Tones & Telemetry

Application Guide

Data Communications
Analog Telemetering
Supervisory Control
Control Systems

Printed in the U.S.A.
May 1993

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Chapter 1. INTRODUCTION

Purpose and Scope

This Application Guide is designed to impart the basic fundamentals and considerations to allow technicians and other knowledgeable personnel to design industrial control, telemetry, and information systems using RFL's modular building blocks. Among the considerations to be covered will be choice of modulation, communication media, multiplexing, security, speed, accuracy, dependability, size, and power sources. The information given should be sufficient for the reader to design most system types; however, it would be advantageous to remember that RFL Electronics Inc. maintains a staff of system engineers that will check your design and answer any questions you may have. They can be reached by calling the main plant; the telephone number is (201) 334-3100.

The scope of this Application Guide will include only information required to design the control/telemetry communication system. It will not include theory or circuit information concerning the internal working of the individual products (modules). These products will be treated like black boxes, with only the inputs and outputs of interest. Further information on the internal theory of these products can be found in the individual Instruction Data sheets.

Information on maintenance, except for general considerations as applicable to system design, will not be considered in this Application Guide.

This Application Guide is intended to show that with some imagination and intelligent application of fundamentals, many control/telemetry problems can be solved by using the broad scope of products described here.

Elements of Remote Systems

In a general sense, there are only four elements of remote control systems: control signals, status signals, telemetry signals, and set point signals. (See Figure1.)

Control Signals are used to remotely actuate various devices. There are two types. One is a momentary signal, designed to operate controllers that will latch up to keep the device actuated. With this type, two signals are required: one to latch the controller, the other to unlatch it. The other type is non-momentary, in which the signal is maintained in one position for "ON" and in the other for "OFF".

Note that in either type, these signals have two discrete states. Also, control signals are almost always sent from the master (manned) station to the remote (unmanned) station.

Another concern in control is the security required; that is, consideration of the problems created if a control is actuated improperly. All communications are subject to adverse conditions, and these may affect the transmission of signals. There is some degree of security built into all control methods discussed here, but some systems may require ultra-secure communications because the consequences of misoperation are so great. All degrees of

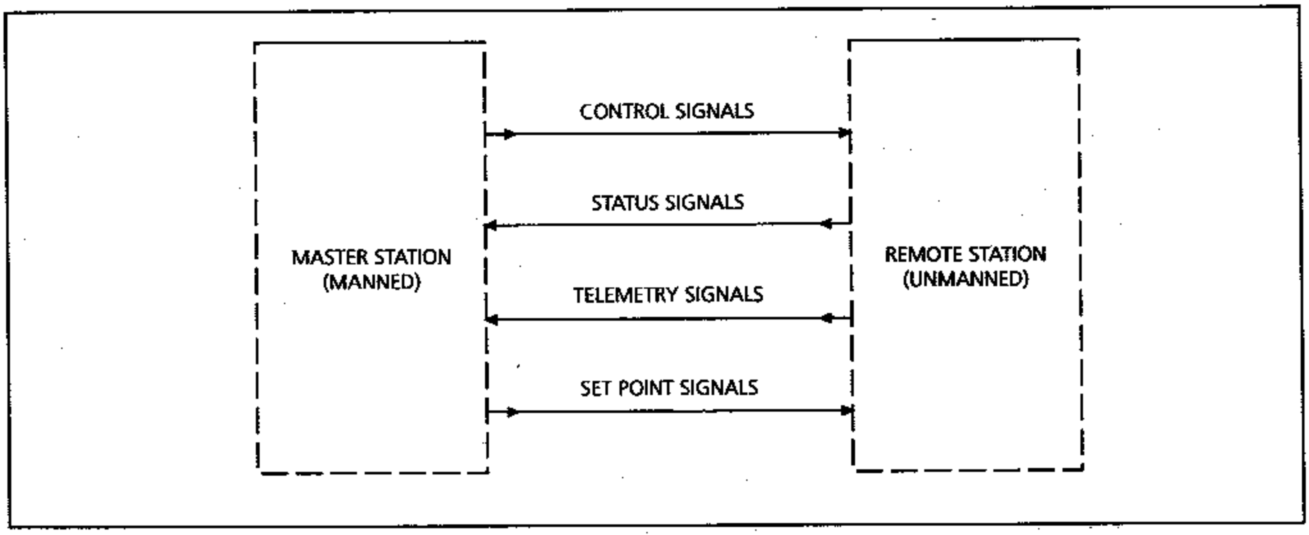


Figure 1. Normal direction of signal flow between Master and Remote stations

security are possible with the products discussed later, but there are trade-offs in many cases to the master.

Status Signals are used to report conditions as they exist at a remote station. The condition may be one that was changed by a control signal (in which case, the status change is used as a verification), or it may be some other condition that is not under control.

Status signals have two discrete states (on/off; open/close, etc). They are almost always sent from the remote station to the master.

In the design of a system, it is important that status signals be derived so as to be most meaningful to the operator. For instance, status information on whether a pump is running should be taken from a transducer on the pressure side of the pump, and not from a control signal used to start the pump.

Telemetry Signals are used to report gradually changing measurements, generally from the remote station to the master. The scale limits are usually thought of as zero to 100-percent of scale, but the parameters represented may be of any type (watts, VARs, voltage, pressure, water flow, etc). What is important is that the communication system transmits the signals on a linear and stable basis. How well it does this is described as accuracy. Unlike control or status signals, telemetry signals gradually change between two limits, and some telemetry signals may have negative values.

Set Point Signals are used to transmit scale percentage for control purposes. For example, it may be necessary to control a valve to be 50-percent open, 25-percent open, or some other degree of open. Set point signals are similar to telemetry signals, but are sent from the master to the remote. This form of control is not used very often, but no primer on control/telemetry systems is complete without mentioning it.

It should be mentioned at this point that this Application Guide only describes the communication system for modulating, demodulating, and sending the required signals between stations. The actual controlling, controlled, telemetry, and transducer devices are not within the scope of this manual. (See Figure 2.)

Early Methods

Early methods of remote control used dc currents, physical wire pairs, and hydraulics to perform the functions of control and telemetry. Hydraulics severely limited the distances between stations, and was almost always used on an intra-plant basis.

Dc signals on physical wire pairs were somewhat better suited than hydraulics for information transfer over distances, but were still severely limited by the resistance and capacitance of the cable. The resistance caused voltage drops and the capacitance tended to deteriorate and distort the dc pulses that were used to convey the information. Voltages in

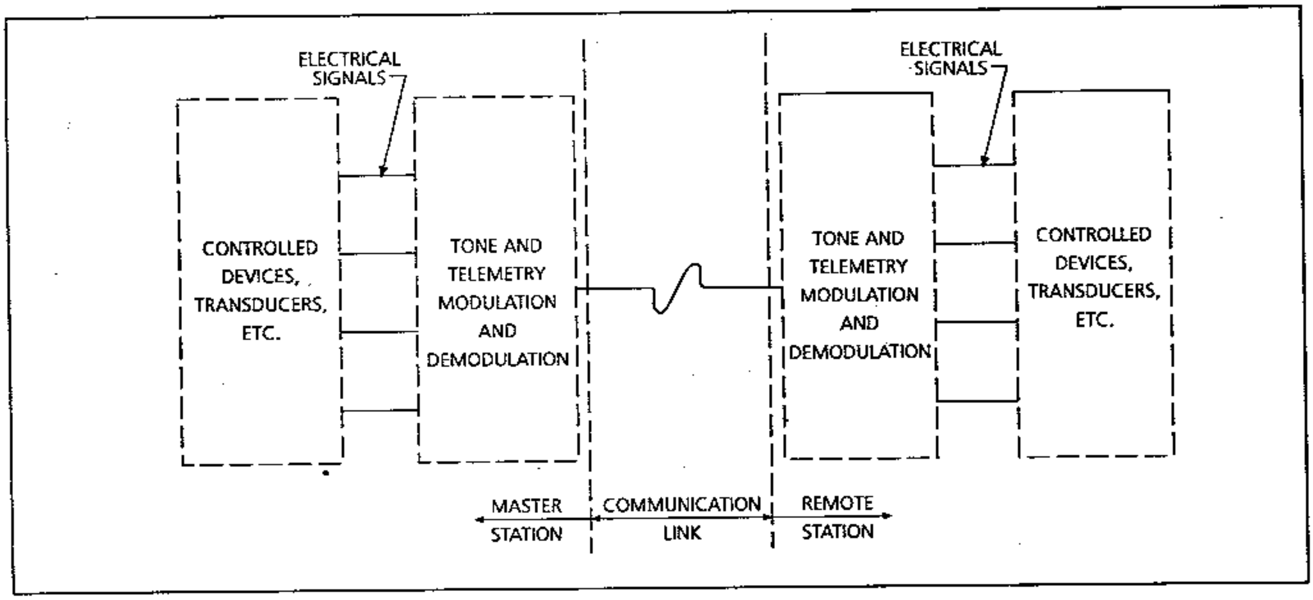


Figure 2. Relationship between basic operating system and communication system

excess of 250 Vdc and frequent and complex repeating were required to help overcome these problems.

In addition, most system operators did not have rights-of-way to be able to operate off their properties. So many systems depended upon dc lines leased from the local telephone companies to be used for transmission. As demand for telephone service grew, the telephone companies switched from physical trunk lines (connections between central offices) to carrier-derived trunks. Because of this, dc lines became unavailable over any but very short distances. Also, use of a single pair for each function resulted in very high lease charges for larger systems.

For these reasons, multiplexing (deriving more than one signal over a circuit) and modulation (using a carrier for the information transfer) were developed. Multiplexing greatly reduced the number of circuits required for a specific system. Modulation on a carrier greatly reduced the deterioration over communication circuits. Modulation on audio carriers allowed transmission over the carrier trunk circuits that the telephone companies were switching to, and also allowed easier repeating by audio repeating equipment.

This is how the current methods of data transmission have developed. The next chapter will describe these advancements in detail.

Chapter 2. FUNDAMENTALS

Multiplexing

Webster defines "multiplex" as "relating to a system of transmitting several messages simultaneously on the same circuit or channel". This is a good start for a definition, but it should be extended to specify that each signal should be individually identifiable at the receiving terminals and be relatively free of noticeable interference or distortion caused by other signals sharing the same link. An important advantage of multiplexing is that the cost of a communication link can be amortized over all the data signals that are multiplexed over the link.

There are two commonly used forms of multiplexing in industrial communication systems: Frequency Division Multiplexing and Time Division Multiplexing.

Frequency Division Multiplexing (FDM) is the division of a typical wideband communication link into smaller, narrower channels. For the purposes of this Application Guide, it is generally the division of a 300- to 3400-Hz voice channel into narrower channels by means of filters. (See Figure 3.) The filters keep the individual channels from interfering with one another.

The bandwidth of these narrower channels determines the speed of the signal that can be sent over them. The sub-multiplex channels are offered in a number of different bandwidths, depending on the application. The number of sub-multiplex channels that can be derived from a wideband communication link depends on the bandwidth of the link and the widths of the sub-multiplex channels. (See Figure 4.) As a practical matter, the spacings of sub-multiplex is twice the bandwidth to allow the filters to provide sufficient rejection of the adjacent channels. Also, the narrowest practical bandwidth is 50 Hz.

Time Division Multiplexing (TDM) separates each input signal in time. Each input signal is sampled for a short period; then the samples from all the signals are arranged in sequence and transmitted. The process is repeated continuously to update the information.

At the receiving terminal, the signals are synchronously directed to their proper and respective designations, where a memory device for each signal retains the information received, for display or action, until updated by a subsequent scan. (See Figure 5.)

TDM signals are dc pulse trains, and would be subject to deterioration. (See Chapter 1.) Because of this, they are usually transmitted over an FDM channel. By using TDM on a number of FDM carriers, a large amount of information can be carried simultaneously (multiplexed) on a single voice-frequency channel. The RFL 68P TX and 68P RX can be used for this purpose.

