | 10W – 10W | | X | | | | | | | | | X | | | | X | |
| | | | | When Using 67 PLC 1W Amp | | X | | | | | | | X | | | | X | | |

## TABLE 2.2
## KEYING TO SELECT OUTPUT FREQUENCY, MODEL 67 PLC INPUT
(X = Don't Care)

| Keying Mode | Trip 1 (2) | Trip 2 (2) | Logic Term 11 | Logic Term 12 | Oscillator Chosen | Jumper Used | Comment |
|---|---|---|---|---|---|---|---|
| 2-F Mode 1 | 0 | X | 0 | – | 1 | U | Standard 2-F operation (1) |
| | 1 | X | 1 | – | 2 | | |
| 2-F Mode 2 | 0 | 0 | 0 | – | 1 | V | Requires two trip inputs for shift of output frequency |
| | 0 | 1 | 0 | – | 1 | | |
| | 1 | 0 | 0 | – | 1 | | |
| | 1 | 1 | 1 | – | 2 | | |
| 2-F Mode 3 | X | 1 | 0 | – | 1 | W | Trip 2 cancels Trip 1 |
| | 0 | 0 | 0 | – | 1 | | |
| | 1 | 0 | 1 | – | 2 | | |
| 3-F Mode 4 | 0 | 0 | 0 | 1 | 1 | U | Trip 2 chooses OSC 3 and cancels both OSC 1 and OSC 2 |
| | 1 | 0 | 1 | 1 | 2 | | |
| | X | 1 | X (3) | 0 | 3 | | |

(1) This connection is also used for on-off keying of a single oscillator, which is plugged into OSC 1 or OSC 2 position on the transmitter card according to whether positive or negative logic is desired.

(2) For Trip 1 or 2 a logic 1 (high) at the input terminal is a trip command.

(3) OSC 3 cancels OSC 1 and OSC 2 in logic on the transmitter card.

Mode 1 = Single Opto Isol Keying
Mode 2 = Dual Opto Isol Keying (Redundant)
Mode 3 = Start/Stop Keying for Directional Comparison Relaying
Mode 4 = Dual Function DTT/POTT

## TABLE 2.3
## KEYING, VOICE CONTROL, AND OUTPUT POWER, MODEL 67 PLC INPUT
(X = Indifferent)

| LINE | KEYING MODE (1) | TRIP 1 (2) | TRIP 2 (2) | VOICE ENABLE (3) | MOD ENABLE (4) | SWITCH A (TERM 6) (5) | SWITCH B (TERM 7) (5) | OUTPUT POWER, WATTS | JUMPERS USED | COMMENT |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2-F Mode 1 | 0 | | X | X | 1 | 1 | 1 | A, K, N | No-voice system |
| | | 1 | | X | X | 1 | 1 | 1 | | |
| | | 0 | | X | X | 1 | 1 | 1 | A, F, N | No-voice system, trip-boost = 10W |
| | | 1 | | X | X | 0 | X | 10 | | |
| 5 | | 0 | | X | X | 0 | X | 10 | A, E, N | No-voice system, no trip boost, output = 10W |
| 6 | | 1 | | X | X | 0 | X | 10 | | |
| 7 | 2-F Mode 2 | 0 | | 0 | 0 | 1 | 1 | 1 | C, K, P | Voice system, no trip boost<br>No voice mute during trip |
| | | 0 | | 1 | 1 | 1 | 0 | 3 | | |
| | | 1 | | 0 | 0 | 1 | 1 | 1 | | |
| 10 | | 1 | | 1 | 1 | 1 | 0 | 3 | | |
| | | 0 | | 0 | 0 | 1 | 1 | 1 | C, H, P | Voice system<br>Trip-boost = 10W<br>No voice mute during trip |
| | | 0 | | 1 | 1 | 1 | 0 | 3 | | |
| | | 1 | | 0 | 0 | 1 | 1 | 10 | | |
| | | 1 | | 1 | 1 | 1 | 0 | 3 | | |
| 15 | | 0 | | 0 | 0 | 0 | X | 10 | B, J, P | Voice system<br>Output 10W without voice<br>Output 3W with voice<br>No voice mute during trip |
| | | 0 | | 1 | 1 | 1 | 0 | 3 | | |
| | | 1 | | 0 | 0 | 0 | X | 10 | | |
| 18 | | 1 | | 1 | 1 | 1 | 0 | 3 | | |
| 19 | 2-F Mode 3 | 0 | | 0 | 0 | 1 | 1 | 1 | C, K, R | Voice system<br>Trip-boost = 3W<br>Voice muted during trip |
| 20 | | 0 | | 1 | 1 | 1 | 0 | 3 | | |
| | | 1 | | 0 | 0 | 1 | 1 | 1 | | |
| | | 1 | | 1 | 0 | 1 | 0 | 3 | | |
| | | 0 | | 0 | 0 | 1 | 1 | 1 | C, F, R | Voice system<br>Trip-boost = 10W<br>Voice muted during trip |
| | | 0 | | 1 | 1 | 1 | 0 | 3 | | |
| 25 | | 1 | | 0 | 0 | 0 | X | 10 | | |
| | | 1 | | 1 | 0 | 0 | X | 10 | | |
| | | 0 | | 0 | 0 | 0 | X | 10 | B, D, R | Voice system<br>Output 10W without voice<br>Output 3W with voice<br>Voice muted during trip |
| | | 0 | | 1 | 1 | 1 | 0 | 3 | | |
| | | 1 | | 0 | 0 | 0 | X | 10 | | |
| 30 | | 1 | | 1 | 0 | 0 | X | 10 | | |
| 31 | 3-F Mode 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | C, K, S | Voice system<br>Output 1W without voice<br>Output 3W with voice<br>Trip-boost = 3W<br>Voice muted during Trip 1 plus Trip 2 |
| | | 0 | 0 | 1 | 1 | 1 | 0 | 3 | | |
| | | 1 | 0 | 0 | 0 | 1 | 1 | 1 | | |
| | | 1 | 0 | 1 | 1 | 1 | 0 | 3 | | |
| 35 | | 1 | 1 | 0 | 0 | 1 | 1 | 1 | | |
| 36 | | 1 | 1 | 1 | 0 | 1 | 0 | 3 | | |
| | 3-F Mode 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | C, L, S | Voice system<br>No trip = 1W<br>Trip 1 = 10W alone, or 3W with unmuted voice<br>Trip 1 plus Trip 2 = 10W with muted voice |
| | | 0 | 0 | 1 | 1 | 1 | 0 | 3 | | |
| | | 1 | 0 | 0 | 0 | 0 | X | 10 | | |
| 40 | | 1 | 0 | 1 | 1 | 1 | 0 | 3 | | |
| | | 1 | 1 | 0 | 0 | 0 | X | 10 | | |
| 42 | | 1 | 1 | 1 | 0 | 0 | X | 10 | | |
| 43 | 3-F Mode 3 | 0 | 0 | 0 | 0 | 0 | X | 10 | B, M, S | Voice system<br>No trip = 10W alone, or 3W with voice<br>Trip 1 = 10W alone, or 3W with unmuted voice<br>Trip 1 plus Trip 2 = 10W with muted voice |
| | | 0 | 0 | 1 | 1 | 1 | 0 | 3 | | |
| 45 | | 1 | 0 | 0 | 0 | 0 | X | 10 | | |
| | | 1 | 0 | 1 | 1 | 1 | 0 | 3 | | |
| | | 1 | 1 | 0 | 0 | 0 | X | 10 | | |
| 48 | | 1 | 1 | 1 | 0 | 0 | X | 10 | | |

(1) For selection of keying mode and use of Trip 2 in 2-F mode, see Table 2.1.
(2) 1 = Trip command present.
(3) 1 = Speech signal present.
(4) 1 = Modulator enabled on transmitter card.
(5) See power-switch logic table on schematic.

## TABLE 2.4
## SUMMARY OF INPUT SIGNALS AND POWER OUTPUT, MODEL 67 PLC INPUT

| KEYING MODE (1) | INPUT SIGNALS (2) | | | PWR OUT-WATTS | | JUMPERS USED | COMMENT |
|---|---|---|---|---|---|---|---|
| | Guard | Trip 1 | Trip 2 | Voice | No Voice (3) | | |
| 2-F Mode 1 | 1 | 0 | – | – | 1 | A, K, N | No voice |
| | 0 | 1 | – | – | 1 | | |
| | 1 | 0 | – | – | 1 | A, F, N | |
| | 0 | 1 | – | – | 10 | | |
| | 1 | 0 | – | – | 10 | A, E, N | |
| | 0 | 1 | – | – | 10 | | |
| 2-F Mode 2 | 1 | 0 | – | 3 | 1 | C, K, P | Voice system, no muting |
| | 0 | 1 | – | 3 | 1 | | |
| | 1 | 0 | – | 3 | 1 | C, H, P | |
| | 0 | 1 | – | 3 | 10 | | |
| | 1 | 0 | – | 3 | 10 | B, J, P | |
| | 0 | 1 | – | 3 | 10 | | |
| 2-F Mode 3 | 1 | 0 | – | 3 | 1 | C, K, R | Voice system, muted during trip |
| | 0 | 1 | – | 0 | 1 | | |
| | 1 | 0 | – | 3 | 1 | C, F, R | |
| | 0 | 1 | – | 0 | 10 | | |
| | 1 | 0 | – | 3 | 10 | B, D, R | |
| | 0 | 1 | – | 0 | 10 | | |
| 3-F Mode 1 | 1 | 0 | 0 | 3 | 1 | C, K, S | Voice system muted during Trip 2 |
| | 0 | 1 | 0 | 3 | 1 | | |
| | 0 | 1 | 1 | 0 | 1 | | |
| 3-F Mode 2 | 1 | 0 | 0 | 3 | 1 | C, L, S | Voice system muted during Trip 1 plus Trip 2 |
| | 0 | 1 | 0 | 3 | 10 | | |
| | 0 | 1 | 1 | 0 | 10 | | |
| 3-F Mode 3 | 1 | 0 | 0 | 3 | 10 | B, M, S | Voice system muted during Trip 1 plus Trip 2 |
| | 0 | 1 | 0 | 3 | 3 | | |
| | 0 | 1 | 1 | 0 | 10 | | |

(1) For selection of keying mode and use of Trip 2 in 2-F mode, see Table 2.1.

(2) Logic 1 = signal present.

(3) Power outputs in this column are in absence of voice. If voice input is present and enabled, output power is always 3 watts.

# Table 2.5
# Replaceable Parts

| Circuit Symbol (See Figure 2.2) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC INPUT - Assembly No. HB-95545** | |
| | **CAPACITORS** | |
| C1, 3 | Capacitor, tantalum, 0.47μF, 10%, 35V, Kemet T322A474K035AS, or equiv. | 1007 511 |
| C2, 4 | Capacitor, ceramic disc, 0.0047μF, 10%, 500V, Erie 811-000X5R042K, or equiv. | 1007 92 |
| C5 | Capacitor, tantalum, 1μF, 10%, 35V, Kemet T110A105K035AS, or equiv. | 1007 1156 |
| | **RESISTORS** | |
| R1, 8 | Resistor, composition, 430 ohm, 5%, 1W, Allen-Bradley GB, or equiv. | 1009 258 |
| R2, 9 | Resistor, metal film, 150 ohm, 1%, ¼W, Type RN¼ | 0410 1209 |
| R3, 10 | Resistor, metal film, 3.92K, 1%, ¼W, Type RN¼ | 0410 1345 |
| R4, 11 | Resistor, metal film, 33.2K, 1%, ¼W, Type RN¼ | 0410 1434 |
| R5, 12 | Resistor, metal film, 4.75K, 1%, ¼W, Type RN¼ | 0410 1353 |
| R6, 13 | Resistor, metal film, 3.32K, 1%, ¼W, Type RN¼ | 0410 1338 |
| R7, 14 | Resistor, metal film, 825 ohm, 1%, ¼W, Type RN¼ | 0410 1280 |
| R15 | Resistor, metal film, 2.74K, 1%, ½W, Type RN½ | 0410 2330 |
| R16-20, 22, 23 | Resistor, metal film, 10K, 1%, ¼W, Type RN¼ | 0410 1384 |
| R21 | Resistor, metal film, 20K, 1%, ¼W, Type RN¼ | 0410 1413 |
| | **SEMICONDUCTORS** | |
| CR1, 2 | Diode, Zener, 12V, 5%, 2W, Siemens 2EZ12D5, or equiv. | 35319 |
| CR3 | Diode, silicon, 1N4003 | 30769 |
| DS1-3 | Light-emitting diode, Dialight 550-0102, or equiv. | 39568 |
| IC1, 4 | Optical isolator, General Electric 4N35, or equiv. | 47104 |
| IC2, 6 | MOS, hex Schmitt trigger, Motorola MC14584CP, or equiv. | 0615 60 |
| IC3, 5, 7 | MOS, quad, 2-input AND gate, RCA CD4081BE, or equiv. | 0615 31 |
| IC8 | MOS, quad, 2-input OR gate, RCA CD4071BE, or equiv. | 0615 24 |
| Q1, 2 | Transistor, NPN, 2N2222A, plastic package | 37445 |
| | **MISCELLANEOUS COMPONENTS** | |
| K1 | Relay, DPDT, 24-volt coil, Aromat NC2D-JP24VDC, or equiv. | 94810 |
| --- | Shorting bar, single, Aries LP300, or equiv. | 42904 |

| SWITCH | | OUTPUT POWER LEVEL |
|---|---|---|
| A | B | |
| 1 | 1 | 1W |
| 1 | 0 | 3W |
| 0 | X | 10W |

NOTE:
UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE EXPRESSED IN OHMS AND ARE 1/4W, 5%.

Figure 2.2. Schematic- Model 67 PLC INPUT

| STOCK LIST | | | |
|---|---|---|---|
| ITEM | PART NO. | REQD | DESCRIPTION |

| SWITCH | | OUTPUT POWER LEVEL |
|---|---|---|
| A | B | |
| 1 | 1 | 1W |
| 1 | 0 | 3W |
| 0 | X | 10W |

+12V C,3 +V
+ C5 1UF 35V
COM B,2

TRIP 1 (LOGIC LEVEL) W

+V 16
TRIP 1 0=OSC 1 1=OSC 2
-V T
CR1 12V 2W
+ C1 .47UF 35V
R1 430 1W
R2 150
IC1

9 KEY

TRIP 2 (LOGIC LEVEL) 19

+V 17
TRIP 2 1=OSC3
-V U
CR2 12V 2W
+ C3 .47UF 35V
R8 430 1W
R9 150
IC4

14 Z T
DS3 PWR LEV
R15 2.7K 1/2W
CR3
K1 5 4
13 LO
P HI

POWER-LEVEL ALARM
14 2 13 11 7 12
23 X 21 Z 20 Y

R3 3.9K
C2 .0056UF
R4 33K
IC2E
0=OSC 1 1=OSC 2

R10 3.9K
C4 .0056UF
R11 33K
IC2D IC2C
1=OSC 3

DS1 TRIP 1
+V R7 820
TRIP 1 M
11 0=OSC 1 1=OSC 2
R5 4.7K
Q1
R6 3.3K
IC2F IC2B

R16 10K U V W
IC3C IC3D
TRIP=1

IC8C
10
8 9

DS2 TRIP 2
R14 820
IC2A R12 4.7K Q2
R13 3.3K
12 0=OSC 3
N TRIP 2

IC3A
IC3B
VOICE=1
R18 10K
R17 10K
J VOICE ENABLE=1

IC6C
VOICE ENABLE=1
VOICE ENABLE=0
VOICE ENABLE=1

IC5D IC6D IC5C IC6F IC5A IC8D IC5B
IC7A

0=OSC 1 1=OSC 2

R21 20K
IC7C
IC6A
R20 10K
R19 10K
FORCE BOOST=1
8 (NO VOICE SYSTEMS ONLY)

IC7B
7 B SWITCH (TO XMTR 13 )
IC8B
6 A SWITCH (TO XMTR 6 )
IC6E IC7D IC8A
IC6B
R22 10K
R23 10K

10 AM MOD ENABLE
1=VOICE OUT
0=VOICE MUTE

H CHECKBACK INPUT

NOTE:
UNLESS OTHERWISE SPECIFIED
ALL RESISTORS ARE EXPRESSED IN OHMS
AND ARE 1/4W,5%.

| ISSUE | CHANGE | DATE | DRN | CKD | APP |
|---|---|---|---|---|---|
| F | REV C2, C9 ECO 6780-089 | 12-7-92 | GW | ML | |
| E | REV. PER ECO 6780-075 | 2-22-91 | EW | CS | ES |

USED ON: NEXT ASSY | MODEL | REQ

COMMERCIAL TOLERANCES APPLY TO STOCK SIZES
DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE DECIMAL ± .02
3 PLACE DECIMAL ± .005
ANGULAR ± 2.5°

SCHEMATIC 67 PLC INPUT
MATERIAL:
FINISH:
SCALE
DRN: E.D.M. DATE: 3-12-91
CKD: D.B DATE: 5/20/91
APP: CS DATE: 5/17/91

RFL Electronics Inc.
Boonton, New Jersey USA
DWG SIZE D
DWG NO 95549-F
SHEET 1 OF 1
6 INCH FULL SCALE

# Section 3
# TRANSMITTER

## MODEL 67 PLC TRANS
### DESCRIPTION

The Model 67 PLC TRANS is the signal-generating portion of a complete power-line carrier-frequency transmitter which includes also a power amplifier and output filter, each on separate cards. The power amplifier is described in a later section.

This card contains up to three crystal oscillators for generating a choice of output frequencies, control switches for setting output-power level, a monitor for low power-supply voltage, a plug-on bandpass filter centered on the output frequency, a driver amplifier, and an AM modulator used for modulating the output signal when the optional Model 67 PLC VOICE card is used. Figure 3.1 is a block diagram showing the organization of the transmitter section of the system.

Frequency of the output signal may be selected anywhere in the range from 30 to 500 kHz. Modulation may be either two-frequency or three-frequency frequency-shift keying. When voice transmission is used, the carrier frequency is that of whatever signal is transmitted for protective-relaying purposes. The output frequency at any instant is taken from one of the oscillators according to the status of input terminals on the input card, jumper settings for logic circuits on the input card, and the status of logic gates on the transmitter card.

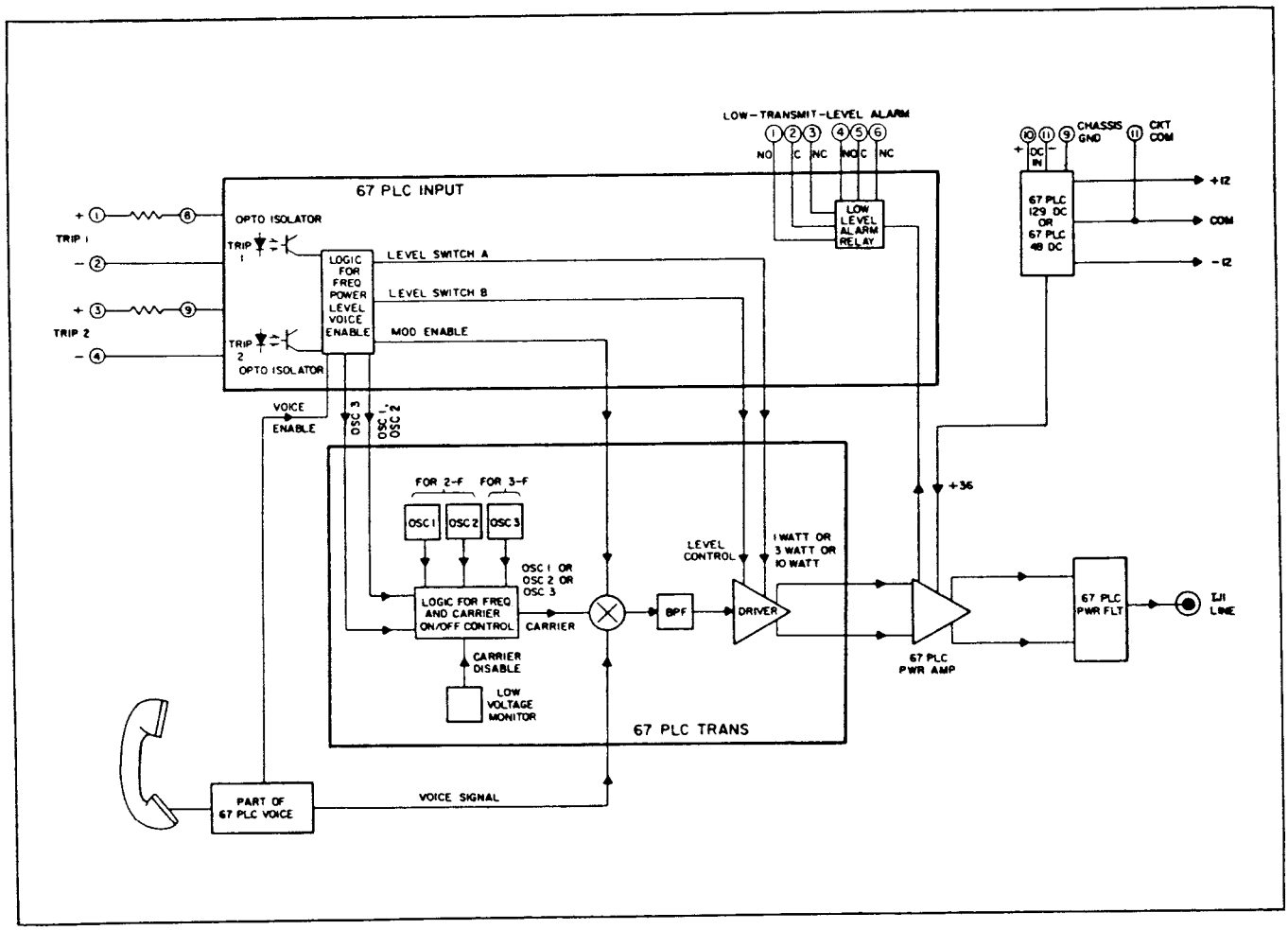



Figure 3.1. Block diagram- transmitter section

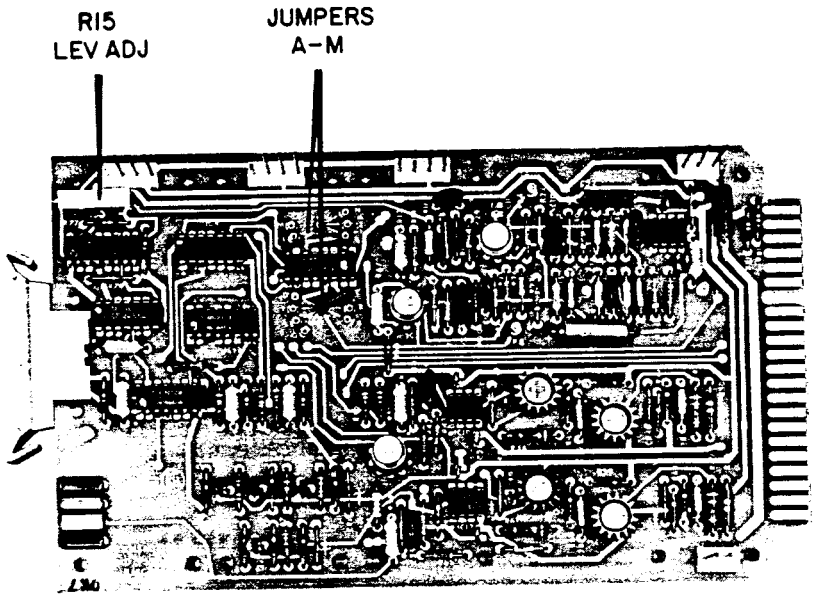



Figure 3.2. Location of controls and adjustments, Model 67 PLC TRANS

## TABLE 3.1
## CARRIER-FREQUENCY GENERATION, MODEL 67 PLC TRANS

### TABLE 3.1A
### CARRIER GENERATION

| Total Division | Use Jumper |
|---|---|
| 8 | A |
| 16 | B |
| 32 | C |
| 64 | D |
| 128 | E |
| 256 | F |
| 512 | G |
| 1024 | H |
| 2048 | J |
| 4096 | K |
| 8192 | L |
| 16384 | M |

### TABLE 3.1B

| PART NUMBERS | |
|---|---|
| CRYSTAL | OPTION |
| HB-46544-(X) | HB-90303-(X) and oven HB-46928 |
| Stability ±10 PPM | Stability ±2 PPM |

NOTES:
(1) Use crystals in the range from 4 to 9 MHz.

TABLE 3.2
SELECTION OF OUTPUT FREQUENCY, Model 67 PLC TRANS
(X = INDIFFERENT)

| Terminal 11 Logic Level | Terminal 12 Logic Level | Output Frequency Set By |
|---|---|---|
| 0 | 1 | OSC 1 |
| 1 | 1 | OSC 2 |
| X | 0 | OSC 3 |

TABLE 3.3
SELECTION OF OUTPUT LEVEL, Model 67 PLC TRANS
(X = INDIFFERENT)

| Switch A Logic Level | Switch B Logic Level | Output Power |
|---|---|---|
| 1 | 1 | 1 Watt |
| 1 | 0 | 3 Watts |
| 0 | X | 10 Watts |

# CIRCUIT DETAILS

This discussion is based on the schematic of the circuit of the transmitter, which appears as Figure 3.3.

## Oscillator

Up to three crystals oscillators, identified as OSC 1, OSC 2, and OSC 3, may be used on the transmitter card. All use the same circuit, and all carry the same circuit-symbol numbers.

Transistor Q1 and crystal Y1 form a Colpitts oscillator. Capacitor C3 may be used to adjust the oscillator to its exact frequency after stabilization at room temperature. The output of Q1 is buffered by dual-gate field-effect transistor Q2. The signal at the drain of Q2 is approximately a squarewave with a peak-to-peak amplitude of about 11 volts, and the frequency of this signal is divided by four in IC1.

The outputs of all oscillators are selected and gated by the three gates of IC3, under control of logic signals at Terminals 11 and 12. The selected signal is further divided to the output frequency in divided IC6. The combination of frequency divisor selected with jumpers at IC6 and selected crystal frequency determine the output frequency. Details appear in Table 3.1.

Table 3.1B shows applicable DRFL part numbers for crystals and the optional crystal oven. Table 3.2 shows which oscillator controls the output frequency as selected by the logic levels at terminals 11 and 12. It should be noted that a logic 0 at terminal 12, which turns on OSC 3, pre-empts the channel for the frequency of OSC 3 irrespective of the logic state at terminal 11, the control point for OSC 1 and OSC 2.

## Voice Modulator

The line-frequency signal from the frequency divider is passed through semiconductor-switch IC7A and drives IC8, a double-balanced modulator. This circuit serves as a carrier buffer when the voice signal is absent and as an AM speech modulator when speech is present. The voice signal, which passes through semiconductor switch IC7B, is under control of a logic signal which comes from the input card via terminal 10. A logic 1 passes the voice signal under ordinary conditions but the logic circuits of the input card may, if desired, be set so that the voice signal is muted, through this control, when a trip signal is commanded.

The modulator's output is buffered by IC9, and it then passes to the driver amplifier through a band-pass filter tuned to the output frequency. The schematic of the filter is shown in Figure 3.4. Component values depend on frequency.

Fine control of the output level of the transmitter is done with R15, which is the null-balance control of the balanced modulator. The level thus set is under control of power switches A and B, in the driver amplifier section.

## Driver Amplifier

The output amplifier of the transmitter card is the driver amplifier for the power-amplifier card. The driver amplifier uses opamps IC10 and IC12 and transistors Q5 through Q8.

The output level of the driver, which determines the output-power level of the power amplifier, is controlled by semiconductor switches A and B, IC11A and IC11B, respectively. These switches are controlled by logic levels from the input card, which enter the transmitter card at terminals 6 and 13. A logic 0 at Pin 1 or 2 of IC11 renders the corresponding switch conductive.

Switches A and B are in the negative-feedback path of an amplifier which uses IC12, Q7, and Q8 as its active elements. The feedback factor and the gain of the amplifier is set by the status of these switches. The input to the amplifier using IC10, Q5, and Q6, as its active elements, the gain of which is essentially unity, is taken from the output of the switch-controlled amplifier.

The output level of the power amplifier is a function of logic levels at terminals 6 and 13 as tabulated in Table 3.3.

## Carrier Control

The output of the transmitter may be controlled with a logic signal to terminal 9, where a logic 0 will cancel the output signal by closing semiconductor gate IC7A through which the output signal is passed. The logic level not only closes the switch but it also disables the frequency divider IC6 by placing a logic 1 on its RESET input, (Pin 11).

## Low-Voltage Monitor

To protect the system against the possibility of low power-supply voltage, which could cause faulty operation, a low-voltage monitor is used for both positive and negative 12-volt power sources. The circuit uses transistors Q1 through Q4. These monitor the positive voltage across zener diode CR1 and the negative voltage across CR2.

When either power supply drops below the level of the zener, the logic level at IC1A-3 changes from 1 to 0. This signal closes switch IC7A and disables the frequency divider through IC4B.

# Table 3.4
# Replaceable Parts

| Circuit Symbol (See Figure 3.7) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC TRANS - Assembly No. HB-95500** | |
| | **CAPACITORS** | |
| C1-4 | Not used | |
| C5 | Capacitor, ceramic, 0.47μF, +80-20%, 50V, Sprague 5CZ5U474D8050C5 or equiv. | 1007 939 |
| C6 | Capacitor, tantalum, 33μF, 20%, 20V, Kemet T110C336M020AS or equiv. | 1007 906 |
| C7, 10 | Capacitor, tantalum, 15μF, 20%, 20V, Kemet T322D156M020AS or equiv. | 1007 716 |
| C8, 9 | Capacitor, ceramic disc, 0.01μF, 20%, 100V, Sprague TG-S10 or equiv. | 1007 1261 |
| C11 | Capacitor, ceramic, 0.033μF, 20%, 50V, Centralab CY15C333M or equiv. | 1007 1370 |
| C12, 14, 15, 20, 22, 24, 30 | Capacitor, tantalum, 1μF, 10%, 35V, Kemet T110A105K035AS or equiv. | 1007 1156 |
| C13 | Capacitor, tantalum, 2.2μF, 20%, 25V, Kemet T322B225M025AS or equiv. | 1007 645 |
| C16, 17, 20, 21, 26, 27 | Capacitor, ceramic, 0.1μF, GMV, 50V, Centralab CY20C104P or equiv. | 1007 1366 |
| C18, 19, 25 | Capacitor, mica, 10 pf, 5%, 500, Electro Motive DM-15 or equiv. | 16504 |
| C23, 29 | Capacitor, ultra-stable ceramic, 100 pF, 10%, 100V, Kemet C315C101K1G5EA or equiv. | 1007 1364 |
| C31, 32 | Capacitor, tantalum, 6.8μF, 20%, 35V, Kemet T322D685M035AS or equiv. | 1007 655 |
| | **RESISTORS** | |
| R1, 4-6, 8, 10, 17, 20 | Resistor, metal film, 1K, 1%, ¼W, Type RN¼ | 0410 1288 |
| R2 | Resistor, metal film, 3.32K, 1%, ¼W, Type RN¼ | 0410 1338 |
| R3, 7, 11, 12, 40, 42, 51, 52, 75, 76 | Resistor, metal film, 10K, 1%, ¼W, Type RN¼ | 0410 1384 |
| R9 | Resistor, metal film, 475 ohm, 1%, ¼W, Type RN¼ | 0410 1257 |
| R13, 22, 30, 34, 37, 39, 41, 67, 69, 71, 73 | Resistor, metal film, 100 ohm, 1%, ¼W, Type RN¼ | 0410 1192 |
| R14 | Resistor, metal film, 499 ohm, 1%, ¼W, Type RN¼ | 0410 1259 |
| R15 | Resistor, variable, cermet, 50K, 10%, ¾W, Beckman Helipot 89PHR50K or equiv. | 39503 |
| R16 | Resistor, metal film, 8.06K, 1%, ¼W, Type RN¼ | 0410 1375 |
| R18, 29 | Resistor, metal film, 909 ohm, 1%, ¼W, Type RN¼ | 0410 1284 |
| R19, 38 | Resistor, metal film, 301 ohm, 1%, ¼W, Type RN¼ | 0410 1238 |
| R21, 43, 54, 56 | Resistor, metal film, 5.11K, 1%, ¼W, Type RN¼ | 0410 1356 |
| R23 | Resistor, metal film, 1.5K, 1%, ¼W, Type RN¼ | 0410 1305 |
| R24, 26 | Resistor, metal film, 402 ohm, 1%, ¼W, Type RN¼ | 0410 1250 |
| R25 | Resistor, metal film, 15 ohm, 1%, ⅛W, Type RN55D | 1510 1317 |
| R27 | Resistor, metal film, 604 ohm, 1%, ¼W, Type RN¼ | 0410 1267 |
| R28 | Resistor, metal film, 11K, 1%, ¼W, Type RN¼ | 0410 1388 |
| R31, 32 | Resistor, metal film, 2K, 1%, ¼W, Type RN¼ | 0410 1317 |
| R33 | Resistor, metal film, 4.75K, 1%, ¼W, Type RN¼ | 0410 1353 |

# Table 3.4
# Replaceable Parts

| Circuit Symbol (See Figure 3.7) | Description | Part Number |
|---|---|---|
| R35 | Resistor, metal film, 4.64K, 1%, ¼W, Type RN¼ | 0410 1352 |
| R36 | Resistor, metal film, 15K, 1%, ¼W, Type RN¼ | 0410 1401 |
| R44, 45, 48, 49, 59, 60, 63, 64 | Resistor, metal film, 2.21K, 1%, ¼W, Type RN¼ | 0410 1321 |
| R46, 47, 61, 62 | Resistor, composition, 10 ohm, 5%, ½W, Allen-Bradley EB Series or equiv. | 1009 238 |
| R50, 65 | Resistor, composition, 5.1 ohm, 5%, ½W, Allen-Bradley EB Series or equiv. | 1009 712 |
| R53 | Resistor, metal film, 6.98K, 1%, ¼W, Type RN¼ | 0410 1369 |
| R55 | Resistor, metal film, 4.02K, 1%, ¼W, Type RN¼ | 0410 1346 |
| R57 | Resistor, metal film, 13.3K, 1%, ¼W, Type RN¼ | 0410 1396 |
| R66 | Resistor, metal film, 1.33K, 1%, ¼W, Type RN¼ | 0410 1300 |
| R68, 70, 72, 74, 77-79 | Resistor, metal film, 20K, 1%, ¼W, Type RN¼ | 0410 1413 |
| R80, 81 | Resistor, composition, 2.7 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 900 |
| | **SEMICONDUCTORS** | |
| CR1, 2 | Diode, Zener, 9.1V, 5%, 400 mW, 1N960B | 41014 |
| CR3-6 | Diode, silicon, 1N914B or 1N4448 | 26482 |
| IC1, 2, 13 | MOS hex inverting buffer, Toshiba TC4049BP or equiv. | 0615 257 |
| IC3 | MOS triple 3-input AND gate, RCA CD4073BE or equiv. | 0615 32 |
| IC4 | MOS triple 3-input OR gate, RCA CD4075BE or equiv. | 0615 33 |
| IC5 | Not Used. | |
| IC6 | MOS 12-stage binary counter/divider, RCA CD4040BE or equiv. | 0615 21 |
| IC7, 11 | CMOS analog switch, dual SPST, Siliconix DG200BA or equiv. | 0605 3 |
| IC8 | Balanced modulator/demodulator, Motorola MC1496G or equiv. | 0620 110 |
| IC9, 10, 12 | Operational amplifier, National Semiconductor LM318N or equiv. | 0620 126 |
| Q1, 4 | Transistor, PNP, 2N2907A, plastic package | 37439 |
| Q2, 3 | Transistor, NPN, 2N2222A, plastic package | 37445 |
| Q5, 7 | Transistor, NPN, 2N2219A, plastic package | 39569 |
| Q6, 8 | Transistor, PNP, 2N2905A, plastic package | 39567 |
| | **MISCELLANEOUS COMPONENTS** | |
| FL1 | Bandpass filter, center frequency at specified carrier frequency | Contact Factory |
| --- | Shorting bar, single, Augat 8136-475G1 or equiv. | 42904 |

## Plug-on Carrier Oscillator - Assembly No. HB-95505

| | | |
|---|---|---|
| | **CAPACITORS** | |
| C1, 7-10 | Capacitor, ceramic, 0.033μF, 20%, 50V, Centralab CY15C333M or equiv. | 1007 1370 |
| C2 | Capacitor, tantalum, 1μF, 10%, 35V, Kemet T110A105K035AS or equiv. | 1007 1156 |
| C3 | Capacitor, variable, ceramic, 2.5-20pF, Sprague-Goodman GKB20000 or equiv. | 45363 |
| C4 | Capacitor, ultra-stable ceramic, factory-selected value, 10%, 100V: | |
| | 22pf; Kemet C312C220K1G5EA or equiv. | 1007 1362 |
| | 33pf; Kemet C312C330K1G5EA or equiv. | 1007 1363 |
| C5 | Capacitor, ultra-stable ceramic, 22pF, 10%, 100V, Kemet C315C220K1G5EA or equiv. | 1007 1362 |
| C6 | Capacitor, ceramic, 82pF, 5%, 100V, AVX SA101A820J11 or equiv. | 0125 18205 |
| C7 | Capacitor, ceramic, 100pF, 10%, 100V, Kemet C315C101K1G5EA or equiv. | 1007 1364 |

# Table 3.4
# Replaceable Parts

| Circuit Symbol (See Figure 3.7) | Description | Part Number |
|---|---|---|
| | **RESISTORS** | |
| R1 | Resistor, metal film, 24.9K, 1%, ¼W, Type RN¼ | 0410 1422 |
| R2 | Resistor, metal film, 8.25K, 1%, ¼W, Type RN¼ | 0410 1376 |
| R3 | Resistor, composition, 47 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 832 |
| R4 | Resistor, metal film, 5.62K, 1%, ¼W, Type RN¼ | 0410 1360 |
| R5, 8 | Resistor, metal film, 100K, 1%, ¼W, Type RN¼ | 0410 1480 |
| R6 | Resistor, metal film, 22.1K, 1%, ¼W, Type RN¼ | 0410 1417 |
| R7 | Resistor, metal film, 2K, 1%, ¼W, Type RN¼ | 0410 1317 |
| R9 | Resistor, metal film, 150K, 1%, ¼W, Type RN¼ | 0410 1497 |
| R10 | Resistor, metal film, 825 ohm, 1%, ¼W, Type RN¼ | 0410 1280 |
| R11 | Resistor, metal film, 1.5K, 1%, ¼W, Type RN¼ | 0410 1305 |
| R12 | Resistor, metal film, 100 ohm, 1%, ¼W, Type RN¼ | 0410 1192 |
| | **SEMICONDUCTORS** | |
| CR1 | Diode, silicon, 1N914B or 1N4448 | 26482 |
| Q1 | Transistor, NPN Darlington, TO-92 case, 2N918 | 46541 |
| Q2 | Transistor, N-channel MOSFET, dual gate protected, TO-72 case, Motorola MFE201 or equiv. | 0715 8 |
| IC1 | MOS 12-stage binary counter, Signetics HEF4040BP or equiv. | 0615 258 |
| | **MISCELLANEOUS COMPONENTS** | |
| L1 | Inductor, molded, 220$\mu$H, 5%, Dale Electronics IM-4 or equiv. | 46598 |
| OV1 (optional) | Crystal oven assembly | 46928 |
| Y1 | Crystal, value and type per sales order | Contact factory |

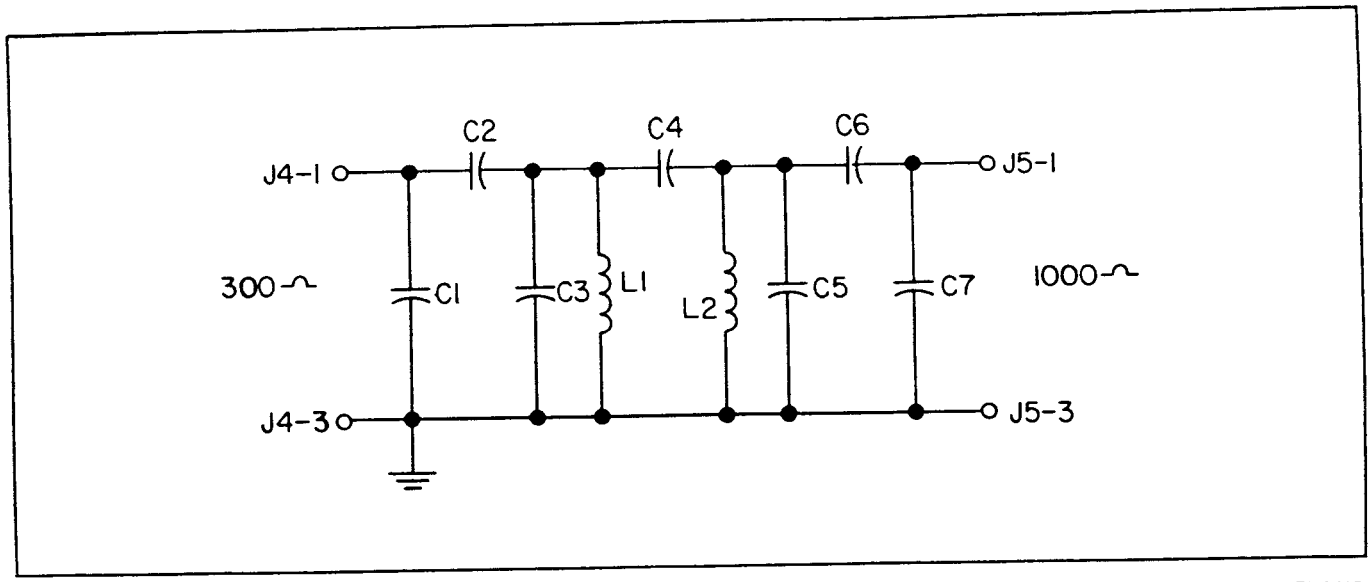



Figure 3.3. Schematic-plug-on carrier frequency bandpass filter for Model 67 PLC TRANS

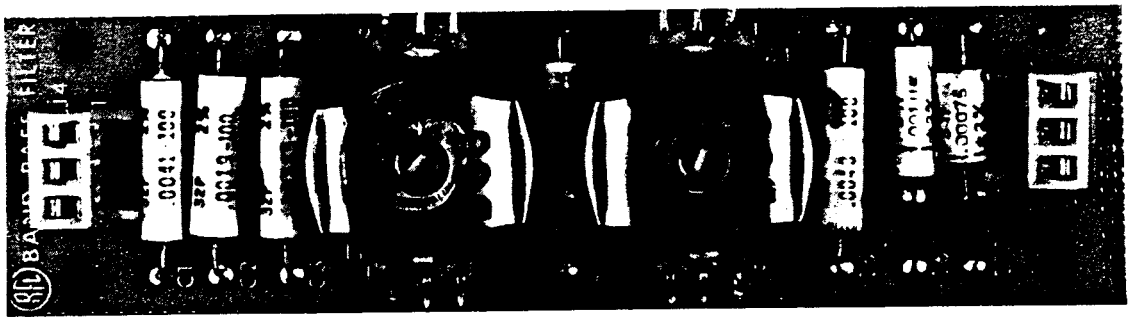


Figure 3.4. Plug-on carrier frequency bandpass filter for Model 67 PLC TRANS

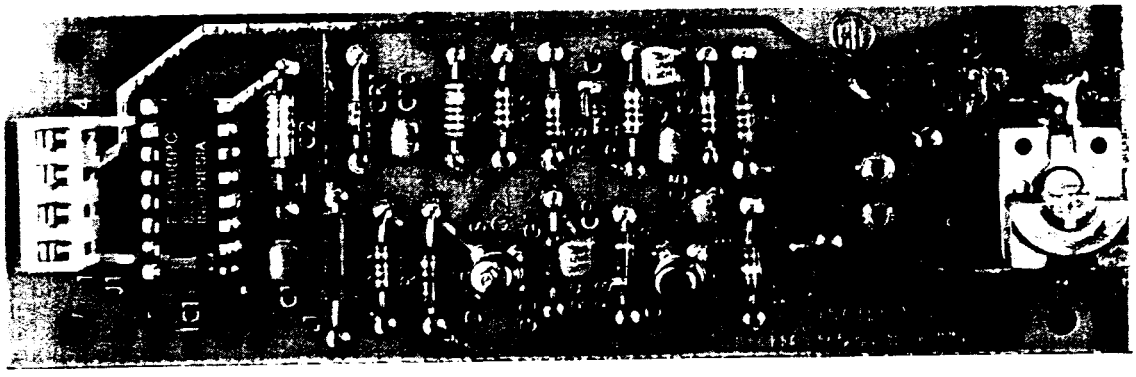


Figure 3.5. Plug-on carrier oscillator for Model 67 PLC TRANS.

OSC 1
(SAME AS OSC 2)

OSC 2

OSC 3
(SAME AS OSC 2)

FREQUENCY DIVIDER

DRIVER AMPLIFIER

LOW VOLTAGE MONITOR

DRIVER AMPLIFIER

NOTES:
1. ALL RESISTORS ARE IN OHMS; 5%, 1/4W UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE MEASURED IN MF UNLESS OTHERWISE SPECIFIED.

Figure 3.6 Schematic- Model 67 PLC TRANS
3-9 (3-10 blank)

# Section 4
# POWER AMPLIFIER

## INTRODUCTION

Two different power amplifiers are available for use in the transmitter chassis. The Model 67A PLC PWR AMP is used in medium-power applications and has an adjustable output of 1, 3, or 10 watts. The Model 67A PLC 1W AMP is used in low-power applications and has a fixed output level of 1 watt.

## MODEL 67A PLC PWR AMP

### DESCRIPTION

The Model 67A PLC PWR AMP is used to raise the power level of the transmitter's carrier-frequency output signal to that required for transmission over the powerline. Three output-power levels, (1, 3, and 10 watts), are established by the two power switches on the transmitter card.

The output of the power amplifier drives the Model 67A PLC PWR FLT, a bandpass filter centered on the output frequency, which then drives the line either directly or through a hybrid, depending upon the application. The power capability of the system is 10 watts into a 50-ohm load connected across the output J1 and after losses in output filter and hybrid.

For full-power output, the input transformer requires 5.4 volts rms across its primary. The required input currents are:

| Input Current ±10% Amperes | Output Power Watts |
|---|---|
| 0.4 | 1 |
| 0.5 | 3 |
| 0.7 | 10 |

The power-amplifier card also contains a level-monitoring circuit which controls an alarm relay, located on the input card, to signal when the output power of the system falls below a predetermined level.

### Operation at Reduced Power

To obtain an output-power level of 10 watts, the power amplifier requires a 36-volt power source such as that available from the Model 67 PLC 129 DC

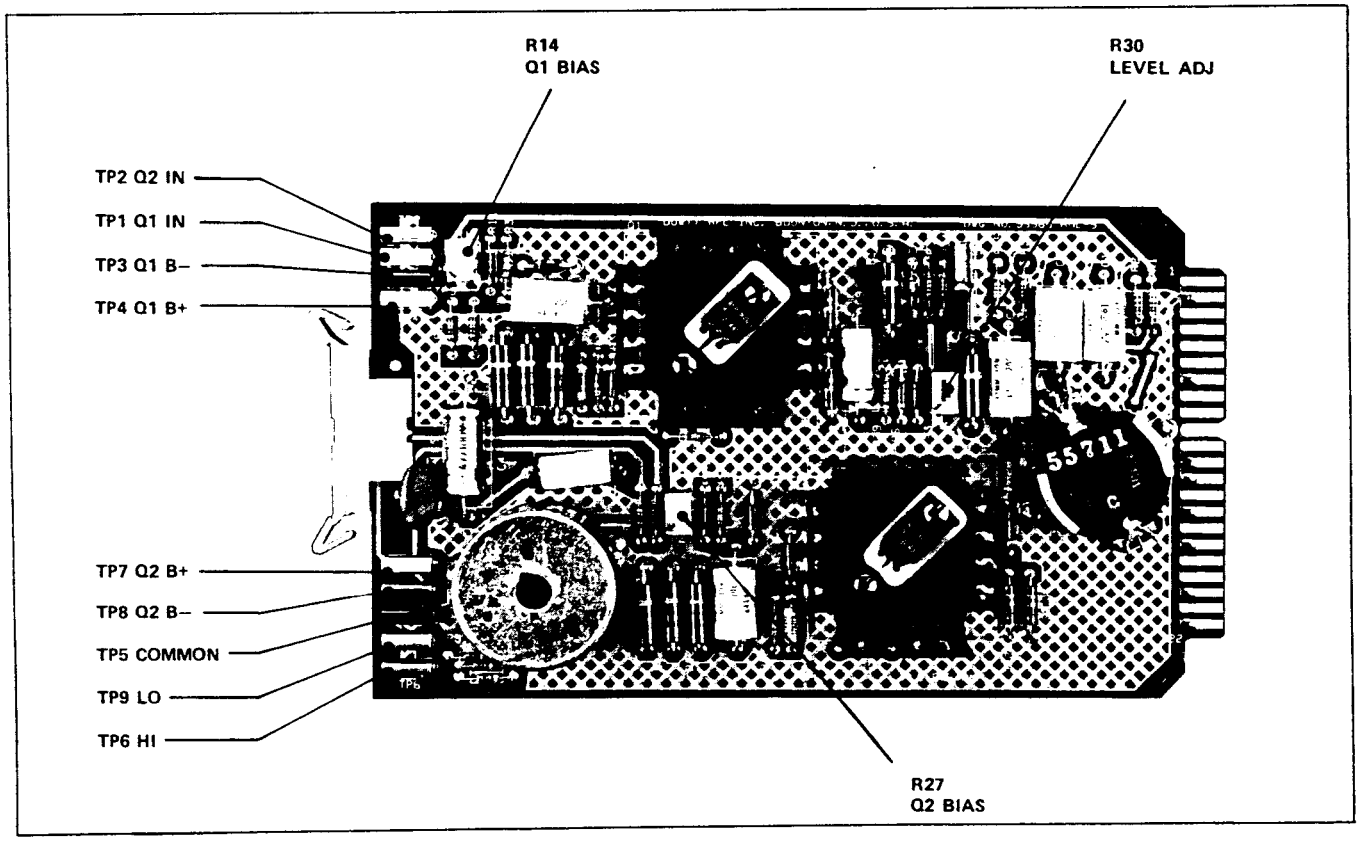



Figure 4.1. Location of controls and adjustments, Models 67A PLC PWR AMP and 67A PLC 1W AMP

or 67 PLC 48 DC dc-dc converter. If, however, a power output of only one watt to the transmission line is adequate, then it will be more economical to operate the power amplifier and all other modules of the terminal from the 24-volt output available from the Model 68 HPS series of dc-dc converters.

When this choice is made, details of the simple modification made to the power amplifier will be supplied with the equipment. Data on the Model 68 HPS series of dc-dc converter are included in Section 9 of this manual when these converters are used.

# MODEL 67A PLC 1W AMP

## DESCRIPTION

The Model 67A PLC 1W AMP is used to raise the power level of the transmitter's carrier-frequency output signal to one watt.

The output of the power amplifier drives the Model 67 PLC 1W FLT, a bandpass filter centered on the output frequency, which then drives the line either directly or through a hybrid, depending upon the application. The power capability of the system is 1 watt into a 50-ohm load connected across the output J1 and after losses in output filter and hybrid.

The 1W-amplifier card also contains a level-monitoring circuit which controls an alarm relay, located on the input card, to signal when the output power of the system falls below a predetermined level.

The voltage requirement for the card is 24 Vdc derived from both plus and minus side of the 12 Vdc system power supply.

## CIRCUIT DETAILS

### Amplifiers

A schematic diagram of the circuit of the power amplifier is shown in Figure 4.4 where T1, the input transformer, is driven by the push-pull driver amplifier of the transmitter. The power level is raised with two VMOS FET transistors, Q1 and Q2, connected in push-pull. Voltage feedback at the gates, and current feedback at the sources, of each transistor are proportioned to set the output impedance of the amplifier at 50 ohms. The output transformer is T2.

### Power-Level Alarm

This circuit senses the level of the output signal at the junction of R22 and R28. The sensing level is adjusted with R20 and the signal is rectified and filtered with CR3, CR5 and C8. Q3 is an emitter follower driving zener diode CR4, which functions as a level detector.

When CR4 conducts, which is the normal condition, Q5 energizes the alarm relay. If the output-power level falls so that the voltage across CR4 becomes less than 2.4 volts, then Q5 becomes non-conducting, the alarm relay is de-energized, and an alarm is indicated. Q4, driven from the collector of Q5, provides hysteresis for the system.

### Output Filter

The output of the power amplifier is filtered by the Model 67 PLC PWR FLT before passing to the output circuit. The position of this bandpass filter in the signal path is shown in Figure 3.1. The output-power rating of the amplifier is given at the output of the filter.

A schematic of the circuit of the filter is shown in Figure 4.2. Electrical values of components and positions of jumpers are determined by the operating frequency, and they are set at the factory.

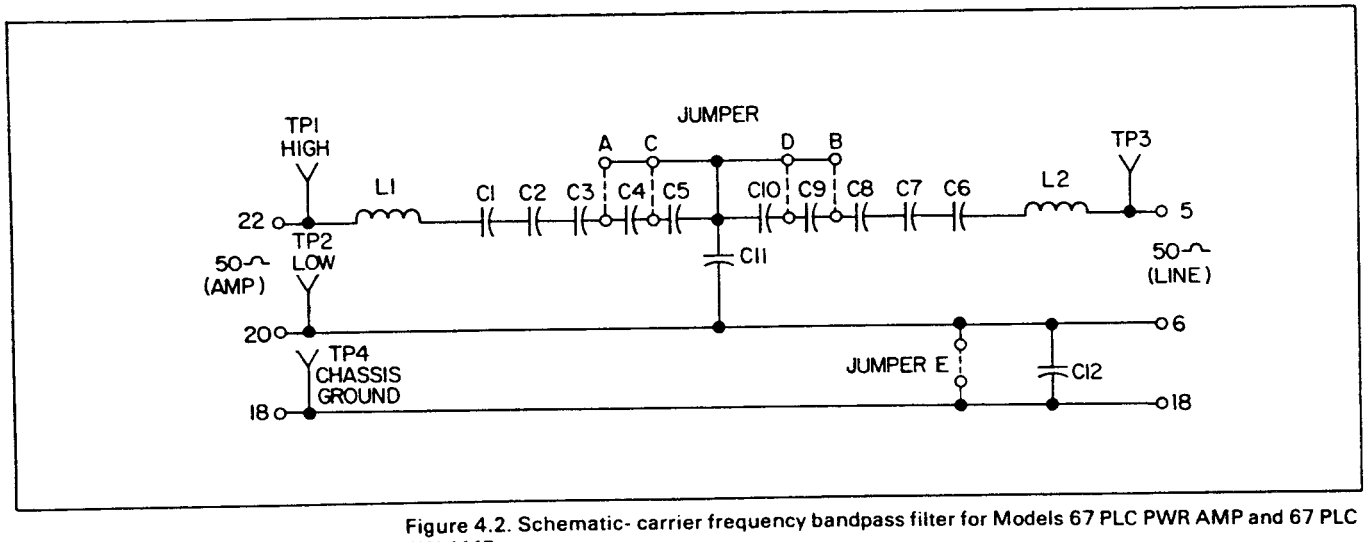



Figure 4.2. Schematic- carrier frequency bandpass filter for Models 67 PLC PWR AMP and 67 PLC 1W AMP

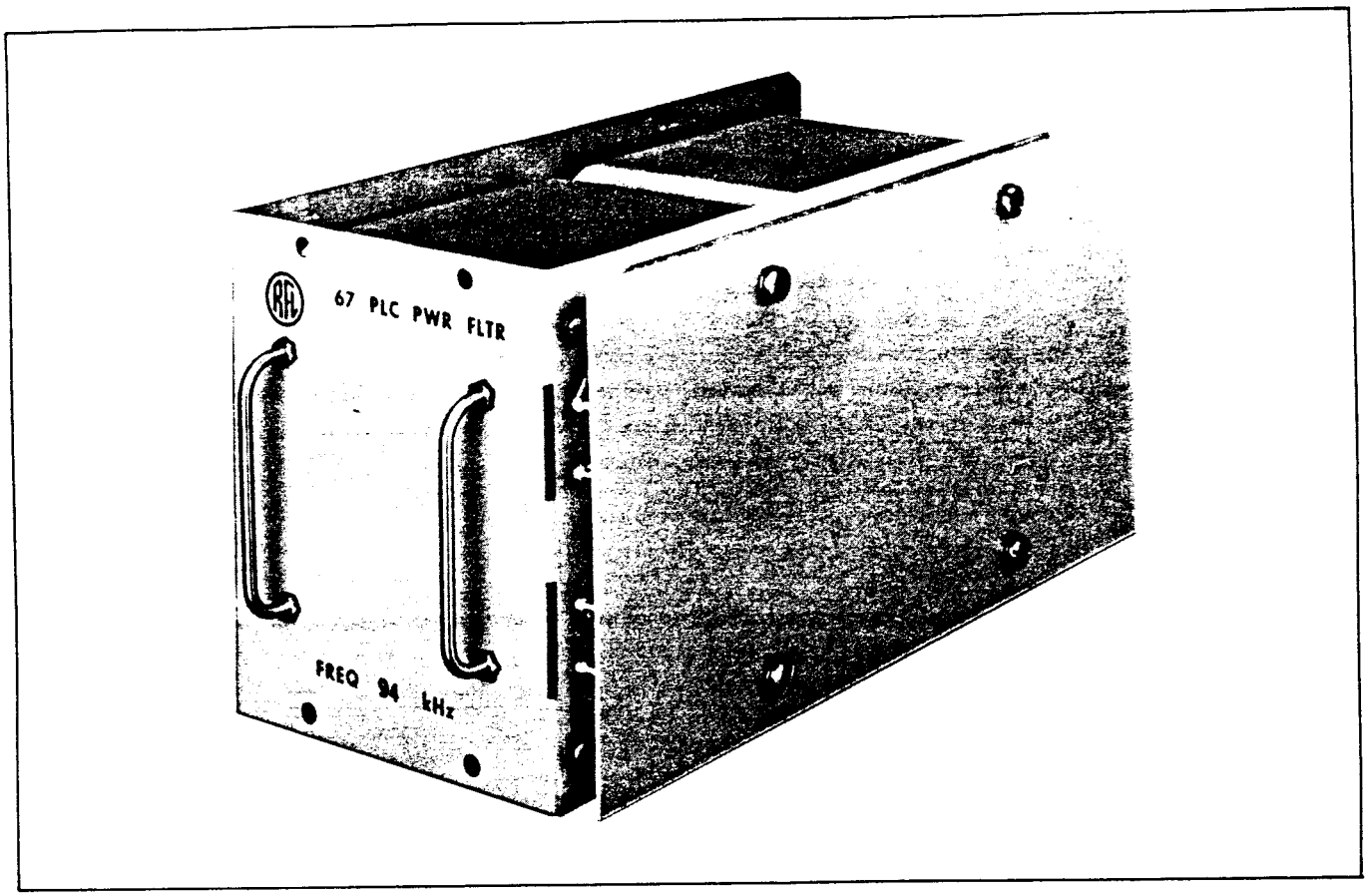
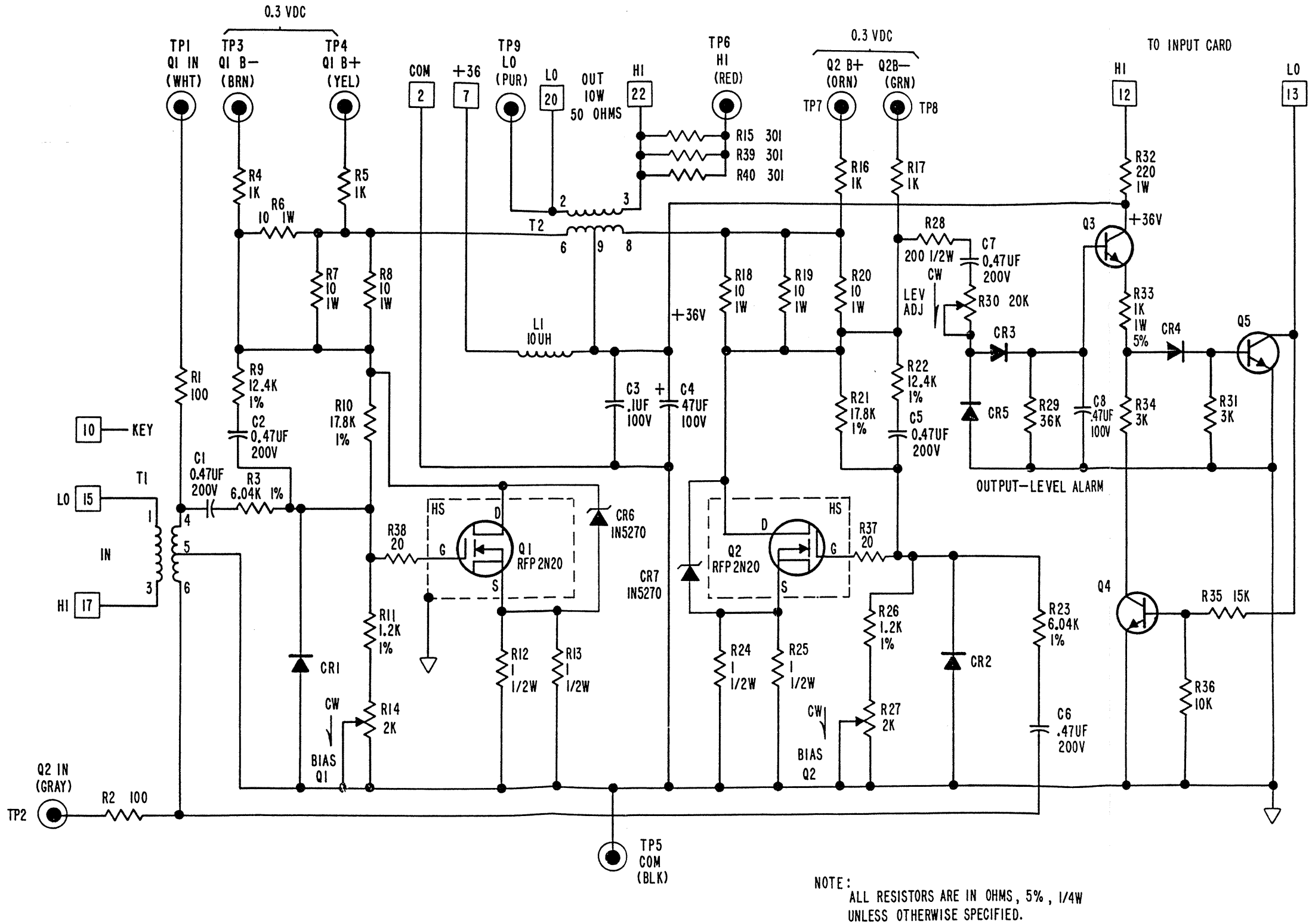



Figure 4.3. Carrier frequency bandpass filter for Models 67 PLC PWR AMP and 67 PLC 1W AMP

# Table 4.1
# Replaceable Parts

| Circuit Symbol (See Figure 4.4) | Description | Part Number |
|---|---|---|
| **Model 67A PLC PWR AMP 10 Watt Amplifier - Assembly No. HB-95565 and Model 67A PLC 1W AMP 1 Watt Amplifier - Assembly No. HB-95565-1** | | |
| | **CAPACITORS** | |
| C1, 2, 5-7 | Capacitor, metallized mylar, 0.47μF, 10%, 200V, Wesco 32MM or equiv. | 1007 912 |
| C3 | Capacitor, ceramic disc, 0.1μF, 20%, 100V, Sprague 33C41B6 or equiv. | 1007 289 |
| C4 | Capacitor, electrolytic, 47μF, +100-10%, 100V, Stettner-Trush EB47/100 or equiv. | 1007 1350 |
| C8 | Capacitor, metallized polycarbonate, 0.47μF, 2%, 100V, Wesco 32MPC or equiv. | 1007 971 |
| C9, 10 | Capacitor, mica, 20 pF, 5%, 500V, Electro Motive DM-15 or equiv. | 16507 |
| | **RESISTORS** | |
| R1, 2 | Resistor, metal film, 100 ohm, 1%, ¼W, Type RN¼ | 0410 1192 |
| R3, 23 | Resistor, metal film, 6.04K, 1%, ¼W, Type RN¼ | 0410 1363 |
| R4, 5, 16, 17 | Resistor, metal film, 1K, 1%, ¼W, Type RN¼ | 0410 1288 |
| R6-8, 18-20 | Resistor, composition, 10 ohm, 5%, 1W, Allen-Bradley GB Series or equiv. | 1009 4 |
| R9, 22 | Resistor, metal film, 12.4K, 1%, ¼W, Type RN¼ | 0410 1393 |
| R10, 21 | Resistor, metal film, 1%, value and type dependent upon model:<br>Model 67PLC PWR AMP: 17.8K, ½W, Type RN½<br>Model 67PLC 1W AMP: 11.8K, ¼W, Type RN¼ | <br>0410 2408<br>0410 1391 |
| R11, 26 | Resistor, metal film, 1.21K, 1%, ¼W, Type RN¼ | 0410 1296 |
| R12, 13, 24, 25 | Resistor, composition, 1 ohm, 5%, ½W, Allen-Bradley EB Series or equiv. | 1009 978 |
| R14, 27 | Resistor, variable, 18-turn cermet, 2K, 10%, ½W, Beckman Helipot 68WR2K or equiv. | 90392 |
| R15, 39, 40 | Resistor, metal film, 301 ohm, 1%, ¼W, Type RN¼ | 0410 1238 |
| R28 | Resistor, metal film, 200 ohm, 1%, ½W, Type RN½ | 0410 2221 |
| R29 | Resistor, metal film, 36.5K, 1%, ¼W, Type RN¼ | 0410 1438 |
| R30 | Resistor, variable, 18-turn cermet, 20K, 10%, ½W, Beckman Helipot 68WR20K or equiv. | 44529 |
| R31, 34 | Resistor, metal film, 3.01K, 1%, ¼W, Type RN¼ | 0410 1334 |
| R32 | Resistor, composition, value dependent upon model, 5%, 1W, Allen-Bradley GB Series or equiv.:<br>For Model 67 PLC PWR AMP, 220 ohm<br>For Model 67 PLC 1W AMP, 5.1 ohm | <br>1009 316<br>1009 925 |
| R33 | Resistor, composition, 1K, 5%, 1W, Allen-Bradley GB Series or equiv. | 1009 6 |
| R35 | Resistor, metal film, 15K, 1%, ¼W, Type RN¼ | 0410 1401 |
| R36 | Resistor, metal film, 10K, 1%, ¼W, Type RN¼ | 0410 1384 |
| R37, 38 | Resistor, metal film, 20 ohm, 1%, ⅛W, Type RN55D | 1510 1412 |
| | **SEMICONDUCTORS** | |
| CR1-3, 5 | Diode, silicon, 1N4003 | 30769 |
| CR4 | Diode, silicon, 1N914B or 1N4448 | 26482 |
| CR6, 7 | Diode, Zener, 91V, 5%, 500mW, 1N5270B | 32539 |
| Q1, 2 | Transistor, N-channel MOSFET, 200V, 25W, TO-220AB plastic case, RCA RFP2N20 or equiv. | 0715 19 |
| Q3, 5 | Transistor, NPN, Texas Instruments TIP 111 or equiv., plastic package | 39589 |
| Q4 | Transistor, NPN, Texas Instruments TIP 29A or equiv., plastic package | 36995 |
| | **MISCELLANEOUS COMPONENTS** | |
| L1 | Inductor, 10μH, 5%, 4A, resonant frequency greater than 10 MHz, Stanwyck ER3114 or equiv. | 92620 |
| T1 | Transformer, input, 10-ohm primary, 1440-ohm CT secondary | 55711 |
| T2 | Transformer, output, 89-ohm CT primary, 50-ohm secondary | 55712 |




NOTE:
ALL RESISTORS ARE IN OHMS, 5%, 1/4W
UNLESS OTHERWISE SPECIFIED.

Figure 4.4. Schematic- Models 67A PLC PWR AMP and 67A PLC 1W AMP

# Section 5
# RECEIVING SECTION

## INTRODUCTION

This section discusses those receiving-circuit cards which process the received carrier-frequency, intermediate-frequency, base-frequency, and dc analog signals found in the receiving section of the Series 6780 System.

The organization of the entire receiving section appears in the block diagram shown in Figure 5.1. This diagram includes not only signal-frequency components but also logic components and the output card.

The communication signal on the powerline first passes, either directly or through an rf hybrid, to an input attenuator and filter, shown at the upper left of Figure 5.1. The attenuator reduces the received-signal level, if necessary, to the center of the dynamic range of the receiving system. A bandpass filter passes the frequency of interest while rejecting signals of other frequency which may be multiplexed on the same powerline.

The line-frequency signal then passes to the Model 67 PLC IF/BF. This circuit card provides for two frequency translations. In the first, the input signal is translated to an intermediate frequency of 24 kHz, using a heterdyne oscillator whose divided frequency is 24 kHz above that of the line-frequency signal. If a voice channel is used, the modulated, intermediate-frequency signal is sent also to the voice card for demodulation and processing.

In the Model 67 PLC IF/BF card, the 24-kHz signal is translated, once again, to a baseband frequency of 4 kHz. The 4-kHz signal is passed through a narrow-band bandpass filter on the Model 67 PLC DISC/CLI card to the Model 67 PLC LM/SL. This last card controls the amplitude of the signal with a limiter, sends it to a frequency discriminator which distinguishes among the two or three frequencies of the FSK system used, and then selects the proper output channel.

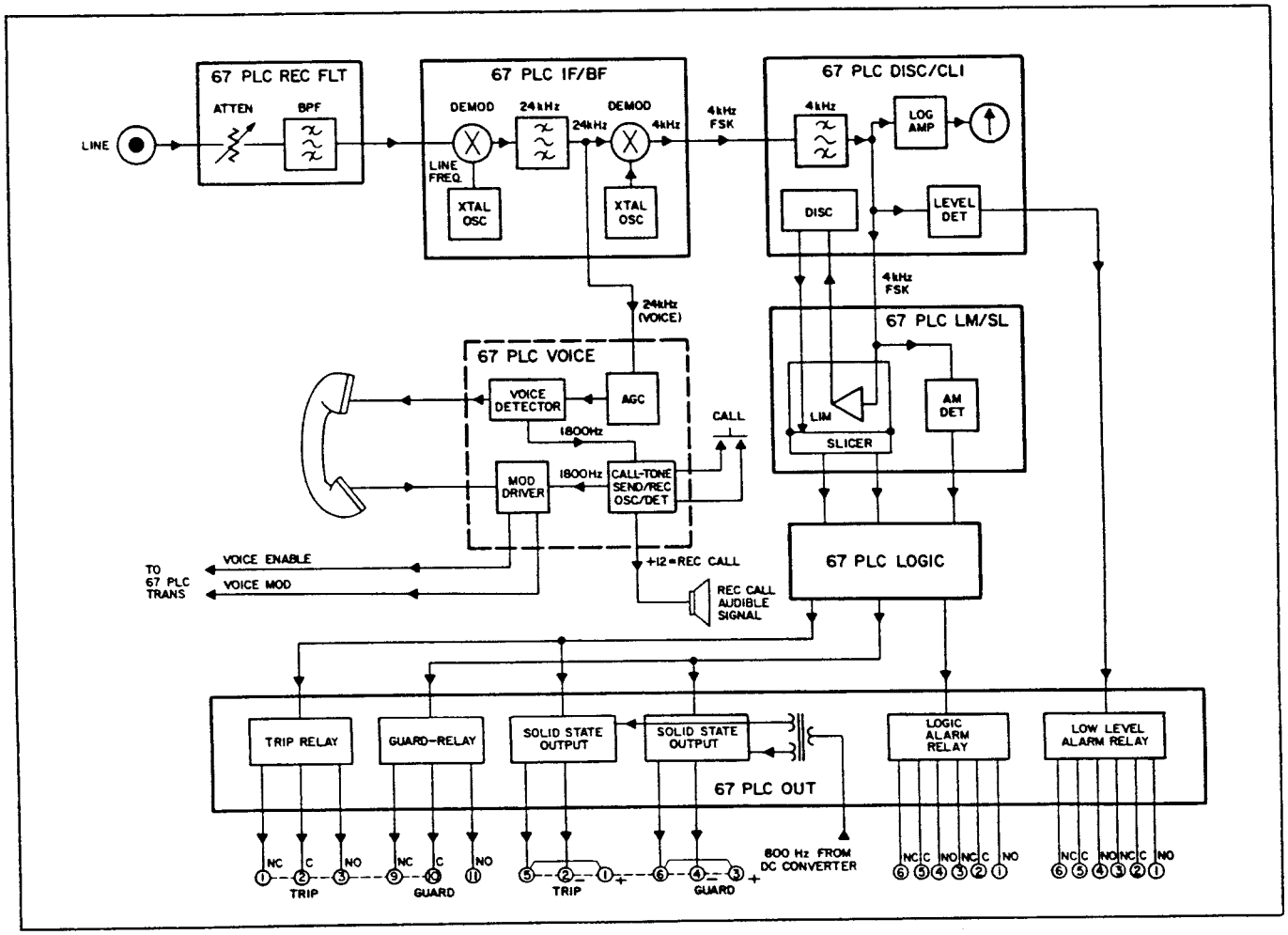



Figure 5.1. Block diagram- Series 6780 System receiver

In the limiter-and-slicer card, an AM detector rectifies the 4-kHz signal and filters it with a long time constant so that an output signal corresponding to the envelope of the received signal is produced. In the logic card, this index of average signal amplitude is used as a reference for detecting and evaluating instantaneous bursts of noise on the received signal.