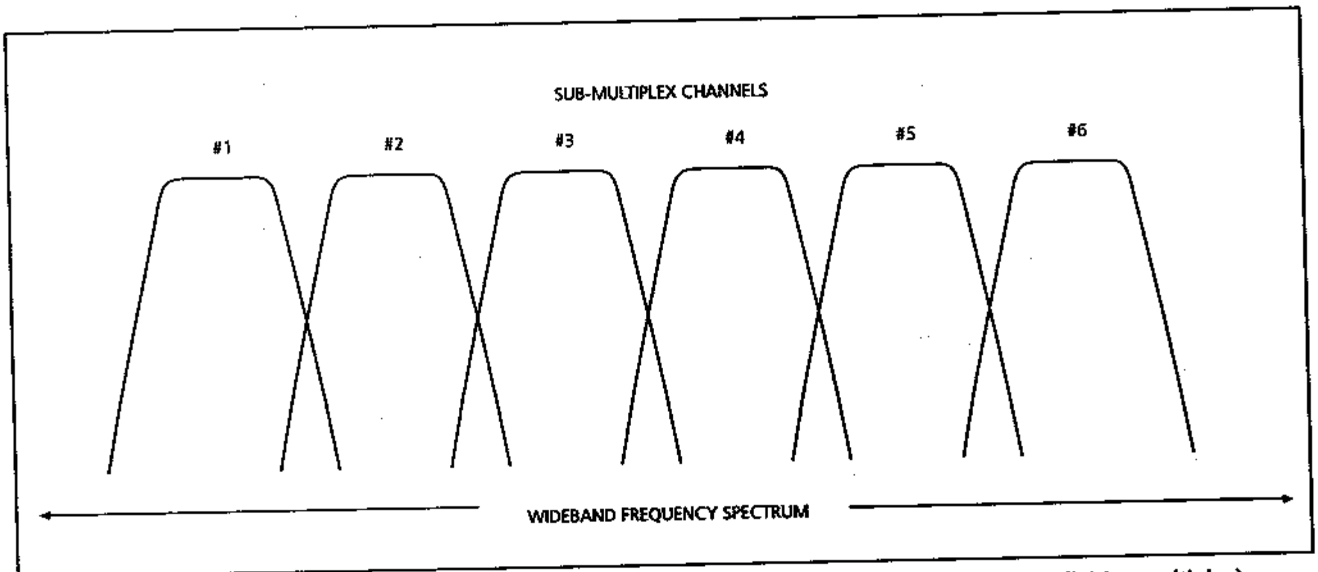


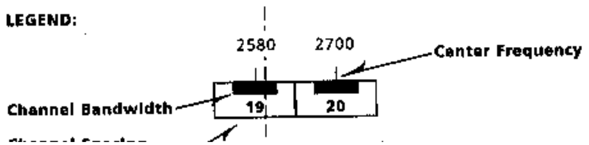
Figure 3. Diagram showing division of wideband frequency spectrum into narrower channels (frequecy division multiplex)

NOMINAL DATA RATE (BAUD)	NO. OF CHANNELS	CHANNEL SPACING & FREQ. SHIFT (Hz)	APPLICATION	UNCONDITIONED LINE — Channel center frequencies (Hz)
50	27	100 ±25	STATUS AND CONTROL	1: 365, 2: 465, 3: 565, 4: 665, 5: 765, 6: 865, 7: 965, 8: 1075, 9: 1175, 10: 1275, 11: 1375, 12: 1475, 13: 1575, 14: 1675, 15: 1775, 16: 1875, 17: 2000, 18: 2100, 19: 2200, 20: 2300, 21: 2400, 22: 2500, 23: 2600, 24: 2700, 25: 2800, 26: 2900, 27: 3000
60	24	120 ±30	CONTROL, STATUS, AND TELEGRAPH CCITT R35	1: 420, 2: 540, 3: 660, 4: 780, 5: 900, 6: 1020, 7: 1140, 8: 1260, 9: 1380, 10: 1500, 11: 1620, 12: 1740, 13: 1860, 14: 1980, 15: 2100, 16: 2220, 17: 2340, 18: 2460, 19: 2580, 20: 2700, 21: 2820, 22: 2940, 23: 3060, 24: 3180
85	18	170 ± 42.5 OR ±35	CONTROL AND TELEGRAPH 43A1/43B1	1: 425, 2: 595, 3: 765, 4: 935, 5: 1105, 6: 1275, 7: 1445, 8: 1615, 9: 1785, 10: 1955, 11: 2125, 12: 2295, 13: 2465, 14: 2635, 15: 2805, 16: 2975, 17: 3145, 18: 3315
120	12	240 ±60	TELEGRAPH/ DATA CCITT R.37	1: 480, 2: 720, 3: 960, 4: 1200, 5: 1440, 6: 1680, 7: 1920, 8: 2160, 9: 2400, 10: 2640, 11: 2880, 12: 3120
240	6	480 ±120	TELEGRAPH/ DATA CCITT R.38A (2F ONLY)	1: 600, 2: 1080, 3: 1560, 4: 2040, 5: 2520, 6: 3000
300	4	600 ±150	LOW SPEED DATA (2F ONLY)	1: 900, 2: 1500, 3: 2100, 4: 2700
600	2	1200 ±300	MEDIUM SPEED DATA (2F ONLY)	1: 1200, 2: 2400

C1 C2 C4

68 LPF 60-dB Point (Hz):	1944	2160	2376	2592	2808	8% Guard Band
68 LPF Nominal 3-dB Cutoff Freq (Hz):	1800	2000	2200	2400	2600	

LEGEND:



NOTE: For speech-plus-data applications, data channels may be located above the 60-dB cutoff point of the lowpass filter, so long as the channel's entire bandwidth (channel spacing) is above that point. In example at left, Channels 20 is permitted, whereas Chanel 19 is prohibited, even though it lies, in part, beyond the 60-dB point.

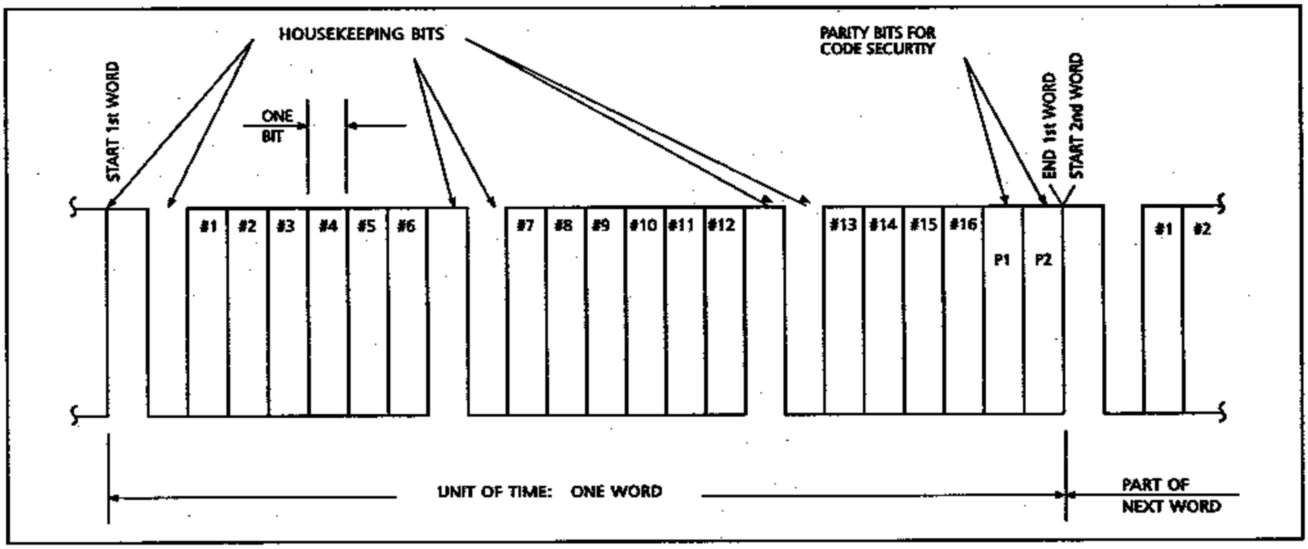


Figure 5. Division of a time unit into sixteen smaller units to transmit two discrete state messages (time division multiplex)

Systems of Modulation

In frequency division multiplexing, modulated carrier signals are used to transmit the information on a communication link. When designing such a system, one of the first decisions is the choice of the mode of modulation to be used. Because of this, it is helpful to know the capabilities and limitations of the types available. The choice often depends upon the transmission medium used, the bit rate required, the level of security against noise, distortion, and other sources of error in the transmission medium, the size of the system, and the amount of information to be transmitted.

Amplitude Modulation (AM) data signals usually modulate a carrier between ON and OFF, as shown in Figure 6. This provides the optimum performance for this type modulation. With AM, the link attenuation (whichis sometimes sporadically variable), transmission echoes, noise peaks, and crosstalk may distort the receiver's output signal.

Although a properly adjusted AM channel can operate creditably in most applications, it is sensitive to level variations on the communication link. Since this is a characteristic that is not always easy to control, the AM channel may be subject to high distortion. Another drawback peculiar to an AM channel is that when the carrier is off, the channel is not self-monitoring. That is, without carrier present, it is not possible to tell if the channel is operating. To a great extent, the previous cost advantages of AM channels have been eliminated by newer circuit technologies.

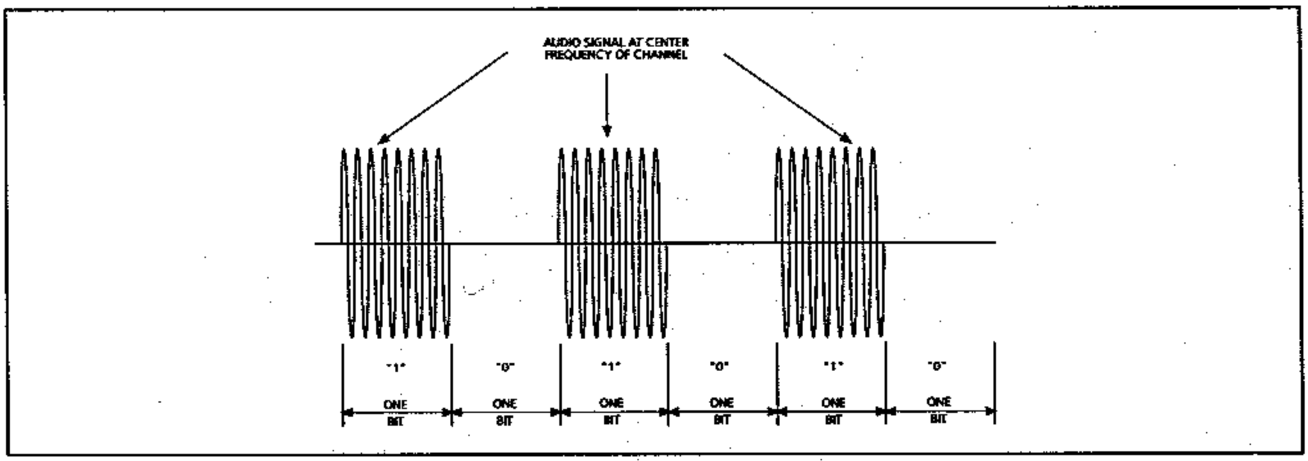


Figure 6. Amplitude modulation channel; succesive bits of ones and zeroes

Despite the disadvantages, AM channels are used for signaling non-critical control functions and telemetry. Here, intelligence is applied in the form of a switch closure or a voltage input. The receiver responds to the AM signal and creates an output which may be a voltage, a current, or a relay contact closure. The duration of the output is dictated entirely by the duration of the input signal.

As compared to channels where a carrier is transmitted continuously, AM channels can be used economically in applications where more than one transmitter must control a single receiver. Continuous carrier channels must use a receiver for each transmitter and combine their outputs with an OR circuit.

Frequency Modulation (FM) is more commonly known in data transmission as "frequency-shift keying", or "FSK". FSK uses two discrete frequencies within the passband of the channel for transmitting the two stable binary states. (See Figure 7.) Full carrier modulation is used during both states of the transmission, and this accounts for the general insensitivity of FSK to noise, inter-modulation, and crosstalk. Because the carrier is always present, the S/N ratio is constant over large changes in transmission media levels, and the receiver output signal is relatively free of distortion over these conditions. FSK modulation is sensitive to frequency distortion (shift) that can occur in certain transmission media. In modern communications systems, however, frequency distortion in the transmission line is not hard to control, so this is not generally a serious problem.

The idle (unkeyed) condition of an FSK transmitter is generally referred to as SPACE (or low) frequency. Application of an input signal causes the output frequency to shift to MARK (or high) frequency. The state of an FSK receiver's output reflects the state of the transmitter with which it is associated. The FSK receiver has a discrete output circuit controlled by the frequency of the input. Normally, for an idle (unkeyed) state of the transmitter input, the receiver output will be in an idle (or SPACE) state. Similarly, the keyed input state of the transmitter would cause a keyed (or MARK) output state of the receiver. For special applications, however, the normal conditions given above can be reversed by proper programming of the channel.

Since carrier is normally present in an FSK channel, a circuit that monitors the presence of carrier is included in the receiver. The output of this circuit can be used for an alarm, since the absence of carrier could indicate a failure of the transmission link or the FSK transmitter. The carrier detector circuit can also be used to force the receiver output into the SPACE or MARK condition in case of carrier failure. The choice is programmable and would depend upon the system requirements.