The discriminator card includes a carrier-level monitor and indicator. The level monitor activates an alarm relay when the input-signal level falls below a predetermined amplitude. The carrier-level indicator uses a logarithmic amplifier to drive a front-panel-mounted meter which indicates deviation of the input-signal level, in dB, from an established reference.

## Receiver Section Modules

The receiver section of the Series 6780 System contains four individual modules. Information of these modules can be found on the following pages of this manual.

# MODEL 67 PLC REC FLT

## CIRCUIT DETAILS

This circuit card contains a bandpass filter which selects the desired frequency signal from others that may be multiplexed on the communication line and rejects extraneous noise. Each filter is tuned to the frequency at which the system is intended to receive signals from the powerline.

A schematic of the circuit is shown in Figure 5.3. Electrical values of many components are not given because they are determined by operating frequency. This module has three sections. The first, consisting of straps A thru H and associated components, is used to match the filter input characteristics to that of the communication line. The section which follows is simply a variable attenuator, adjustable from the front of the module. The range of this variable attenuator is from 0 to 30 dB. The third section, fed from the variable attenuator, is the channel filter and is protected on its input by a surge arrestor device. The output of the filter is floating, for it terminates with a transformer.

Straps A and C provide a bridging option with about 30 dB of attenuation, and present a 2 kΩ impedance to the line. Straps B and D offer a bridging configuration also, but with only about 15 dB of attenuation.

This is accomplished with the use of a step-down transformer. This strapping mode presents the line with at least 1 kΩ of impedance.

Strap positions J and H are holders for the jumpers used for strapping to positions A, C and B, D when the A, C and B, options are not used.

Strap E provides a direct short circuit from the card's input to the input of the variable attenuator. Strap F places R5, a 51.1Ω resistor, across the input of the module. Strap position G removes R5 from the circuit.

See Table 5.1 for an itemized listing of attenuations possible with this card.

The bridging connection is employed when several receivers are connected in parallel to the same receiving line. The jumpers will be installed at the factory in accordance with the performance requirements in the system.

**TABLE 5.1**
**Input Impedance and Attenuation Settings**

| Input Z | Straps | For Signal Attenuation | Notes |
|---|---|---|---|
| 50 ohms (Terminate mode) | B, D, F<br>A, C, F | 18 - 48 dB<br>33 - 63 dB | ------ |
| 75 ohms (Used with 67 PLC SK HYB) | E, H, G | 0 - 30 dB | ------ |
| 1K ohms (Bridging mode) | B, D, G | 18 - 48 dB | Transformer Bridging |
| 2K ohms (Bridging mode) | A, C, G | 33 - 63 dB | Resistive Bridging |

* Less than 1 dB in passband of RCVR BPF.

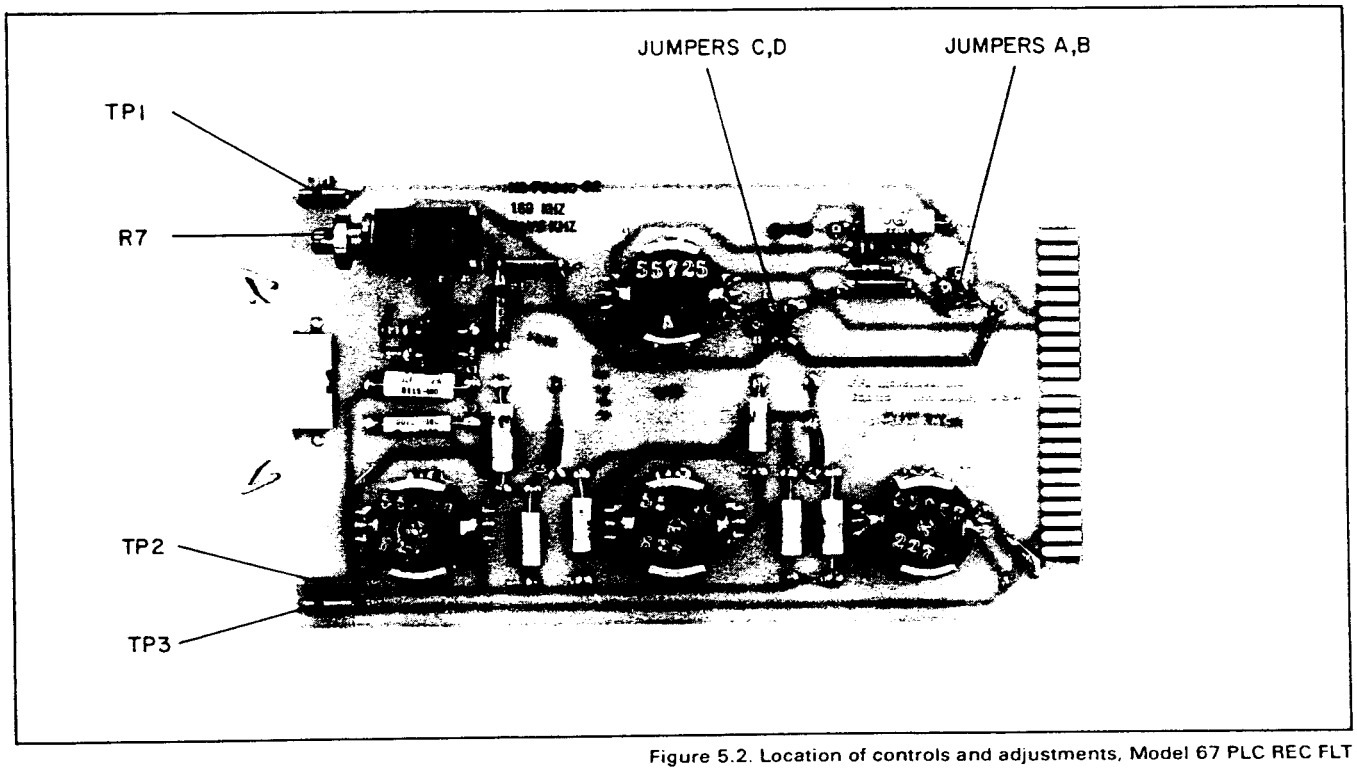



Figure 5.2. Location of controls and adjustments, Model 67 PLC REC FLT

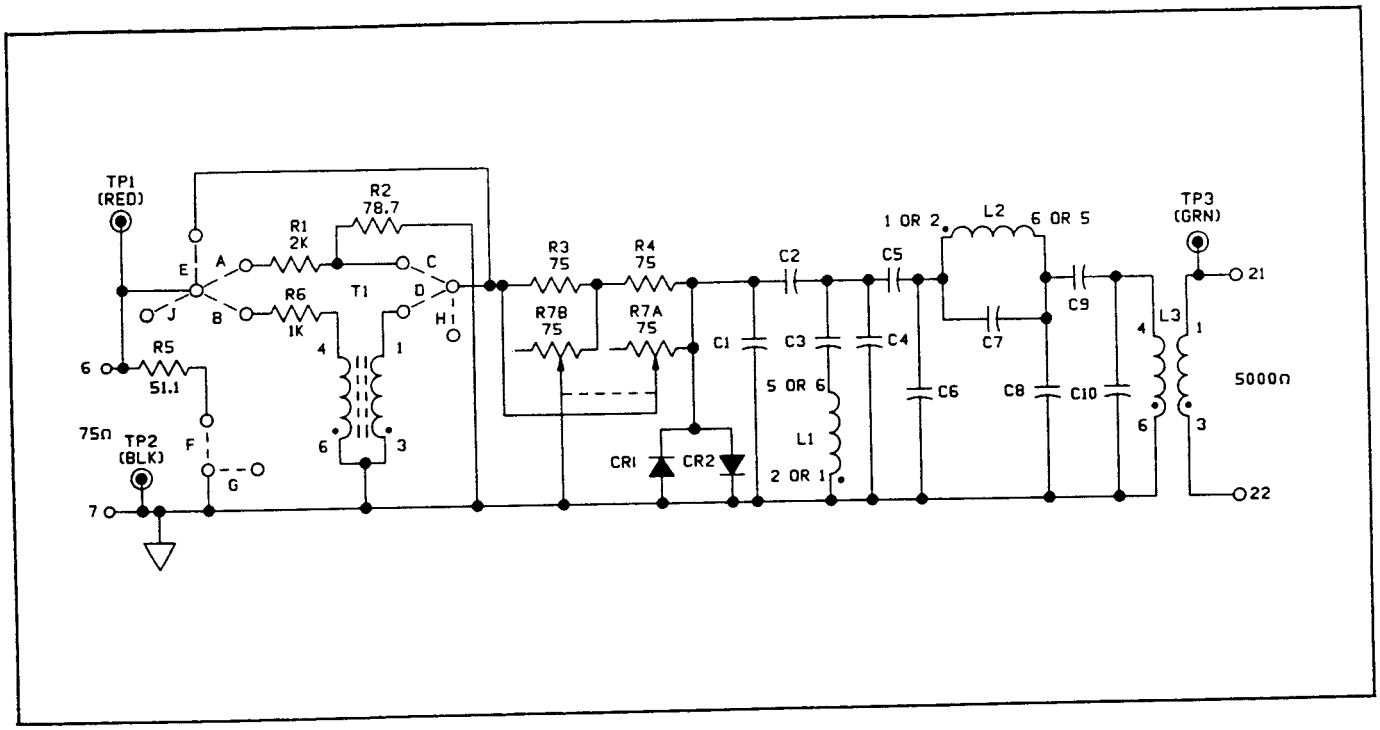



Figure 5.3. Schematic- Model 67 PLC REC FLT

# Table 5.2
# Replaceable Parts

| Circuit Symbol (See Figure 5.3) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC REC FLT - Assembly No. HB-79640** | |
| | **CAPACITORS** | |
| C1-10 | Capacitor, value determied by operating frequency | Contact Factory |
| | **RESISTORS** | |
| R1 | Resistor, metal film, 2K, 1%, ¼W, Type RN¼ | 0410 2317 |
| R2 | Resistor, metal film, 78.7 ohm, 1%, ¼W, Type RN¼ | 0410 1182 |
| R3, 4 | Resistor, metal film, 75 ohm, 1%, ¼W, Type RN¼ | 0410 2180 |
| R5 | Resistor, metal film, 51.1 ohm, 1%, ¾W, Type RN70D | 1510 2120 |
| R6 | Resistor, metal film, 1K, 1%, ¼W, Type RN¼ | 0410 2288 |
| R7 | Attenuator, variable T-pad, 75 ohm, 15%, ½W, Allen-Bradley 73P4M040S75ON or equiv. | 43136 |
| | **MISCELLANEOUS COMPONENTS** | |
| CR1, 2 | Surge suppressor, low-voltage, General Semiconductor LCE8.5 or equiv. | 93609 |
| L1-3 | Inductor, value determined by operation frequency | Contact Factory |
| T1 | Transformer, bridging | 55725 |
| --- | Shorting bar, single, Aries LP300 or equiv. | 42904 |

# MODEL 67A PLC IF/BF

## CIRCUIT DETAILS

This circuit card carries two demodulators, two oscillators to provide the reference frequency for each demodulator, and a 24-kHz bandpass filter. The schematic of the circuit is shown in Figure 5.5.

The high-frequency line signal, filtered by the bandpass input filter, enters this card at terminals 21 and 22, and passes to the demodulator, IC1. The local oscillator is crystal controlled and it is identical to the crystal oscillator used in the transmitter. Its operation is discussed in Section 3 of this Manual.

To obtain a 24-kHz intermediate frequency output from the demodulator, the local oscillator is set to generate a signal of frequency equal to the input frequency plus 24 kHz. The frequency of the piezo-electric crystal, Y101, must be between 4 and 9 MHz and the quotient of crystal frequency divided by the division effected in IC101 must be equal to the line frequency plus 24 kHz. (See Table 5.3).

For example, if the line frequency were 500 kHz then the local-oscillator frequency must be 524 kHz. Assume a division of 8, for which 524 x 8 = 4.192 MHz, a frequency that falls between the limits of 4 and 9 MHz. Thus, a crystal of this frequency may be used with jumper A at IC101. It will be noted that with a divisor of 16, obtainable with jumper B, a crystal frequency of 8.384 MHz is indicated, and this is also within the specified frequency limits. Either choice is acceptable.

The output of IC1 feeds a plug-on 24-kHz bandpass filter (Figure 5.6), the output of which feeds another demodulator, IC2. This demodulator converts the 24-kHz intermediate-frequency signal to a baseband frequency (BF) of 4 kHz. The frequency of the local oscillator for IC2; (28 kHz), is set 4 kHz above the frequency of its input signal. This is determined by the frequency of Y1, 3.584 MHz, which is divided by 128 using jumper P on divider IC5.

The output of the second demodulator is buffered by IC3, after which it passes, through terminal 8, to a 4-kHz narrowband filter on the Model 67 PLC DISC/-CLI circuit card (Figure 5.8).

Potentiometers R9 at IC1, and R28 at IC2, are used to null the local-oscillator component in the outputs of the demodulators.

R9 is adjusted to obtain a null of 10 mVRMS, or less, at TP5.

To adjust R28, the high-frequency local oscillator is disabled by temporarily removing the jumper associated with IC101. Then adjust R28 for a null of less than 10 mVRMS at TP4 (GRN). Then replace the jumper.

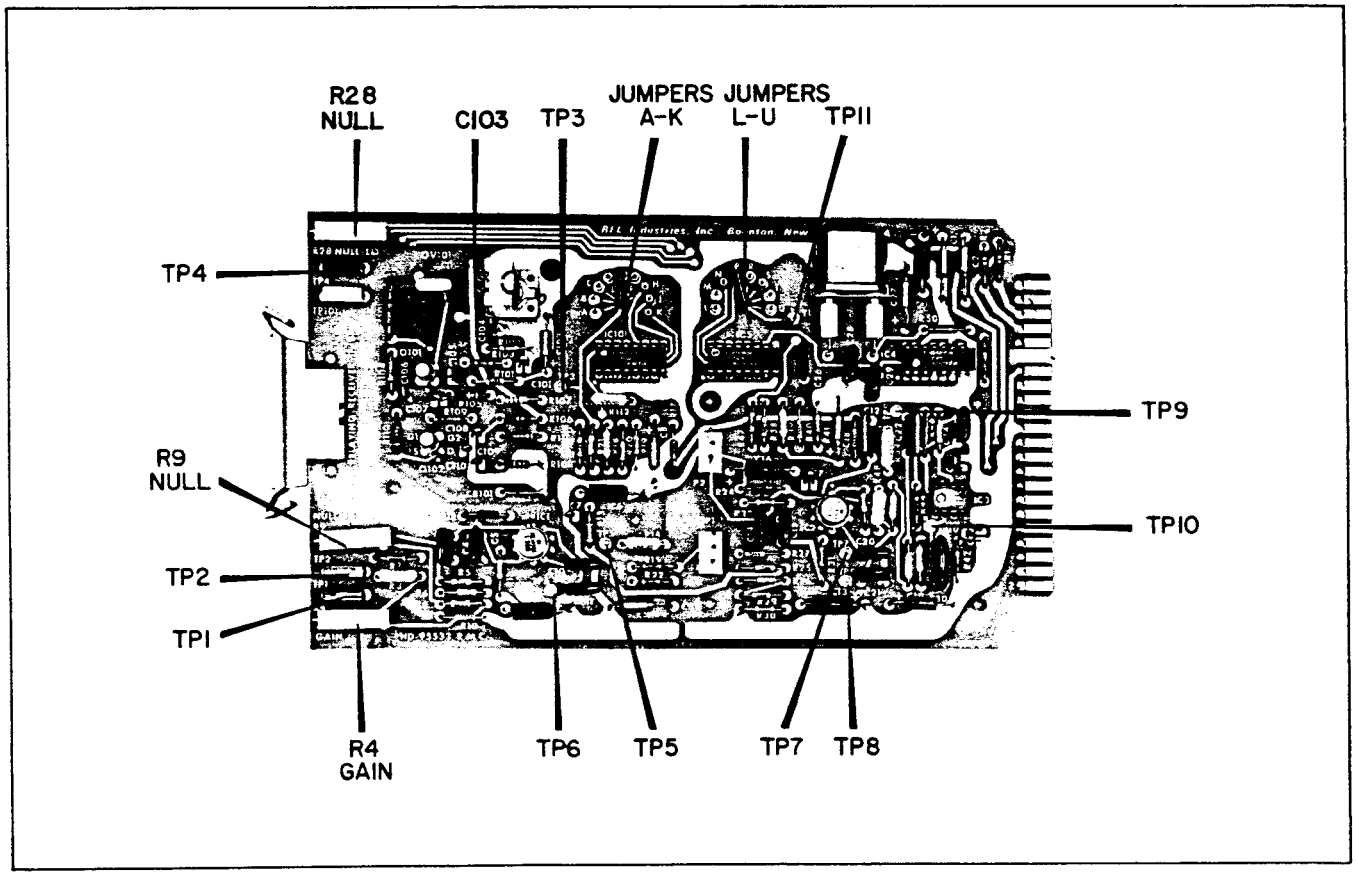



Figure 5.4. Locations of controls and adjustments, Model 67 PLC IF/BF

## TABLE 5.3
## LOCAL-OSCILLATOR-FREQUENCY SELECTION

### TABLE 5.3
### IF Frequency Generation

| Division | Use Jumper |
|---|---|
| 8 | A |
| 16 | B |
| 32 | C |
| 64 | D |
| 128 | E |
| 256 | F |
| 512 | H |
| 1024 | J |
| 2048 | K |

### TABLE 5.3

| PART NUMBERS | |
|---|---|
| CRYSTAL | OPTION |
| HB-46544-(X) | HB-90303-(X) and oven HB-46928 |
| Stability ±10 PPM | Stability ±2 PPM |

**NOTES:**

(1) Use crystals in the range from 4 to 9 MHz.

# Table 5.4
# Replaceable Parts

| Circuit Symbol (See Figure 5.6) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC IF/BF - Assembly No. HB-95530** | |
| | **CAPACITORS** | |
| C1, 2, 8, 9, 18, 27, 102 | Capacitor, tantalum, 1μF, 10%, 35V, Kemet T110A105K035AS or equiv. | 1007 1156 |
| C3, 6, 13, 16 | Capacitor, tantalum, 15μF, 20%, 20V, Kemet T322D156M020AS or equiv. | 1007 716 |
| C4, 5, 10, 11, 14, 15, 20, 21 | Capacitor, mica, 5 ±0.5pF, 500V, Electro Motive DM-15 or equiv. | 16503 |
| C7, 17, 101, 107-110 | Capacitor, ceramic, 0.033μF, 20%, 50V, Centralab CY15C333M or equiv. | 1007 1370 |
| C12, 22 | Capacitor, ceramic, 0.47μF, +80-20%, 50V, Sprague 5CZ5U474D8050C5 or equiv. | 1007 939 |
| C19 | Capacitor, tantalum, 2.2μF, 20%, 25V, Kemet T322B225M025AS or equiv. | 1007 645 |
| C23, 25 | Capacitor, ceramic, 0.1μF, GMV, 50V, Centralab CY20C104P or equiv. | 1007 1366 |
| C24 | Capacitor, mica, 10pF, 5%, 500V, Electro Motive DM-15 or equiv. | 16504 |
| C26 | Capacitor, mica, 100pF, 5%, 500V, Electro Motive DM-15 or equiv. | 16600 |
| C28, 29 | Capacitor, mica, 39pF, 5%, 500V, Electro Motive DM-15 or equiv. | 16513 |
| C30 | Capacitor, mica, 0.001μF, 2%, 500V, Electro Motive DM-15 or equiv. | 1080 286 |
| C30-100 | Not Used. | |
| C103 | Capacitor, variable, 2.2 to 34pF, E.F. Johnson 193-10-5 or equiv. | 1007 1363 |
| C104 | Capacitor, ultra-stable ceramic, 33pF, 10%, 100V, Kemet C312C330K1G5EA or equiv. | 1007 1363 |
| C105 | Capacitor, ultra-stable ceramic, 330pF, 10%, 100V, Kemet C315C331K1G5EA or equiv. | 1007 1365 |
| C106 | Capacitor, ultra-stable ceramic, 120pF, 10%, 100V, Kemet C315C121K1G5EA or equiv. | 1007 1395 |
| | **RESISTORS** | |
| R1, 2 | Resistor, composition, 2.7 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 900 |
| R3, 7, 13, 14, 27, 32, 34, 48, 112 | Resistor, metal film, 100 ohm, 1%, ¼W, Type RN¼ | 0410 1192 |
| R4 | Resistor, variable, 15-turn cermet, 5K, 10%, ¾W, Beckman Helipot 89PHR5K or equiv. | 39538 |
| R5, 25 | Resistor, metal film, 909 ohm, 1%, ¼W, Type RN¼ | 0410 1284 |
| R6, 8, 26, 29 | Resistor, metal film, 10 ohm, 1%, ⅛W, Type RN55D | 1510 1092 |
| R9, 28 | Resistor, variable, 15-turn cermet, 200 ohm, 10%, ¾W, Beckman Helipot 89PHR200 or equiv. | 39573 |
| R10, 30 | Resistor, metal film, 301 ohm, 1%, ¼W, Type RN¼ | 0410 1238 |
| R11, 31 | Resistor, metal film, 6.19K, 1%, ¼W, Type RN¼ | 0410 1364 |
| R12 | Resistor, metal film, 374 ohm, 1%, ¼W, Type RN¼ | 0410 1247 |
| R15, 22, 103 | Resistor, composition, 47 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 832 |
| R16, 20, 38, 40 | Resistor, metal film, 402 ohm, 1%, ¼W, Type RN¼ | 0410 1250 |
| R17, 37, 104, 111 | Resistor, metal film, 1.5K, 1%, ¼W, Type RN¼ | 0410 1305 |
| R18, 39 | Resistor, metal film, 15 ohm, 1%, ⅛W, Type RN55D | 1510 1317 |
| R19, 41, 46 | Resistor, metal film, 604 ohm, 1%, ¼W, Type RN¼ | 0410 1267 |
| R21, 47 | Resistor, metal film, 11K, 1%, ¼W, Type RN¼ | 0410 1388 |
| R23 | Not Used. | |
| R24 | Resistor, metal film, 1K, 1%, ¼W, Type RN¼ | 0410 1288 |

# Table 5.4
## Replaceable Parts - continued

| Circuit Symbol (See Figure 5.6) | Description | Part Number |
|---|---|---|
| R33 | Resistor, metal film, 750 ohm, 1%, ¼W, Type RN¼ | 0410 1276 |
| R35, 36, 107 | Resistor, metal film, 2K, 1%, ¼W, Type RN¼ | 0410 1317 |
| R42, 43 | Resistor, metal film, 10K, 1%, ¼W, Type RN¼ | 0410 1384 |
| R44 | Resistor, metal film, 5.11K, 1%, ¼W, Type RN¼ | 0410 1356 |
| R45 | Resistor, metal film, 15K, 1%, ¼W, Type RN¼ | 0410 1401 |
| R49 | Resistor, composition, 10M, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 811 |
| R50 | Resistor, metal film, 2.21K, 1%, ¼W, Type RN¼ | 0410 1321 |
| R51-100 | Not Used. | |
| R101 | Resistor, metal film, 24.9K, 1%, ¼W, Type RN¼ | 0410 1422 |
| R102 | Resistor, metal film, 8.25K, 1%, ¼W, Type RN¼ | 0410 1376 |
| R105, 108 | Resistor, metal film, 100K, 1%, ¼W, Type RN¼ | 0410 1480 |
| R106 | Resistor, metal film, 22.1K, 1%, ¼W, Type RN¼ | 0410 1417 |
| R109 | Resistor, metal film, 150K, 1%, ¼W, Type RN¼ | 0410 1497 |
| R110 | Resistor, metal film, 825 ohm, 1%, ¼W, Type RN¼ | 0410 1280 |
| | **SEMICONDUCTORS** | |
| CR101 | Diode silicon, 1N914B or 1N4448 | 26482 |
| IC1, 2 | Balanced modulator/demodulator, Motorola MC1496G or equiv. | 0620 110 |
| IC3 | Operational amplifier, National Semiconductor LM318N or equiv. | 0620 126 |
| IC4 | MOS hex inverting buffer, Signetics HEF4049BP or equiv. | 0615 248 |
| IC5, 101 | MOS 12-stage binary counter, Signetics HEF4040BP or equiv. | 0615 258 |
| Q101 | Transistor, NPN, 2N918, TO-72 package | 46541 |
| Q102 | Transistor, N-channel MOSFET, TO-72 package, Motorola MFE201 or equiv. | 0715 8 |
| | **MISCELLANEOUS COMPONENTS** | |
| L1, 101 | Inductor, molded, 220$\mu$H, 5%, Dale Electronics IM-4 or equiv. | 46598 |
| OV101 | Crystal oven (optional), 57 to 63°C, Ovenaire PCL1-27-24-60 or equiv. | 46540 |
| Y1 | Crystal, 3.584000 MHz | 41034 52 |
| Y101 | Crystal, value and type per sales order | Contact Factory |
| --- | Shorting bar, single, Aries LP300 or equiv. | 42904 |

# Table 5.5
# Replaceable Parts

| Circuit Symbol (See Figure 5.5) | Description | Part Number |
|---|---|---|
| | **24-kHz BANDPASS FILTER - Assembly No. HB-55710** | |
| C1 | Capacitor, polystyrene, 0.0041μF, 2%, 400V, F-Dyne Electronics PST-11-.0014-400-2 or equiv. | 5115 281 |
| C2 | Capacitor, polystyrene, 0.0082μF, 2%, 100V, Wesco 32P or equiv. | 5115 31 |
| C3 | Capacitor, polystyrene, 0.001μF, 2%, 400V, F-Dyne Electronics PST-11-.001-400-2 or equiv. | 5115 274 |
| C4 | Capacitor, polystyrene, 0.00345μF, 2%, 100V, Wesco 32P or equiv. | 5115 12 |
| C5 | Capacitor, polystyrene, 0.00115μF, 2%, 400V, F-Dyne Electronics PST-11-.00115-400-2 or equiv. | 5115 277 |
| C6 | Capacitor, polystyrene, 0.0027μF, 2%, 100V, Wesco 32P or equiv. | 5115 7 |
| L1 | Coil, cup-core, 35.48mH | 55952 6155 |
| L2 | Coil, cup-core, 10.72mH | 55952 6103 |
| L3 | Coil, cup-core, 3.773mH | 55952 3188 |
| R1 | Resistor, metal film, 3.01K, 1%, ¼W, Type RN¼ | 0410 1334 |

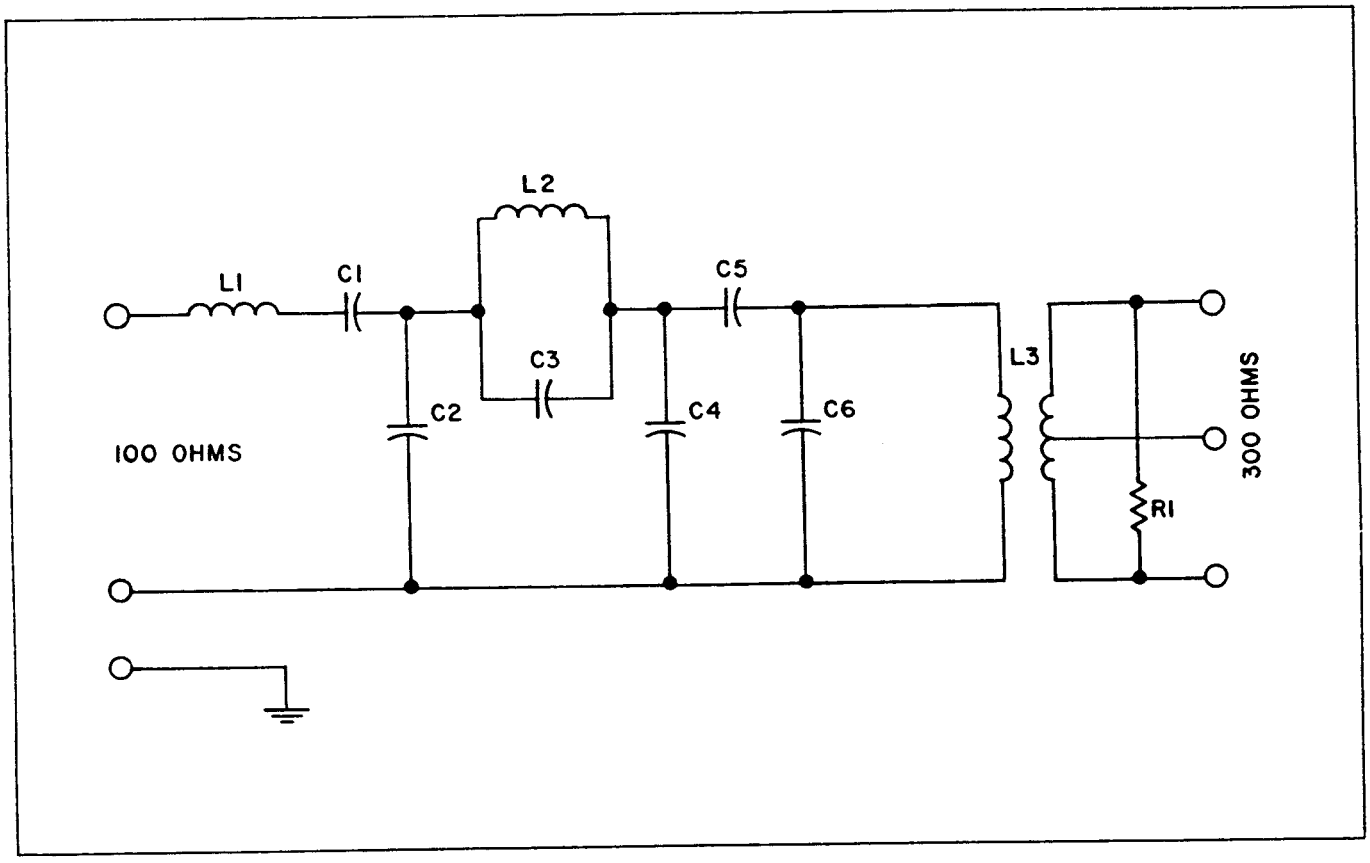



Figure 5.5. Schematic- plug-on 24 kHz bandpass filter for Model 67 PLC IF/BF

# MODEL 67 PLC DISC/CLI

## DESCRIPTION

This circuit card carries four elements of the receiving system: (a) narrowband, active, bandpass filter which is the element ultimately setting the bandpass of the system, (b) the resonant circuit and output amplifier for the frequency descriminator, (c) a signal-monitoring circuit which initiates an alarm when the received signal falls below a set level, and (d) a signal-level indicator using a front-panel-mounted d'Arsonval meter to indicate deviation of the received-signal level, in dB, from a specified nominal level.

## CIRCUIT DETAILS

The circuit of the Model 67 PLC DISC/CLI is detailed in its schematic diagram, Figure 5.8.

### Narrowband Filter

Signals from the intermediate-frequency and base-frequency module (IF/BF) enter an active, narrowband bandpass filter at terminal B. The standard filter has a bandwidth of approximately 200 Hz, which provides for a frequency shift of ±100 Hz about the center frequency of an FSK system. Other filters with different bandwidths may be required. For this reason, electrical values of frequency-determining components in the active filter are not given in Figure 5.8.

The output of the filter is buffered by IC1D, and R73 varies the output level from the filter by changing the feedback factor of this opamp.

The narrowband filter supplies the input signal to the signal-level monitor and indicator, and to signal limiters and slicers.

### Level Monitor

The signal from the narrowband filter is detected in a precision rectifier using IC4B and IC4C, and its level is tested with comparator IC4D. The nominal level of 0 dBmO will correspond to 1 Vdc at TP5.

The threshold of the low-level detector is set by R58, and it is adjustable between -5 and -15 dBmO.

The output of IC4D drives output transistor Q4, an open-collector transistor which keeps the alarm relay energized unless the input signal fails. DS1 is a supervisory lamp, and it is illuminated at low signal levels.

### Level Indicator

IC5B and IC5A form a logarithmic amplifier which, with linearly varying input signal, drives a d'Arsonval indicator to show signal-level variations from normal on a linear dB scale. The amplifier drives the signal-level meter on the front panel of the card, and it will also drive an external meter, with a full-scale range of 100 μA, connected to terminal 11.

With an input signal of 0 dBmO connected to the receiver's input, the level indicating meter is set to the center of its scale (0 dB), with NOM potentiometer R30.

### Discriminator

The receiver's discriminator, consisting of L101, C102, and associated components is located on this circuit card. It operates with the Model 67 PLC LM/SL card, and it is discussed in the description of that module.

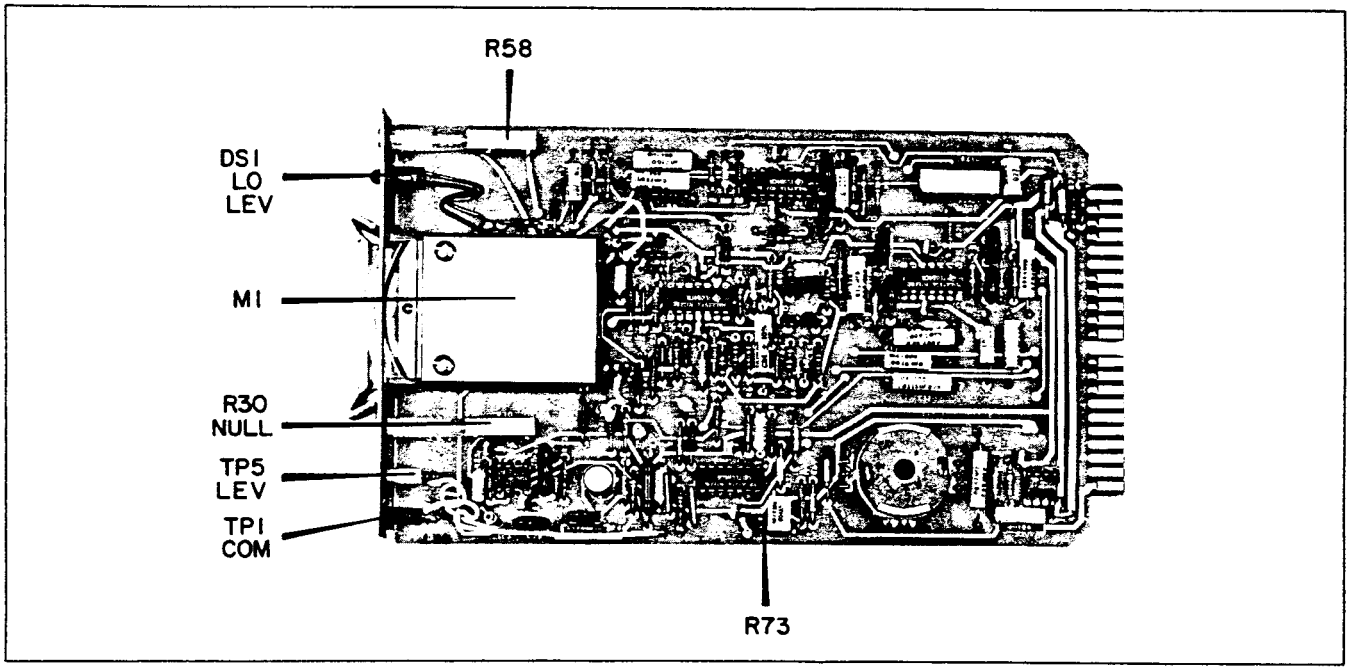



Figure 5.7. Location of controls and adjustments, Model 67 PLC DISC/CLI

# Table 5.6
# Replaceable Parts

| Circuit Symbol (See Figure 5.8) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC DISC/CLI - Assembly No. HB-95560** | |
| | **CAPACITORS** | |
| C1, 2, 23, 101 | Capacitor, tantalum, 1μF, 10%, 35V, Kemet T110A105K035AS or equiv. | 1007 1156 |
| C3, 10, 15 | Capacitor, metallized polycarbonate, 0.01μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1115 |
| C4, 5, 8, 13, 24-26, 29, 33, 35, 104, 105 | Capacitor, ceramic, 0.1μF, GMV, 50V, Centralab CY20C104P or equiv. | 1007 1366 |
| C6, 7 | Capacitor, polystyrene, 0.0062μF, 2%, 100V, Wesco 32P or equiv. | 5115 25 |
| C9, 11, 20, 21, 37, 38 | Capacitor, mica, 27pF, 5%, 500V, Electro Motive DM-15 or equiv. | 16509 |
| C12 | Capacitor, metallized polycarbonate, 0.049μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1197 |
| C14 | Capacitor, polystyrene, 0.00375μF, 2%, 100V, Wesco 32P or equiv. | 5115 14 |
| C16 | Capacitor, polystyrene, 0.0082μF, 2%, 100V, Wesco 32P or equiv. | 5115 31 |
| C17 | Capacitor, metallized polycarbonate, 0.0255μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1185 |
| C18 | Capacitor, polystyrene, 0.0027μF, 2%, 100V, Wesco 32P or equiv. | 5115 7 |
| C19 | Capacitor, metallized polycarbonate, 0.0155μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1111 |
| C22 | Capacitor, metallized polycarbonate, 0.02μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1127 |
| C27 | Capacitor, mica, 300pF, 2%, 500V, Electro Motive DM-19 or equiv. | 16622 |
| C28 | Capacitor, mica, 150pF, 2%, 500V, Electro Motive DM-15 or equiv. | 16608 |
| C30 | Capacitor, ceramic, 0.01μF, 20%, 50V, Sprague 3CZ5U103X0050C5 or equiv. | 1007 1352 |
| C31, 32 | Capacitor, ceramic, 0.47μF, +80-20%, 50V, Murata RE50-474M or equiv. | 1007 939 |
| C34 | Capacitor, tantalum, 0.33μF, 10%, 35V, Mallory TAC334K035P02 or equiv. | 1007 1281 |
| C36 | Capacitor, polystyrene, 0.047μF, 10%, 100V, Cornell-Dublier WMF-1S47 or equiv. | 1007 631 |
| C39-100 | Not Used. | |
| C102 | Capacitor, polystyrene, 0.0155μF, 2%, 100V, Wesco 32P or equiv. | 5115 44 |
| C103 | Capacitor, polystyrene, 0.00105μF, 2%, 400V, F-Dyne Electronics PST-11-.00105-400-2 or equiv. | 5115 275 |
| | **RESISTORS** | |
| R1, 2 | Resistor, composition, 2.7 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 900 |
| R3, 29, 35, 54 | Resistor, metal film, 100 ohm, 1%, ¼W, Type RN¼ | 0410 1192 |
| R4, 5, 32, 43, 45-48, 50, 52, 56 | Resistor, metal film, 10K, 1%, ¼W, Type RN¼ | 0410 1384 |
| R6 | Resistor, metal film, 100K, 1%, ¼W, Type RN¼ | 0410 1480 |
| R7 | Resistor, metal film, 2.61K, 1%, ¼W, Type RN¼ | 0410 1328 |
| R8 | Resistor, metal film, 4.87K, 1%, ¼W, Type RN¼ | 0410 1354 |
| R9, 10 | Resistor, metal film, 6.49K, 1%, ¼W, Type RN¼ | 0410 1366 |
| R11 | Resistor, metal film, 5.9K, 1%, ¼W, Type RN¼ | 0410 1362 |
| R12 | Resistor, metal film, 1.96K, 1%, ¼W, Type RN¼ | 0410 1316 |
| R13 | Resistor, metal film, 8.25K, 1%, ¼W, Type RN¼ | 0410 1376 |
| R14 | Resistor, metal film, 787 ohm, 1%, ¼W, Type RN¼ | 0410 1278 |
| R15, 16 | Resistor, metal film, 4.12K, 1%, ¼W, Type RN¼ | 0410 1347 |
| R17 | Resistor, metal film, 3.65K, 1%, ¼W, Type RN¼ | 0410 1342 |
| R18, 19, 20, 101 | Resistor, metal film, 5.11K, 1%, ¼W, Type RN¼ | 0410 1356 |
| R21 | Resistor, metal film, 4.53K, 1%, ¼W, Type RN¼ | 0410 1351 |
| R22-24 | Resistor, metal film, 2.1K, 1%, ¼W, Type RN¼ | 0410 1319 |
| R25 | Resistor, metal film, 1.58K, 1%, ¼W, Type RN¼ | 0410 1307 |
| R26 | Resistor, metal film, 1.96K, 1%, ¼W, Type RN¼ | 0410 1316 |

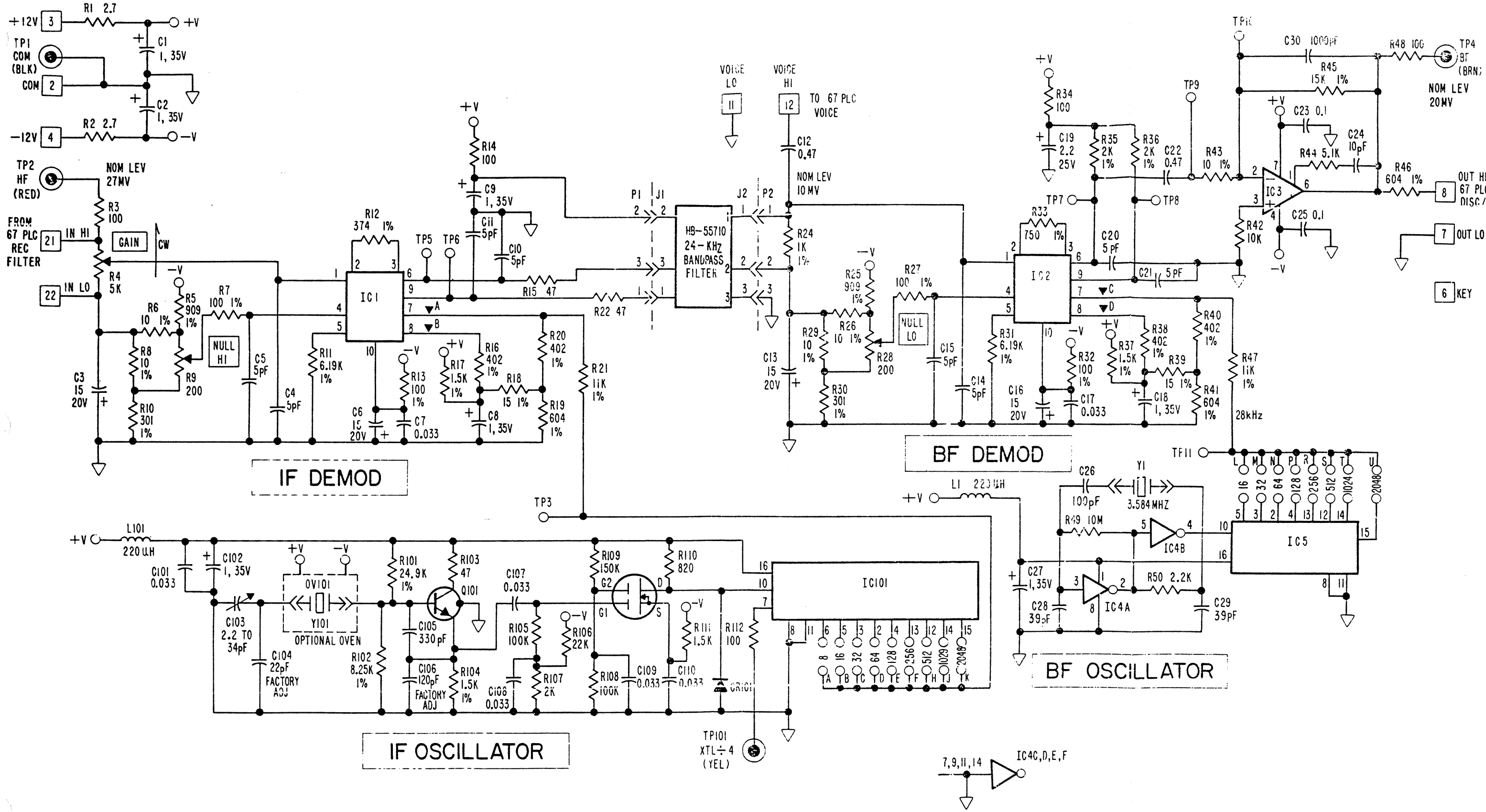
# Table 5.6
# Replaceable Parts

| Circuit Symbol (See Figure 5.8) | Description | Part Number |
|---|---|---|
| R27 | Resistor, metal film, 15K, 1%, ¼W, Type RN¼ | 0410 1401 |
| R28, 69 | Resistor, metal film, 604 ohm, 1%, ¼W, Type RN¼ | 0410 1267 |
| R30 | Resistor, variable, 15-turn cermet, 100K, 10%, ¾W, Beckman Helipot 89PHR100K or equiv. | 47540 |
| R31, 34 | Not Used. | |
| R33, 51, 61 | Resistor, metal film, 4.99K, 1%, ¼W, Type RN¼ | 0410 1355 |
| R36 | Resistor, metal film, 82.5K, 1%, ¼W, Type RN¼ | 0410 1472 |
| R37 | Thermistor, 1000 ohms @ 25°C, Tel-Labs Type Q81 or equiv. | 91529 |
| R38 | Resistor, metal film, 2.21K, 1%, ¼W, Type RN¼ | 0410 1321 |
| R39 | Resistor, metal film, 1.21K, 1%, ¼W, Type RN55D | 1510 2029 |
| R40 | Resistor, composition, 1.2M, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 860 |
| R41 | Resistor, metal film, 5.23K, 1%, ¼W, Type RN¼ | 0410 1357 |
| R42 | Resistor, metal film, 48.7K, 1%, ¼W, Type RN¼ | 0410 1450 |
| R44 | Resistor, metal film, 3.65K, 1%, ¼W, Type RN¼ | 0410 1342 |
| R49, 72 | Resistor, metal film, 4.75K, 1%, ¼W, Type RN¼ | 0410 1353 |
| R53 | Resistor, metal film, 11.5K, 1%, ¼W, Type RN¼ | 0410 1390 |
| R55 | Resistor, metal film, 2.49K, 1%, ¼W, Type RN¼ | 0410 1326 |
| R57, 68 | Resistor, metal film, 1K, 1%, ¼W, Type RN¼ | 0410 1288 |
| R58 | Resistor, variable, 15-turn cermet, 25K, 10%, ¾W, Beckman Helipot 89PHR25K or equiv. | 45829 |
| R59, 62 | Resistor, metal film, 2K, 1%, ¼W, Type RN¼ | 0410 1317 |
| R60 | Resistor, metal film, 39.2K, 1%, ¼W, Type RN¼ | 0410 1441 |
| R63 | Resistor, metal film, 475K, 1%, ¼W, Type RN¼ | 0410 1545 |
| R66 | Resistor, metal film, 6.81K, 1%, ¼W, Type RN¼ | 0410 1368 |
| R64, 65, 67, 71 | Resistor, metal film, 3.32K, 1%, ¼W, Type RN¼ | 0410 1338 |
| R70 | Resistor, metal film, 41.2K, 1%, ¼W, Type RN¼ | 0410 1443 |
| R73 | Resistor, variable, 18-turn cermet, 50K, 10%, ½W, Beckman Helipot 68XR50K or equiv. | 91956 |
| R74-100 | Not Used. | |
| R102 | Resistor, metal film, 3.74K, 1%, ¼W, Type RN¼ | 0410 1343 |
| R103 | Resistor, metal film, 37.4K, 1%, ¼W, Type RN¼ | 0410 1439 |
| R104-107 | Resistor, variable, 12-turn cermet, 1K, 10%, ¼W, top adjust, Bourns 3266W-1-102 or equiv. | 32993 |
| | **SEMICONDUCTORS** | |
| CR1-4 | Diode, silicon, 1N914B or 1N4448 | 26482 |
| CR5 | Diode, Zener, 2.4V, 500 mW, 1N5221B, DO-7 package | 40476 |
| DS1 | Light-emitting diode, red, Dialight 559-0101-003 or equiv. | 91115 |
| IC1-4 | Operational amplifier, JFET input, Texas Instruments T1084CN or equiv. | 0620 151 |
| IC5, 101 | Dual operational amplifier, JFET input, Texas Instruments T1082CP or equiv. | 0620 155 |
| IC6-100 | Not Used. | |
| Q1 | Transistor, dual NPN, 2N2915, metal case w/6 leads | 17128 |
| Q2 | Transistor, PNP, 2N2907A, plastic package | 37439 |
| Q3 | Transistor, PNP, 2N2222A, plastic package | 37445 |
| Q4 | Transistor, Darlington, PNP, Motorola MPS-U95 or equiv. | 47509 |
| | **MISCELLANEOUS COMPONENTS** | |
| L101 | Coil, cup-core, 0.1005H | 55979 1200 |
| M1 | Panel meter, edge-reading, 0 to 1 mA | 41106 |

+12V C,3 R1 2.7 +V
C1, 1UF 35V
COM B,2 TP1 COM (BLK)
C2 1UF 35V
-12V D,4 R2 2.7 -V
IC6,B,D,E 5,9,11
8,12 9,13 IC7C,D 14 7 +V
DISC IN TO 67 PLC DISC/CLI Z,22 IC6A IC6F IC6C IC7B TP7 0° REF
NORMAL A B INVERT +V
DISC OUT FROM 67 PLC DISC/CLI S,15 C22 .47UF
C4 0.1UF -V +V
4KHZ IN FROM 67 PLC DISC/CLI (1V RMS) R,14 C21 .47UF R4 1K IC1A R5 10K
R3 10K 1%
RG2, 1M
R7 1K R8 10K Q1
INPUT LIMITER CR1
+V R9 5.1K R10 10K
C3 0.1UF R13 10K
RG3, 1M
R11 1K R14 10K Q2
DISC LIMITER CR2
R15 5.1K IC7A TP8 90° CF
LOWPASS FILTER
+V R17 10K R16 3.3K CR4 CR5 8.2V R18 20K
R19 20K C5 0.018UF
C6 0.068UF 2% R20 20K C7 1300PF 2%
IC3B C11 0.1UF -V
R53 20K R54 20K C16 0.018UF
C17 0.068UF R55 20K C18 1300 PF
IC3A R21 4.99K 1%
R22 4.99K 1%
R6 20K 1% CR3 8.2V R25 10K BIAS CW R12 20K 1%
R23 20K R24 10K IC3C
BIAS
R26 2.2K
IC2A R57 3.3K CR9 2.4V DS1 TRIP +V
TP6 +4
+V R31 2.2K R32 4.02K 1% CR7 8.2V C10 0.1UF
R33 10K CW TRIP SLICE
R48 2.2M C12 0.1UF R47 20K
IC4B IC5B
R51 100 TP3 (TRIP)
R50 220 H,7 TRIP TO 67 PLC LOGIC
IC3D R34 5.1K R29 20K
R28 4.99K 1% CW SCALE R30 100
R27 1.47K 1% SCALE TP5 -4 TP2 LPF/DISC (BRN)
R46 10K R52 10K
SLICER
IC2B R58 3.3K CR8 2.4V DS2 GUARD +V
R56 2.2M R35 5.1K R39 3.3K
IC4A C13 0.1UF R45 4.7K R40 20K
C14 0.1UF
R36 2.2K R37 4.02K 1% -V
CR6 8.2V R38 10K CW GUARD SLICE
IC5A C15 0.1UF
R44 100 TP4 (GUARD)
R43 220 GUARD TO 67 PLC LOGIC J,8
R59, 5.11K CR31 M,11 FROM 67 PLC LOGIC
R60, 5.11K CR32
L,10 EYE OUT
C23 .01UF 50V R61 10K
E,5 KEY
ENVELOPE LEVEL TO 67 PLC LOGIC T,16 1 VDC
R116 47
R109 20K 1%
R104 10K 1% R108 20K 1% R110 20K 1%
C105 0.0049UF
R107 10K CR101
C101 0.47UF R101 10K 1%
IC101D R105 20K 1% IC101C CR102 R111 10K 1% IC101B
R102 10K 1% R103 6.34K 1% C102 0.47UF
R106 4.7K C103 0.1UF
R112 4.7K C104 0.1UF
R113 20K 1% R114 20K 1% C106 0.0345UF
C107 0.00715UF R115 20K 1% C108 510 pF
IC101A

NOTE:
1. UNLESS OTHERWISE SPECIFIED, ALL RESISTOR VALUES ARE IN OHMS 1/4W, 5%.

Figure 5.10. Schematic- Model 67 PLC LM/SL
5-23 (5-24 blank)




NOTE:

1. ALL RESISTORS ARE 1/4W, 5% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN UF UNLESS OTHERWISE SPECIFIED.

Figure 5.6. Schematic- Model 67 PLC IF/BF
5-11 (5-12 blank)

# MODEL 67 PLC LM/SL

## CIRCUIT DETAILS

A schematic of the circuits of the Model 67 PLC LM/SL appears in Figure 5.10.

### Limiter and Discriminator

The 4-kHz signal from the narrowband filter on the DISC/CLI module enters the LM/SL module at terminals R and 14. This signal is amplitude limited in opamp IC1A and it is then returned to the discriminator on the DISC/CLI card, shown in Figure 5.8.

In Figure 5.8, L101 and C102 are resonant at the center frequency of the channel, and there is no phase shift across the terminals of the resonant circuit at that frequency. R103 and C103, connected across the resonator, cause a 90° phase shift of the signal at the non-inverting input of IC101A. The phase-shifted output of IC101A is then returned to the LM/SL module through terminals S and 15, Figure 5.10, where it is limited by IC1B. The two limited signals, which are now squarewaves with a phase shift of 90° with respect to each other when center frequency is received, are then applied to the input of EXCL-OR gate IC7A. The resultant output of IC7A is a squarewave at twice the carrier frequency, and with a duty cycle of 50%.

As the input frequency changes, the phase across the resonator will lag or lead with respect to the input. Thus the phase difference between the two inputs of IC7A will change from approximately 90° to -90°, depending upon the input frequency. These phase differences change the duty cycle of the squarewave output of IC7A and their dc component is proportional to the pulse width, which is proportional to the input frequency. Thus the frequency-shifted input creates an output whose dc level is a function of frequency.

The jumpers connected to pin 6 of IC7B change the polarity of the output so that either a positive or a negative output can be obtained for either a positive or a negative change in frequency.

The output of IC7A is held at constant level with zener diode CR5, and it goes through a lowpass, active filter using IC3A and IC3B.

### Slicer

The lowpass filter's output is biased at about six volts, and this bias is removed by applying an equal but opposite voltage through IC3C. The voltage is set by adjusting R25. IC3D then scales the amplitude of the signal before entering the slicers. This is determined by the gain of IC3D, which is controlled by SCALE potentiometer R29.

The two slicers are IC4B and IC4A, and their slicing levels are set by R33 and R38. R33 varies the level for IC4B from 0 to 5 volts, as measured at TP6; and R38 varies the level for IC4A from 0 to -5 volts, as measured at TP5. The slicing levels may be set to plus and minus 4 Vdc. Outputs of the slicers are buffered, respectively, by IC5B and IC5A. At terminals H and 7, TRIP output is approximately 11 Vdc. At terminals J and 8, GUARD output is about -11 Vdc.

The trip output also drives IC2A, which causes DS1 to illuminate when a trip signal is present. Similarly, IC2 illuminates DS2 when the guard signal is present.

### Envelope Detection

The 4-kHz signal received at terminals R and 14 also enters amplifier IC101D, which drives a precision rectifier using IC101C and IC101B. The rectified signal then passes through a lowpass, active filter using IC101A. The output is an envelope slowly following the average amplitude of the input signal, and is sent, through terminals T and 16, to the logic card, where it is used for signal analysis.

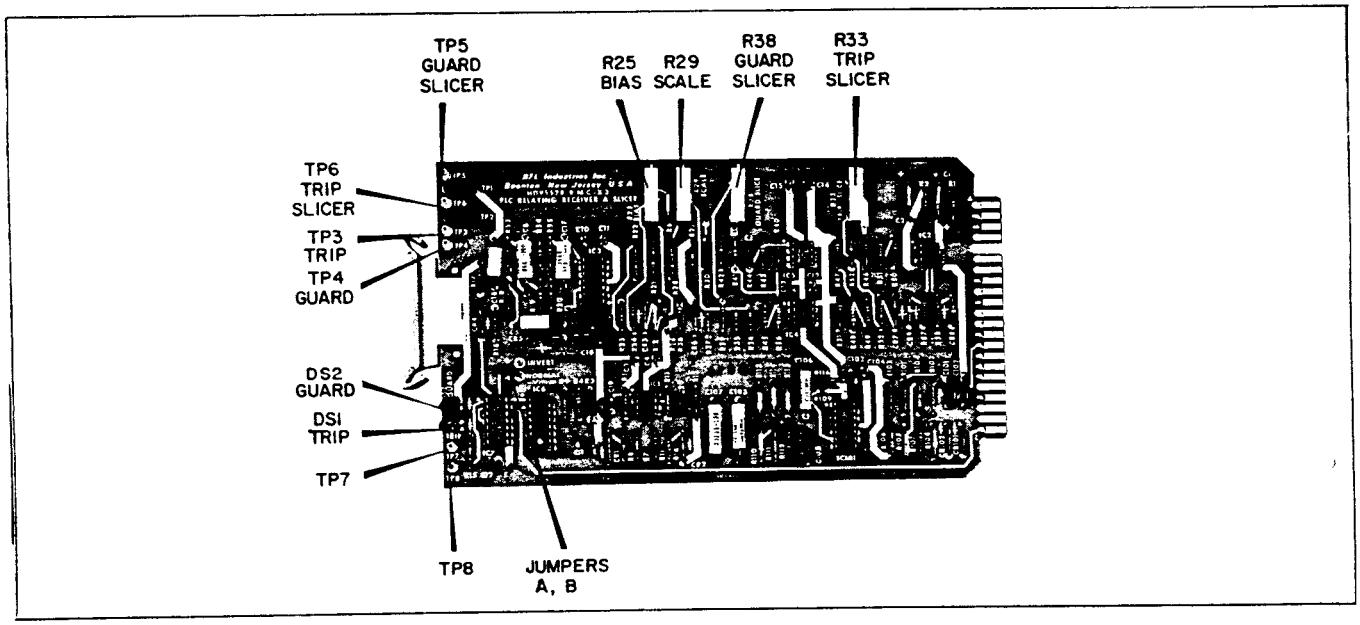



Figure 5.9. Location of controls and adjustments, Model 67 PLC LM/SL

# Table 5.7
# Replaceable Parts

| Circuit Symbol (See Figure 5.10) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC LM/SL - Assembly No. HB-95525** | |
| | **CAPACITORS** | |
| C1, 2 | Capacitor, tantalum, 1μF, 10%, 35V, Kemet T110A105K035AS or equiv. | 1107 1156 |
| C3, 4, 10-15, 103, 104 | Capacitor, ceramic, 0.1μF, GMV, 50V, Centralab CY20C104P or equiv. | 1007 1366 |
| C5, 16 | Capacitor, metallized polycarbonate, 0.018μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1125 |
| C6, 17 | Capacitor, metallized polycarbonate, 0.068μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1176 |
| C7, 18 | Capacitor, mica, 0.0013μF, 2%, 500V, Electro Motive DM-19 or equiv. | 16214 |
| C19, 20 | Capacitor, mica, 10μF, 5%, 300V, Electro Motive DM-10 or equiv. | 1080 336 |
| C21, 22, 101, 102 | Capacitor, ceramic, 0.47μF, +80-20%, Murata RE50-474M or equiv. | 1007 939 |
| C23 | Capacitor, X7R ceramic, 0.01μF, 10%, 50V, AVX SA105C103KAA | 0130 51031 |
| C24-100 | Not used. | |
| C105 | Capacitor, polystyrene, 0.0049μF, 2%, 100V, Wesco 32P or equiv. | 5115 20 |
| C106 | Capacitor, metallized polycarbonate, 0.345μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1190 |
| C107 | Capacitor, polystyrene, 0.00715μF, 2%, 100V, Wesco 32P or equiv. | 5115 28 |
| C108 | Capacitor, mica, 510pF, 2%, 500V, Electro Motive DM-19 or equiv. | 16634 |
| | **RESISTORS** | |
| R1, 2 | Resistor, composition, 2.7 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 900 |
| R3, 5, 8, 10, 11, 13, 14, 17, 24, 41, 42, 46, 52, 61, 101, 102, 104, 107, 111 | Resistor, metal film, 10K, 1%, ¼W, Type RN¼ | 0410 1384 |
| R4, 7, 11 | Resistor, metal film, 1K, 1%, ¼W, Type RN¼ | 0410 1288 |
| R6, 12, 18-20, 23, 40, 47, 53-55, 105, 108-110, 113-115 | Resistor, metal film, 20K, 1%, ¼W, Type RN¼ | 0410 1413 |
| R9, 15, 34, 35, 59, 60 | Resistor, metal film, 5.11K, 1%, ¼W, Type RN¼ | 0410 1356 |
| R16, 39, 57, 58 | Resistor, metal film, 3.32K, 1%, ¼W, Type RN¼ | 0410 1338 |
| R21, 22, 28 | Resistor, metal film, 4.99K, 1%, ¼W, Type RN¼ | 0410 1355 |
| R25, 33, 38 | Resistor, variable, 15-turn cermet, 10K, 10%, ¾W, Beckman Helipot 89PHR10K or equiv. | 39539 |
| R26, 31, 36 | Resistor, metal film, 2.21K, 1%, ¼W, Type RN¼ | 0410 1321 |
| R27 | Resistor, metal film, 1.47K, 1%, ¼W, Type RN¼ | 0410 1304 |
| R29 | Resistor, variable, 15-turn cermet, 20K, 10%, ¾W, Beckman Helipot 89PHR20K or equiv. | 39504 |
| R30, 44, 51 | Resistor, metal film, 100 ohm, 1%, ¼W, Type RN¼ | 0410 1192 |
| R32, 37 | Resistor, metal film, 4.02K, 1%, ¼W, Type RN¼ | 0410 1346 |
| R43, 50 | Resistor, metal film, 221 ohm, 1%, ¼W, Type RN¼ | 0410 1225 |
| R45, 49, 106, 112 | Resistor, metal film, 4.75K, 1%, ¼W, Type RN¼ | 0410 1353 |
| R48, 56 | Resistor, composition, 2.2M, 5%, ¼W, Allen Bradley CB Series or equiv. | 1009 820 |
| R62, 63 | Resistor, metal film, 1M, 1%, ¼W, Type RN60D | 1510 508 |
| R61, 64-100 | Not used. | |
| R103 | Resistor, metal film, 6.34K, 1%, ¼W, Type RN¼ | 0410 1365 |
| R116 | Resistor, composition, 47 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 832 |

# Table 5.7
## Replaceable Parts - continued

| Circuit Symbol (See Figure 5.10) | Description | Part Number |
|---|---|---|
| | **SEMICONDUCTORS** | |
| CR1, 2, 4, 31, 32 101, 102 | Diode, silicon, 1N914B or 1N4448 | 26482 |
| CR3, 5-7 | Diode, Zener, 8.2V, 5%, 400mW, 1N756A | 26482 |
| CR8, 9 | Diode, Zener, 2.4V, 5%, 500mW, 1N5221B | 40476 |
| CR10-30, 33-100 | Not Used. | |
| DS1, 2 | Light-emitting Diode, Dialight 550-0102 or equiv. | 39568 |
| IC1, 4 | Voltage comparator, dual, low offset, National Semiconductor LM393AN or equiv. | 0620 144 |
| IC2 | Operational amplifier, dual, Texas Instruments MC1458P or equiv. | 0620 51 |
| IC3, 101 | Operational amplifier, JFET input, Texas Instruments TL084CN or equiv. | 0620 151 |
| IC5 | Operational amplifier, dual JFET input, Texas Instruments TL082CP or equiv. | 0620 155 |
| IC6 | MOS hex inverting buffer, Toshiba TC4049BP or equiv. | 0615 257 |
| IC7 | MOS quad exclusive-OR gate, Motorola MC14070BCP or equiv. | 0615 69 |
| IC8-100 | Not Used. | |
| Q1, 2 | Transistor, NPN, 2N2222A, plastic package | 37445 |
| | **MISCELLANEOUS COMPONENTS** | |
| TP1 | Test jack, black, E. F. Johnson 105-2203-101 or equiv. | 38116 3 |
| TP2 | Test jack, brown, E. F. Johnson 105-2208 101 or equiv. | 38116 4 |
| TP3-8 | Not Replaceable. | |
| --- | Shorting bar, single, Aries LP300 or equiv. | 42904 |

4KHz FSK TO 67 PLC REC LM/SL 1VRMS =0dB Mo

14 R69 604 1% R44 3.65K 1% R45 10K 1% C32 0.47 C31 0.47 IC1B R43 10K R46 10K 1% R29 100 TP3 R48 10K 1% R49 4.7K IC4C R47 10K C33 0.1 +V CR2 CR3 R50 10K 1% R53 11.5K 1% R54 100 TP5 LEVEL (YEL) C34 .33 35V R51 4.99K 1% R52 10K IC4B C35 0.1 −V R55 2.49K 1% R56 10K IC4A

1VDC = 0dB Mo

R58 SETS CD FOR −10 dB Mo TO −20 dB Mo

LOW LEVEL = −V AUX 9 R57 1K 1% R58 25K CD R59 2K 1% C36 0.047 R61 4.99K 1% R60 39.2K 1% −V R63 470K R62 2K 1% IC4D R64 3.3K R65 3.3K Q2 CR4 DS1 R68 1K +V R66 6.8K CR5 2.4V R67 3.3K Q3 −V R71 3.3K R72 4.7K Q4 +V 10 ALARM RELAY

## LEVEL INDICATOR

R33 4.99K 1% C27 300pF CR1 Q1A Q1B C28 150pF R39 1.21M 1% +V CW R30 100K NOM IC5B R32 10K 1% C26 0.1 +V R35 100 TP4 R36 82.5K 1% T R37 1K,1% R38 2.2K IC5A C29 0.1 −V R40 1.2M C30 0.01 −M M1 +M R41 5.23K 0.1% R42 48.7K 1% 11 EXTERNAL METER 0−100 UA

| M1-dB Mo | TP5 | TP4 |
|---|---|---|
| −10 | +0.3=VDC | 0 VDC |
| 0 | +1.0 | −2.5 |
| +10 | +3.16 | −5.0 |

13 4KHZ OUT R28 604 1% FILT. LEVEL CW R27 15K 1% R73 50K C23 1 35V R26 1.96K 1% IC1D

TP2 R3 100 C3 IC1A R6 100K 1% R7 R8 R13 C10 C9 27pF R15 IC2D C13 0.1 C14 C15 C18 R22 +V C24 0.1

4KHz BF IN FROM 67PLC REC IF/BF 8 R4 10K 1% R5 10K 1%

20 MV RMS =0dB Mo

KEY 12

C6 R9 IC2B IC2C C7 R10 R11 R105 R12 R14 IC2A C8 0.1 R16 R17 R104 C11 27pF C12 R18 R19 C37 27pF IC3A R20 C38 27pF C16 R21 R106 C17 C19 IC3B C25 0.1 −V R23 C20 27pF IC3C R24 C21 27PF C22 R25 R107 R70

+12V 3 R1 2.7 +V C1 1 35V TP1 COM (BLK) COM 2 C2 1, 35V −12V 4 R2 2.7 −V

NOTES:

1. ALL RESISTORS ARE 1/4W, 5% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN UF UNLESS OTHERWISE SPECIFIED.

DISC IN FROM 67PLC REC LM/SL 22 R101 C101 1, 35V L101 R102 C102 R103 C103 IC101A C104 0.1 15 DISC OUT TO 67 PLC REC LM/SL IC101B C105 0.1 IC1C C4 0.1 C5 0.1

## LEVEL-INDICATOR LOG AMP

## 4KHz BASEBAND−FREQ. FILTER

## DISCRIMINATOR

Figure 5.8. Schematic- Model 67 PLC DISC/CLI

# Section 6

# LOGIC

## MODEL 67 PLC LOGIC

## DESCRIPTION

The logic card receives the output from the frequency-shift receiver and, after applying various tests on the validity of the system to optimize security, dependability, and speed, delivers appropriate output signals for guard, trip, or alarm.

### Inputs to the Logic Card

Several input signals, including signals from the receiving system, are applied to the logic card, as shown on its schematic (Figure 6.5).

(a) Trip input is applied as a logic-high signal at terminal 7. In the guard mode this terminal is low.

(b) Guard input is applied as a logic-high signal at terminal 9. If the guard signal fails or if the frequency of the input signal changes to trip then the input to this terminal will be low.

(c) In the receiver the BF signal fed to the limiter and discriminator is also amplified, rectified, and filtered to develop a positive dc voltage proportional to received-signal level. This voltage enters the logic card at terminal 16. If the level exceeds 7 volts it will be interpreted as excessively high, and suitable blocking or alarm measures will ensue. If the voltage drops below 0.09 volts, it will be interpreted as excessively low, and the same protective measures will follow.

When there is no noise associated with the signal at terminal 16, the dc voltage at that point will be constant. Noise, however, will amplitude modulate that signal and rapidly drop its level. When jumper D, at the output of IC7A, is installed, an instantaneous drop of 11% or more of that signal will be interpreted as noise, but in a trip-boost system a rise in voltage will not be interpreted as noise.

(d) If terminal T is LO, a positive level at one or more terminals N, P, 12, and 13 will block the system and a trip signal will be blocked even if terminal 7 is high.

(e) No matter what the condition of any other input, trip output will be blocked if terminal W is high.

(f) No matter what the condition of any other input, if terminal W is low then a trip output will occur if terminal V is high.

(g) Under an alarm condition, the alarm can be terminated if terminal M is driven high.

(h) The circuitry that initiates a blocked condition on the basis of an irregularity in the envelope of the carrier (observed at terminal 16) delivers a high to terminal 11. If terminal T is low, this same block initiate signal is deliverd to several points in the card. If terminal T is high, however, the block initiate signal, though it is still gener-

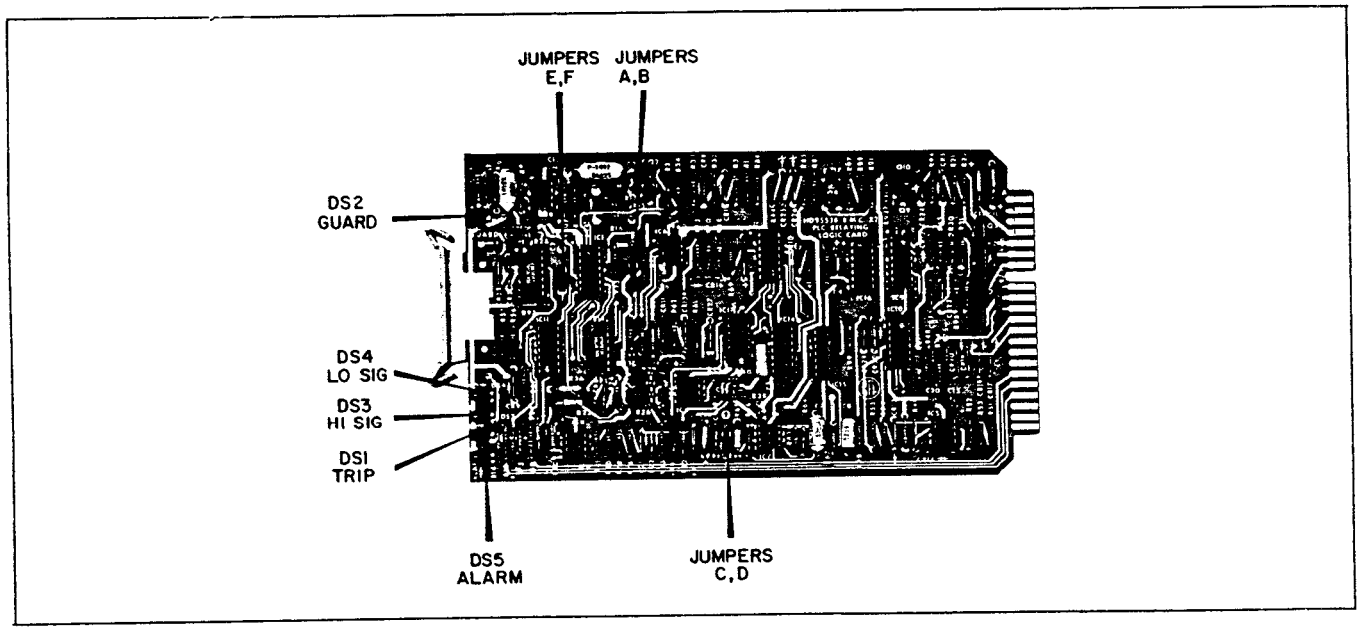



Figure 6.1. Locations of controls and adjustments, Model 67 PLC LOGIC

ated for system use, no longer affects other portions of the card's circuitry. Instead, an external (digital) signal existing at terminal S will be gated to the block initiate line and drive the same points the card's own internal block initiate signal drove.