Three Frequency-Shift Keyed (3FSK) is a special form of FSK. In 3FSK, the transmitter at an idle, or unkeyed, condition is in center frequency. There are two inputs; one would key the TX into MARK; the other would key the TX into SPACE.. This means that this type of channel has three discrete states: MARK, center, and SPACE. Since only one condition can

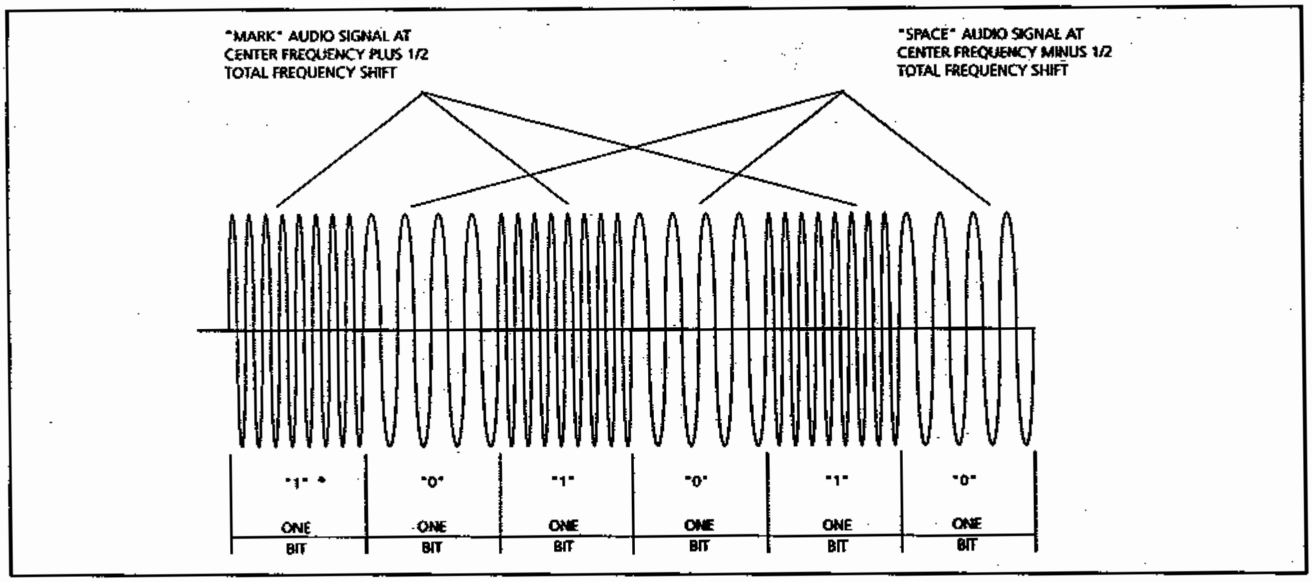


Figure 7. Alternate ones and zeroes modulated onto a two-frequency FSK channel

exist at a time, the three conditions must be mutually exclusive. This channel is very well suited to control signals (such as raise/off/lower), or status signals (such as high/no/low alarm), where only one condition can logically occur at any one time.

The 3FSK receiver has two output circuits: one for the MARK output and one for the SPACE output. The Off condition results if neither output is energized.

The RFL 9850 TX/RX is a programmable transmitter and receiver built on a single module; it can also operate as an AM, FSK, or 3FSK channel. It is particularly well-suited for applications where there is two-way communications between stations, such as in data transfer. Because of their programmability and versatility, only a single spare unit is required for a system.

The RFL 68P TX and RFL 68P RX are a separate transmitter and receiver that can be programmed by the user to operate as AM, FSK, or 3FSK channels. The units can also be programmed by the user to any standard or non-standard channel frequency and standard bandwidths within the unit frequency range. With these units in a system, only one TX module and one RX module are enough to spare all the TX and RX modules in the system, regardless of channel frequency or operating mode.

The RFL 9850 TX/RX is part of the 9800 Series, and uses the RFL 98 CHAS as the basic chassis. The RFL 68P TX and RFL 68P RX are part of the 6000 Series, and use the RFL 68 CHAS as the basic chassis. Each series has its own power supplies, and are not mechanically compatible with each other.

TELEMETRY

A telemetry system converts a continuously varying analog measurement to a form suitable for transmission over a communication system without serious degradation. At the receiving terminal, the received data is converted back to the same or representative value of the original data. This output can be used to operate an indicating instrument (such as a meter), a recording device, or may be further converted for entry into a computer. Systems for converting the analog data to a form suitable for transmission are further classified as analog or digital.

In **analog telemetry**, the transmitted signal is proportional to the measured variable and can assume an infinite number of values. As noted above, it can be reconstructed once again in a form the same as or representative of the original variable.

In early analog telemetry, the ratio between the width of a pulse and the total span time was used to transmit a particular value. This was called "pulse duration telemetry" and was characterized by slow speed. It typically took between 5 and 15 seconds to transmit a full-scale change. (See Figure 8.)

Modern analog telemetry channels are of the frequency type; that is, the value to be transmitted is converted to a proportional frequency that falls between two other frequencies that set the range limits (called "span") of the channel. (See Figure 9.) The 10- to 30-Hz band and the 5-to 25-Hz band are two commonly-used frequency ranges. The lower frequency is called "left scale"; the higher frequency

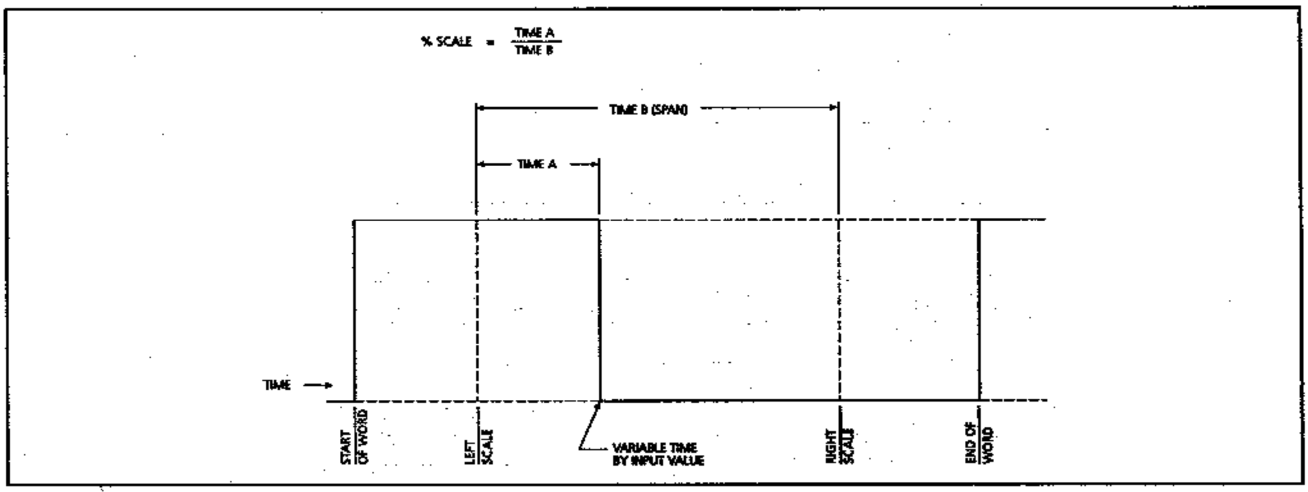


Figure 8. How pulse duration telemetry information is transmitted

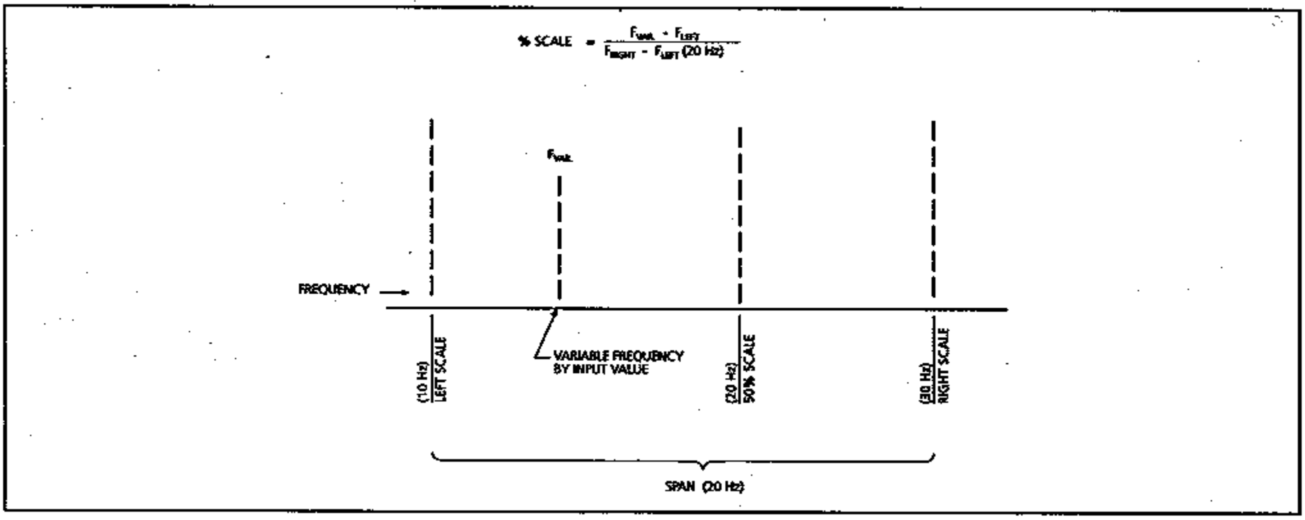


Figure 9. How analog frequency telemetry information is transmitted (using a 10- to 30-Hz frequency span)

is called "right scale." The range between the two can represent various telemetered values. The speed of the frequency-type analog telemetry is typically 0.75 to 1.25 seconds for a full-scale change, which is much faster than pulse duration.

In either type of analog telemetry, a multiplex tone channel of the kind described above is required to transmit the signal over the communication link. Use of the channel allows more than one telemetry value to be transmitted over the same link. Both types also require suitable transducers to convert the measured values to electrical form on the transmitting end, and indicating devices at the receiving end. (See Figure 10.)

The RFL 98 TMX and RFL 98 TMR in the 9800 Series are available for analog telemetry. The RFL 98 TMX is a combination telemetry transmitter and tone transmitter; the 98 TMR is a combination telemetry receiver and tone receiver. These units are completely programmable as to channel frequency, bandwidth, input/output ranges, frequency span, and other parameters.

RFL 64B TMX/TMR and RFL 64A TMX/TMR modules from the 6405 Series can also be used for analog telemetry. The RFL 64B TMX (transmitter) and RFL 64B TMR (receiver) use the 5- to 25-Hz frequency range and are designed specifically for transmission of the 4- to 20-mA, 10- to 50-mA, and 1- to 5-V values used

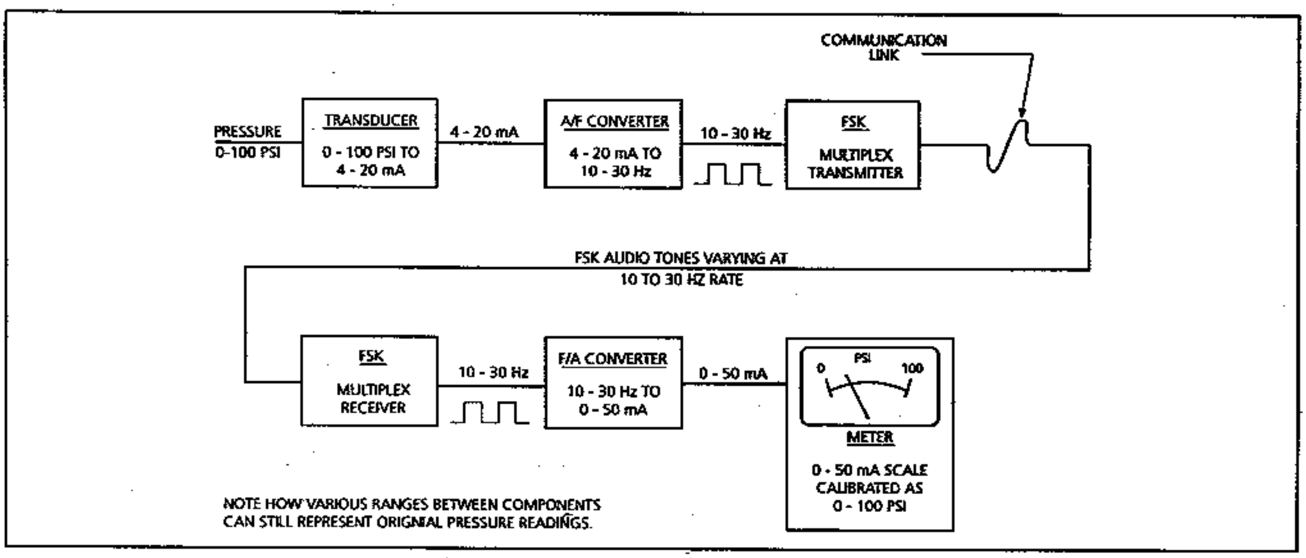


Figure 10. Typical analog telemetry system operating over telephone line

in the process control industry. The RFL 64A TMX and RFL 64 TMR are used primarily by the electric power industry. The latter units are very versatile, and can be supplied in most all value ranges. These units use 10 to 30 Hz as a standard frequency range, but can be set up to match most other manufacturer's ranges for replacement purposes. The RFL 68P TX and RFL 68P RX are suitable for use as the tone multiplex for the RFL 6405 telemetry channels.

Series 6405 and 9800 analog telemetry systems both offer calibration and signal loss circuits. A calibration circuit allows an operator to send a signal measuring 10, 50, or 90 percent of scale from the transmitter to test the accuracy of the channel at the receiver output, or for adjustment purposes. The channel must be taken out of service for this test. The signal loss circuit monitors the sub-audio receiver input and can signal a failure if no input is present.

In **Digital Telemetry** the analog input values are converted to representative digital pulses by an analog-to-digital (A/D) converter. These can be either binary (as in binary mathematics), or BCD (where four pulses are used to represent each digit). Binary coding is more efficient than BCD; it is used in most applications, unless BCD is required.