## Outputs from the Logic Card

(a) The trip, guard, low-signal, and alarm outputs are all PNP transistors capable of sinking current from either common or V– up to V+. When conducting, these transistors will pull their load to within one volt of V+. The usual load is either an optically coupled isolator or a relay coil.

(b) Trip output appears at terminal E. Transistor Q3 conducts only when a valid trip is received or when terminal V is driven high.

(c) Guard output appears at terminal F. Transistor Q4 conducts only when a valid guard is received. Trip and guard outputs will not be activated simultaneously.

(d) The low-signal output appears at terminal H. Q5 will conduct when the voltage received at terminal 16 drops below 0.09 volt.

(e) The alarm output appears at terminal L. Q6 conducts continuously except during an alarm condition. Thus, an alarm relay will be energized under normal conditions and will be de-energized during an alarm or a power-failure condition.

(f) At terminal U, a logic high appears when a valid trip has been detected, and this signal will appear irrespective of the condition of terminal W, STOP TRIP.

(g) A fast-block output, at terminal K, goes high when a detected abnormal condition signifies that blocking, and subsequently if blocking should persist, alarm should take place. The output at terminal K responds immediately to any abnormal condition, whereas the alarm output does not activate until the abnormality has persisted for at least 300 ms.

(h) As mentioned under "inputs", the internally generated block initiate signal is available at finger 11.

## Test Functions

The logic card applies several tests to the input signal for coincidence, timing, and level to determine whether the output function should be guard, trip, or alarm. Several adjustable jumpers provide for enabling or disabling some of the tests. This allows the user to add or delete tests and so effect a trade-off among security, dependability, and speed. All tests should be used for high-security, direct-trip requirements, but where speed and dependability are more important, such as for directional-comparison relaying applications, some of the tests may be disabled. Test functions include the following:

(a) If (1) the logic card is not in the alarm state, and if (2) the dc voltage at terminal 16 is stable and within operating limits, and (3) no blocking voltage is applied to terminals N, P, 12, or 13, then (4) if guard input, terminal 9 was high and then goes low, and (5) shortly thereafter trip input, terminal 7, goes high, a trip output will appear at terminal E after the pretrip-timing interval of 6 ms.

The pretrip timer, an important factor in security, requires that trip input be sustained for 6 ms before a trip output occurs. It is unlikely that noise corresponding to a trip signal will persist in that state for as long as 6 ms. Moreover, if the noise is of sufficiently great amplitude to activate the bipolar-noise detector, then the period of the pretrip timer will be increased to 18 ms.

(b) The receiver has three output states: guard, trip, and neither. When the received signal changes from guard to trip frequency the output of the receiver goes through this sequence:

(1) guard goes low,
(2) no output for about two ms,
(3) trip goes high.

If the channel is free of noise, then the trip output will remain high.

A small amount of noise could drive the trip output low but not swing the discriminator so far as to drive the guard output high again. The bipolar-noise detector ensures that if the trip output of the receiver has gone high after its guard output has dropped low, the trip delay time of the pre-trip timer will be extended from 6 to 18 ms should the receiver's trip output drop low and its guard output go high within 6 ms of the initial appearance of the high on the receiver's trip output.

If noise is so severe as to swing the output of the receiver from guard to trip, and then back to guard before expiration of the 6-ms pretrip timing period, then the bipolar noise detector is activated and its 30-ms timer reprograms the pretrip timer from 6 to 18 ms, providing that jumper F at the output of IC1C is in place. Thus, if the channel is relatively free of noise and the bipolar noise detector is not activated, the pretrip timing period is 6 ms. But, when noise is high, then every time the bipolar noise detector is activated its timer will change the pretrip timing period from 6 to 18 ms.

It is unlikely that noise of trip frequency would be sustained for 6 ms, and it is far more unlikely that it could last for 18 ms. This novel feature, therefore, causes the system's security and speed to adapt to the environment. Channel speed is fast for clear-channel conditions, but it changes to the slower, more secure state when subjected to high noise levels.

When activated, the bipolar noise detector always applies a signal to the alarm circuit, but the alarm timer requires the disturbance to persist for 300 ms before it activates the alarm circuit.

The change of pretrip timer period from 6 to 18 ms under conditions of heavy noise can be defeated by using jumper E in lieu of jumper F.

(c) A preguard timer, similar to the pretrip timer just discussed, provides that a received guard signal be sustained for 4 ms before there is a guard output from the logic card. This timer has only a single period of 4 ms.

(d) The logic card has a combined guard-before-trip and trip-after-guard (GT/TG) timer which is enabled when jumper A, at the output of IC6A, is in place. Activation of this timer will block the trip channel in its path prior to the pretrip timer, and it will block the trip channel until an error-free guard signal has been received continuously for at least 100 ms. And the trip channel will be blocked again if a trip signal is not received within 100 ms after guard disappears. But the timer is reset if trip appears within the prescribed 100-ms period.

The purpose of the GT/TG timer is to ensure that a dependable guard signal has been received before the trip channel is armed to accept a trip input.

There are several causes for disappearance of the guard signal, such as overriding noise on the line, a disconnected line, equipment failure, and others; but the only valid reason for the guard signal to disappear is when the transmitted signal shifts from guard to trip, in which case trip should be sensed shortly thereafter. The 100-ms period is allowed because noise could be overriding the trip signal for a short period after the transmitter shifts to trip frequency. But if trip is not detected within that period then it is assumed that the condition was invalid, and the trip channel will be disarmed. Only after a guard signal has been sustained for at least 100 ms will the trip channel be rearmed. This function is deleted when jumper B is used in lieu of jumper A.

(e) Another test, mentioned previously, monitors the dc signal-level voltage at terminal 16 to look for noise modulation with a carrier-envelope detector. A slowly changing signal level will not be classed as noise; but if the level drops rapidly (by 11% or more) indicating noise, then a blocking signal will be generated. If jumper D, at the output of IC7A, is installed, and terminal T is low (inactive), then the noise will block the input to the pretrip timer. The alarm timer also will be activated, and if the noise continues for 300 ms an alarm will be signaled.

(f) The trip channel will be blocked, ahead of the pretrip timer, if terminal T is low and a logic high is applied to one or more of terminals N, P, 12, and 13. The alarm timer will be activated, but the disturbance must last for 300 ms to operate the alarm. These inputs are provided for special situations, such as use of a supplementary receiver for extremely high security.

(g) If the signal at terminal 16 is above 7 Vdc or below 0.09 Vdc, it will be sensed by the threshold detectors as being out of limits. These detectors will block the input to the pretrip timer, provided terminal T is low, and activate the alarm circuit to start its 300-ms timer. The input to the preguard timer can only be blocked by the detection of a low signal level.

(h) If one of the foregoing abnormal conditions persists for at least 300 ms, and if terminal T is low, then the alarm timer will activate the alarm circuit which applies a blocking signal to the guard-output circuit. The alarm circuit will be reset to normal only when the signal level is within operating limits, free of noise, and in the guard mode for at least 300 ms.

(j) The logic card contains an undervoltage detector to prevent a false trip by shutting down the output circuits when either power-supply voltage falls below 9.5 volts, which is still a safe level for the transmitter, receiver, and logic circuits.

**Summary**

Both guard and trip channels are protected with slow-to-operate, fast-to-release timers. Thus, short noise bursts cannot cause false trip or guard outputs. Protection is provided, also, against bipolar noise, which is defined as a signal, probably noise, which moves from guard through center to trip frequencies and then back through center to guard, but not lasting long enough to create an output from the pretrip timer. Upon receipt of such a signal, the bipolar noise detector will be activated and it will reprogram the period of the pretrip timer from 6 to 18 ms.

The GT/TG timer ensures that noise-free guard signal has been received for at least 100 ms before the trip channel is open, and then the trip channel will be closed if, trip is not received within 100 ms after the guard signal ceases.

The carrier-envelope noise detector blocks the trip channel if the incoming signal is amplitude modulated by more than 11 percent.

The trip channel will be blocked if the incoming signal level goes above or below a preset limit. The guard channel will be blocked if the incoming signal level drops below the preset limit.

The alarm timer will be started if any of the foregoing anomalies occurs, and if one persists for 300 ms or more, the alarm circuits will operate.

The GT/TG timer is provided to enhance security, but the added security is unnecessary after the trip

command has been passed through. This timer, therefore, is defeated when a trip is detected, and it is operative again only after a guard signal has been received for at least 100 ms. Automatic defeat of this timer is important as, for example, the case where a trip signal is sent continuously to hold open a breaker which takes a line out of service. In this situation, if the GT/TG timer were not defeated then, after a short loss of signal, the logic circuit sees a trip input not preceded by guard and the trip input would be blocked by the guard-before-trip timer. The GT/TG timer, therefore, is disabled when a valid trip is detected, and signal failure will not again enable the timer. This timer will be enabled only by the presence of an uninterrupted, noise-free guard signal for at least 100 ms.

# CIRCUIT DETAILS

## Timers

The logic circuits make extensive use of logic gates and timers. While gates are generally understood because of their broad usage, the following discussion on timers is introduced because timers are not so frequently encountered.

All timers use some sort of driving source, such as a logic gate, a resistor and capacitor for timing, usually with different charge and discharge paths, and a voltage comparator which functions also as an output device. Timers may have more than one time constant, with the choice among them made, for example, according to the presence or absence of some significant event. They may be fast-responding, slow-releasing, or slow-responding and fast-releasing.

A basic timer is shown in Figure 6.2, with a timing diagram at the lower part.

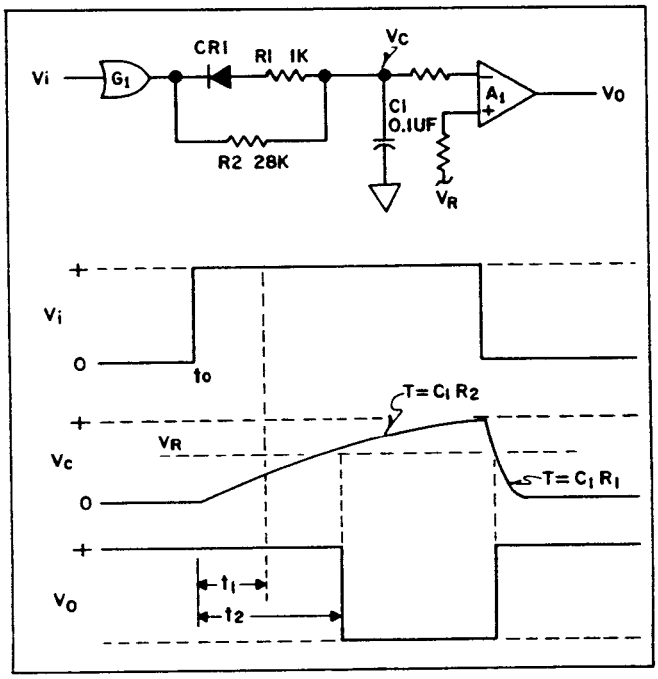



Figure 6.2. Basic timer circuit, Model 67 PLC LOGIC

In the quiescent condition, the input to the gate, $V_i$ is at a logic low and C1 is discharged. When the input to G1 is raised to a logic high, C1 begins to charge through R2 so that it follows the curve for $V_c$ shown on the timing diagram. When $V_i$ reaches the reference voltage, $V_R$, of the comparator, A1, the output of A1 changes state as shown for voltage $V_o$ on the timing diagram. Note that the change of state of the output is delayed from $t_o$, the moment of input change, by the period $t_2$, which represents the time necessary for $V_c$ to rise from zero to $V_R$, at which voltage the comparator changes state.

Upon return of $V_i$ to the quiescent state, the polarity of the output of G1 makes CR1 conduct; therefore, the time constant following a change to a logic low is equal to the product of C1 times R1, a relatively short period.

It may be noted that if the input had returned to a logic low at time $t_1$, or at any other time before $V_c$ rose to the level of $V_R$, the output of A1 would not have changed state. This principle is used in certain protective circuits where when the abnormal condition (represented by $V_i$) disappears before a certain prescribed period then protective measures need not be taken.

This timer is slow to respond and fast to release. If the polarity of the diode were reversed from that shown, the same timer would become fast responding and slow releasing. In the form shown, this timer exemplifies the preguard timer used on the logic card. With the diode reversed, it represents the pulse stretcher.

Figure 6.3 illustrates a timer in which either of two time constants is selected according to the control voltage applied to the input of G2.

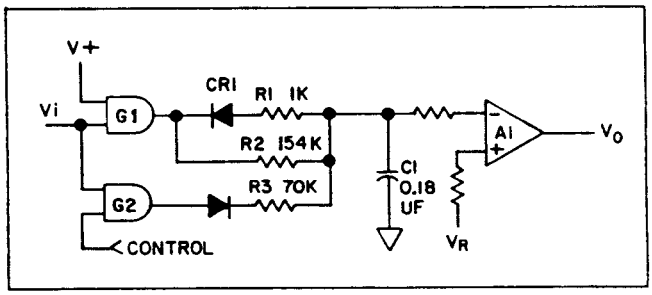



Figure 6.3.
Basic timer with two selectable delays, Model 67 PLC LOGIC

Under normal conditions the control signal is always a logic high. Thus, when the input signal, $V_i$, is high G2 is conducting and R2 and R3 are connected in parallel. With these resistors in parallel, the delay of the timer is about 6 ms. If, however, the control signal is low when $V_i$ is high, then the time constant is set by R2 alone in series with C1. In this case, the delay is about 18 ms.

This timer exemplifies the pretrip timer. Under clear-channel conditions it is required to verify the trip signal for only 6 ms. But when the channel is noisy the control signal goes low and requires that the trip signal persist uninterruptedly for 18 ms before it is considered valid.

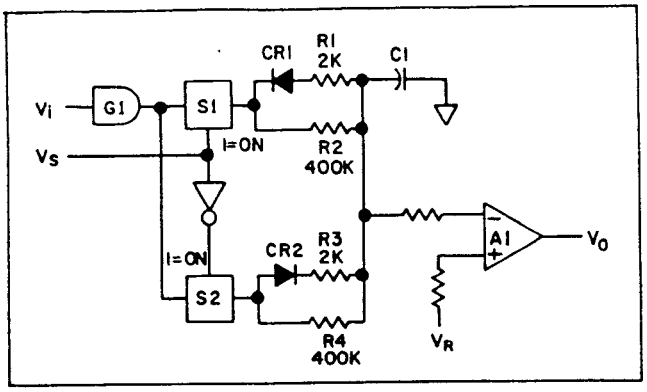



Figure 6.4.
A timer with selectable timing circuits, Model 67 PLC LOGIC

Figure 6.4 shows a timer capable of operating with either fast attack and slow release or with slow attack and fast release.

S1 and S2 are semiconductor switches which become conducting (closed) when a logic high is at their control terminal, and non-conducting (open) when a logic zero is there. The control terminals are connected through an inverter so that when the control signal, $V_s$, is high S1 is conducting and S2 is cutoff. When $V_s$ is low, the condition of the switches is reversed.

With $V_s$ high, a logic high at $V_i$ will pass through S1 and cause C1 to charge slowly through R2. And when $V_i$ goes low C1 will discharge rapidly through R1 and CR1.

With $V_s$ low, a logic high at $V_i$ will pass through S2, and C1 will charge rapidly through R3 and CR2. When $V_i$ goes low, C1 will discharge relatively slowly through R4. The comparator, A1, operates as described for the previous cases. Although the time constants shown are identical, there is nothing to prevent their being different, if needed. This timer exemplifies the alarm timer and the guard-before-trip and trip-after-guard timer used on the logic card.

## Guard-Signal Path

In Figure 6.5, a guard signal, which is a logic high from the receiver, appears at terminal 9 and causes Q2 to conduct. The output of IC1F will go high, and the output of IC13B will go high. If the logic high at IC13B-4 persists for 4 ms, then the voltage on C5, which is charging through R36, will rise so that the inverting input of comparator IC4A is more positive than the non-inverting input.

IC4B-7 will then go low and, if the trip output is not activated, then both inputs of IC14D will be low. In the absence of a hard block (alarm output) condition, both inputs to IC12C will be low. The output of IC9D will then go low and cause the guard-output transistor, Q4, to conduct. Simultaneously, guard lamp DS2 will glow.

IC16A and IC16B form a flip-flop, the purpose of which is to defeat the guard-before-trip and trip-after-guard timer (GT/TG), IC6A, when a trip is detected. This flip-flop is reset, when the output of IC14D goes low (guard), by causing C4 to discharge through R41 which, after 150 ms, resets the flip-flop. Then, through gate IC12B and semiconductor switches IC17A and IC17D, the timer IC6A is controlled.

## Trip-Signal Path

A trip command from the receiver appears as a logic high at terminal 7 on the logic card, and this signal causes Q1 to conduct and the output of IC1A to go high. If there is no inhibiting signal from the GT/TG timer, then both inputs of IC2C will be high and IC2C-10 will also be high. Next, if there is no blocking signal from IC16C, then both inputs of IC2A will be high and IC2A-3 will be high.

If there is no inhibiting signal from the GT/TG timer, then both inputs of IC2C will be high and IC2C-10 will also be high. Next, if there is no blocking signal from IC12D, then both inputs of IC2A will be high and IC2A-3 will be high.

Pretrip-timer capacitor C1 will be charged either through R5 alone, in which case the pretrip time constant is 18 ms, or by R5 in parallel with R6 through IC2B, so that the pretrip time constant is 6 ms. For R6 to be in parallel with R5, IC2B-4 must be high coincidentally with IC2A-3, and this can occur only if IC2B-6 is high; this is under control of the bipolar noise detector.

IC3A is the comparator for the pretrip timer. After the prescribed period, its output will go low and cause IC1C-4 to be high (trip).

If either input to IC11A goes high, and if STOP TRIP input terminal W is low, then the output at IC11C-10 will be high. If the trip-hold function is not used, then R16 and C2 are insignificantly small, and the output of the trip-hold timer's comparator IC3B-7, will immediately follow the signal from IC11C-10 by going low. Then IC9B-4 will go high, and IC9F-15 will go low to drive the base of open-collector transistor Q3 into conduction. This is the trip output. The trip lamp, DS1, will also glow.

The components associated with the inputs to IC3 form a trip-hold timer. If the transmission path is noisy when a trip command is being carried, then the trip output at IC11C-10 may go high for only a very short period before a noise burst again blocks the trip channel, and this short interval may be insufficient to actuate a circuit breaker. But the trip signal at IC11C-10 has already been fully validated, so it is presumably acceptable. The trip-hold timer ensures that acceptance with a trip-hold time constant of, say, 50 ms. R17 limits the charging rate of C2 so that an extremely short period of trip signal, which could be a noise-initiated false trip, will not initiate the trip-hold timer. But, if IC11C-10 goes high for, say, 5 ms then C2 will be charged through CR4, R15, and R17 and then if, after 5 ms, the output of IC11C-10 again goes low, C2 will require 50 ms to discharge through R16 and R17. So the trip output is held, at IC3B-7 for 50 ms.

## Guard-Before-Trip and Trip-After-Guard Timer

When a guard signal is received for at least 150 ms, IC16B-6 goes low and resets the flip-flop. The output at IC16A-3 then goes low and unblocks gate IC12B. Because a guard signal is being received, IC16D-11 goes high, and this will cause IC12B-4 to go low. Semiconductor switch IC17D is conducting and IC17A is cut off. After 100 ms, R61 will have discharged C6 to 6 volts, at which point the output of comparator IC6A will go high. If jumper A is installed, this will open the trip path at IC2C-9.

When the guard signal fails, the output of IC12B will go high, and since IC17A is now conducting, with IC17D open, C6 will begin to charge through R44. If a trip signal is received within 100 ms, then IC12B-4 will again go low; but if 100 ms passes without trip being detected then IC6A-1 will go low and block the trip path at IC2C-9, and again switch IC17D on and IC17A off.

Detection of trip will put a low at IC16A-1 and set the flip-flop of IC16A and IC16B. This will put a logic high at IC12B-5, and this will cause the output of IC6A to continue high; that is, not blocking the trip channel. The flip-flop can be reset only after a guard signal is received continuously for 150 ms, and this will re-enable the GT/TG timer.

If neither trip nor guard signal is present, then the output of IC16D will be low. This will cause the outputs of IC13D, IC13C, and IC14B to go low. If this situation persists for 300 ms, then the alarm timer will cause an alarm output, which is merited for the abnormal condition of having neither trip nor guard present.

## Noise-Control Signals

A number of different circuits respond to noise in the channel. These are described in the following.

### Signal-Level Detector

The signal-level detector is a window detector using two comparators to detect signal levels above or below prescribed limits.

Comparator IC5A is biased, at pin 2, so that its output will go high if the signal-envelope level, at terminal 16, exceeds 7 volts. A logic high will cause high-signal lamp DS3 to glow, and it will enter the blocking path through IC15D-12.

Comparator IC5B is biased, at pin 6, so that its output will go high if the signal-envelope level, at terminal 16, falls below 0.09 volt. A logic low will cause low-signal lamp DS4 to glow, and it will enter the blocking path through IC15D-13.

For either high or low signal, the output of IC15D will go high. In addition, if the signal is too low the output of IC5B will pass through IC10E and cause Q5 to conduct, which is a low-signal command at terminal H. This will also block the input to the pre-guard timer.

### Envelope-Noise Detector

The carrier-envelope signal, which is developed in the receiving system, enters the logic card at terminal 16 (Figure 6.5). This voltage is smoothed by an active, 50-Hz, lowpass filter using IC7B, and 89% of IC7B's output is fed to the non-inverting input of IC7A. This opamp is connected as a comparator, with its inverting input connected directly to the signal received at terminal 16. As long as this signal stays above 89% of its average value, so that the inverting input of IC7A is higher than the non-inverting input, then IC7A-1 will be low. But, if noise downward modulates the signal at terminal 16 by 11% or more, then because the lowpass filter acts as a delay line, the rapid change will appear only at IC7A-2. This causes IC7A-1 to go high and indicate that envelope noise is present.

The output of IC14A will go HI. If terminal T is LO, this will interrupt the trip-signal path if:

(a) there is a fast block signal received through terminals N, P, 12, 13 and IC15C, or

(b) input signal is too high or too low as detected by IC5A and IC5B and passed through IC15D, or

(c) envelope noise is detected and passed through jumper D and IC15C.

### Pulse-Stretcher

Noise disturbances manifest themselves as a series of short-duration pulses, and although they indicate an abnormal condition they may not have sufficient energy to charge C1, the timing capacitor of the alarm timer, which is driven by the pulse-stretcher. Short noise pulses, therefore, are elongated in the pulse-stretcher, which uses IC12A, IC6B, and C9.

With terminal T low, and under normal no noise conditions, IC12A-3 is low and C9 is fully charged. Any noise pulse will move IC12A-3 high and very rapidly discharge C9 through R68 and CR16. When the noise disappears, IC12A-3 goes low and C9 slowly charges through R69. On the other hand, IC12A-3 will go high and rapidly discharge C9 if (a) there is a fast-block input at any of terminals N, P, 12, or 13, received at IC12A-2 through IC15C and IC12D, or (b) signal-envelope noise is detected through jumper D, IC15C, and IC15D.

When C9 is rapidly discharged, the output of comparator IC6B will go low to produce the stretched pulse. Pulse duration will be equal to the period of the disturbance plus the 30-ms period of the stretcher. This is set by C9 and R69. For example, a 2-ms noise disturbance will cause a 32-ms pulse at IC6B-7. The stretched pulse will cause the outputs of IC13D, IC13C, and IC14A to go low.

It should be noted that the disturbances which drive the pulse stretcher are blocked from activating the alarm timer after a valid trip has been detected. This is because IC12A-1 and IC14A-1 are driven high when there is a trip output. These gates are similarly disabled, through IC14C, when a logic high is placed at STOP ALARM INPUT terminal M.

### Alarm Timer

The alarm timer (which appears near the lower left of Figure 6.5) consists of semiconductor switches IC17B and IC17C and comparator IC8B.

In the normal no-alarm state, IC8B-7 is low, IC17B is conducting because of the signal inversion through IC10F, IC17C is open, IC14B pin 3 is high, and capacitor C10 is charged to V+ through IC17B. In this state, DS5 is extinguished and Q6 will be conducting to hold the alarm relay energized.

When an abnormal condition drives IC14B pin 3 low, then C10 will be discharged slowly through R79 and IC17B. If the condition persists for 300 ms, C10 will be discharged to the voltage where IC8B-6 falls below ICIC8B-5. Then IC8B-7 will go high and cause IC17B to conduct and IC17C to cut off, C10 will then rapidly discharge through R76, CR21, and IC17C. Lamp DS5 will glow to signal an alarm, and Q6 will open to de-energize the alarm relay.

To clear the alarm, IC14B pin 3 must go high and then stay high for at least 300 ms while C10 charges slowly through R77 and IC17C. After 300 ms, IC8B-7 will again go low, IC17B will conduct, IC17C will be open, and C10 will charge rapidly to V+ through CR22 and IC17B.

### Bipolar-Noise Detector

Bipolar noise is defined as a noise that causes a bipolar system to change from an existing state to the alternate state and then back, again, to the previous state. If a system, for example, were in guard then a noise signal momentarily inducing a trip would cause the system to shift from guard to trip and then back to predominant state, which is guard. The bipolar noise detector recognizes this condition and reprograms the trip timer for a longer period when this abnormality occurs. But it does not act when the predominant signal is a trip signal because after cessation of the noise a trip will be detected, and in this case the timer of the bipolar noise detector will not be triggered, for no return to the guard signal has occurred.

If there is either a trip or a guard output from the logic card, which is the normal state, then one of the inputs to IC16D will be low and will hold its output high. This will reset the flip-flop, IC11A and IC11B. The output of IC11B will be high, so that C3 will be charged to V+ through R23. The output of comparator IC4A will be low and IC1C-6 will be high. With Jumper F installed, IC2B-6 will be high and the pretrip timer will have a period of 6 ms.

When the received signal goes from guard to trip, the guard output disappears and, because there is momentarily no output, IC16D-11 will go low.

A trip command from the receiver will cause IC1A-2 to go high and set flip-flop IC11A and IC11B, which will drive IC13A-1 high. But IC13A-3 will remain low because the absence of guard holds Input Pin 2 low.

If there is no disturbance and the trip signal lasts long enough to be recognized, then IC16D-12 will go low, IC16D-11 will go high, and the flip-flop will be reset.

If, however, the input command was not trip, but was actually noise, then the receiver's output will return to guard before expiration of the pretrip timing interval. In this case, both inputs to IC13A will be high, and the output of IC1E will go low and rapidly discharge C3 through R24 and CR6. The low output of IC1C will block gate IC2B, and this will program the pretrip timer to 18 ms. This program will persist for 30 ms, which is the time constant of R23 and C3.

The output of the bipolar noise detector, at IC1C-6, is also fed to the alarm timer, through IC13C and IC14B, so that if a bipolar noise condition persists for 300 ms an alarm output will occur.

## Undervoltage Detector

Q7, Q8, Q9, and Q10 are the active elements of an undervoltage detector provided to protect the system against false trips caused by inadequate power-supply potential.

If V+ is greater than 10 volts then zener diode CR25 conducts and thereby causes Q7 to conduct. If V- is greater than -10 volts, then zener diode CR26 conducts and thereby causes Q8 to conduct. Both Q7 and Q8 must conduct to permit Q9 to conduct, and Q10 will conduct only when Q9 is conducting.

If either supply falls below 10 volts, Q9 will be cut off and this will cut off Q10, which is the current source for trip, guard, low-signal, and alarm outputs. Thus the first three outputs will be disabled and the alarm will signal an abnormal condition.

## Functions of Jumpers

The functions of all jumpers on the logic card are summarized in Table 6.1.

**TABLE 6.1**
**JUMPER FUNCTIONS - MODEL 67 PLC LOGIC**

| | |
|---|---|
| A | Renders guard-before trip and trip-after-guard timer functional. |
| B | Disables guard-before-trip and trip-after-guard timer. |
| C | Disables envelope-noise detector. |
| D | Causes pulse stretcher to respond to envelope noise as well as other signals. |
| E | Disables bipolar noise detector. |
| F | Permits bipolar noise detector to extend the period of the pretrip timer when bipolar noise appears. |
| G | Sets IC16A and B flip-flop by internal trip only. |
| H | Sets IC16A and B flip-flop by internal trip or by trip introduced at terminal V. |

# Table 6.2
# Replaceable Parts

| Circuit Symbol (See Figure 6.5) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC LOGIC - Assembly No. HB-95535** | |
| | **CAPACITORS** | |
| C1 | Capacitor, metallized polycarbonate, 0.18μF, 2%, 100V, Wesco 32MPC or equiv. | 1007 974 |
| C2 (TRIP HOLD) | Capacitor, mylar, 0.39μF, 2%, 100V, Wesco 32M or equiv. | 1007 444 |
| (NO TRIP HOLD) | Capacitor, polyester, 0.01μF, 2%, 100V, Wesco 32P or equiv. | 5115 35 |
| C3, 9 | Capacitor, tantalum, 0.33 μF, 20%, 35V, Kemet T322A334M035AS or equiv. | 1007 871 |
| C4, 6 | Capacitor, tantalum, 0.47 μF, 10%, 35V, Kemet T322A474K035AS or equiv. | 1007 511 |
| C5 | Capacitor, metallized polycarbonate, 0.1μF, 2%, 100V, Wesco 32MPC or equiv. | 1007 1331 |
| C7 | Capacitor, metallized polycarbonate, 0.059μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1177 |
| C8 | Capacitor, metallized polycarbonate, 0.0315μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1188 |
| C10-12 | Capacitor, tantalum, 1μF, 10%, 35V, Kemet T110A105K035AS or equiv. | 1007 1156 |
| C13-20 | Capacitor, ceramic, 0.1μF, GMV, 50V, Kemet C320C104PU5EA or equiv. | 1007 1366 |
| | **RESISTORS** | |
| R1, 2, 8, 11-14, 18, 19, 26, 32, 34, 35, 39, 47, 48, 51, 54, 55, 60, 67, 71, 74, 75, 81, 88, 97, 100-103 | Resistor, metal film, 10K, 1%, ¼W, Type RN¼ | 0410 1384 |
| R3, 21, 30, 33, 45, 86 | Resistor, metal film, 3.32K, 1%, ¼W, Type RN¼ | 0410 1338 |
| R4, 7, 15, 24, 25, 37, 38, 42, 53, 59, 66, 68, 70, 80, 84, 85, 87, 91 | Resistor, metal film, 1K, 1%, ¼W, Type RN¼ | 0410 1288 |
| R5 | Resistor, metal film, 154K, 1%, ¼W, Type RN¼ | 0410 1498 |
| R6 | Resistor, metal film, 69.8K, 1%, ⅛W, Type RN60C | 1510 1788 |
| R9, 20, 27, 40, 58, 72, 82 | Resistor, composition, 510K, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 809 |
| R10, 73, 93, 104 | Resistor, metal film, 475 ohm, 1%, ¼W, Type RN¼ | 0410 1257 |
| R16 (TRIP HOLD) | Resistor, metal film, 348K, 1%, ¼W, Type RN¼ | 0410 1532 |
| (NO TRIP HOLD) | Resistor, metal film, 1K, 1%, ¼W, Type RN¼ | 0410 1288 |
| R17 (TRIP HOLD) | Resistor, metal film, 10K, 1%, ¼W, Type RN¼ | 0410 1384 |
| (NO TRIP HOLD) | Resistor, metal film, 100 ohm, 1%, ¼W, Type RN¼ | 0410 1192 |
| R22, 31, 46, 96 | Resistor, metal film, 1.5K, 1%, ¼W, Type RN¼ | 0410 1305 |
| R23, 69 | Resistor, metal film, 130K, 1%, ¼W, Type RN¼ | 0410 1491 |
| R28, 29, 43, 56, 57, 62, 76, 78, 83, 95 | Resistor, metal film, 2.21K, 1%, ¼W, Type RN¼ | 0410 1321 |
| R36 | Resistor, metal film, 57.6K, 1%, ¼W, Type RN¼ | 0410 1457 |
| R41 | Resistor, metal film, 294K, 1%, ¼W, Type RN¼ | 0410 1525 |
| R44, 61 | Resistor, metal film, 316K, 1%, ¼W, Type RN¼ | 0410 1528 |
| R49 | Resistor, metal film, 3.40K, 1%, ¼W, Type RN¼ | 0410 1339 |
| R50, 89, 90 | Resistor, metal film, 4.99K, 1%, ¼W, Type RN¼ | 0410 1355 |
| R52 | Resistor, metal film, 127K, 1%, ¼W, Type RN¼ | 0410 1490 |
| R63, 64 | Resistor, metal film, 75K, 1%, ¼W, Type RN¼ | 0410 1468 |
| R65 | Resistor, metal film, 8.06K, 1%, ¼W, Type RN¼ | 0410 1375 |
| R77, 79 | Resistor, metal film, 442K, 1%, ⅛W, Type RN60C | 1510 1607 |
| R92 | Resistor, metal film, 33.2K, 1%, ¼W, Type RN¼ | 0410 1434 |
| R94 | Resistor, metal film, 4.75K, 1%, ¼W, Type RN¼ | 0410 1353 |
| R98, 99 | Resistor, metal film, 22.1K, 1%, ¼W, Type RN¼ | 0410 1417 |

# Table 6.2
# Replaceable Parts - continued

| Circuit Symbol (See Figure 6.5) | Description | Part Number |
|---|---|---|
| | **SEMICONDUCTORS** | |
| CR1-24, 27-31 | Diode, silicon, 1N914B or 1N4448 | 26482 |
| CR25, 26 | Diode, Zener, 9.1V, 5%, 400mW, 1N960B | 41014 |
| DS1-5 | Light-emitting diode, red, Dialight 550-0102 or equiv. | 39568 |
| IC1, 9, 10 | MOS hex inverter/buffer, RCA CD4049AE or equiv. | 0615 7 |
| IC2, 13 | MOS quad 2-input AND gate, RCA CD4081BE or equiv. | 0615 31 |
| IC3-6, 8 | Operational amplifier, dual, high-gain, Raytheon 4558NB or equiv. | 0620 129 |
| IC7 | Operational amplifier, dual, JFET-input, Texas Instruments TL082CP or equiv. | 0620 155 |
| IC11, 12 | MOS quad 2-input NOR gate, RCA CD4001BE or equiv. | 0615 3 |
| IC14, 15 | MOS quad 2-input OR gate, RCA CD4071BE or equiv. | 0615 24 |
| IC16 | MOS quad 2-input NAND gate, RCA CD4011BE or equiv. | 0615 5 |
| IC17 | MOS quad bilateral switch, Motorola MC14066BCP or equiv. | 0615 246 |
| Q1, 2, 8, 9 | Transistor, NPN, 2N222A, plastic package | 37445 |
| Q3-6, 10 | Transistor, PNP, Motorola MPS-U95 or equiv. | 47509 |
| Q7 | Transistor, PNP, 2N4249, TO-106 case | 41919 |
| | **MISCELLANEOUS** | |
| --- | Shorting bar, single, Aries LP300 or equiv. | 42904 |

TRIP INPUT FROM 67 PLC LM/LS

GUARD INPUT FROM 67 PLC LM/SL

SIGNAL ENVELOPE INPUT FROM 67 PLC LM/SL

WZKS

NOISE TO HIGH

ACC OUT OF LIMITS

FAST BLOCK INPUT

PRE-TRIP TIMER

BIPOLAR NOISE DETECTOR

PREGUARD TIMER

THRESHOLD DETECTORS

CARRIER ENVELOPE NOISE DETECTOR

ALARM TIMER

GUARD BEFORE TRIP/TRIP AFTER GUARD TIMER

30-MS PULSE STRETCHER

TRIP-HOLD TIMER

UNDERVOLTAGE DETECTOR

EXTERNAL TRIP INPUT

EXTERNAL BLOCK INPUT

BLOCK OUTPUT

TRIP OUTPUT TO 67 PLC OUT

GUARD OUTPUT TO 67 PLC OUT

LOW SIGNAL OUTPUT

KEY

STOP ALARM INPUT

LOGIC ALARM TO 67 PLC OUT

FAST BLOCK OUTPUT

NOTES:
1. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE IN OHMS 1/4 W 5%.
2. WITH NO TRIP HOLD R16 - 1K R17 - 100 OHMS, C2 - 0.01 UF FOR TRIP HOLD R16 - 348K 1% R17 - 10K 1%, C2 - .39 UF 2%.

SCHEMATIC LOGIC SYSTEM PLC PROT. REL.

RFL Industries, Inc.

DWG. NO. HD-95539-K

45°

# Section 7
# OUTPUT

## MODEL 67 PLC OUT

### DESCRIPTION

The Model 67 PLC OUT circuit card consolidates the various signal and alarm outputs of the Series 6780 System on one card. It carries output relays for trip, guard, low-signal alarm, and logic alarm. Two solid-state, electrically isolated trip outputs are also supplied.

### CIRCUIT DETAILS

A schematic of the circuits on the card is shown in Figure 7.2.

Relays K1, K2, K3, and K4 all are spring relays, and the function of each is shown on the schematic. Relay K1, K3, and K4 all have 24-volt coils and they are operated across the series-connected 12-volt power supplies. Relay K2, the trip relay, is also powered with 24 volts, but it has a 12-volt coil so that a speed-up network, C5 and R13, may be used. When 24-volt power is first applied to K2, the full voltage of the power supply appears across its coil, through C5, to move the armature rapidly. Then as C5 charges the current through the coil is limited by R13.

The two independent, isolated, solid-state trip-output circuits appear in the upper portion of Figure 7.2.

Transformer T1 is powered by an isolated secondary winding, on the transformer in the main power supply, which has been provided for this purpose. This electrically isolates the trip-output circuits from each other and from the remainder of the system. CR1, CR2, CR3, and CR4 form a bridge rectifier to create a dc power source for the trip-output circuit at the top of Figure 7.2. Its voltage is held at 27 Vdc by CR5. From the logic circuit, a valid trip signal will appear at terminal 5 and will illuminate the light-emitting diode in opto-isolator IC1. This will cause current to pass through the opto-isolator and drive the base of Q1, an open-collector output transistor, so that it becomes conducting and acts as a switch for an external load circuit. Q1 is protected by CR7 and CR8.

Operation of the second, isolated, trip-output circuit is identical to the foregoing except for appropriate changes in circuit-symbol designations.

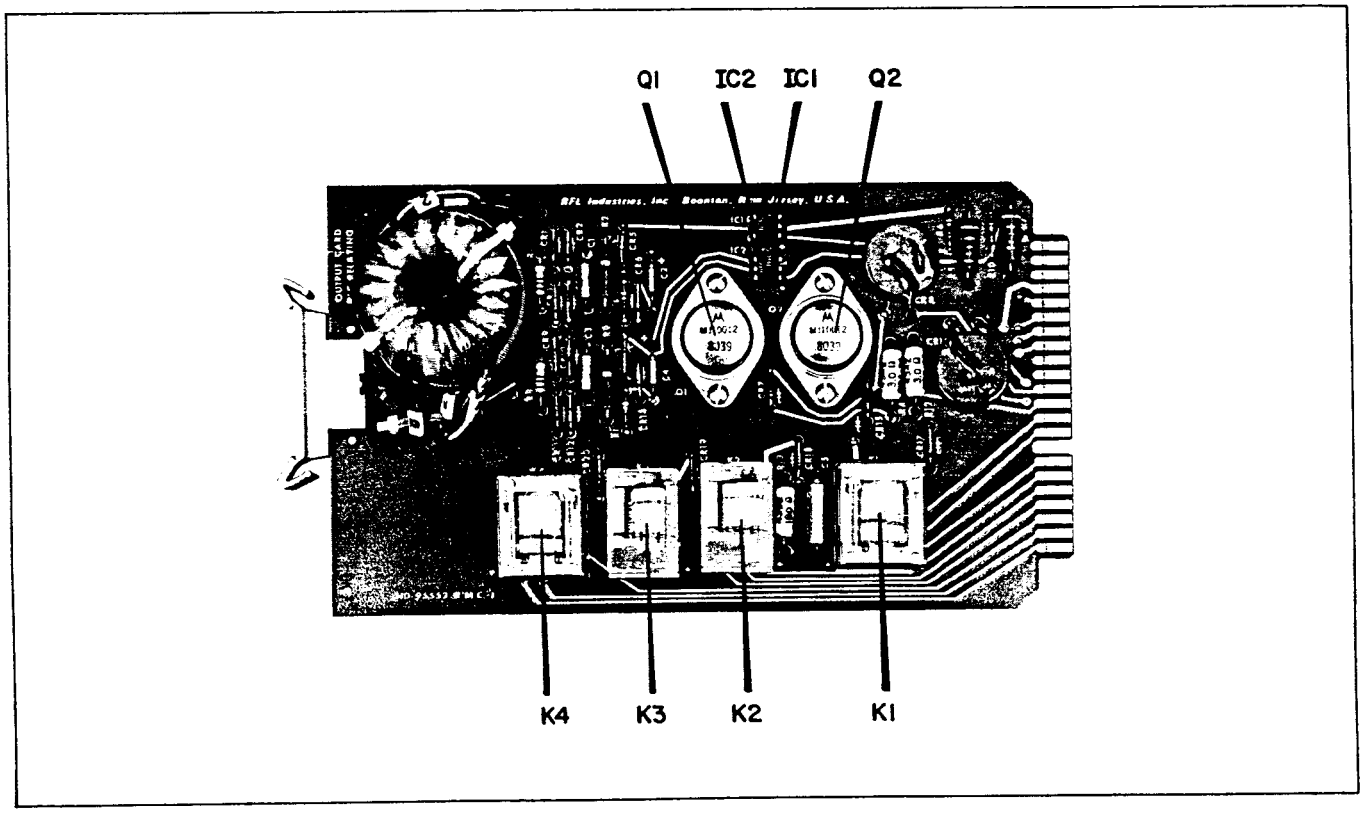
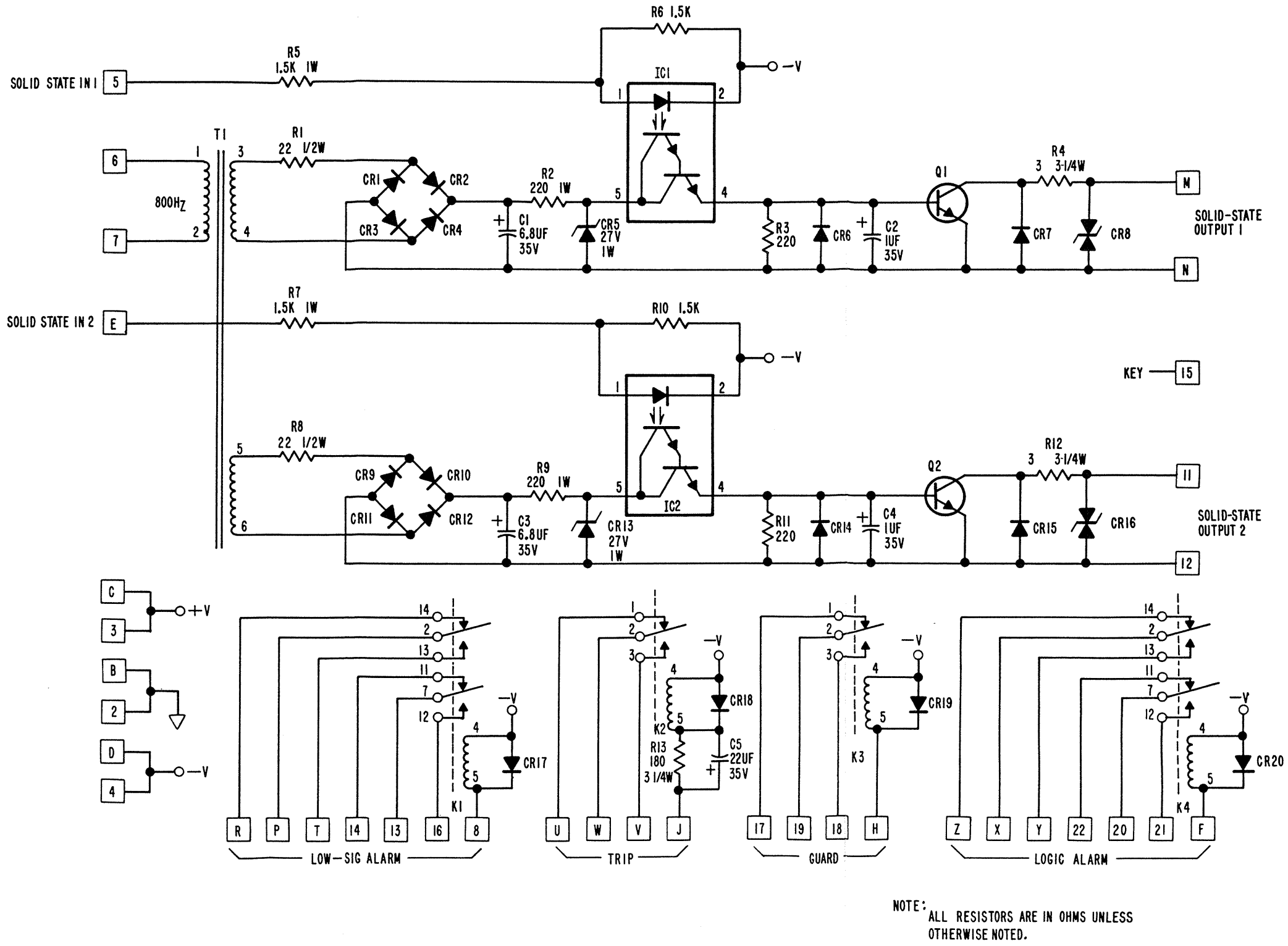



Figure 7.1. Location of components, Model 67 PLC OUT




NOTE: ALL RESISTORS ARE IN OHMS UNLESS OTHERWISE NOTED.

Figure 7.2. Schematic- Model 67 PLC OUT

# Table 7.1
# Replaceable Parts

| Circuit Symbol (See Figure 7.2) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC OUT - Assembly No. HB-95550** | |
| | **CAPACITORS** | |
| C1, 3 | Capacitor, tantalum, 6.8μF, 20%, 35V, Kemet T322D685M035AS or equiv. | 1007 655 |
| C2, 4 | Capacitor, tantalum, 1μF, 10%, 35V, Kemet T110A105K135AS or equiv. | 1007 1156 |
| C5 | Capacitor, tantalum, 22μF, 20%, 35V, Corning CCZ-035-226-20 or equiv. | 1007 657 |
| | **RESISTORS** | |
| R1, 8 | Resistor, composition, 22 ohm, 5%, ½W, Allen-Bradley EB Series or equiv. | 1009 239 |
| R2, 9 | Resistor, composition, 220 ohm, 5%, 1W, Allen-Bradley GB Series or equiv. | 1009 316 |
| R3, 11 | Resistor, metal film, 221 ohm, 1%, ¼W, Type RN¼ | 0410 1225 |
| R4, 12 | Resistor, wirewound, 3 ohm, 5%, 3.25W, Ohmite 4232, Style 995-3A or equiv. | 1100 667 |
| R5, 7 | Resistor, composition, 1.5K, 5%, 1W, Allen-Bradley GB Series or equiv. | 1009 7 |
| R6, 10 | Resistor metal film, 1.5K, 1%, ¼W, Type RN¼ | 0410 1305 |
| R13 | Resistor, wirewound, 180 ohm, 5%, 3.25W, Ohmite 4398, Style 995-3A or equiv. | 1100 464 |
| | **SEMICONDUCTORS** | |
| CR1-4, 6, 9-12, 14, 17-20 | Diode, silicon, 1N4003 | 30769 |
| CR5, 13 | Diode, Zener, 27V, 5%, 1W, 1N4750A | 29758 |
| CR7, 15 | Diode, avalanche, 600V, 1A, 1N4005 | 26935 |
| CR8, 16 | Varistor, 130Vac, General Electric V130LA20B or equiv. | 41079 |
| IC1, 2 | Photodarlington optoisolator, General Instrument MCA230 or equiv. | 41084 |
| Q1, 2 | Transistor, NPN Darlington, Motorola MJ10012 or equiv. | 91124 |
| | **MISCELLANEOUS COMPONENTS** | |
| K1, 4 | Relay, DPDT, 24-volt coil, Aromat NC2D-JP-24VDC or equiv. | 94810 |
| K2 | Relay SPDT, 12-volt coil, Schrack RU110-012 or equiv. | 48166 |
| K3 | Relay SPDT, 24-volt coil, Schrack RU110-024 or equiv. | 48167 |
| T1 | Transformer, power | 48707 |

# Section 8
# VOICE

## MODEL 67 PLC VOICE

### DESCRIPTION

The Model 67 PLC VOICE circuit card (Figure 8.1) is an optional element of the Series 6780 System. By using the protective relaying signal as a carrier for amplitude modulation, the Model 67 PLC VOICE provides a service channel for transmitting and receiving voice communications.

The Model 67 PLC VOICE has a detector for received circuits with AGC control, a call-tone generator and detector, an input amplifier with a carbon microphone current source, and output and control circuits, (See block diagram in Figure 8.2).

**NOTE**

Use of the Model 67 PLC VOICE in a system which shifts the carrier frequency more than 100 Hz from the channel frequency is only permissable in low security applications, such as unblock relaying.

### CIRCUIT DETAILS

The Model 67 PLC VOICE performs three basic functions; speech transmission, speech reception, and call-tone generation/detection. All circuits are shown in schematic form in Figure 8.3.

#### Speech Transmission

Voice signals for the Model 67 PLC VOICE are generated by a carbon microphone in a telephone type handset. This handset is connected to the Voice Accessory Panel which is located on the front of the chassis. Transistor Q2 provides the current necessary to operate the carbon microphone. This current will vary between 15 and 20 mA. The speech signal generated by the carbon microphone enters the transmitter circuit at edge connector terminal 16 and passes through operational amplifier IC5A, which serves as a high-pass filter with a 250 Hz cutoff frequency. The signal then passed to IC5C, an operational amplifier with a diode bridge (CR7 through CR10) and Zener diode CR11 in its feedback circuit. IC5C acts as a limiter, holding the peak signal amplitude to about 2.4 volts. This prevents overmodulation of the protective relaying signal, which could be interpreted by the relaying circuit as a failure.

After limiting, the speech signal passes through IC5D. This operational amplifier is connected as a low-pass filter with a 4 kHz cutoff frequency. Potentiometer R63 controls the amount of voice signal that will be sent to the 67 PLC TRANS module, which determines the percent modulation to be applied to the carrier.

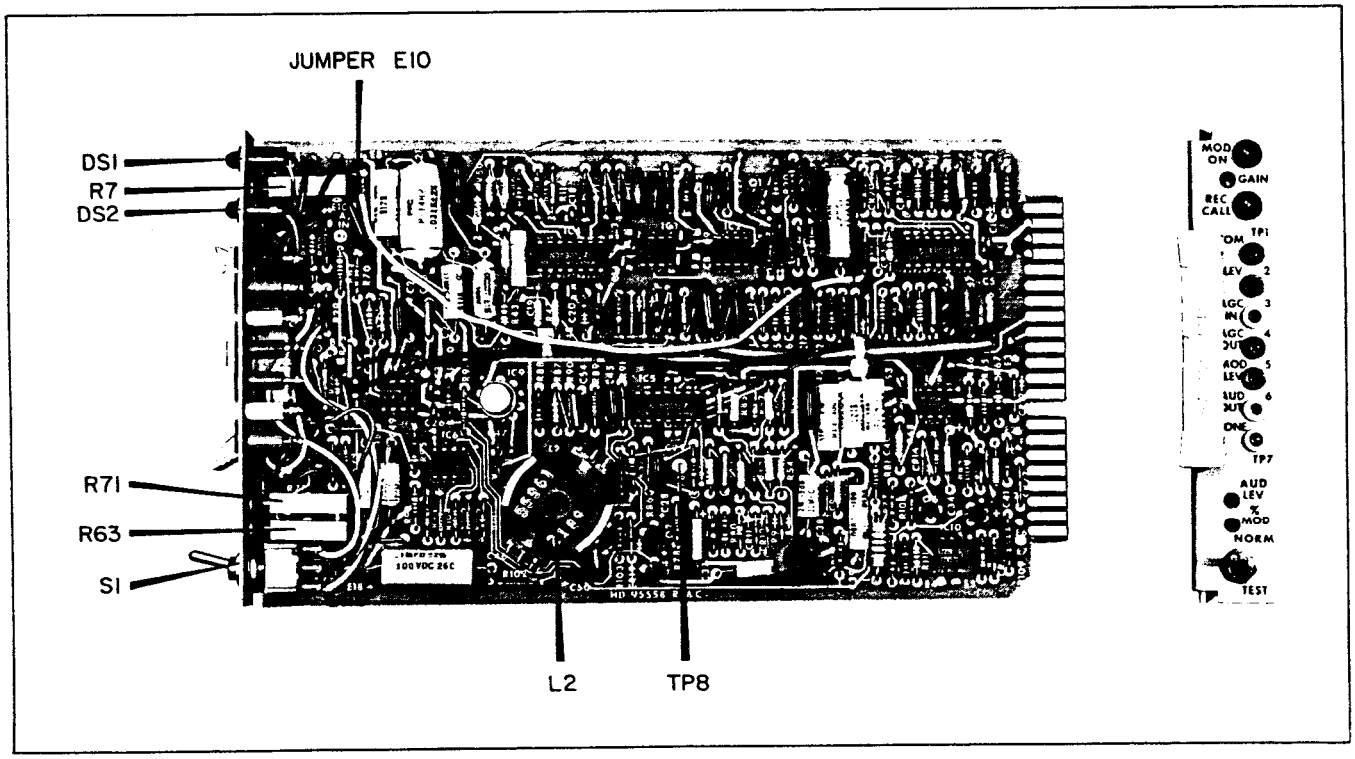



Figure 8.1. Location of controls and adjustments, Model 67 PLC VOICE

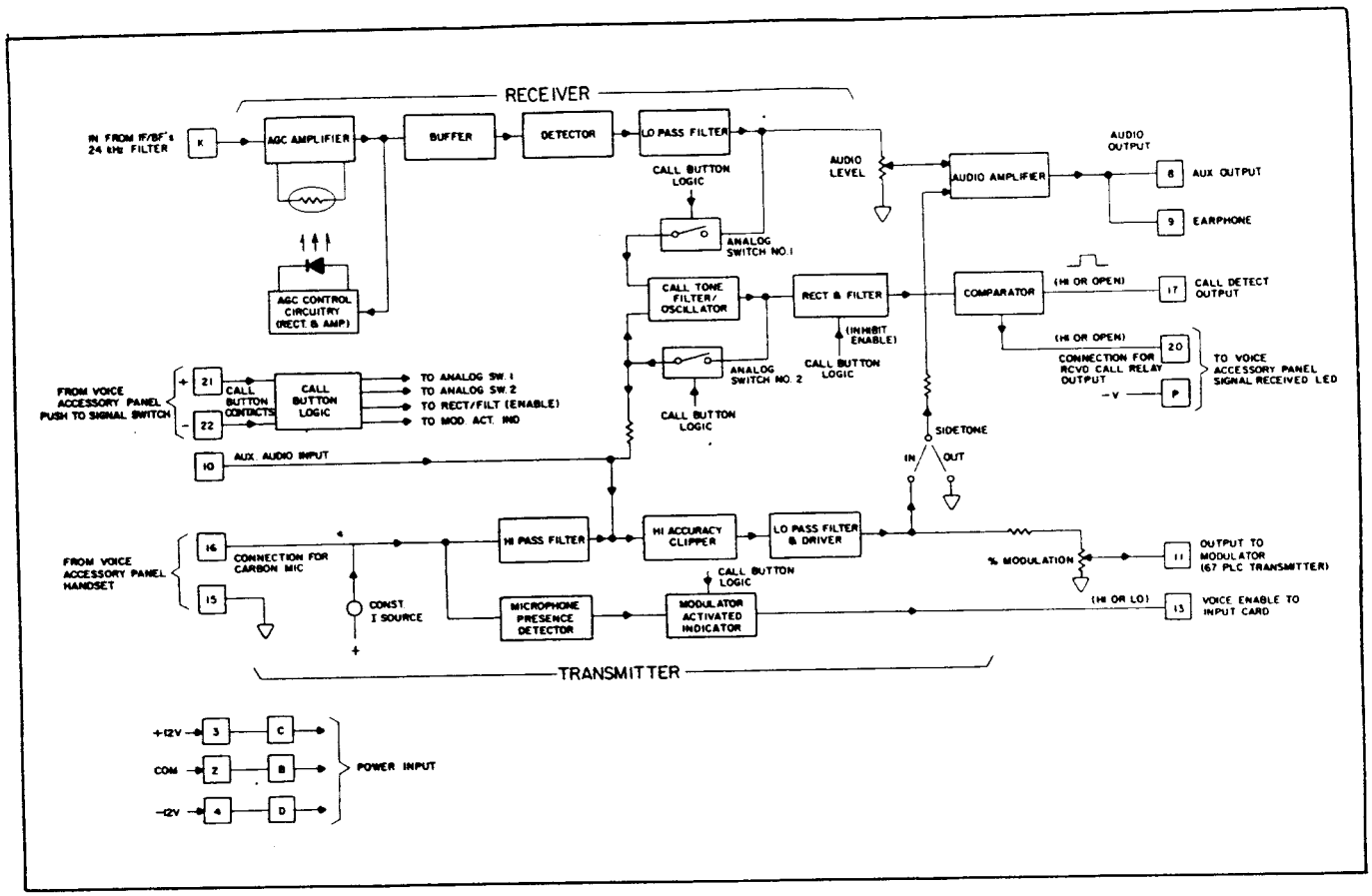



Figure 8.2. Block diagram, Model 67 PLC VOICE

Call tones enter the speech signal path at the input terminal of IC5C and from there on follow the same path as voice signals.

Comparator IC8A is used to control the entire transmission process. When a carbon microphone is connected to the Voice Accessory Panel and its low impedance is detected by IC8A, its output shifts from logic low to logic high. This high is fed to the 67 PLC INPUT module, which will send an enable signal to the 67 PLC TRANS module when voice signals can be transmitted. Indicator LED DS1 (MOD ON) will light when the output of IC8A is high, providing a visual indication that the voice-enable signal has been sent to the input card. Comparator IC8A can be bypassed by connecting the voice signal input to edge connector terminal 10, which is an auxiliary audio input. Signals applied to this terminal are fed directly to the input of IC5C and from there out to the 67 PLC TRANS module, where they will modulate the carrier without being controlled by the enable signal from the input card.

## Speech Reception

Voice signals are received by the 67 PLC VOICE module as modulation on a 24 kHz carrier at edge connector terminal K and are fed to the input of buffer-amplifier IC3. The output of IC3 becomes the input for IC2, an operational amplifier with the detector portion of photoisolator LCR1 in its feedback circuit. The action of LCR1 makes IC2 act as an AGC amplifier. The output of IC2 is sent to edge connector terminal J. In most applications, terminal J will be connected to terminal 6; in some, additional control circuitry may be placed between terminals J and 6.

The signal at terminal 6 becomes the reference signal for the AGC circuit. It is buffered by operational amplifier IC1D, rectified at operational amplifier IC1C, and then compared at operational amplifier IC1A with the reference voltage established by Zener diode CR3. IC1A generates an error voltage that drives transistor Q1. The emitter portion of photoisolator LCR1 is in series with the emitter of Q1, so that when Q1 conducts, the photoisolator varies the feedback resistance in IC2, changing its gain and providing AGC action.

The gain-regulated output of IC2 becomes the input for operational amplifier IC1B, the first stage of the voice detector circuit. Operational amplifiers IC4D and IC4B, along with diodes CR5 and CR6, rectify and demodulate the signal. Operational amplifiers IC4A, IC4C, and IC7A form a low-pass filter with a 2000 Hz cutoff frequency. This removed the 24 kHz portion of the demodulated signal, leaving only the audio portion. This audio is amplified by operational amplifier IC7B, whose output is regulated by potentiometer R71. The output of IC7B is fed to edge

connector terminal 9. From there, the received voice signal is fed to the receiver portion of the telephone handset connected to the Voice Accessory Panel.

## Call Tone Generation and Detection

Call tones are generated and detected by the same circuit. Operational amplifiers IC5B and IC6B form the generation/detection circuit, which is controlled by analog switch IC9, optoelectric coupler IC10, and transistors Q4 and Q5.

### Generation of Call Tones

When the operator presses the call button on the Voice Accessory Panel, a 12 Vdc potential is placed across edge connector terminals 21 and 22. This voltage caused an LED inside optoelectric coupler IC10 to light, which causes its output to go high. This turns on transistor Q5, which pulls pin 2 of analog switch IC9 low. With pin 2 held low, the B switch in IC9 closes, completing a positive feedback path from IC6B to IC5B. With the feedback path completed, the circuit starts to oscillate. Inductor L2 and capacitor C46 hold the oscillation at their resonant frequency, 1800 Hz. This call tone signal is fed to the input of operational amplifier IC5C, where it enters the speech transmission path.

When transistor Q5 is turned on, transistor Q4 is turned off. When Q4 is off, a logic high is present at pin 1 of analog switch IC9. This opens the A switch in IC9, and speech signals from the speech reception path are kept from entering the call tone circuit.

### Detection of Call Tones

When the call tone circuit is not generating tones, it is standing by ready to detect incoming tones. In this state, transistor Q5 is turned off and Q4 is on. As a result, the feedback path between IC6B and IC5B is kept open and no oscillations occur. Incoming signals are fed to the input of IC5B by way of the speech reception circuit, analog switch IC9B, and resistor R90. Inductor L2 and capacitor C46, connected in parallel across the output of IC5B, will resonate when an 1800 Hz tone is present in the incoming signal. The 1800 Hz tone will be amplified by IC6B and rectifier by diodes CR15 and CR17. The rectified signal is filtered by resistor R102 and capacitor C50, then fed to the input of comparator IC6A, which turns on transistor Q3. Q3 can be used to drive a signaling device connected to edge connector terminal 17 or a relay coil connected across terminals P and 20. Indicator LED DS1 (REC CALL) is in series with the base of Q3, and lights to indicate that a call is being received.

The call detection function is disabled while the call button is pressed by diode CR19, which conducts when Q5 is turned on, holding the input of operational amplifier IC6A high.

# Table 8.1
# Replaceable Parts

| Circuit Symbol (See Figure 8.3) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC VOICE - Assembly No. HB-95555** | |
| | **CAPACITORS** | |
| C1, 2, 34, 41 | Capacitor, tantalum, 1μF, 10%, 35V, Kemet T110A105K035AS or equiv. | 1007 1156 |
| C3, 27, 33, 35, 54 | Capacitor, ceramic, 0.47μF, +80-20%, 50V, Sprague 5CZ5U474D8050C5 or equiv. | 1007 939 |
| C4, 5, 8, 9, 13, 14, 18, 20, 26, 29, 36, 44, 47, 51-53 | Capacitor, ceramic, 0.1μF, GMV, 50V, Centralab CY20C104P or equiv. | 1007 1366 |
| C6 | Capacitor, electrolytic, 100μF, +75-10%, 25V, Sprague 30D107G025DD2 or equiv. | 1007 882 |
| C7 | Capacitor, ceramic disc, 0.0068μF, 20%, 1000V, Erie CK62AW682M or equiv. | 1007 91 |
| C10, 15 | Capacitor, mica, 150pF, 2%, 500V, Electro Motive DM-15 or equiv. | 16608 |
| C11 | Capacitor, mica, 0.0015μF, 2%, 500V, Electro Motive DM-19 or equiv. | 1080 285 |
| C12, 38, 56, 57 | Capacitor, ceramic disc, 0.05μF, 100V, Erie 845-X5V-5032 or equiv. | 1007 219 |
| C16, 17 | Capacitor, ceramic disc, 0.0047μF, 10%, 500V, Erie 811-000X5R0472K or equiv. | 1007 92 |
| C19 | Capacitor, polystyrene, 0.001μF, 2%, 400V, F-Dyne Electronics PST-11-.001-400-2 or equiv. | 5115 274 |
| C21 | Capacitor, polystyrene, 0.0315μF, 2%, 400V, Wesco 32P or equiv. | 5115 158 |
| C22 | Capacitor, polystyrene, 0.016μF, 2%, 100V, Wesco 32P or equiv. | 5115 45 |
| C23 | Capacitor, mica, 0.00125μF, 2%, 500V, Electro Motive DM-19 or equiv. | 16213 |
| C24 | Capacitor, metallized polycarbonate, 0.043μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1195 |
| C25 | Capacitor, mica, 255pF, 2%, 500V, Electro Motive DM-19 or equiv. | 16619 |
| C28 | Capacitor, mica, 100pF, 5%, 500V, Electro Motive DM-15 or equiv. | 1080 338 |
| C30 | Capacitor, polystyrene, 0.0036μF, 2%, 100V, Wesco 32P or equiv. | 5115 13 |
| C31 | Capacitor, metallized polycarbonate, 0.013μF, 2%, 200V, Wesco 32MPC or equiv. | 1007 1121 |
| C32 | Capacitor, mica, 270pF, 2%, 500V, Electro Motive DM-19 or equiv. | 16620 |
| C37 | Capacitor, tantalum, 15μF, 20%, 20V, Kemet T322D156M020AS or equiv. | 1007 716 |
| C39 | Capacitor, polystyrene, 0.0082μF, 2%, 100V, Wesco 32P or equiv. | 5115 31 |
| C40, 42, 43 | Capacitor, polystyrene, 0.013μF, 2%, 100V, Wesco 32P or equiv. | 5115 41 |
| C45 | Capacitor, mica, 15pF, 5%, 500V, Electro Motive DM-15 or equiv. | 16506 |
| C46 | Capacitor, polystyrene, 0.1μF, 2%, 100V, Wesco 32P or equiv. | 5115 83 |
| C48, 49 | Capacitor, metallized polycarbonate, 0.22μF, 2%, 50V, Wesco 32P or equiv. | 1007 1329 |
| C50 | Capacitor, tantalum, 2.2μF, 10%, 25V, Kemet T322B225K025AS or equiv. | 1007 752 |
| C55 | Capacitor, polystyrene, 0.011807μF, 1%, 100V, F-Dyne Electronics PST-11-.011807-100-1 or equiv. | 5115 355 |
| | **RESISTORS** | |
| R1, 2 | Resistor, composition, 2.7 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 900 |
| R3, 6, 57, 62, 65, 81, 83, 92, 98 | Resistor, metal film, 1K, 1%, ¼W, Type RN¼ | 0410 1288 |
| R4, 9-11, 13, 18, 27, 28, 33, 35, 37-40, 42, 45, 88, 99, 100 | Resistor, metal film, 10K, 1%, ¼W, Type RN¼ | 0410 1384 |
| R5 | Resistor, metal film, 3.01K, 1%, ¼W, Type RN¼ | 0410 1334 |
| R7, 71 | Resistor, variable, 15-turn cermet, 25K, 10%, ¾W, Beckman Helipot 89PHR25K or equiv. | 45829 |
| R8, 22, 29, 61, 74, 96 | Resistor, metal film, 100 ohm, 1%, ¼W, Type RN¼ | 0410 1192 |
| R12, 115 | Resistor, metal film, 4.75K, 1%, ¼W, Type RN¼ | 0410 1353 |
| R14, 43, 66 | Resistor, metal film, 4.99K, 1%, ¼W, Type RN¼ | 0410 1355 |
| R15, 78 | Resistor, metal film, 3.32K, 1%, ¼W, Type RN¼ | 0410 1338 |

# Table 8.1
## Replaceable Parts - continued

| Circuit Symbol (See Figure 8.3) | Description | Part Number |
|---|---|---|
| R16 | Resistor, metal film, 30.1K, 1%, ¼W, Type RN¼ | 0410 1430 |
| R17 | Resistor, metal film, 475K, 1%, ¼W, Type RN¼ | 0410 1545 |
| R19, 41 | Resistor, metal film, 2.21K, 1%, ¼W, Type RN¼ | 0410 1321 |
| R20 | Resistor, metal film, 221 ohm, 1%, ¼W, Type RN¼ | 0410 1225 |
| R21, 93 | Resistor, metal film, 68.1K, 1%, ¼W, Type RN¼ | 0410 1464 |
| R23 | Resistor, metal film, 6.65K, 1%, ¼W, Type RN¼ | 0410 1367 |
| R24, 64, 70, 89, 94, 106 | Resistor, metal film, 100K, 1%, ¼W, Type RN¼ | 0410 1480 |
| R25 | Resistor, metal film, 750 ohm, 1%, ¼W, Type RN¼ | 0410 1276 |
| R26 | Resistor, metal film, 7.5K, 1%, ¼W, Type RN¼ | 0410 1372 |
| R30, 114 | Resistor, metal film, 31.6K, 1%, ¼W, Type RN¼ | 0410 1432 |
| R31 | Resistor, metal film, 909 ohm, 1%, ¼W, Type RN¼ | 0410 1284 |
| R32 | Resistor, metal film, 18.2K, 1%, ¼W, Type RN¼ | 0410 1409 |
| R34 | Resistor, composition, 47 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 832 |
| R36, 101 | Resistor, metal film, 24.9K, 1%, ¼W, Type RN¼ | 0410 1422 |
| R44, 46-50, 58-60 | Resistor, metal film, 20K, 1%, ¼W, Type RN¼ | 0410 1413 |
| R51, 76 | Resistor, metal film, 604 ohm, 1%, ¼W, Type RN¼ | 0410 1267 |
| R52 | Resistor, metal film, 38.3K, 1%, ¼W, Type RN¼ | 0410 1440 |
| R53 | Resistor, metal film, 6.98K, 1%, ¼W, Type RN¼ | 0410 1369 |
| R54, 55, 68 | Resistor, metal film, 15K, 1%, ¼W, Type RN¼ | 0410 1401 |
| R56 | Resistor, metal film, 40.2K, 1%, ¼W, Type RN¼ | 0410 1442 |
| R63 | Resistor, variable, 15-turn cermet, 1K, 10%, ¾W, Beckman Helipot 89PHR1K or equiv. | 39574 |
| R67 | Resistor, metal film, 392K, 1%, ¼W, Type RN¼ | 0410 1537 |
| R69 | Resistor, metal film, 4.32K, 1%, ¼W, Type RN¼ | 0410 1349 |
| R72, 87 | Resistor, metal film, 33.2K, 1%, ¼W, Type RN¼ | 0410 1434 |
| R73 | Resistor, metal film, 3.16K, 1%, ¼W, Type RN¼ | 0410 1336 |
| R75, 90 | Resistor, metal film, 1.5K, 1%, ¼W, Type RN¼ | 0410 1305 |
| R77, 97, 110 | Resistor, metal film, 332 ohm, 1%, ¼W, Type RN¼ | 0410 1242 |
| R79 | Resistor, metal film, 562 ohm, 1%, ¼W, Type RN¼ | 0410 1264 |
| R80 | Resistor, composition, 43 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 891 |
| R82 | Resistor, metal film, 26.7K, 1%, ¼W, Type RN¼ | 0410 1425 |
| R84 | Resistor, metal film, 7.32K, 1%, ¼W, Type RN¼ | 0410 1371 |
| R85 | Resistor, metal film, 365K, 1%, ¼W, Type RN¼ | 0410 1534 |
| R86 | Resistor, metal film, 140K, 1%, ¼W, Type RN¼ | 0410 1494 |
| R91 | Resistor, metal film, 34.8K, 1%, ¼W, Type RN¼ | 0410 1436 |
| R95 | Resistor, composition, 10 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 823 |
| R102 | Resistor, metal film, 562K, 1%, ⅛W, Type RN55D | 1510 2013 |
| R103 | Resistor, metal film, 47.5K, 1%, ¼W, Type RN¼ | 0410 1449 |
| R104, 107, 113 | Resistor, metal film, 3.92K, 1%, ¼W, Type RN¼ | 0410 1345 |
| R105 | Resistor, metal film, 10.5K, 1%, ¼W, Type RN¼ | 0410 1386 |
| R108 | Resistor, metal film, 1.21K, 1%, ¼W, Type RN¼ | 0410 1296 |
| R109 | Resistor, metal film, 681 ohm, 1%, ½W, Type RN½ | 0410 2272 |
| R111 | Resistor, metal film, 2K, 1%, ¼W, Type RN¼ | 0410 1317 |
| R112 | Resistor, metal film, 825 ohm, 1%, ¼W, Type RN¼ | 0410 1280 |