Figure 11 shows a typical digital telemetry system. In this system, the parallel pulses are converted to serial by an encoder (time multiplex) for transmission over a tone transmitter (frequency multiplex). At the receiving end, a tone receiver, decoder, and digital-to-analog (D/A) converter are used to derive an analog value representative of the input. Since the data is received as a series of samples, the D/A converter must contain an update-and-hold circuit so a steady output is obtainable between samples. Under gradually changing input conditions, the digital telemetry output is a step that changes as new samples are received. The time between updates is dependent upon the scan speeds of the encoder and decoder.

As an alternative, the decoder's digital output can be connected directly into a digital meter or a computer without the conversion back into analog. This is one instance where the BCD format would be preferred.

If there are a number of telemetry signals between two stations, further economies can be effected by sequencing these signals into the A/D converter, assigning a binary identifying code to each, and sending it all to the receiving end for decoding. (See Figure 16.) Only one A/D converter is required in this system, but a separate D/A converter with sample-and-hold circuitry is required for each analog value. The time to update each analog value now depends not only on the encoder/decoder scan rate, but also on the number of analog values to be sent.

The RFL 66A Time Multiplex system (when used with the RFL 68P TX and RFL 68P RX) offers all the modules required to perform the digital telemetry described above.

Basic Applications

At this point, it would be timely to review the basic applications and how they apply to the equipment described above. These basic applications are the building blocks of the more extensive and compli-

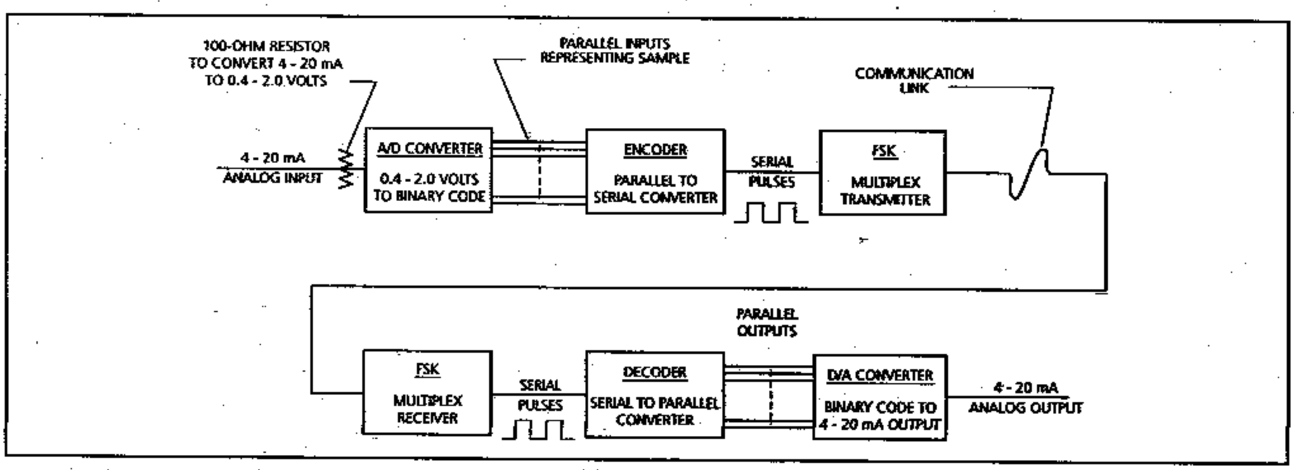


Figure 11. Typical digital telemetry system operating over telephone line

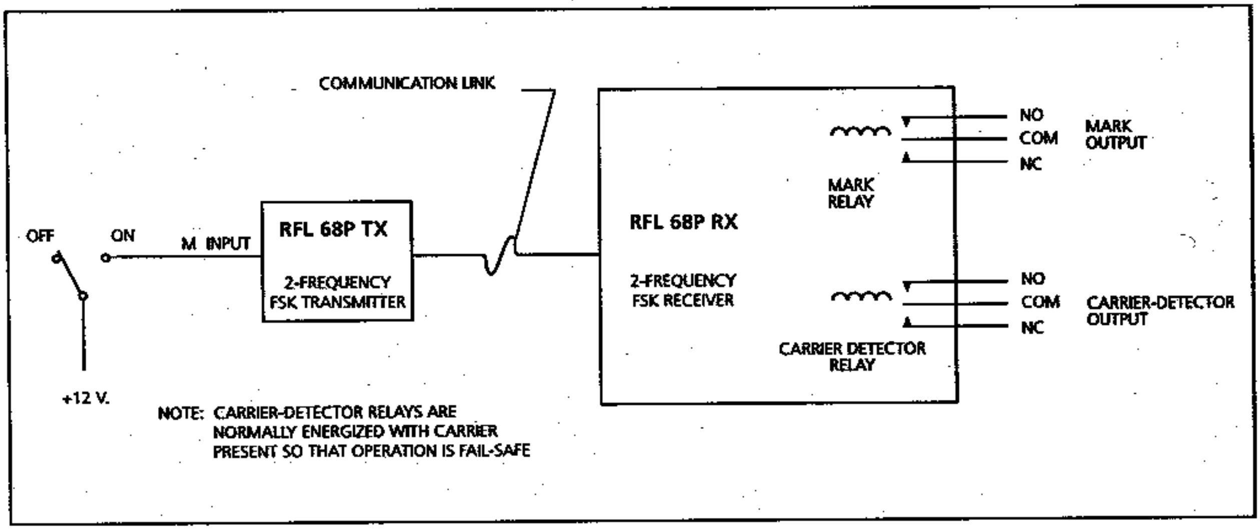


Figure 12. Remote control (or return indication) using a two-frequency (two state) FSK channel

cated systems that will be presented in Chapter 4. It is good to remember that all methods and equipment are really tools. Each system dictates the best methods and equipment to use by its configuration and requirements.

Remote control and status are easily accomplished using tone frequency division multiplexing (FSK) or time division multiplex (TDM). Each offers tradeoffs in cost, complexity, and performance.

Figure 12 shows an FSK tone channel used in a simple control or status application. The input contact can be a switch or a voltage, depending on what is available in the peripheral devices. With the switch closed (or voltage applied), the transmitter generates a MARK frequency, which is the center frequency of the channel plus one-half of the total frequency shift used. With the switch open, the output is at the SPACE frequency, defined as the center frequency minus one-half of the total frequency shift used.

The receiver responds with a voltage output or relay contact closure for the MARK, and no voltage or open contact for SPACE. A relay is an electromechanical device and, therefore, has a limited life. It does, however, make a simple and easily interpreted interface for troubleshooting purposes. In addition, the isolation that a relay offers makes it easy to combine the different equipment used in a system. The RFL 68P RX, RFL 9850 RX, and RFL 9850 TX/RX are available with plug-on, light-duty output relays.

For monitor or safeguard purposes, the carrier detector output (CD) is available to indicate a loss of carrier, which means a failure has occurred in the communication link or the FSK transmitter. The CD circuit is normally operated on a fail-safe basis. That is, under normal conditions, the circuit's output is high or its output relay is energized. In this way, any kind of failure (power supply, carrier, or circuit) will be indicated by a loss of output voltage or the output relay dropping out.

Figure 13 demonstrates the application of a 3FSK channel for remote control or return status signaling. With no input, the 3FSK transmitter normally transmits a center frequency. A MARK switch closure ("Raise" in the example) will transmit a MARK; a SPACE switch closure ("Lower" in the example) will transmit a SPACE. The receiver responds accordingly with either a no output, a MARK output, or a SPACE output.

The 3FSK application is particularly useful for three-state controls or indications, such as Raise/Off/Lower controls or High/No/Low alarm status. The three states must be mutually exclusive, so they cannot key simultaneously.

The direct tone control/status system described above is fast-operating. Time delays through a narrowband tone channel are usually between 25 and 30 ms, plus a relay-operate time of 10 to 15 ms. Direct tone control/status offers reasonable security, with fast and predictable operate times of less than 50 ms. It is simple to troubleshoot and understand,

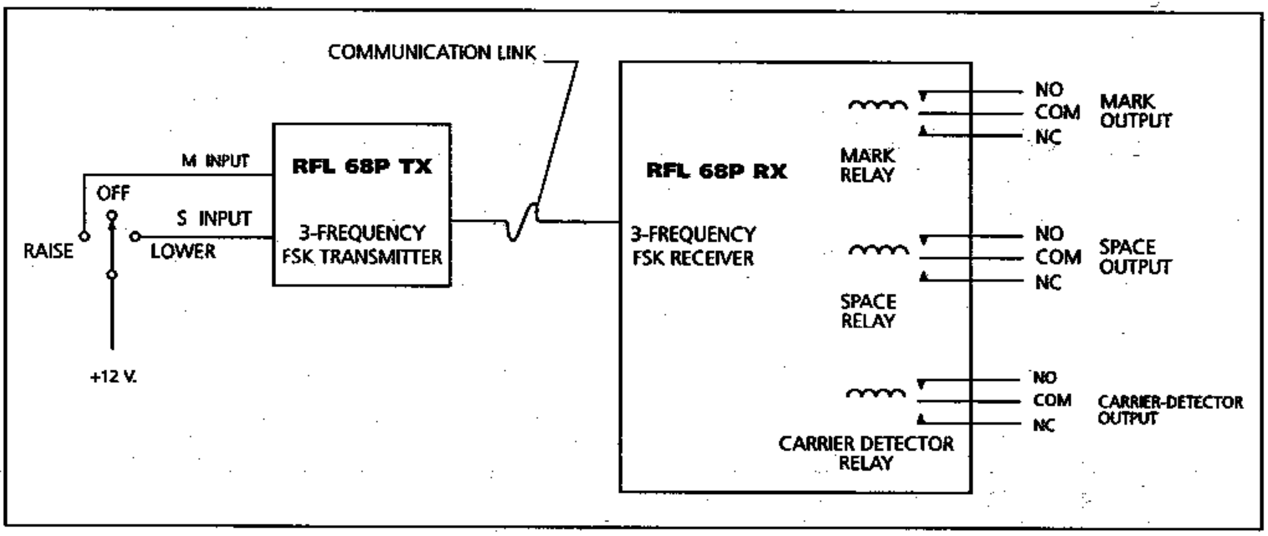


Figure 13. Remote control (or return indication) using a three-frequency (three state) FSK channel

and since separate channels are used for each function, a channel failure will only affect that function. Spares are minimized, since only a few module types are used.

Figure 14 shows the use of a TDM channel to transmit control/status functions. Sixteen points is the modular building block for an RFL 66A ENC/66A DEC channel. Expansion modules can be used to expand the system in 16-point increments (32, 48, etc). The inputs and outputs can be either voltages or contacts. Contacts are shown in the figures for simplicity. Separate modules containing eight relays each are used to add relay outputs to the decoder.

An additional circuit is supplied on the decoder to indicate a scan fail condition by a front panel LED and/or a voltage output.

The use of scanners for control and status transmission is usually quite secure, because of the coding and parity checks built into the system. In addition, doublescan is an option requiring the reception by the decoder of two successive scans that are exactly the same before a decoder registers an output. This offers a higher level of security for control purposes than tone channel control. Scanner control/status is more economical when there are more than three or four in a system. The trade-off is transmission time;

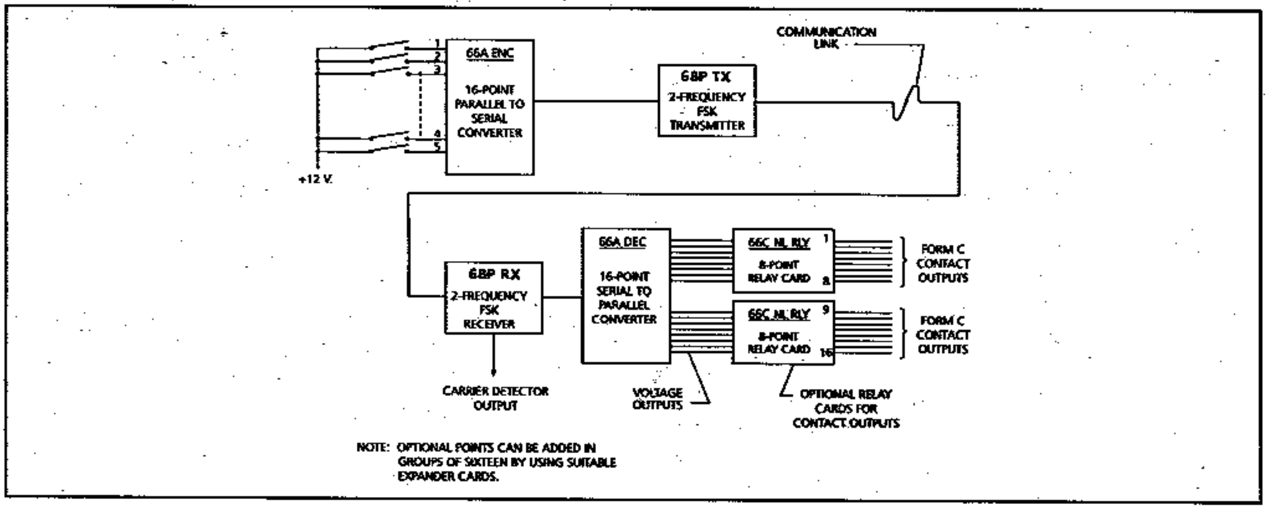


Figure 14. Remote control or status using time division multiplexing

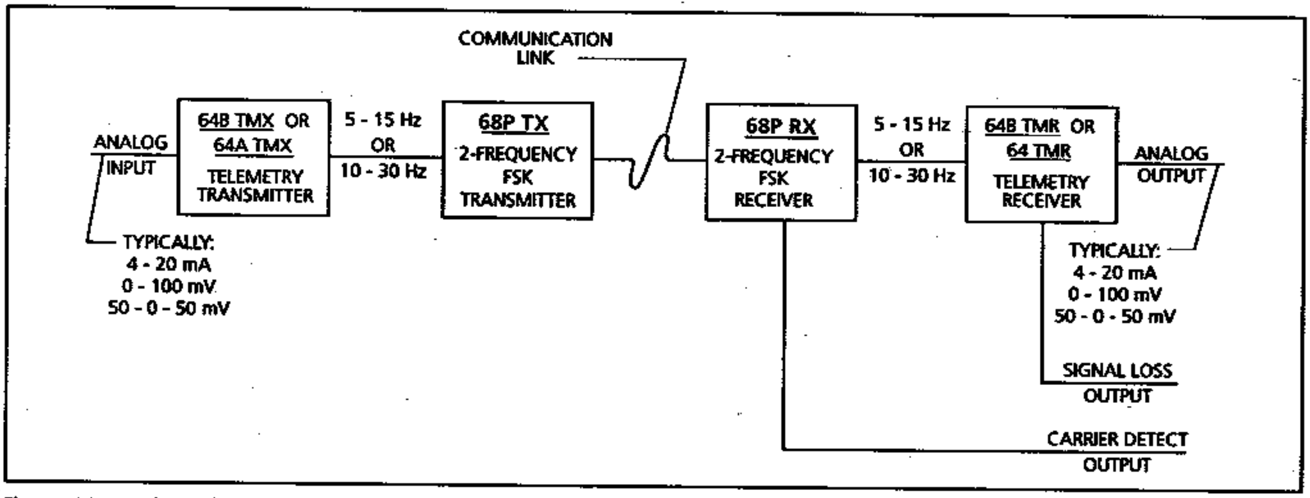


Figure 15. Analog telemetry system

with 60-baud doublescan, it takes 1.1 seconds to update 16 scanner points (0.57 seconds at single-scan). If the status or control change occurs just after sampling, the time to transmit it may approach two scans. A 32-point scanner would almost double these figures. Of course, the update time could be reduced by using a faster scan rate; a 300-baud rate would reduce the time by a factor of five to one.

Also, the scanner method uses a single channel for all functions. Failure of this channel would cause failure of all functions. While not highly complicated the TDM transmission is somewhat more difficult to troubleshoot. The additional module types will also require more spare modules.

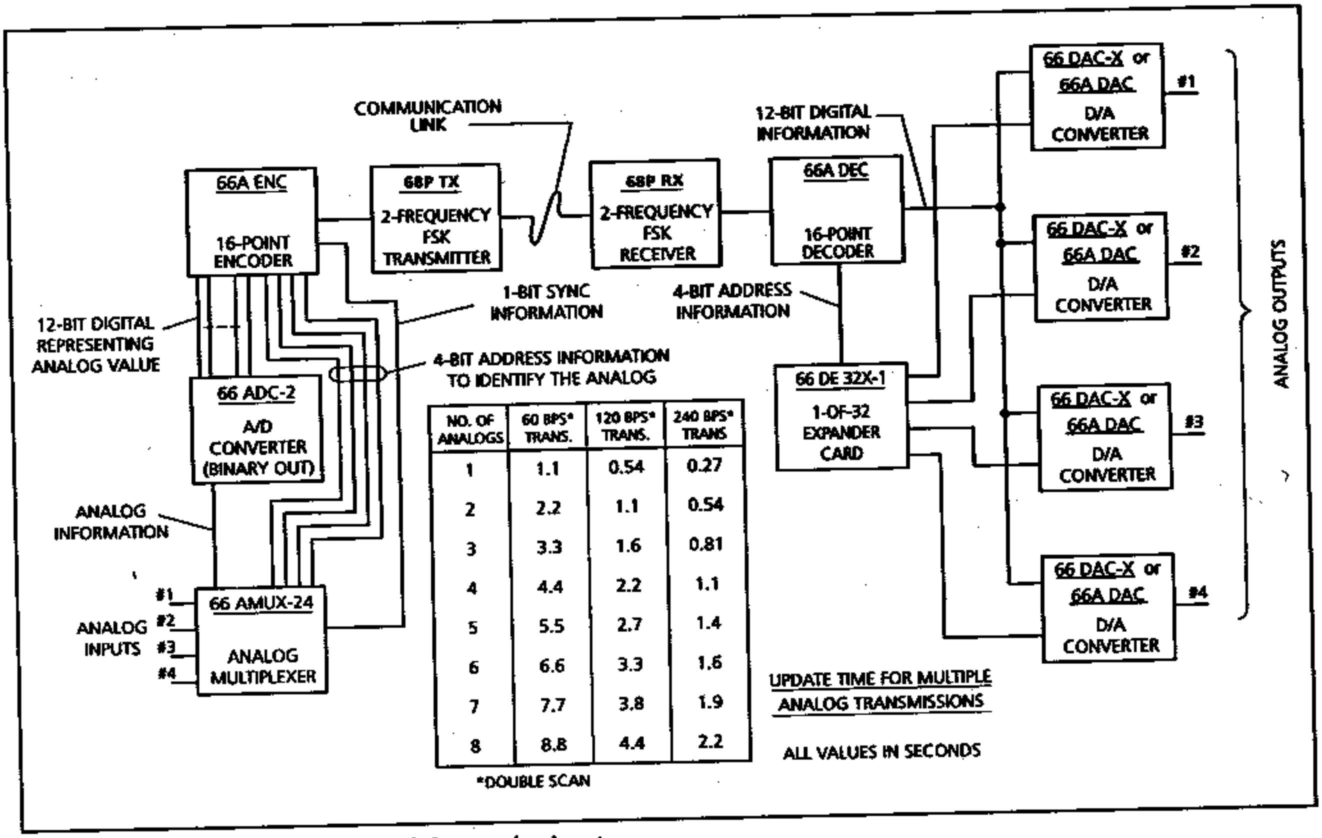
Figure 15 shows remote telemetry using an RFL 64B analog telemetry channel. The RFL 64B TMX functions as a voltage-to-frequency converter by changing the analog voltage input to a square wave, with frequency proportional to the input voltage. A frequency range of 5 to 25 Hz is used to represent an analog change from zero to full scale. The square wave is used to key an FSK transmitter to transmit the information to the master station. At the master, an RFL 64B TMR functions as a frequency-to-voltage (or current) converter and outputs voltages or currents for driving indicators or recorders.

Several analog telemeters can be multiplexed on a single communication link. They all operate separately, and a failure of one will not affect the others. The time of transmission is about 1.25 seconds, or less. Troubleshooting is relatively simple, and spares are minimized.

Figure 11 showed the time division multiplexing of a single analog function; Figure 16 shows the sequencing of a number of analogs over a single digital telemetry system. Since each analog is sequenced into the system on successive scans, the update time is lengthened considerably, as shown in the table. As in other time multiplex applications, there are great economies in sending a number of analogs in this manner. As before, however, there is a greater amount of complexity involved, and more module types to spare.

Data Transmission is the transmission of serial pulse streams using data terminals and/or computers as end devices. The tone channels in this application are often called "data modems" and have standard interface designations and voltages, as shown below. All RFL FDM channels have the capability of meeting these standards, and can supply the special connectors that may be required. Listed below are the pin numbers, designations, and descriptions of these signals as defined by EIA Specification RS-232C. These are always bipolar voltage interfaces. Figure 17 shows a data channel application.

PIN NO.	DESIGNATION	DESCRIPTION
1	AA	Protective Ground
2	BA	Transmitted Data
3	BB	Received Data
4	CA	Request to Send
5	CB	Clear to Send
7	AB	Signal Ground
8	CF	Carrier Detector
9	CD	Data Terminal Ready



NO. OF ANALOGS	60 BPS* TRANS.	120 BPS* TRANS.	240 BPS* TRANS
1	1.1	0.54	0.27
2	2.2	1.1	0.54
3	3.3	1.6	0.81
4	4.4	2.2	1.1
5	5.5	2.7	1.4
6	6.6	3.3	1.6
7	7.7	3.8	1.9
8	8.8	4.4	2.2

*DOUBLE SCAN

Figure 16. Digital telemetry system with four analog inputs

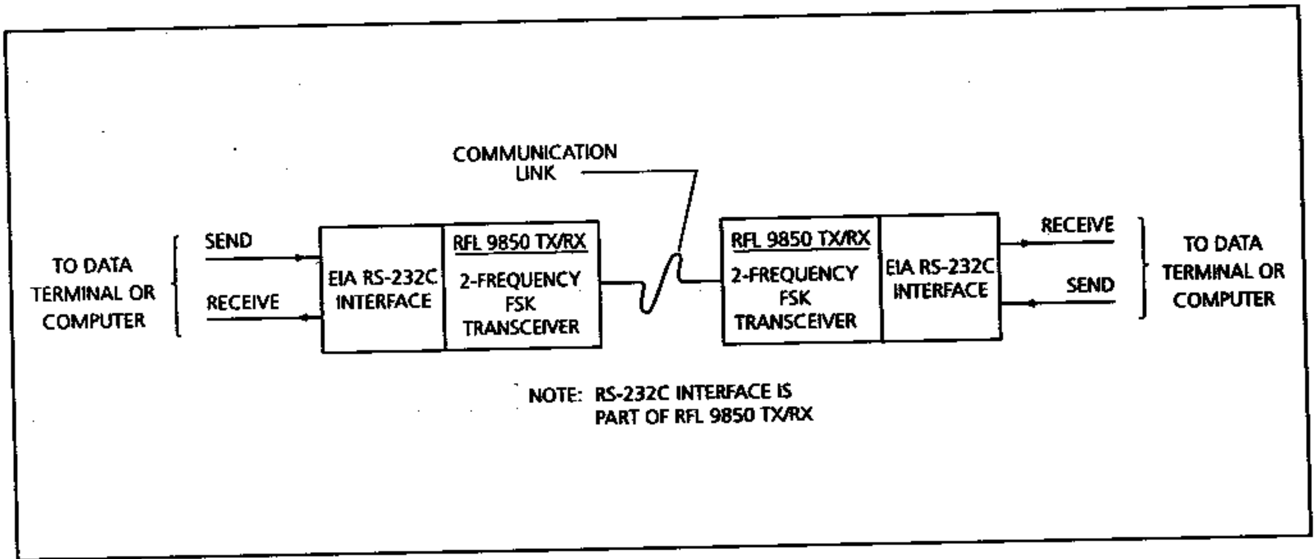
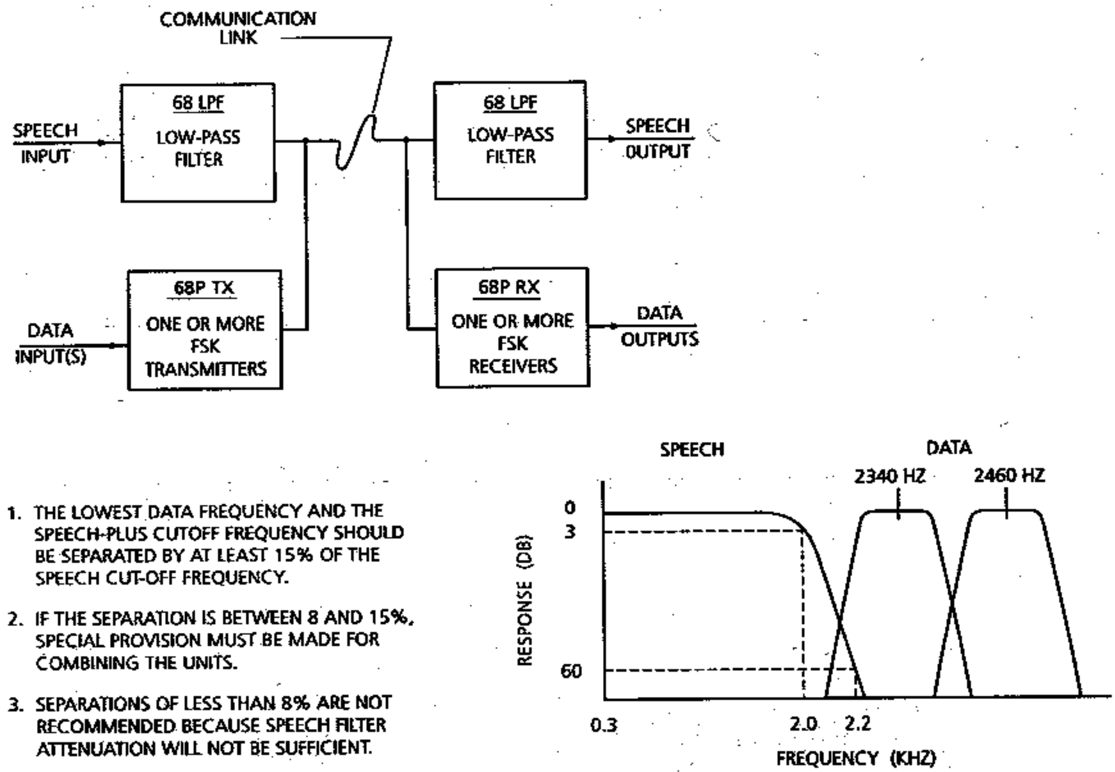


Figure 17. Two-way data transmission using RFL 9850 TX/RX transceivers

Speech Plus is a special type of FDM, where a speech channel is multiplexed with one or more narrowband data channels. In speech-plus systems, speech is confined in the communication link to only a portion of the available spectrum. This is done by using a low-pass filter with a cutoff at an upper frequency limit chosen as an acceptable compromise between intelligibility and the number of data channels required.