# Table 8.1
## Replaceable Parts - continued

| Circuit Symbol (See Figure 8.3) | Description | Part Number |
|---|---|---|
| | **SEMICONDUCTORS** | |
| CR1, 2, 4-10, 12, 15-20, 22 | Diode, silicon, 1N914B or 1N4448 | 26482 |
| CR3 | Diode, Zener, 3.3V, 5%, 400 mW, 1N746A | 18760 |
| CR11 | Diode, Zener, 2.4V, 5%, 500 mW, 1N5221B | 40476 |
| CR13, 14, 21 | Diode, silicon, 1N4003 | 30769 |
| DS1, 2 | Light-emitting diode, red, Dialight 559-0101-003 or equiv. | 91115 |
| IC1, 4, 5 | Operational amplifier, JFET input, Texas Instruments TL084CN or equiv. | 0620 151 |
| IC2, 3 | Operational amplifier, National Semiconductor LM318N or equiv. | 0620 126 |
| IC6-8 | Operational amplifier, dual, JFET input, Texas Instruments TL082CP or equiv. | 0620 155 |
| IC9 | CMOS dual analog switch, SPST, Siliconix DG200BA or equiv. | 0605 3 |
| IC10 | Optoelectronic coupler, Darlington output, Motorola MOC8021 or equiv. | 90271 |
| LCR1 | Optical isolator, Clairex Electronics CLM-6500 or equiv. | 46546 |
| Q1, 5 | Transistor, NPN, 2N2222A, plastic package | 37445 |
| Q2-4 | Transistor, PNP, 2N2907A, plastic package | 37439 |
| | **MISCELLANEOUS COMPONENTS** | |
| L1 | Inductor, molded, 1000$\mu$H, 5%, Stanwyck 410000M or equiv. | 26529 |
| L2 | Coil, cup-core, 7.62mH | 55961 2189 |
| S1 | Switch, toggle, SPDT, C & K Components 7101 or equiv. | 26564 |
| --- | Shorting bar, single, Aries LP300 or equiv. | 42904 |
| | **Voice Accessory Panel, Required Option**<br>**Without Handset; Assembly No. HB-90855**<br>**With Handset; Assembly No. HB-90855-1** | |
| --- | Connector, jack, ¼-inch telephone, 3-conductor, Switchcraft MN-114B or equiv. | 27142 |
| --- | Connector, plug, ¼-inch telephone, 3-conductor, right-angle, Switchcraft 238 or equiv. (HB-90855-1 only) | 35708 |
| --- | Switch, pushbutton, SPDT, momentary subminiature, C & K Components 8121 or equiv. | 26133 |
| --- | Telephone handset with coiled cord and push-to-talk switch, Audiosears Corp. V1801-00-G5CR-05TA or equiv. (HB-90855-1 only) | 29762 |
| --- | Warning device, audible, 12 Vdc, 85 dB pulsing tone, Projects Unlimited X11F12 or equiv. | 47686 |

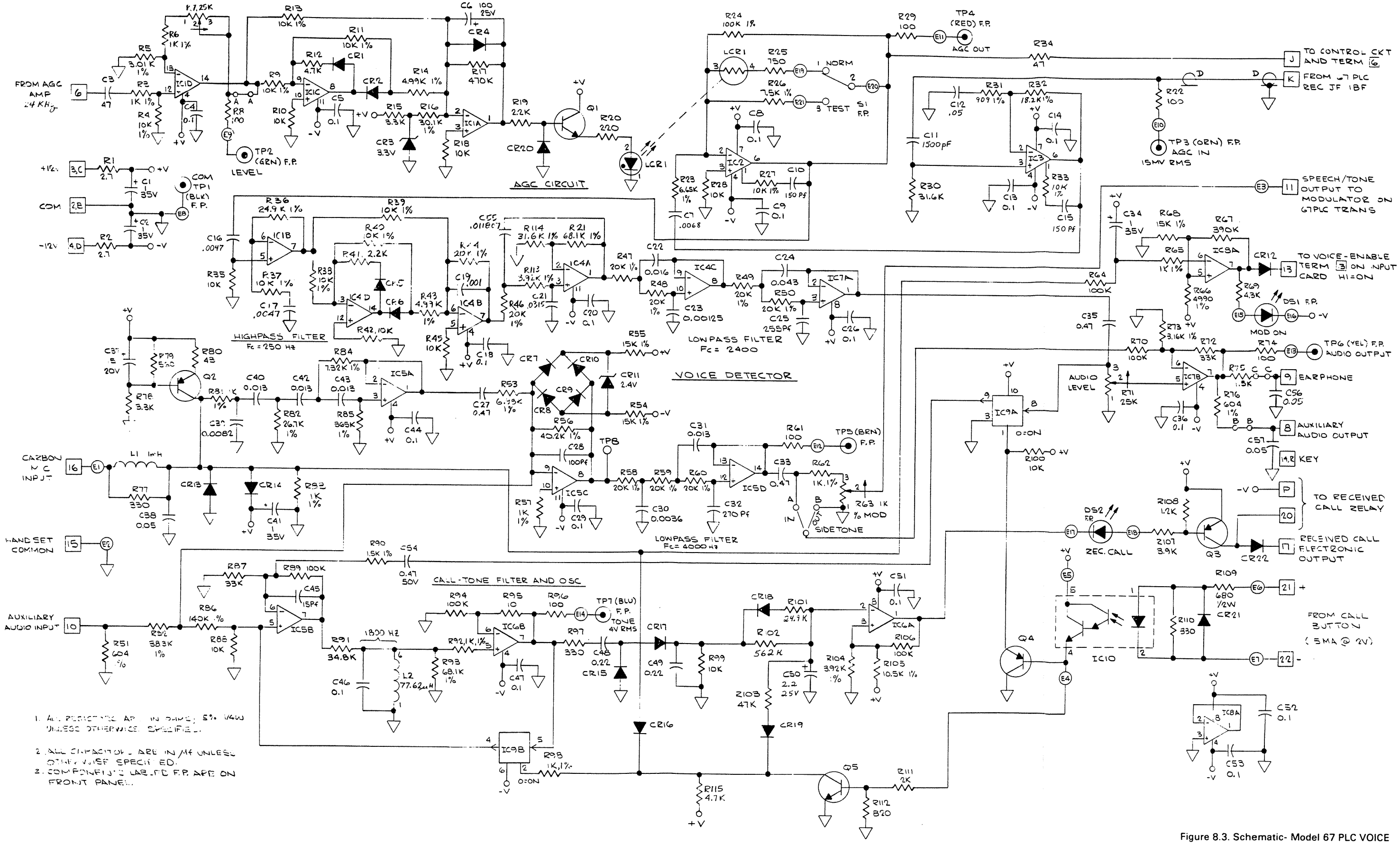



Figure 8.3. Schematic- Model 67 PLC VOICE

# Section 9
# POWER SUPPLIES

## MODELS 67 PLC 48DC and 67 PLC 129DC

### DESCRIPTION

These two power supplies are dc-dc converters designed to convert the station-battery voltage to the voltage levels required for operating the Series 6780 System. Two models are available. One operates from a 48-Vdc source; the other operates from a 129-Vdc station battery. Except for minor differences in components caused by different input voltages, the two power supplies are identical. A typical supply is shown in Figure 9.1.

Either power supply generates bipolar regulated 12 Vdc power for all circuits. In addition, 36-Vdc power is provided for the carrier-frequency power amplifier. A separate winding on the power transformer provides an isolated 800 Hz source for operating isolated trip-output circuits.

The two 12 Vdc outputs are controlled by a Model 68 REG External Regulator mounted on the back panel of the chassis. A heat sink carrying the pass transistor for the regulated 36-volt supply is also mounted on the back panel. All regulators contain protection against overvoltage and overcurrent. A failure monitor for all dc output voltages uses relays connected across each output with their contacts connected in series.

### CIRCUIT DETAILS

The main components of the power supply are a circuit card carrying the oscillator circuits, a circuit card carrying the 36-volt regulator and other protective circuits, and a chassis and front panel between the cards which carries large power components. A schematic of the circuit appears as Figure 9.3.

#### Oscillator Card

The converter is designed as a push-pull switching inverter. Transistors Q101 and Q102 switch the power transformer at a frequency of about 800 Hz.

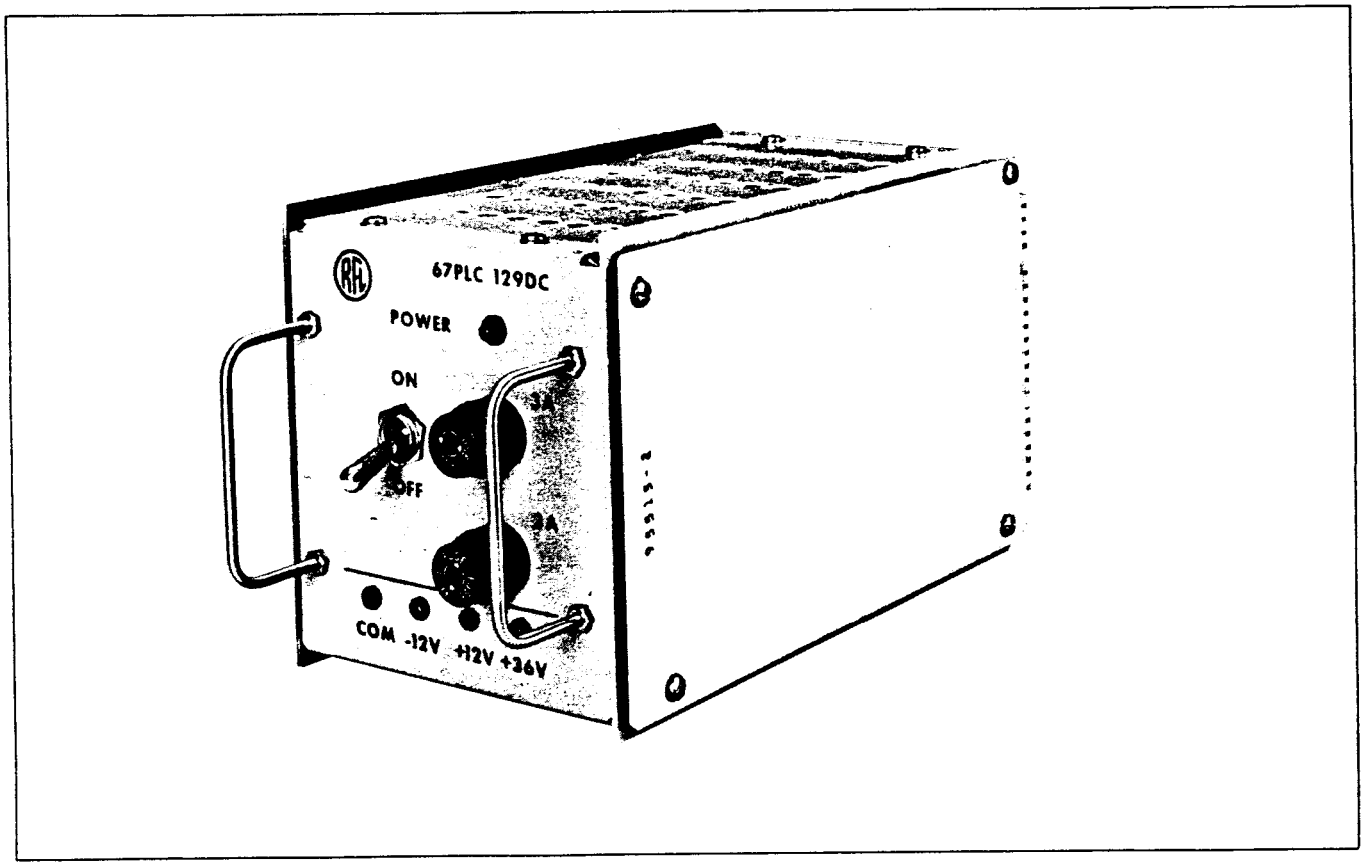



Figure 9.1. Typical 67 PLC DC power supply

The frequency was selected to aid in minimizing harmonic radiation. The circuits are protected by F101 and surge-limiting resistor R1. Capacitor C101 and the surge-protecting varistor CR101 provide compliance with the SWC requirements of the performance specification.

Inductor L1, C1, and C102 form a lowpass filter which reduces switching spikes that may be induced on the dc-input power line by the inverter. The two windings of L1 are connected in parallel in the 48-volt converter, and they are in series for 120-volt models.

The center tap of the primary of T101 is connected to one side of the input power, while either side of the primary is switched, alternately, to the other side of the input power by Q101 or Q102. The base of each transistor is controlled by T2, a saturable transformer which alternately drives the base of each transistor. Transistors Q1 and Q2 direct base current from Q101 and Q102 when it exceeds a preset value, to prevent overload of the switching transistors.

R17 and C6 are connected across the primary of T101, to lengthen the risetime of the switching pulse so as to reduce the radiation of radio-frequency interference.

## Regulator Card

T101 has five secondaries. One is used for feedback to T2. One provides energy to the 36-volt rectifiers. Two are used for the isolated 12-volt supplies. The fifth winding is used for an isolated trip-output supply.

The 36-volt rectifier, CR201, feeds Q103, connected as a series regulator. Zener diode CR205, and diodes CR203 and CR204, provide a 36-volt reference. The output current is specified at 1 ampere and it is limited at about 1.2 ampere.

The 12-volt rectifiers, CR215 and CR216, feed overvoltage detectors and their output then passes to their loads through a standard Model 68 REG external regulator. Output current for each supply is one ampere. The schematic of the regulator is shown in Figure 9.2., and its replacement parts are listed in Table 9.3.

Unregulated outputs are also available from the two 12-volt sources. The unregulated voltage from the negative-grounded 12-volt source is nominally 20 Vdc. The unregulated output voltage from the positive-grounded 12-volt source is nominally 8 Vdc with respect to ground or 20 Vdc with respect to the regulated -12-Vdc output terminal. For either source, the sum of currents taken from both regulated and unregulated terminals must not exceed 1-ampere. (See Table 3.1).

### Power-Failure Monitor

The regulator card also carries the power-failure monitor. This consists of three relays, each energized by one of the three dc-power outputs, whose Form-A contacts are connected in series. Should any output fail, a contact will open. The series-connected contacts may be used to control another relay or other alarm circuit. Lamp DS101 monitors the -12-volt source.

### Thermal Protection

The integrated-circuit regulators used in the 12-volt circuits contain both current limiting and thermal protection.

The pass transistor, Q103, of the 36-volt regulator has a thermistor, R101, mounted to its collector. If a short circuit occurs and the current is limited to 1.2 ampere, there will be about 50 volts across the collector and emitter of Q103. The temperature of Q103 will rise and the thermistor will become a high resistance. When this occurs, Q202 will conduct and cause Q103 to turn off. The temperature will reach equilibrium at about 95°C.

## Isolated AC Output

A separate secondary winding on the power transformer provides a squarewave output at terminals 17 and 18 for external functions. It is used in the Series 6780 as an isolated power source for the isolated solid-state output circuits, each of which requires 19 mArms for this source. The output voltage will vary between 34 and 52 volts, peak-to-peak, depending on input voltage to the converter.

**Table 9.1**
**TECHNICAL DATA**

**Input Voltage:** 48-volt units: 42-56 Vdc
129-volt units: 104-140 Vdc
Allowable ripple: 1.5 Vrms, max.

**Output Voltages:**

12-Volt Outputs: Two independent outputs, each 11.4 to 12.6 volts, not adjustable. Outputs will be within these limits for any combination of input voltage, load, and temperature.

36-Volt Output: Single regulated output, 32 to 38 volts, not adjustable.

**Station Battery:** Switched and fused station battery (input) voltage, unregulated.

**Output Current:** One amp from each 12V output, and 36V output.

**Overvoltage Trip:** 13.5 to 15.5 Vdc, not adjustable.

**Ambient Temperature:** -20°C to +60°.

**Size:** 4.5" x 4.713" x 8". Requires 9 module spaces in Model 68 Chassis.

# Table 9.2
# Replaceable Parts

| Circuit Symbol (See Figure 9.3) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC 48DC - Assembly No. HB-95515-1 and Model 67 PLC 129DC - Assembly No. HB-95515-2** | |
| | **CAPACITORS** | |
| C1 | Capacitor, metallized polyester, 2μF, 10%, 250V, Industrial Condenser 2.5LMZP200 or equiv. | 1007 1289 |
| C2, 3 | Capacitor, ceramic disc, 0.01μF, 20%, 3KV, Sprague 30GA-S10 or equiv. | 1007 1442 |
| C4 | Capacitor, electrolytic, 25μF, +150-10%, 50V, Cornell-Dubilier BR25-50 or equiv. | 1007 207 |
| C5 | Capacitor, metallized polyester, value dependent upon model, 5%, 500V: | |
| | For 48DC, 0.68μF; Siemens MKH B32560 .68/5/100 or equiv. | 1007 960 |
| | For 129DC, 0.33μF; Siemens MKH B32560 .33/5/100 or equiv. | 1007 1459 |
| C6 | Capacitor, polystrene, value dependent upon model, 2%, 400V: | |
| | For 48DC, 0.018μF; Wesco 32P or equiv. | 5115 147 |
| | For 129DC, 0.003μF; Wesco 32P or equiv. | 5115 109 |
| C7-100 | Not Used. | |
| C101 | Capacitor, ceramic disc, 0.005μF, 20%, 3KV, Centralab DD30-502 (Size Code 67) or equiv. | 1007 1264 |
| C102 | Capacitor, computer-grade electrolytic, value dependent upon model: | |
| | For 48DC, 820μF, +75-10%, 75V; Mallory CGS821U075BB1 or equiv. | 48717 |
| | For 129DC, 200μF, +50-10%, 250V; Mallory CGS201T250BB1 or equiv. | 48712 |
| C103-200 | Not Used. | |
| C201 | Capacitor, electrolytic, 100μF, +100-10%, 150V, w/plastic sleeve, Cornell-Dubilier WBR-100-150 or equiv. | 1007 1238 |
| C202, 203 | Capacitor, electrolytic, 47μF, +100-10%, 100V, Stettner-Trush EB47/100 or equiv. | 1007 1350 |
| C204, 207 | Capacitor, tantalum, 22μF, 20%, 35V, Corning Components CCZ-035-226-20 or equiv. | 1007 657 |
| C205, 208 | Capacitor, tantalum, 33μF, 20%, 20V, Kemet T310C336M020AS or equiv. | 1007 1161 |
| C206, 209 | Capacitor, polyester, 0.47μF, 10%, 100V, Cornell-Dubilier WMF-1P47 or equiv. | 1007 629 |
| | **RESISTORS** | |
| R1 | Resistor, wirewound, value dependent upon model, 5%, 5W: | |
| | For 48DC, 0.12 ohm; C.T. Gamble Type, CG-8 or equiv. | 1100 707 |
| | For 129DC, 0.25 ohm; C. T. Gamble Type, CG-8 or equiv. | 1100 713 |
| R2, 4, 17-200 | Not used. | |
| R3 | Resistor, wirewound, value dependent upon model, 5%, 20W: | |
| | For 48DC, 1.5K; Ohmite Brown Devil 1824 or equiv. | 1100 741 |
| | For 129DC, 5K; Ohmite Brown Devil 1836 or equiv. | 1100 742 |
| R5, 6 | Resistor, wirewound, value dependent upon model, 5%, 10W: | |
| | For 48DC, 20 ohm; Ohmite Series 22 #20J20R or equiv. | 1100 739 |
| | For 129DC, 40 ohm; Ohmite Series 22 #20J40R or equiv. | 1100 740 |
| R7, 8, 15, 16 | Resistor, composition, 10 ohm, 5%, 1W, Allen-Bradley GB Series or equiv. | 1009 4 |
| R9, 12 | Resistor, wirewound, value dependent upon model, 5%, 3W: | |
| | For 48DC, 0.15 ohm; LTV Electrosystems RW69VR15 or equiv. | 1100 592 |
| | For 129DC, 0.5 ohm; Dale Electronics Type R2SB or equiv. | 1100 699 |
| R10, 13 | Resistor, metal film, 221 ohm, 1%, ¼W, Type RN¼ | 0410 1225 |
| R11, 14 | Resistor, composition, 16 ohm, 5%, 2W, Allen-Bradley HB Series or equiv. | 1009 1105 |
| R17 | Resistor, wirewound, 1 ohm, 5%, 3.25W, Ohmite 4330 or equiv. | 1100 361 |
| R201 | Resistor, wirewound, 1K, 5%, 5.25W, Ohmite Brown Devil 2894 or equiv. | 1100 677 |
| R202 | Resistor, wirewound, 0.6 ohm, 5%, 5W, Ohmite 995-5B or equiv. | 1100 702 |
| R203 | Resistor, composition, 2.2K, 5%, 1W, Allen-Bradley GB Series or equiv. | 1009 180 |
| R204 | Resistor, composition, 10 ohm, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 823 |

# Table 9.2
# Replaceable Parts - continued

| Circuit Symbol (See Figure 9.3) | Description | Part Number |
|---|---|---|
| R205 | Resistor, metal film, 3.32K, 1%, ½W, Type RN½ | 0410 2338 |
| R206 | Resistor, metal film, 1.5K, 1%, ¼W, Type RN¼ | 0410 1305 |
| R207 | Resistor, metal film, 750 ohm, 1%, ¼W, Type RN¼ | 0410 1276 |
| R208 | Resistor, composition, 3.9K, 5%, 2W, Allen-Bradley HB Series or equiv. | 1009 1032 |
| R209, 212 | Resistor, metal film, 3.32K, 1%, ¼W, Type RN¼ | 0410 1338 |
| R210, 213 | Resistor, metal film, 100 ohm, 1%, ¼W, Type RN¼ | 0410 1192 |
| R211, 214 | Resistor, composition, 47 ohms, 5%, ¼W, Allen-Bradley CB Series or equiv. | 1009 832 |
| R215 | Resistor, metal film, 2.74K, 1%, ½W, Type RN½ | 0410 2330 |
| | **SEMICONDUCTORS** | |
| CR1-6 | Diode, silicon, 1N4003 | 30769 |
| CR7-100, 103-200 | Not Used. | |
| CR101 | Varistor, voltage suppression, type dependent upon model: | |
| | For 48DC, General Electric V100ZA3 or equiv. | 29663 |
| | For 129DC, General Electric V150LA20B or equiv. | 91989 |
| CR102 | Diode, silicon, 400 PIV, 6A, Motorola MR754 or equiv. | 35738 |
| CR201 | Bridge rectifier module, 400V, 6A, Varo VH448 or equiv. | 48731 |
| CR202-204, 206, 208, 210, 211, 213, 214 | Diode, silicon, 1N4003 | 30769 |
| CR205 | Diode, Zener, 36V, 5%, 5W, 1N5365B | 48727 |
| CR207 | Diode, Zener, 2.4V, 5%, 500mW, 1N5221B | 40476 |
| CR209,212 | Diode, Zener, 14V, 5%, 500mW, 1N5244B | 41075 |
| CR215,216 | Bridge rectifier module, 100V, 2A, Varo VS-148X or equiv. | 39509 |
| DS1-100 | Not Used. | |
| DS101 | Light-emitting diode, red, Dialight 559-0101-003 or equiv. | 91115 |
| Q1, 2, 201, 202 | Transistor, NPN, Texas Instruments TIP-49, or equiv. plastic package | 39588 |
| Q3-100, 103-200 | Not Used. | |
| Q101, 102 | Transistor, NPN, type dependent upon model: | |
| | For 48DC, 2N6250, TO-3 case | 47628 |
| | For 129DC, 2N6251, TO-3 case | 46179 |
| SCR1-200 | Not Used. | |
| SCR201, 202 | Silicon-controlled rectifier, 2N4441, plastic package | 41072 |
| | **MISCELLANEOUS COMPONENTS** | |
| F1-100, 103-200 | Not Used. | |
| F101, 102 | Fuse, 3AG, normal-blow, current dependent upon model, 250V: | |
| | For 48DC, 6A; Littlefuse 312 006 or equiv. | 3960 |
| | For 129DC, 3A; Littlefuse 312 003 or equiv. | 1293 |
| F201 | Fuse, 3AG, normal-blow, 2A, 250V, Littelfuse 312 002 or equiv. | 1289 |
| F202, 203 | Fuse, 3AG, normal-blow, 1.5A, 250V, Littelfuse 312 01.5 or equiv. | 41524 |
| K1-200 | Not Used. | |
| K201-203 | Relay, SPST reed, 12-volt coil, Coto-Coil CR-4030-12-1000 or equiv. | 46516 |
| L1 | Inductor, dual-coil 100/400μH, 6/3A, Magnetico 13488 or equiv. | 48737 |
| S1-100 | Not Used. | |
| S101 | Switch, toggle, DPST, 20A, 250V, Cutler-Hammer 7402-K4 or equiv. | 29374 |
| T1, 3-100 | Not used. | |
| T2 | Transformer, control, saturable | 44177 |
| T101 | Transformer, power, type dependent upon model: | |
| | For 48DC | 95051 |
| | For 129DC | 95052 |

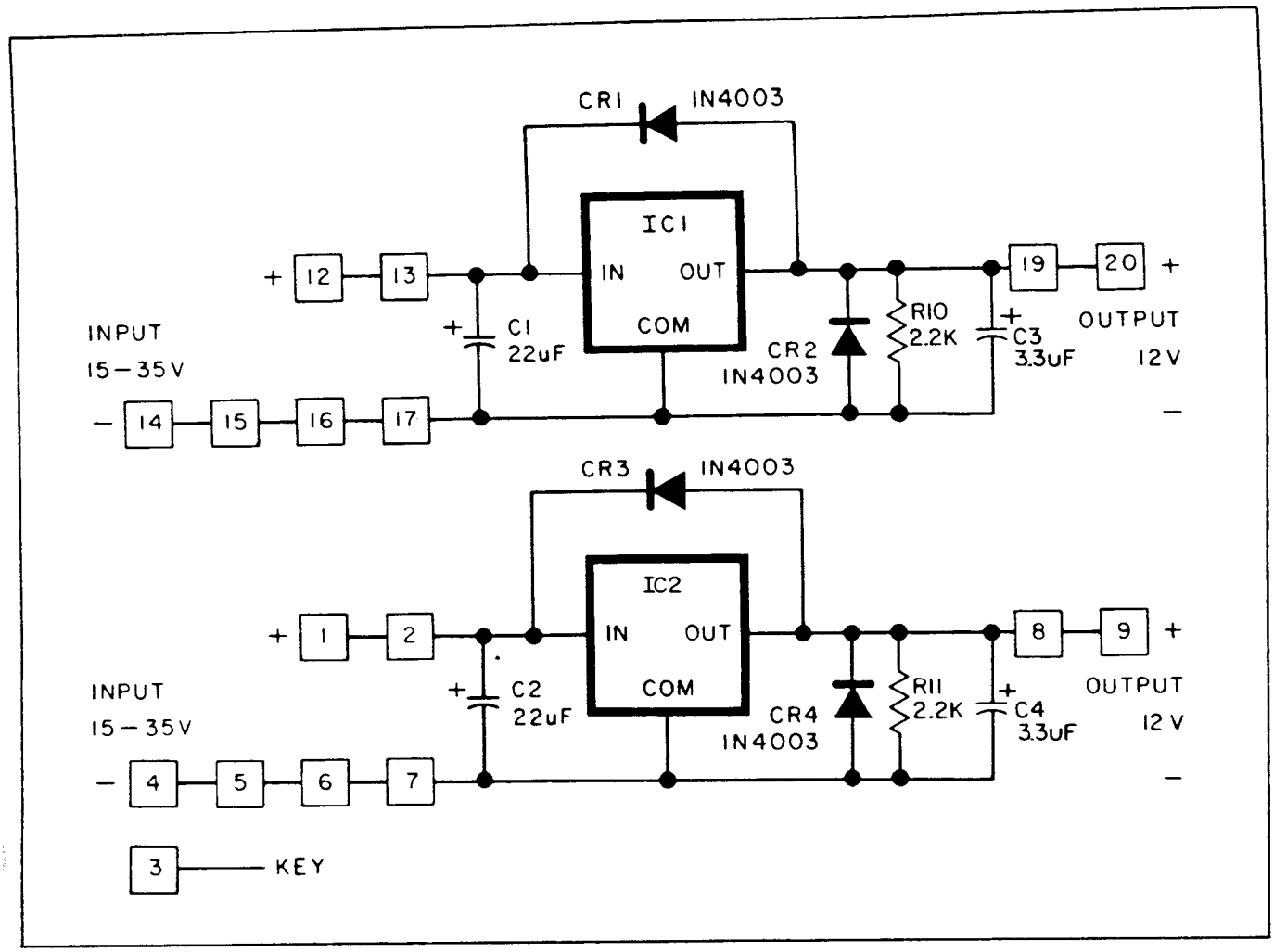
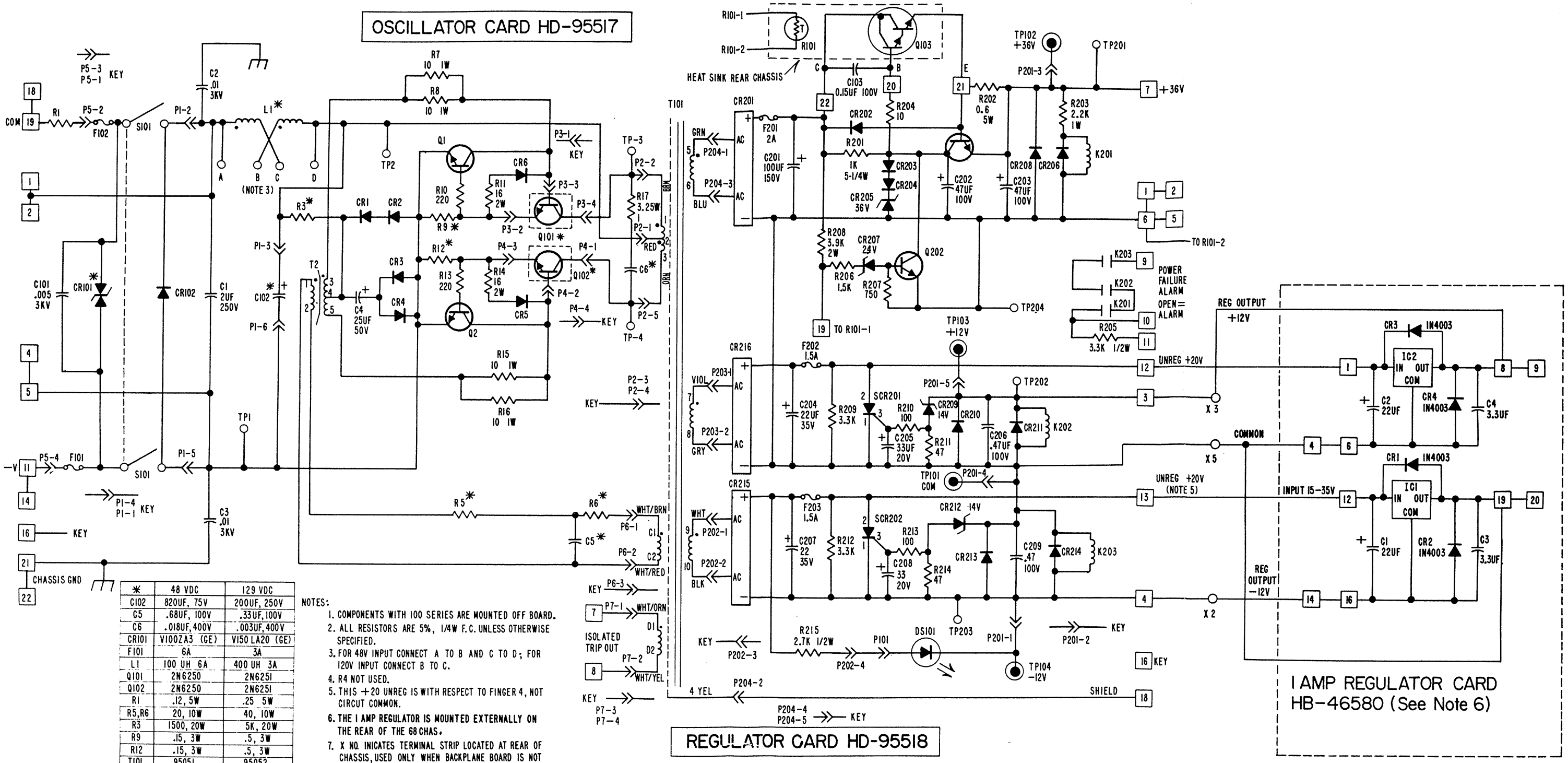



Figure 9.2. Schematic- Model 68 REG external regulator

## Table 9.3
## Replaceable Parts

| Circuit Symbol (See Figure 9.2) | Description | Part Number |
|---|---|---|
| | **Model 68 REG External, Regulator - Assembly No. HB-46580** | |
| C1, 2 | Capacitor, tantalum, 22μF, 20%, 35V, Corning Components CCZ-035-226-20 or equiv. | 1007 657 |
| C3, 4 | Capacitor, tantalum, 3.3μF, 20%, 35V, Kemet T332C335M035AS or equiv. | 1007 1260 |
| CR1-4 | Diode, silicon 1N4003 | 30769 |
| IC1, 2 | Linear voltage regulator, +12-volt, 3-terminal TO-220 case, National Semiconductor LM340T-12 or equiv. | 0620 69 |
| R1-9 | Not Used. | |
| R10, 11 | Resistor, metal film, 2.21K, 1%, ¼W, Type RN¼ | 0410 1321 |




| * | 48 VDC | 129 VDC |
|---|---|---|
| C102 | 820UF, 75V | 200UF, 250V |
| C5 | .68UF, 100V | .33UF, 100V |
| C6 | .018UF, 400V | .003UF, 400V |
| CR101 | V100ZA3 (GE) | V150LA20 (GE) |
| F101 | 6A | 3A |
| L1 | 100 UH 6A | 400 UH 3A |
| Q101 | 2N6250 | 2N6251 |
| Q102 | 2N6250 | 2N6251 |
| R1 | .12, 5W | .25 5W |
| R5,R6 | 20, 10W | 40, 10W |
| R3 | 1500, 20W | 5K, 20W |
| R9 | .15, 3W | .5, 3W |
| R12 | .15, 3W | .5, 3W |
| T101 | 95051 | 95052 |

NOTES:

1. COMPONENTS WITH 100 SERIES ARE MOUNTED OFF BOARD.
2. ALL RESISTORS ARE 5%, 1/4W F.C. UNLESS OTHERWISE SPECIFIED.
3. FOR 48V INPUT CONNECT A TO B AND C TO D; FOR 120V INPUT CONNECT B TO C.
4. R4 NOT USED.
5. THIS +20 UNREG IS WITH RESPECT TO FINGER 4, NOT CIRCUIT COMMON.
6. THE I AMP REGULATOR IS MOUNTED EXTERNALLY ON THE REAR OF THE 68 CHAS.
7. X NO. INICATES TERMINAL STRIP LOCATED AT REAR OF CHASSIS, USED ONLY WHEN BACKPLANE BOARD IS NOT USED.

Figure 9.3. Schematic- Models 67 PLC 48DC and 67 PLC 129DC

# Section 10
# HYBRIDS

## INTRODUCTION

Hybrids are optional interface modules for the Series 6780 System, used to connect transmitters and receivers to line-tuning units. Two basic types of hybrids are available; the Model 67 PLC X HYB Transformer Hybrid and the Model 67 PLC SK HYB Skewed Hybrid. By installing these hybrids in the Series 6780 chassis and making all interconnections as part of the chassis wiring, all external interface wiring is eliminated, except for a single cable to the line-tuning unit. A UHF connector on the rear panel of the chassis is provided for this purpose.

## Model 67 PLC X HYB

### DESCRIPTION

The Model 67 PLC X HYB (Figure 10.1) is a transformer-type hybrid used to connect transmitters and receivers to a line-tuning unit, providing impedance matching, signal separation, and preventing mutual loading and interference. Two different Model 67 PLC X HYB hybrids are available:

**67 PLC X HYB-1.** The -1 version of the Model 67 PLC X HYB is used to connect one transmitter and one receiver to a single line-tuning unit for multiplexing purposes. It presents a 75 ohm impedance to the receiver and a 50 ohm impedance to both the transmitter and the line-tuning unit.

**67 PLC X HYB-2.** The -2 version of the Model 67 PLC X HYB is used to connect two transmitters to a single line-tuning unit for dual channel applications. It presents a 50 ohm impedance to all three devices.

By using the Model 67 PLC X HYB in combination with the Model 67 PLC SK HYB Skewed Hybrid, up to four devices (two transmitters and two receivers, or four transmitters) may be connected to the same line-tuning unit.

### CIRCUIT DETAILS

The 67 PLC X HYB (shown in schematic form in Figure 10.3) used two hybrid transformers (L1 and L2) to couple signals between two transmitters and one line-tuning unit, or between one transmitter and one receiver and one line-tuning unit. Transmitter outputs as high as 10 watts into 50 ohms can be accepted.

L1 and L2 each have two secondaries, interconnected so that secondary #1 of one transformer is in series with secondary #2 of the other. One set of interconnected secondaries is connected to the line-tuning unit; this connects the line-tuning unit to both transformers. The other set of secondaries is connected across balancing resistor R12, which determines the amount of isolation between four-wire ports. If additional isolation is required, R12 can be removed and replaced with an external balancing network connected across edge connector terminals 18 and 19.

In the 67 PLC X HYB-1, a transmitter is connected across the primary of L1 and a receiver across the secondary of L2. Transmitter signals are coupled via L1 to the line-tuning unit and incoming signals detected by the line-tuning unit are coupled via L2 to the receiver, resulting in multiplex capability.