As shown in Figure 18, a low-pass filter is required at both the transmitting and receiving ends. At the transmitting station, the low-pass filter removes the out-of-band frequency components of the speech so they cannot interfere with the data channels. The low-pass filter at the receive station keeps the data channel frequencies out of the speech.

As a practical matter, 2000 or 2200 Hz as a speech cut-off yields quite intelligible speech, with only negligible deterioration compared to normal telephone quality. Depending on the total spectrum available, a number of data channels may be placed above the speech. (See Figure 4.) These can be used for all the functions described above.



1. THE LOWEST DATA FREQUENCY AND THE SPEECH-PLUS CUTOFF FREQUENCY SHOULD BE SEPARATED BY AT LEAST 15% OF THE SPEECH CUT-OFF FREQUENCY.
2. IF THE SEPARATION IS BETWEEN 8 AND 15%, SPECIAL PROVISION MUST BE MADE FOR COMBINING THE UNITS.
3. SEPARATIONS OF LESS THAN 8% ARE NOT RECOMMENDED BECAUSE SPEECH FILTER ATTENUATION WILL NOT BE SUFFICIENT.

Figure 18. Speech-plus data system for transmitting speech and data simultaneously on a single line

Chapter 3. COMMUNICATION LINK

Since remote control and telemetry systems involve distances between stations, there is always a communication link involved. The characteristics of this link become a vital part of the system performance. This chapter will discuss these characteristics and the various means there are to meet them.

General Characteristics

Narrowband audio tone channels are generally very forgiving as to the link they must be transmitted over. Because of the very narrow bands used in most simpler systems (50 or 60 Hz), frequency response is not very critical. In general, the channels can usually operate satisfactorily with as much as a 3 or 4 dB differential across the sub-multiplex channel bandwidth. Because of this, some response irregularities across the communication link passband are not normally a problem to very narrowband channels. However, as the channel bandwidths are widened to support high-speed data rates, the response variations become more important. Still, a 3-dB level variation across the channel bandwidth is acceptable.

Noise is another factor that is minimized by the narrower channel bandwidths, since any noise on the communication link represents a much smaller amount of noise in the narrower bandwidth. Again, as the bandwidth widens for higher-speed data transmission, the noise can be a somewhat greater problem. An in-band 18-dB S/N ratio (peak signal to peak noise) is sufficient to allow almost undeteriorated transmission on a 2F FSK channel; a 24-dB S/N ratio is required for similar performance from a 3FSK channel.

In communication links that have significant lengths of physical wire, the longitudinal balance of these pairs is quite important. These pairs are always twisted and balanced, so that any electric or magnetic interference in the two wires are generated equal in value and in opposite phase, so they will cancel out. The balancing keeps the impedance to ground from each wire equal and helps in the cancellation. The line circuits of the multiplex units described in this Application Guide are also balanced so they can interface directly with these pairs. If it is necessary to use unbalanced equipment on these pairs, a balancing transformer must be used in between.

Provided the S/N ratio remains sufficient, circuit attenuation is not a problem unless the signal goes below the FSK receiver sensitivity. At -50 dBm, the FSK receivers discussed in this Application Guide offer the most margin of any available. Excessive overall circuit attenuation variation of greater than 6 to 8 dB can be a problem to proper carrier detector operation in indicating channel failure.

Leased Telephone Circuits

By far, the most common means of obtaining a communication link between master and remote stations is by a dedicated telephone line from the local telephone company. As shown in Figure 19, a telephone circuit consists of two loops: one from each station to its nearest central office (C.O.) and a trunk circuit between central offices. The loop is most likely a physical twisted pair of wires, and is not usually more than 2500 ohms (20 to 30 miles) long.

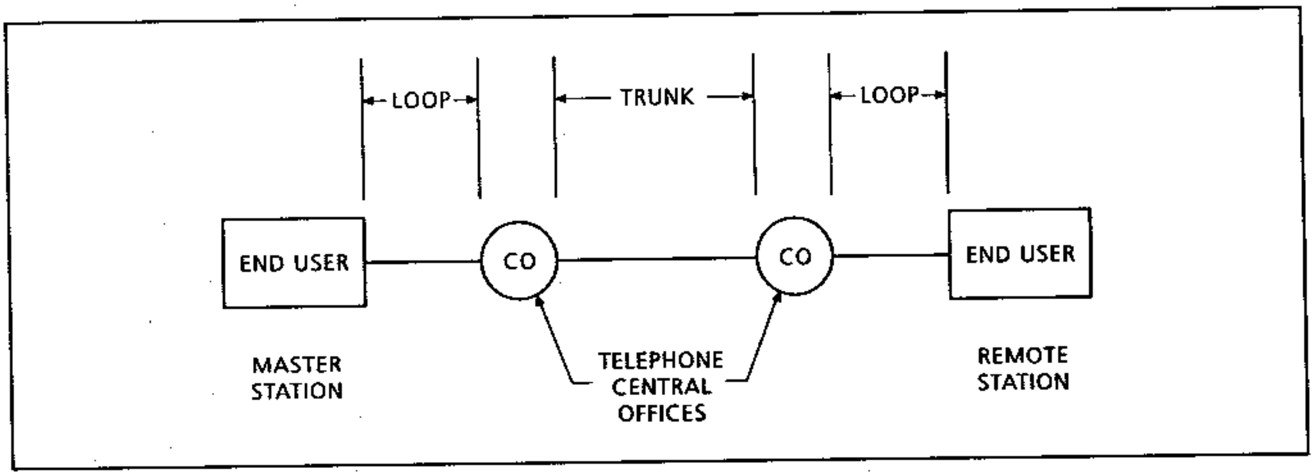


Figure 19. Typical layout of telephone system circuit

In the United States, all loops over about three miles are loaded. Loading consists of small inductors placed at regular intervals into the pair of wires to counteract the distributed capacity between the wires of the pair. Loading tends to flatten the response curve of the line, reduce the loss, and offer a more consistent characteristic impedance over a range of frequencies. The smaller the inductance, the closer they are placed in the line, and the higher the frequency response of the circuit.

The trunk is the circuit between central offices, and currently almost all are on carrier circuits. A carrier circuit is not a physical pair, but an audio circuit (no dc path) that is derived by either frequency multiplex or time multiplex from larger spectrums. Also, the trunk may not be a single circuit; it may consist of a series of interconnected carriers in order to get from one C.O. to the other, and may go through several telephone companies' facilities. Trunk carriers facilities do not usually represent a problem as far as operating characteristics are involved; their frequency response, stability, and noise are far better than required for multiplex channel transmission. The loops are usually the restrictive facility.

On a dedicated line, all the above are for the exclusive use of customer at all times and are paid for by a monthly lease. These monthly fees can be costly; the use of multiplexing can spread these costs over a number of functions. The dedicated line is a dry circuit; that is, there is no current or voltage imposed on it by the telephone company. Lightning protection is normally supplied. Trunk carrier facilities are four-wire circuits; that is, capable of two direction transmission simultaneously. The loops, however, can be supplied as two-wire or four-wire circuits. (See Figure 20.) Two-wire circuits are less expensive than four, since only a single pair must be supplied, as opposed to two pair for the four-wire. Two-wire circuits cannot pass voice in both directions simultaneously, but narrowband tones on different channel frequencies can be passed in both directions simultaneously. This reduces the number of channels available for information, which may be a problem in a larger system.

Dedicated leased circuits are supplied by the local telephone company (Telco), and questions will be asked in the negotiations about what will be imposed on them and what the requirements are. The Telco will usually try to meet the requirements; however, as a practical matter, the easier and more standard the needs are, the lower the monthly rental fee will be.

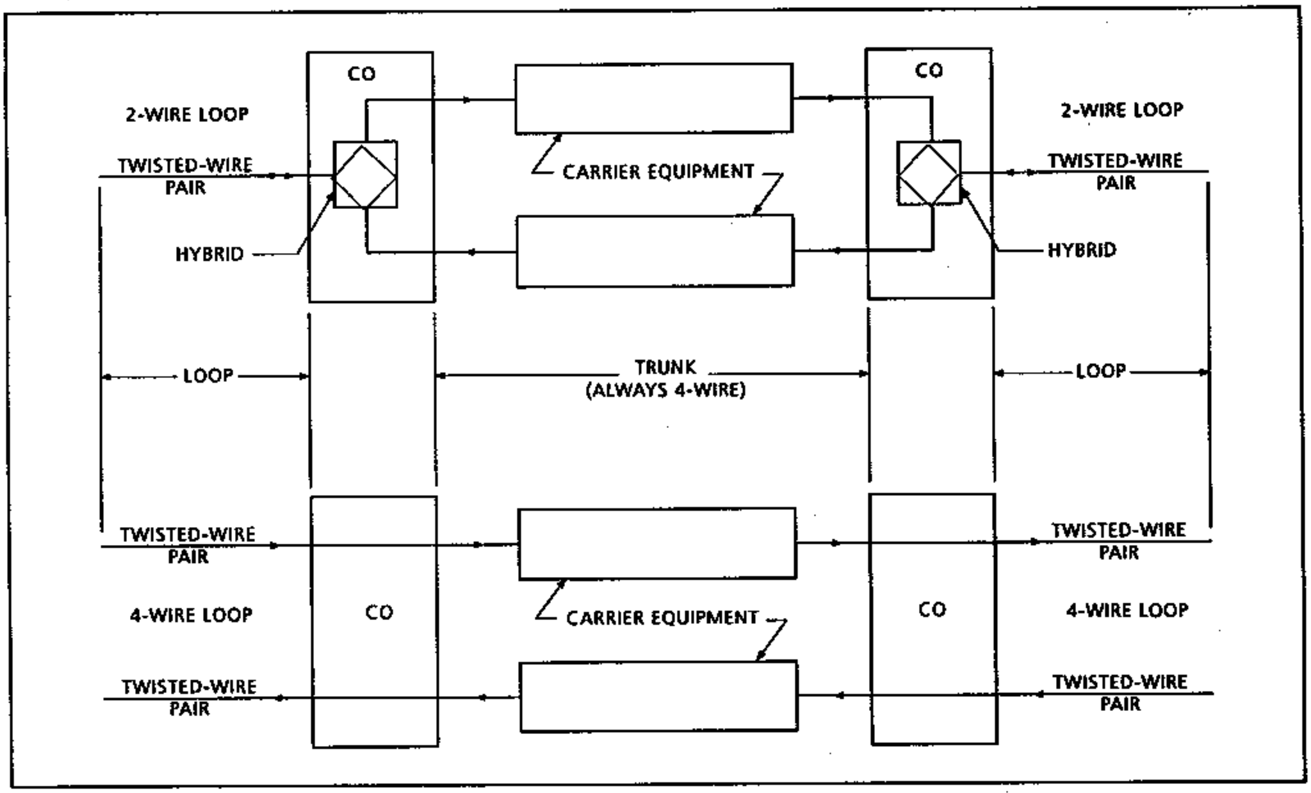


Figure 20. Difference between two-wire and four-wire circuits

Most leased lines have a 300- to 2500-Hz frequency response. The upper frequency will vary, depending on the Telco involved and how well they maintain their facilities. In assigning channel frequencies, it is best to start between 1000 to 2000 Hz, where the transmission is most secure. If more channels are required than can fit in that range, further assignments should be made starting alternately down from l000 Hz, and up from 2000 Hz.

Higher-grade leased circuits are available for certain applications, but these will be increasingly more costly. The 3002 channel is a Telco tariff offering for 600- to 900-bps data applications. The 3002 channel is also available with C1, C2, and C4 conditioning, to allow transmission of 1200- to 1800-bps data. Table 1 shows the tariff requirements for 3002, C1, C2, and C4 equalized data channels. At these higher data speeds, it is normal to assign the channel frequency at 1700 Hz; in reference to performance characteristics, this is the center of the leased circuit. This gives the best chance for successful operation.

Dial-Up Telephone Network

Once the connection is established, the characteristics of the dial-up telephone network are similar to that of a leased dedicated line, and good multiplex channel performance can be maintained over such a facility. The problem is that very few control and telemetry systems can tolerate the time to establish the connection, and the lack of monitoring when it is not. For those systems that can tolerate these problems, the cost savings in monthly fees can be tremendous. Some additional investment in additional equipment for interfacing auto-answer and auto-dialing may be required.

Narrowband tones and data up to 600 baud can operate very successfully over the dial-up network. Speeds higher than 600 baud may require loop equalization to operate properly. Another problem is that whenever the connection is made, the trunk section of the circuit may be through different carriers, causing a variation in the overall characteristics. This can cause erratic performance at higher data speeds. The dial-up circuit is similar to the two-wire dedicated line shown in Figure 20, except that 48 volts is imposed on the loops to activate a telephone, and additional equipment is supplied at the central office to connect the loop into the switch and network. Dial-up lines are always two-wire.

Carrier Circuits

Carrier circuits are derived by frequency- or time-multiplexing wider-band facilities, such as microwave, powerline carriers, coaxial cable, and digital fiber optic circuits. These derived channels are usually very good voice circuits, with frequency responses of 300 to 3400 Hz, and are close equivalents to 3002 data lines with C4 conditioning. These circuits are also four-wire.

The availability of these circuits to a system designer depends on whether his or her company has installed any of these facilities. If available, the system designer should make use of them. They should be quite reliable and economical compared to leased telephone circuits.

If the system audio interfaces are at or very close to the carrier circuit ports, direct connections may be made without concern for balancing. Often, however, there is a considerable distance between the two; in this case, the interconnecting cable run should be twisted pair and the interfaces balanced to minimize the induced noise.

Fiber Optic Circuits

Communications on fiber optic cable are usually accomplished by time multiplex carrier, using high-speed digital pulses, because the medium lends itself so well to that type of modulation. In small systems with an available right-of-way and for short distances (15 miles or less), frequency multiplex channels can be amplitude-modulated onto fiber optic cable. RFL Electronics Inc. manufactures equipment capable of this modulation and interface to the fiber. The modules can mount in the same chassis and use the same power supply as the multiplex and telemetry channels. Fiber circuits are always four-wire, so two fibers are required for two-way communications.

The advantage of fiber optic transmission is its invulnerability to noise and other induced interference. It also offers good security; it is not easy to tap into a light fiber circuit without detection. This type of communication link should certainly be considered for very critical system requirements.

Table 1. Representative specifications for alternate voice-data channels

	3002 Channel	C1 Conditioning	C2 Conditioning	C4 Conditioning
Circuit designation use	Alternate Voice/Data or Data Only			
General chractristics Type of service	Two point or multipoint			Two point or multipoint; maximum of four points
Mode of operation	One way, two way simultaneous, two way non-simultaneous			
Method of termination	Two wire or four wire			
Recommended impedance of terminal equipment	600Ω ± 10% resistive over the voice band and balanced			
Maximum signal power	0 dBm, 3 second average +13 dBm instantaneous			
Attenuation characteristics Initial circuit loss	16 ± 1 dB at 1004 Hz			
Expected Variation	Short-Term + 3 dB Long-Term + 4 dB			
Frequency Response (Reference 1004 Hz) (Note 2)	Frequency Range (Hz) / Variation (dB) 300-3000 / -3 to +12 500-2500 / -2 to + 8	Frequency Range (Hz) / Variation (dB) 300-2700 / -2 to + 6 1000-2400 / -1 to + 3 300-3000 / -3 to +12	Frequency Range (Hz) / Variation (dB) 300-3000 / -2 to +6 500-2800 / -1 to +3	Frequency Range (Hz) / Variation (dB) 300-3200 / -2 to +6 500-3000 / -2 to +3
Frequency Error	No more than ± 5 Hz			
Relay characteristics Absolute delay	Not specified			
Envelope delay	Frequency Range (dB) / Duration (μ) 800-2600 / < 1750	Frequency Range (Hz) / Duration (μ) 1000-2400 / < 1000 800-2600 / < 1750	Frequency Range (Hz) / Duration (μ) 1000-2600 / < 500 600-2600 / < 1500 500-2800 / < 3000	Frequency Range (Hz) / Duration (μ) 1000-2600 / < 300 800-2800 / < 500 600-3000 / < 1500 500-3000 / < 3000
Noise characteristics Message circuit noise	See Note 2			
Impulse noise	Not specified See Note 3			
Other characteristics Local channel balance	Not specified			

Source: IEEE Std. 305-1976

NOTES

1. Direct current continuity (metallic circuits) is not provided on any of these offerings.
2.

Facility Length (Mi)	Noise at Receiver Not to Exceed
0-50	28 dBrnc
51-100	31 dBrnc
[illegible]	[illegible]

3. Impulse Noise

Threshold with Respect to Received 1004 Hz Test-Tone Power	Maximum Counts Above Threshold Allowed in 15 Minutes
-6 dB	15
-2 dB	9
+2 dB	5

Channel Frequency

Once the baud rate is determined, the number of channels possible in the voice band is automatically set. (see Figure 4 in Chapter 2.) The following information should be considered when selecting the channel frequency:

1. For a single-channel system with the entire voice band available, any channel frequency can be selected. However, it is best to use channels near the center of the available spectrum (between 780 Hz and 2100 Hz). This is done because frequency roll-off and noise are usually minimal at the center of the spectrum.

2. Several multiplexed channels with the same baud rate can be located symmetrically around the center of the spectrum.

3. If the system uses several multiplexed channels with different baud rates, they should be arranged as follows:

   a. Set the channel or channels with higher baud rates symmetrically around the mid-band frequency. They may also be set somewhat higher.

   b. With the bandwidth (BW), find the frequencies equal to the center frequency plus and minus 1.5 times BW. These frequencies are the 60 dB points for the high-speed channel. They are the closest permissible for the high and low signal frequencies (either MARK or SPACE) of the adjacent channels. (See Figure 21.)

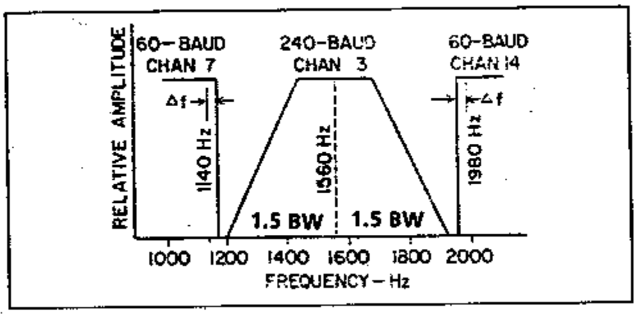


Figure 21. Frequency spacing for mixed high-speed and low-speed channels

   c. If a speech-plus data channel is being used, the center frequencies of the FSK channels must be set above the 60-dB cutoff point of the low-pass speech filter. (See Figure 4 in Chapter 2.) If possible, it is best to use a 15-percent guard band. (See the notes on Figure 18 in Chapter 2 for more information.)

Channel Loading

The use of several tone channels on a communication link requires that individual channel levels be adjusted so that their sum total on a peak basis does not overload the active circuits that must carry them. If the active circuits are overloaded, intermodulation and harmonic products will be generated that will crosstalk into the tone channels (or even the voice circuits) and interfere with their transmissions. The individual channel levels must be set depending on the number of channels and the maximum power level the voice circuit can tolerate without overload. Usually, these individual levels will be assigned by the Telco engineers for a leased line, or by the communication engineers in charge of a private system. The system designer should understand these principles. Table 2 gives the derating required, according to the number of signals to be transmitted.

Table 2. Maximum signal levels per tone

Number of Tones	Level (dB)
1	0
2	-3.0
3	-4.8
4	-6.0
5	-7.0
6	-7.8
7	-8.5
8	-9.0
9	-9.5
10	-10.0
11	-10.4
12	-10.8
13	-11.1
14	-11.5
15	-11.8
16	-12.0
17	-12.3
18	-12.5
19	-12.8
20	-13.0
21	-13.2
22	-13.4
23	-13.6
24	-13.8

NOTE: The values in this table are referenced to the communication channel's maximum allowable single-tone level.

Chapter 4. TYPICAL APPLICATIONS

This chapter will deal with typical system arrangements to meet particular requirements. Most of the systems are based on actual solutions to a particular industry.s needs (using updated modules). The examples are meant to stimulate the system designer's imagination in solving his own problems and to show the versatility of the RFL's product line.

SYSTEM 1. (See Figure 22.) Shown is a control, status, and telemetry system used for the remote control of a local water supply authority. The requirements are to turn two pumps on or off individually, with a return status indication. In addition, two analog channels are required for transmitting pressure and flow quantities.

RFL 9850 modules are used because the system fits the equipment parameters so well; this results in a very economical system. The pump controllers require only a momentary closure for action, and a 3F channel is used for this purpose. The pump running indication uses the return channel of the TX/RXs in the 2F mode. RFL 98TMX and RFL 98TMR modules are used for the 4- to 20-mA telemetry. The hybrid transformers are used to isolate the transmitters and receivers while decreasing crosstalk betweeen channels.

SYSTEM 2. (See Figure 23.) This is a communication system used to control gas pressure in a natural gas distribution system. RFL 66A ENC, 66A DEC, 68P TX and 68P RX modules form a TDM channel that transmits manual and momentary raise and lower signals; these signals control the motorized kick-cell valve. TDM is used for greater security, and a 120-Hz bandwidth is used to decrease the control signal response time to 0.57 seconds. The operator waits until the gas pressure stabilizes and then checks the return telemetry indications to see if further adjustment is required.

The return digital telemetry channels are used to telemeter two pressure signals and one flow analog signal back to the controlling site. In addition, one required status indication is brought back over the telemetry system. Four address bits (for up to sixteen analogs) are normally allocated for address purposes. Since the system requires only two bits (for three analogs), one bit was "borrowed" for the single indication. The update time of the analogs is about 1.7 seconds with the channel operating at 120 baud. Note that four line surge protectors are required to fully protect a four-wire installation. The extra power supply at the regulator site is isolated from the equipment supply, and is used to drive the customer's transducers.

SYSTEM 3. (See Figure 24.) This is a unique system, used at one time by the U.S. Coast Guard to control fog horns at an East Coast harbor. It is only mentioned here to show how some imagination can be used to design a system that is economical to install and operate.

The communication link is over the dial-up network; the same master station can be used to control many remotes, since they would have different telephone numbers. The operator dials each remote station manually, and turns the fog horn on or off as desired. He then monitors the horn on/off status by means of a remote microphone over the speech part of the system. A 3F tone channel can be used for control, but since the tone will be disconnected when on-hook, a latching relay is required at the remote to hold the control on or off as desired. The access arrangements are required by the FCC to protect the integrity of the telephone system.

SYSTEM 4. (See Figures 25 and 26.) These figures show a rather large control, status, and telemetry system used by a utility in a European country. A remote station is shown in Figure 25; Figure 26 shows the master station. The system consists of thirty-two control points, eighty-eight status points, and three analog telemetry functions, using TDM and digital telemetry for the transmission. While all the status and telemetry could have been put on a single encoder/decoder system, three are used to reduce the update times to a more tolerable level. Also, 240-baud transmission speeds were used to further reduce the update times. The telemetry update time is 2.43 seconds; the status update time is 0.81 seconds.

The RFL 68 LINE TERM-5 is an accessory module that isolates the channel units from the line, and allows level adjustment as a group with amplification. The RFL 66 IN/OPI-10 module is another accessory module used to adapt the -48-volt input signals to +12 volts for use directly by the RFL 66A ENC. Note that all the interfaces are solid state (no relays). This is a desirable goal, but the system designer must make sure that all solid-state interfaces are compatible. Also, the contact interfaces of relays and switches can make a system easier to maintain and troubleshoot. In high-speed data applications, voltage interfaces must be used, since relays cannot follow the data accurately.