In the 67 PLC X HYB-2, transmitters are connected across the primaries of both L1 and L2. The transmitter output signals are coupled via L1 and L2 to the line-tuning unit, resulting in dual-channel transmission capability.

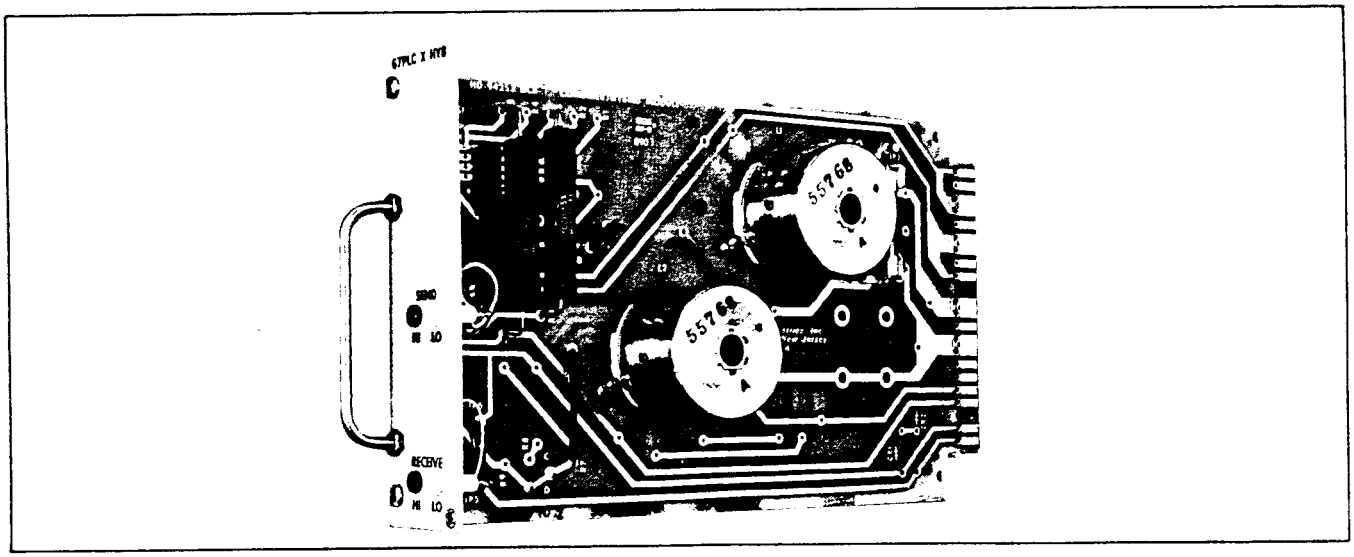



Figure 10.1. Model 67 PLC X HYB Transformer Hybrid

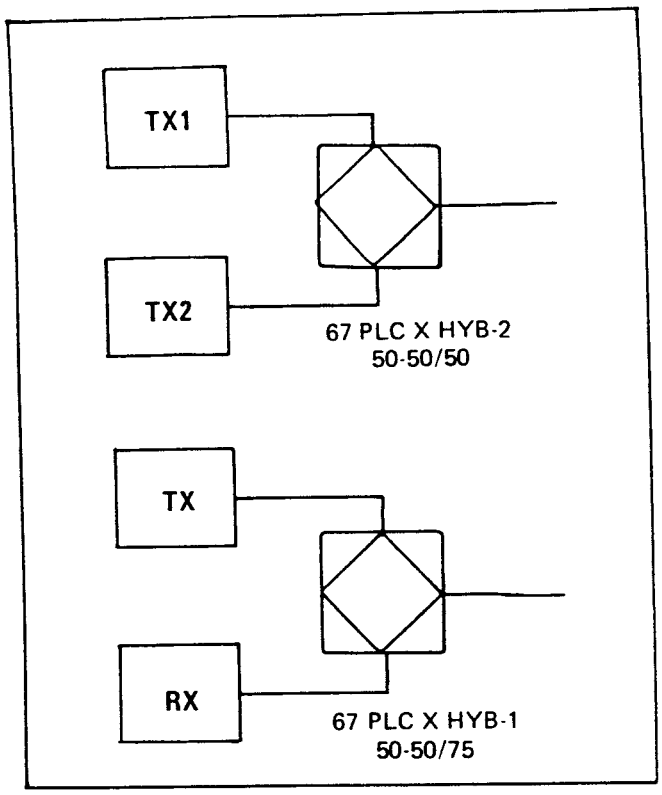
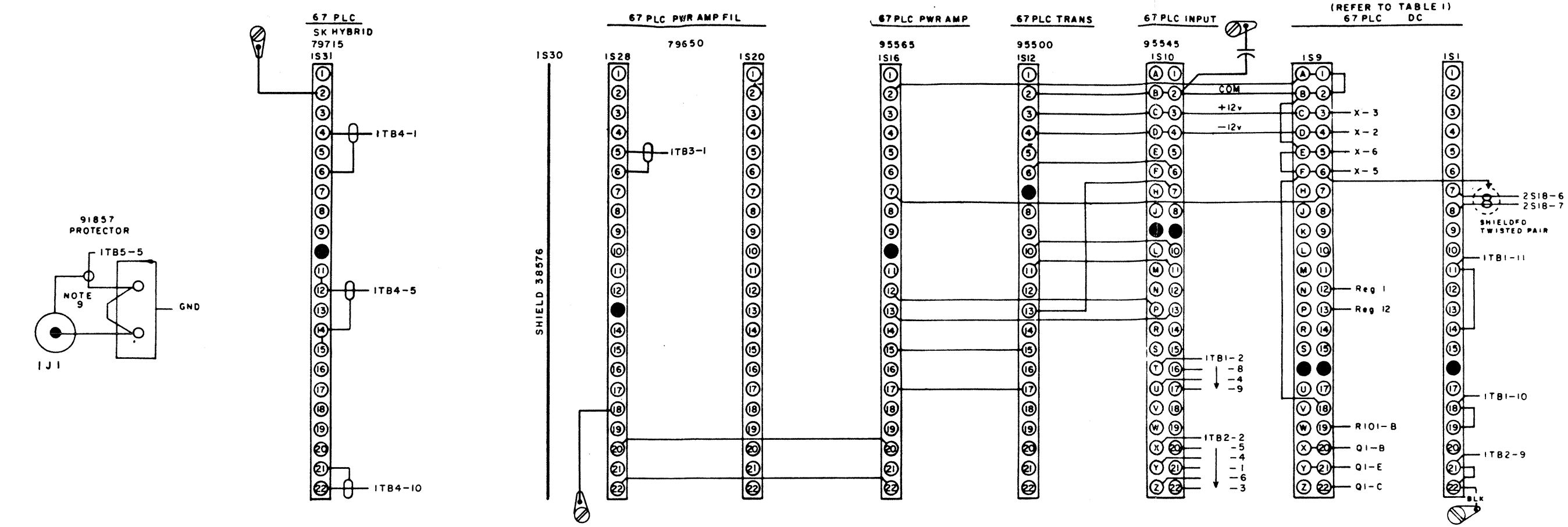



Figure 10.2. Interconnection configurations for Model 67 PLC X HYB

## Table 10.1
## Replaceable Parts

| Circuit Symbol (See Figure 10.3) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC X HYB-1 50-50/75 Ohm Transformer Hybrid Card Assembly No. HB-79710-1** | |
| | **Model 67 PLC X HYB-2 50-50/50 Ohm Transformer Hybrid Card Assembly No. HB-79710-2** | |
| F1 | Fuse, 3AG, slow-blow, 10A, 32V, Littlefuse 313 010 or equiv. | 10758 |
| L1 | Transformer, hybrid, transmit, 50 ohm | 55768 |
| L2 | Transformer, hybrid, receive, impedance determined by model: | |
| | For 67 PLC X HYB-1, 75 ohm | 55769 |
| | For 67 PLC X HYB-2, same as L1 | |
| R1-11 | Not Used. | |
| R12, 13 | Resistor, non-inductive wirewound, 100 ohm, 5%, 10W, C.T. Gamble CGN-10 or equiv. | 1100 795 |
| --- | Shorting bar, single, Aries LP300 or equiv. | 42904 |
| --- | UHF connector, optional, panel-mount female, Type SO-239, Amphenol 83-798 or equiv. | 43819 |



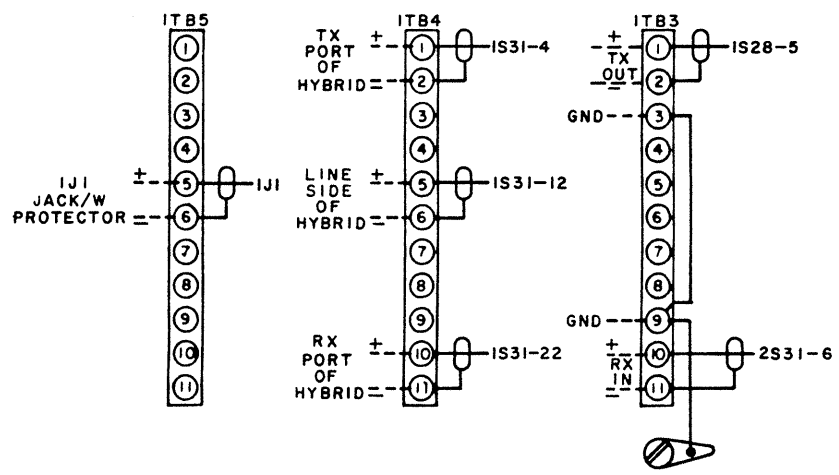
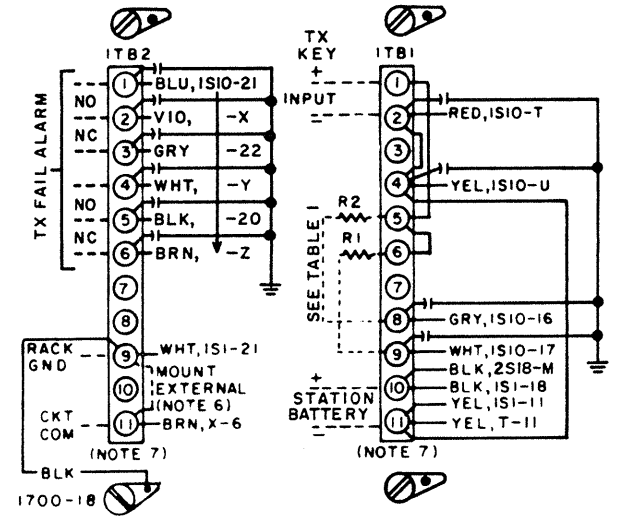




TABLE I (PER SO)

| DC VOLTAGE | 24 V | 48 V | 125 V |
|---|---|---|---|
| R1 & R2 | 500Ω | 1 5k | 4 5k |
| PART NUMBER | 1100-308 | 1220-35 | 1100-690 |
| S1 DC—DC CONVERTER | | 95515-1 | 95515-2 |
| GUARD RELAY | 300662-1 | 96549-1 | 44876-1 |
| TRIP RELAY | | | 44876-3 |



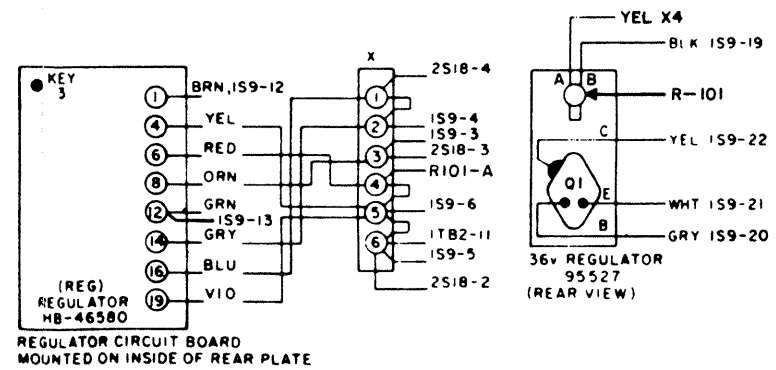




Figure 1.18. Universal chassis wiring diagram (for information only)

# MODEL 67 PLC SK HYB

## DESCRIPTION

The 67 PLC SK HYB (Figure 10.4) is a skewed RF hybrid used to connect Series 6780 transmitters and receivers to a single line-tuning unit and separate transmitter signals from receiver signals. By using the Model 67 PLC SK HYB in combination with the Model 67 PLC X HYB Transformer Hybrid, up to four devices (two transmitters and two receivers, or four transmitters) may be connected to the same line-tuning unit.

### Adjustments

For proper operation, the Model 67 PLC SK HYB must be adjusted for maximum transhybrid loss. Transhybrid loss is a measure of the receiver input's rejection of transmitter output signals. An rms-responding ac voltmeter will be required to adjust the Model 67 PLC SK HYB.

To adjust for maximum transhybrid loss, proceed as follows:

1. Connect voltmeter across test points TP1 (HI) and TP2 (GND).
2. Note and record voltmeter reading while transmitter output is high.
3. Connect voltmeter across test points TP5 (HI) and TP6 (SIG COM).
4. Move COARSE BALANCE switch S1 from position to position until voltmeter indication is lowest.
5. Adjust FINE BALANCE potentiometer R6 for minimum voltmeter indication.

If adjusting S1 and R6 does not provide enough transhybrid loss, the internal balancing network can be disabled by removing jumper A and an external balancing network can be connected across edge connector terminals 18 and 19. Use of an external network will disable the BALANCE controls on the 67 PLC SK HYB front panel.

## CIRCUIT DETAILS

The 67 PLC SK HYB (shown in schematic form in Figure 10.5) uses two hybrid transformers, L1 and L2, to couple signals between a transmitter, a receiver, and a line-tuning unit. Transmitter outputs as high as 10 watts into 50 ohms can be accepted.

L1 and L2 each have two secondaries, interconnected so that the secondary #1 of one transformer hybrid is in series with secondary #2 of the other. One set of interconnected secondaries is connected to the line-tuning unit; this allows both the transmitter output and the receiver input to be coupled to the line-tuning unit. The other set of secondaries is connected across the internal balancing network; resistors R1 through R6, R11, R12, and rotary switch S1. S1 and R6 can be adjusted to vary the resistance across the secondaries, which determines the amount of transhybrid loss. If additional transhybrid loss is required, the internal network can be disabled by removing a jumper and an external network can be connected across edge connector terminals 18 and 19.

The transmitter output is connected across the primary of L1 and the receiver input is connected across the primary of L2. Transmitter signals are coupled via L1 to the line-tuning unit and incoming signals detected by the line-tuning unit are coupled via L2 to the receiver. Transmitter signals are attenuated by about 0.3 dB as they pass through the 67 PLC SK HYB, and received signals are attenuated by about 12.5 dB. Because both the received signal and its noise content are attenuated equally, signal-to-noise ratios are unaffected.

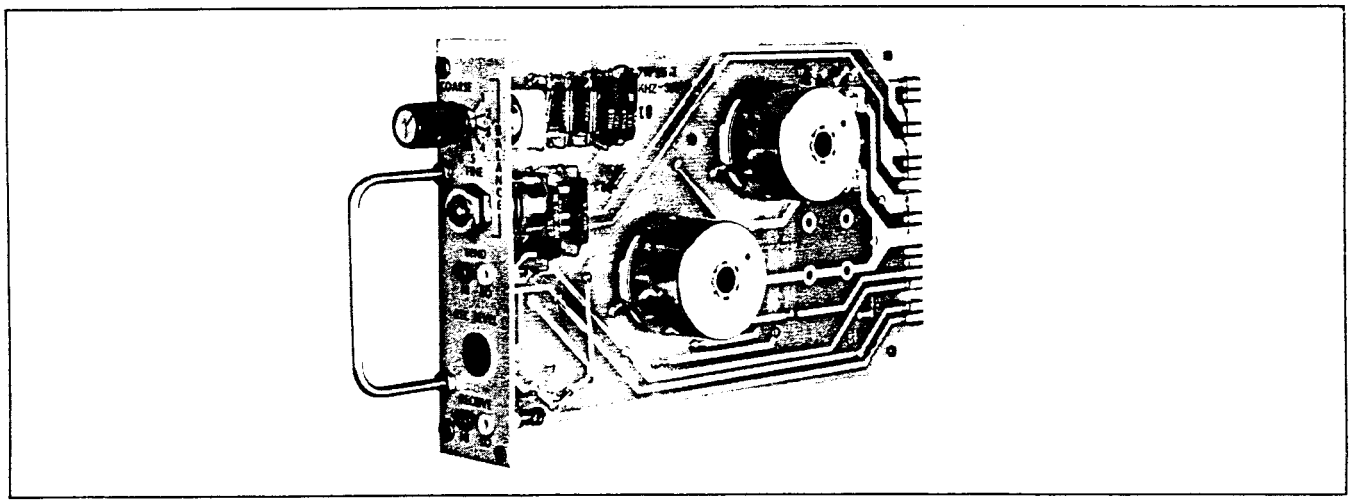


Figure 10.4. Model 67 PLC SK HYB Skewed Hybrid

# Table 10.2
# Replaceable Parts

| Circuit Symbol (See Figure 10.5) | Description | Part Number |
|---|---|---|
| | **Model 67 PLC SK HYB Skewed Hybrid Module - Assembly No. HB-79715** | |
| F1 | Fuse, 3AG, slow-blow, 10A, 32V, Littlefuse 313 010 or equiv. | 10758 |
| R1, 2 | Resistor, non-inductive wirewound, 12 ohm, 5%, 2.5W, C.T. Gamble CGN-4 or equiv. | 1100 745 |
| R3-5 | Resistor, metal film, 12.1 ohm, 1%, ½W, Type RN65D | 1510 2109 |
| R6 | Resistor, variable, linear-taper cermet, 100 ohm, 10%, 2W, CTS X55OLT Series or equiv. | 44356 |
| R7-10 | Not Used. | |
| R11 | Resistor, non-inductive wirewound, 50 ohm, 5%, 2.5W, C.T. Gamble CGN-4 or equiv. | 1100 747 |
| R12 | Resistor, non-inductive wirewound, 50 ohm, 5%, 10W, C.T. Gamble CGN-10A or equiv. | 1100 755 |
| --- | Shorting bar, single, Aries LP300, or equiv. | 42904 |
| --- | UHF connector, optional, panel-mount female, Type SO-239, Amphenol 83-798, or equiv. | 43819 |

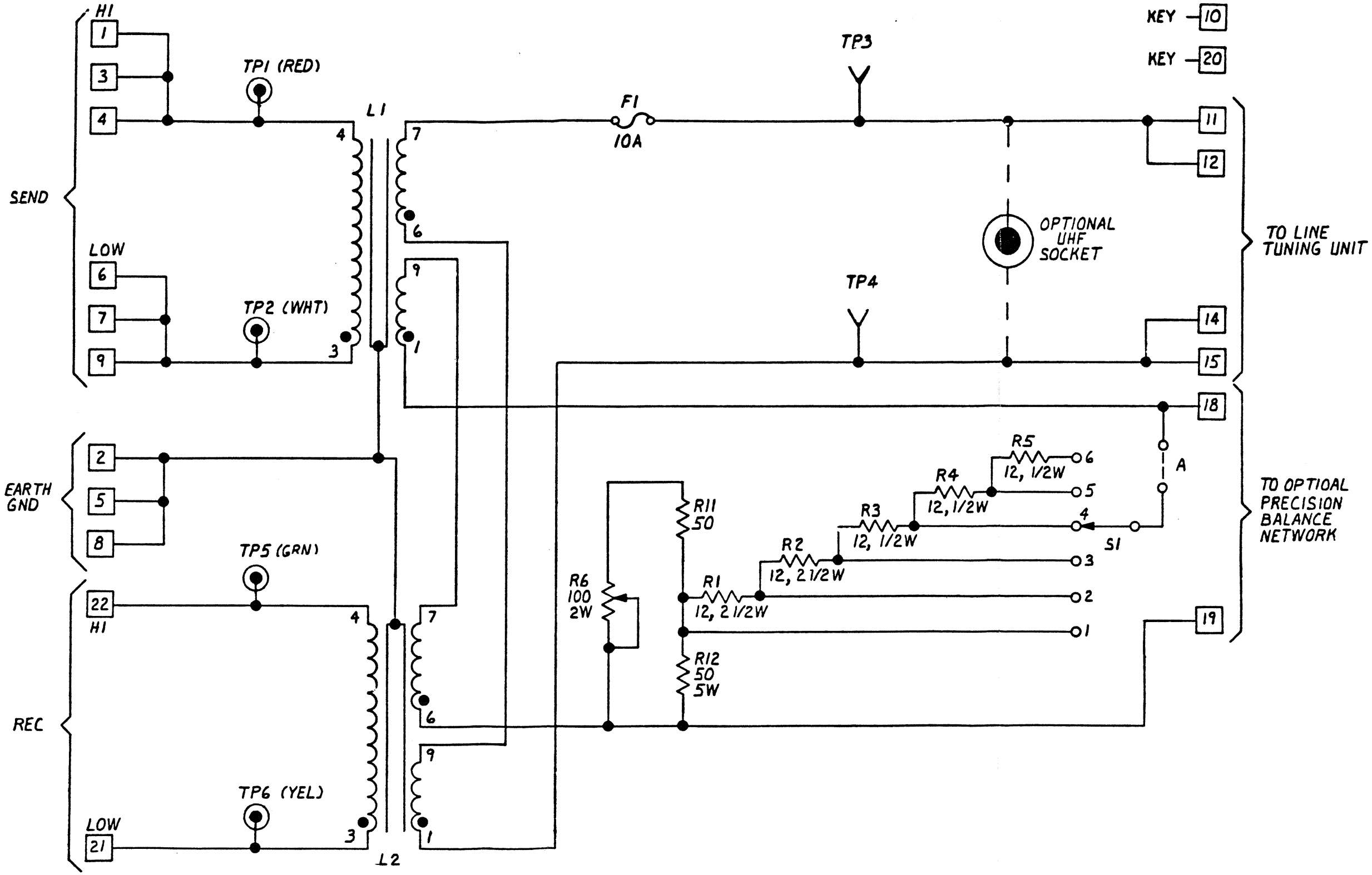



Figure 10.5. Schematic- Model 67 PLC SK HYB
10-7 (10-8 blank)

# Section 11
# ACCESSORY EQUIPMENT

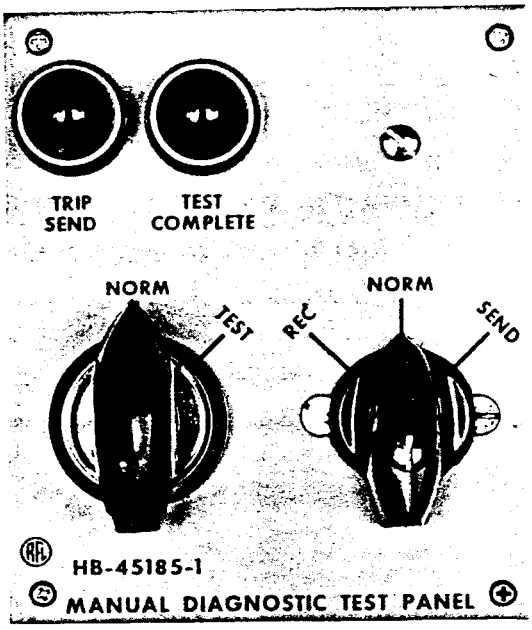
## OTHER MODULES
### DESCRIPTION

Supplementing the basic modules which comprise all Series 6780 Systems described in the foregoing part of this manual, is a group of modules used to perform useful auxiliary functions. When these are used in a system, data describing their operation and maintenance will be included, following this page, in the manual prepared specifically for that system. A list and brief description of modules current at the time of writing follows. Others may be added from time to time. In all cases, detailed information is available; consult factory applications engineer for further information.

### Manual Diagnostics (67 MAN DIAG)

This diagnostic component affords continuity testing of the system, namely the transmitter, communication system, and receiver (but not the trip relay). The unit mounts internally in the basic system chassis. Indicator lamps, a send-receive test switch (spring return to send), and a key-lock switch for normal-test permit the operator to check out the system without tripping the associated breakers.

**Universal Interface Assembly Model 67 UNIV:** Nearly every installation of the Series 6710 equipment has a requirement for one or more auxiliary circuits needed to fit it into the system with which it is to be used. To implement this need, the Model 67 UNIV has been designed as a support for accommodating a wide variety of auxiliary circuits often used to support the Series 6780.




While installations differ in detail, it has been possible to conceive several such auxiliary circuits, to standardize them, and to provide for mounting them as an integral part of the equipment by using the Model 67 UNIV. These include:

**Model HB-90120 Seal-In** is an SCR-controlled latch circuit which will hold a relay energized after an initiating pulse has disappeared.

**Model HB-90130 Mercury Relay and Driver** drives a relay with a single set of Form-C mercury-wetted contacts in response to either a logic one or a logic zero as the initiating signal.

**Model HB-90135 Lockout Relay** is an assembly in which a spring-type relay, whose contacts serve as an output signal, is controlled by a silicon-controlled rectifier which, in turn, is controlled either locally or remotely.

**Model HB-90140 AND Driver** uses a two-input AND gate to drive an open-collector PNP output transistor capable of pulling 100 mA.

**Model HB-90145 One-Shot Timer** provides a buffer and driver for operating a totalizing counter with an open-collector transistor.

**Model HB-90150 Mercury Relay** is a relay with a single set of Form-C mercury-wetted contacts.

**Model HB-90160 Relay DPDT** is a relay, mounted on a plug-on card, with two sets of Form-C contacts.

**Model HB-90165 Delay Timer** is a Schmitt-trigger timer designed to require that the input be at a logic high for at least 100 ms before the output will go high. Provision for override is available.

**Model HB-90170 Opto-Isolator** provides for electrical isolation between two circuits. It is frequently used as a keying circuit.

**Model HB-90175 Hold Timer** is a Schmitt-trigger which holds its output at a logic high for at least 100 ms after its input goes low. Provision for an override is available.

**Model HB-90185 Trip Seal-In** provides for holding a received trip signal and sustains its own trip-output signal even though the carrier for a valid trip signal may subsequently fail. Return of guard signal will reset, or clear, the circuit.

# Errata Sheet
# RFL Model 6780 Instruction Manual

The following information is provided to update the Model 6780 Instruction Manual dated October, 1989.

## 67 PLC logic Module:

The 67 PLC logic module has been modified to provide two jumper selectable time intervals for the pre-trip timer. The pre-trip timer provides significant protection against potential false outputs that may be generated during periods of poor signal or high noise conditions.

Jumper position "J" provides the normal channel times of 12 ms, 7 ms, and 5 ms, for frequency shifts of 100 Hz, 250 Hz, and 500 Hz respectively.

Jumper position "K" provides the option of adding an additional 8 ms delay to these normal channel times. Jumper position "K" should be used when system security is solely dependent upon the powerline carrier equipment, as would be the case in a single channel direct transfer trip application.

The new module can be identified by the presence of the J/K jumper and is pin for pin compatible with previous versions of the 67 PLC logic module. A revised schematic, drawing number 95539 revision K, has been provided in section 6 of this manual.

FINAL TEST PROCEDURE

APRIL 1994

FT-024 A

6780 SYSTEM ALIGNMENT PROCEDURE

A INITIAL ISSUE

## 1.0 TRANSMITTER SECTION

1.1 Connect appropriate station battery voltage to power in terminals. Check all modules for proper strapping per chart on drawing. Remove TX module.

1.2 With 67 PLC PWR AMP on extender card turn on 67 PLC PWR supply. Check output voltages on front panel test points. Adjust bias currents on 67 PLC PWR AMP. With TX removed, allow approximately 10 minutes warmup of PWR AMP. Use ungrounded meter.

Adjust R14 for .3 Vdc ±.025 at TP4 (yellow) to TP3 (brown).
Adjust R27 for .3 Vdc ±.025 at T87 (orange) to TP8 (green).
Reinsert PWR AMP.

1.3 Place 67 PLC Trans on Extender Card. Ensure that crystals are the proper frequency and in the correct position. Check divider strap. Adjust C3 on Osc. board for proper output frequency. TP3 (yellow) to TP4 (green) for both Osc. boards. The variable cap. should not be fully closed or open. Frequency total is ±2 Hz. C4 can be changed if frequency cannot be obtained.

1.4 (This step requires that the input card be strapped for a transmitter power level of 1 watt. This power level may or may not be available from the transmitter as per sales order. Placing straps "A" and "K" in place on input card will yield the 1 watt setting. Note where straps are before relocating them if they are not there already.) Check LOW TRANSMIT level alarm on 67 PLC PWR AMP by lowering output until ALARM relay (accessible on ITB4) de-energizes. Raise level until relay energizes. This should presently take place between 3 Vrms and 6 Vrms on the 67 PWR AMP out. Modification of this level may be made with R30. Return strapping and levels to normal.

1.4.1 If skewed hybrid is used, it should be nulled after output level is established. Monitor receive T.P. and null using balance adjustments. 40 dB min.

1.5 Observe ouput 67 PWR AMP. Set system up for proper power out and adjust R15 (Level Adj.) on TRANS card if necessary. If system has several power options (that is, 1W - 3W - 10W) activate the proper inputs and check for proper levels. Adjust system for stated maximum power output. The lower levels should be correct to ±1.5 dB. Briefly check the 67 PLC TRANS card, TP3 (yellow) and TP4 (green) to ensure the driver is not limited or saturated.

| | |
|---|---|
| 1W | 7.07 Vrms |
| 3W | 12.25 Vrms |
| 10W | 22.36 Vrms |

## 2.0 RECEIVER

2.1 The nominal system receive level is 27 mVrms measured at TP2 on the IF/BF. This level is adjusted by strapping and R7 on the REC FLT. Strap filter for proper operation during test. Strap F should be installed if skewed hybrid is used, loads rec. hybrid output. If more than one receiver is connected to the hybrid, only one receiver is to be strapped F. Note: Adjustment of IF/BF input and output must be done with board in chassis because of level changes. Selective voltmeter is required to adjust output.

2.2 67 PLC IF/BF. Check crystals and strapping are per sales order. With IF/BF on card extender, adjust C103 for channel frequency +24 kHz at TP3 (±2 Hz). Check 28 kHz frequency at TP11 (±2 Hz).

2.2.1 Adjusting carrier nulls, use selective voltmeter if available; if not, crystals must be pulled.

2.2.1.1 Observe TP5 and adjust R9 for null. Y1 must be pulled if S.V. not used; replace.

2.2.1.2 Observe TP4 and adjust R28 for a null. Y101 must be pulled if S.V. not used; replace.

2.2.1.3 Replace IF/BF, with input set to 27 mV. Adjust R4 for 20 mVrms at TP4.

2.3 With DISC/CLI card on extender, adjust R73 for 1.0 Vdc ±0.5 Vdc at TP5 (yellow). Adjust R30 ("NOM") for a nominal (0 dB) reading on meter. Vary the input ±10 dB and observe the meter to read ±2 dB at these extremes.

2.3.1 Check TP3 for 1 Vrms ±150 mV.

2.3.2 Adjust R58 for carrier low level detect drop out of 15 dB. The carrier LO LEV LED should just come on at this level. Reset levels to nominal.

2.4 67 PLC LM/SL

2.4.1 For Trip-DN, use invert Strap B.
For Trip-UP, use normal Strap A.

2.4.2 With card on extender, adjust the slicing levels as follows:

2.4.2.1 When activating TRIP/GUARD, the change in frequency should produce a 16 volt peak-to-peak change in voltage at TP2 (brown). Adjust pot R29 to obtain this. Center this to be -8 Vdc to +8 Vdc, ±0.5 Vdc with pot R25.

Apply +12 Vdc to Pin M (stop alarm input).
Trig. IC17 Pin 4
Read IC17 Pin 6
Apply +12, Trig ; Read 300 ms
Remove +12, Trig ; Read 300 ms

2.5.7 Total tripping time.
Trig. bottom of R14 (or R7) on TX input card.
Read Pin E of Logic Card. 12 ms BW 200
TX to trip. 7 ms BW 500

2.6 See description of 67 PLC VOICE option card. If this is used, align as follows: (The AGC switch should be in the test position.)

2.6.1 Apply 600 ohm oscillator with 300 ohm resistor across it to input terminal Pin 16 and ground. This enables the modulator on the 67 PLC TRANS card if the 67 PLC INPUT card is strapped appropriately. Set the input voltage to 0.3 Vrms at 1 kHz. This should produce a sine wave that is just clipping at TP8.

Check to see that with the 300 ohm resistor applied, but the audio signal at zero or off, the power output is 12.5 Vrms ±1.5 dB (3 watts).

| |
|---|
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| |

3 watt carrier, no audio = 6 units ±0.25 unit.

2.6.2 With audio signal applied, adjust R63 on 67 VOICE card for the approximate output waveform as shown below.

2.6.3 Remove 300 ohm resistor and audio tone. Apply 12 Vdc to call button input terminals to activate the call tone. Observe the amplifier output for a similar waveform, however, the modulating frequency will be 1800 Hz ±15 Hz. Measure this frequency at TP5 (brown).

2.6.4 Activate the remote call signal and observe TP6 (yellow). Adjust R71 for 0.8 Vrms. While sending remote call, observe TP7 (blue) for 4 Vrms ±2 dB.

2.6.5 Observe TP2 (green) and adjust R7 for 1 Vrms. Set switch to NORM and note (after several seconds) that TP2 returns to 1 Vrms ±2 dB.

## ADDENDEUM TO 6780

6780 FSK and AM TX additional testing. Testing 80 watt systems using two 6515 40 watt units or a single 40 watt system with one amp., utilizing a 65 pre-amp to drive 40 watt amps.

### 6780 FSK

The 6780 PLC TX must be modified to a -13. This will allow the TX to be adjusted to 27 mV on the output pin, not the test points. Because the maximum volt to the 65 pre-amp must be limited to 27 mV, this voltage must be set with the 6780 FSK in the 10 watt mode. When aligning a dual TX system, both TX's will be on line together and you will need to use the selective voltmeter to adjust the 27 mV. Both TX's must be left in to maintain loading on 65 pre-amp.

### 6785 AM

The 6780 PLC TX must be modified to a -10. This will allow the TX to be adjusted to 27 mV on the output pin, not the test points. The maximum voltage to the 65 pre-amp must be limited to 27 mV; this voltage must be set with the 6780 AM carrier on. When adjusting on line power to 80 watts (63 Vac), adjust the reserve signal to 8 watts (20 Vac). When testing a two amp, 80 watt system, both amps must produce equal power. Shutting off one amp will reduce output power by 3 dB. The outputs of the amps are in

parallel and are at 25 ohm. The power filter is a 25 ohm to 25 ohm impedance and a transformer is provided for the 50 ohm output.

After adjusting level into Pre-amp look on load and adjust for proper power output using pot on Pre-amp.

2.4.2.2 Set level at TP6 for +4 Vdc ±0.1 Vdc with pot R33. Set level at TP5 for -4 Vdc ±0.1 Vdc with pot R38.

2.4.3 Observe DS1 to light for TRIP and DS2 to light for GUARD.

2.5 67 PLC LOGIC. Place on card extender; check strapping. Signal envelope input pin 16 should be 1.00 Vdc ±.15 nominal. Trip and guard outputs should be checked if not driving an output source.

2.5.1 Pre-trip timer. Trig on IC1 Pin 2. Read timer top side of R9. In guard go to trip app. 6 ms.

2.5.1.2 Remove E-F strap and repeat timer will become extended pre-trip timer.

2.5.2 Pre-guard timer. Trig. IC1 Pin 15. Read timer rear of R40 (below IC 17). Place C-D jumper in C for test. In trip go to guard app. 4 ms.

2.5.3 Guard before trip/trip after guard. Remove LM/SL; apply +12 to Pin 9 (switch). Trig on IC17 Pin 2. Read IC17 pin 13. Jumper +12 to Pin T.

T/G remove +12, Trig.; ; Read 100 ms

G/T apply +12, Trig.; ; Read 100 ms

Functional:
Receiving guard, monitor trip out, remove TX from line. Set TX to trip, restore TX to line. Receive end should not go to trip with A strap in on logic card. Put B strap in. Repeat above test. Logic will go to trip.
Note: To remove TX, short tone line on RX end. Turning off T causes a problem.

2.5.4 Bipolar noise det:
Connect Pin 7 to +12 Vdc (set BPN DET F-F)
Connect Pin 9 to +12 Vdc with switch
Jumper +12 to Pin T.
Trig. on IC 13 Pin 3.
Read front side R27
Apply +12 to Pin 9; app. 30 ms
Reinsert LM/SL card.

2.5.5 Pulse stretcher:
Apply +12 Vdc to Pin 13.
Trig. IC12 Pin 2.
Read top of R72.
In guard; remove +12; app. 30 ms.

2.5.6 Alarm timer. Remove TX signal (logic in alarm).