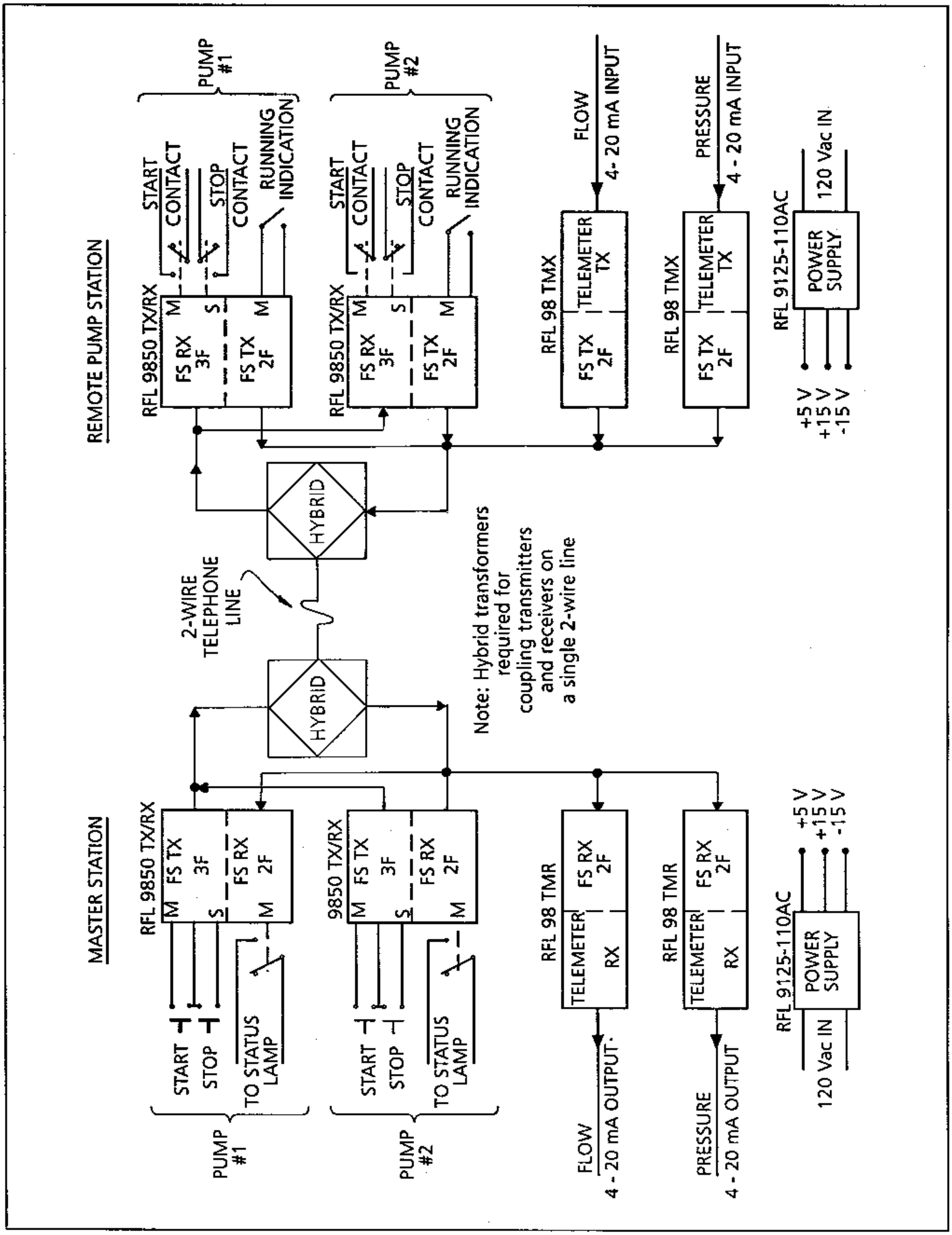


Figure 22. Pump control and telemetry for water supply authority

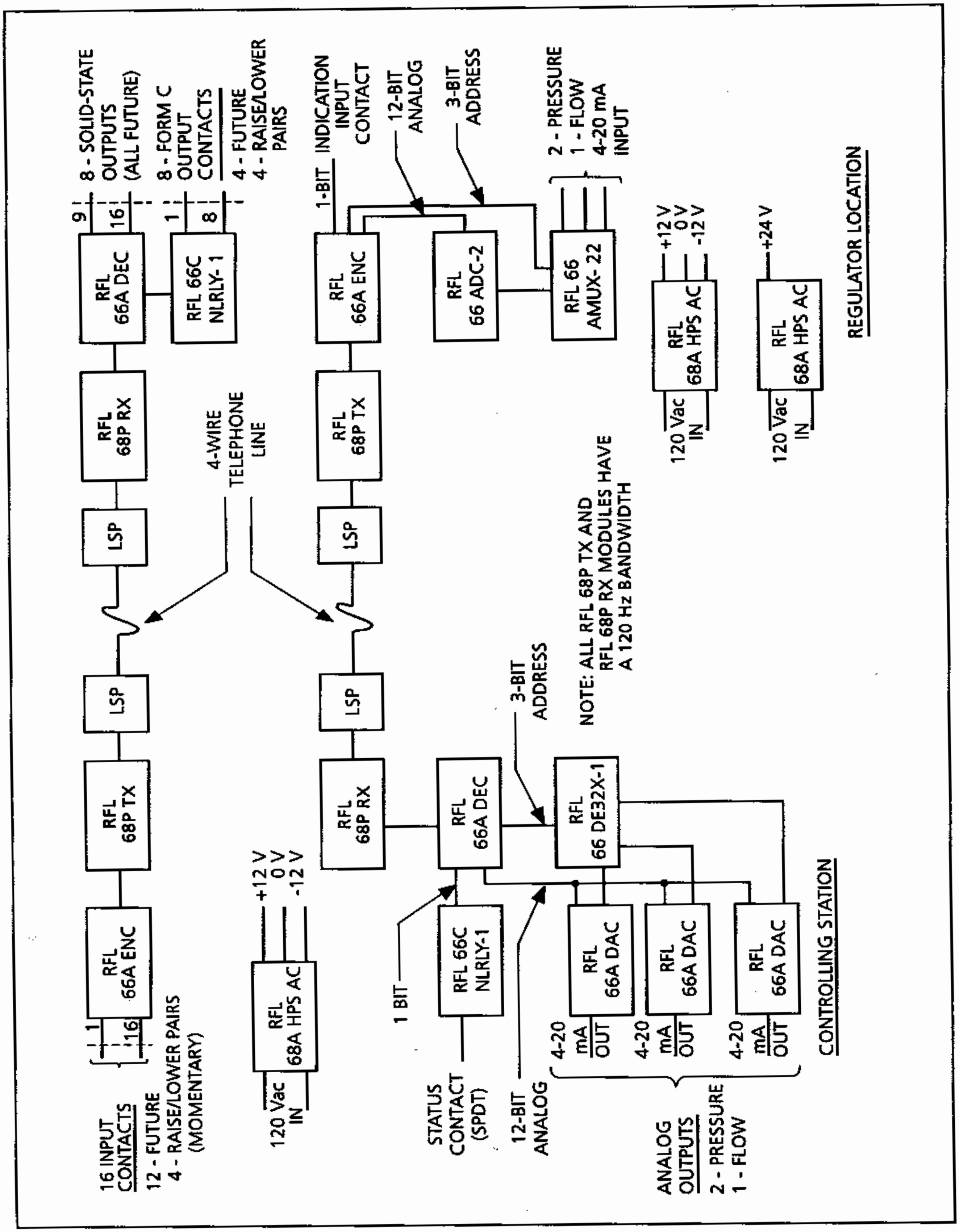


Figure 23. System for control and monitoring of natural gas main pressure for gas distribution utility

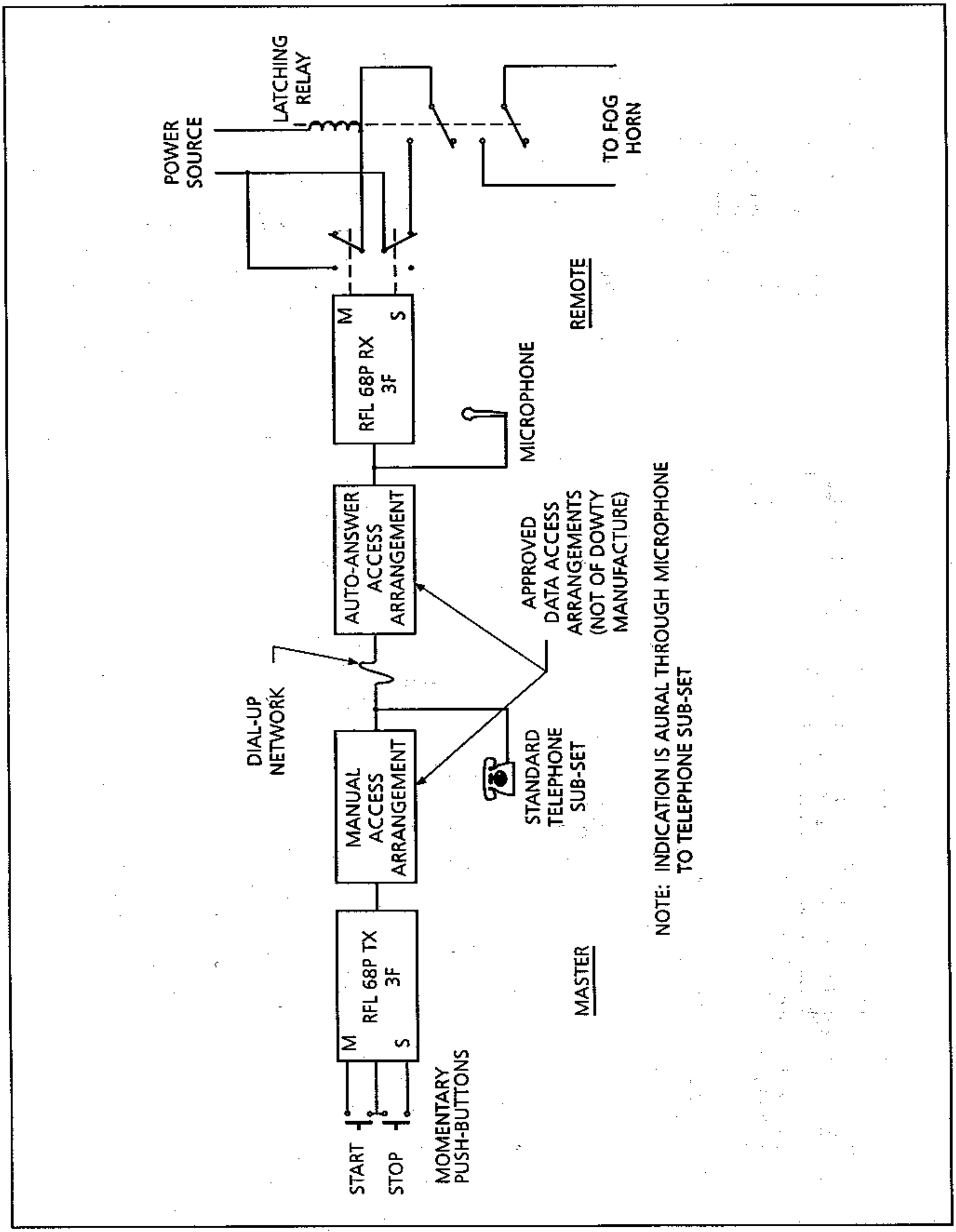


Figure 24. Simple control system over dial-up network

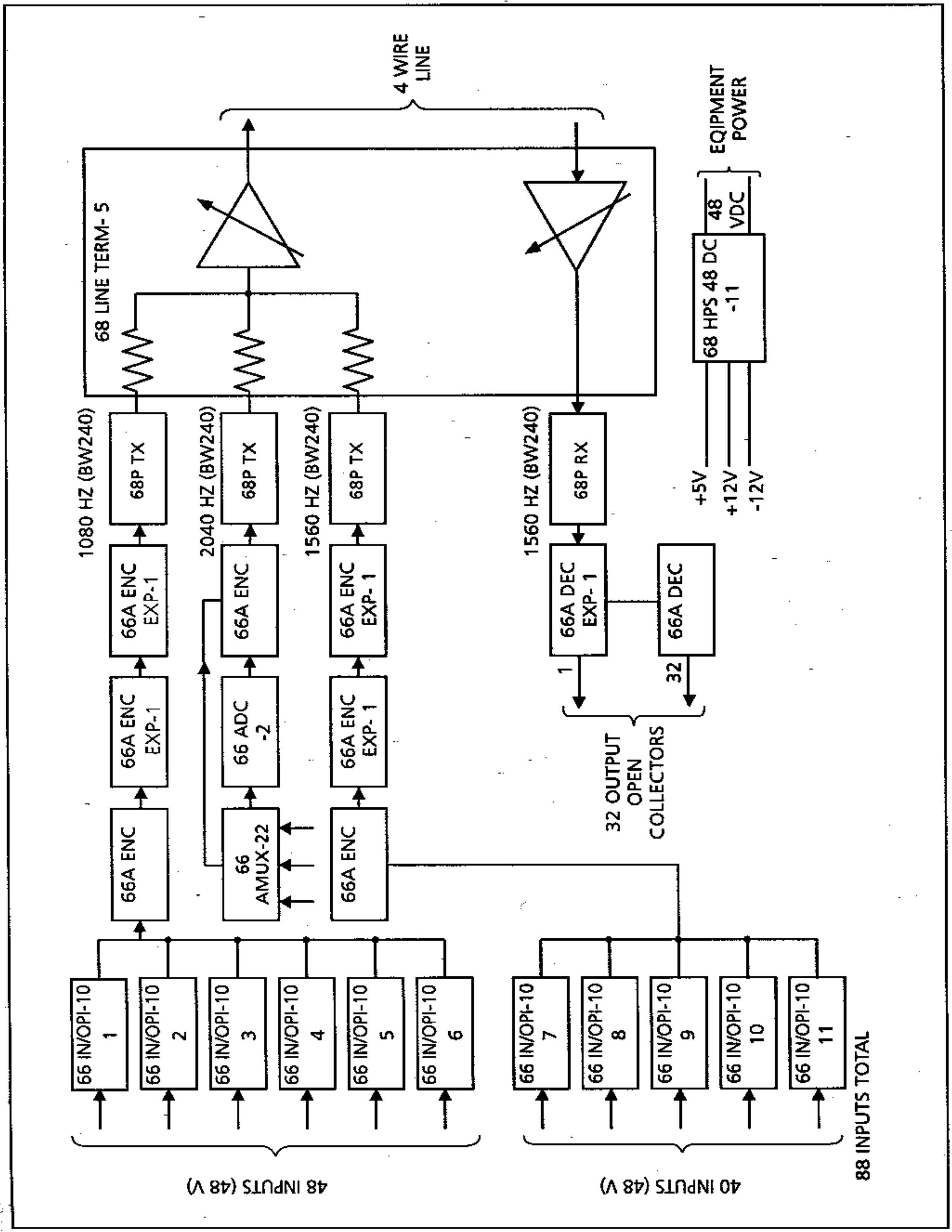


Figure 25. Remote block diagram

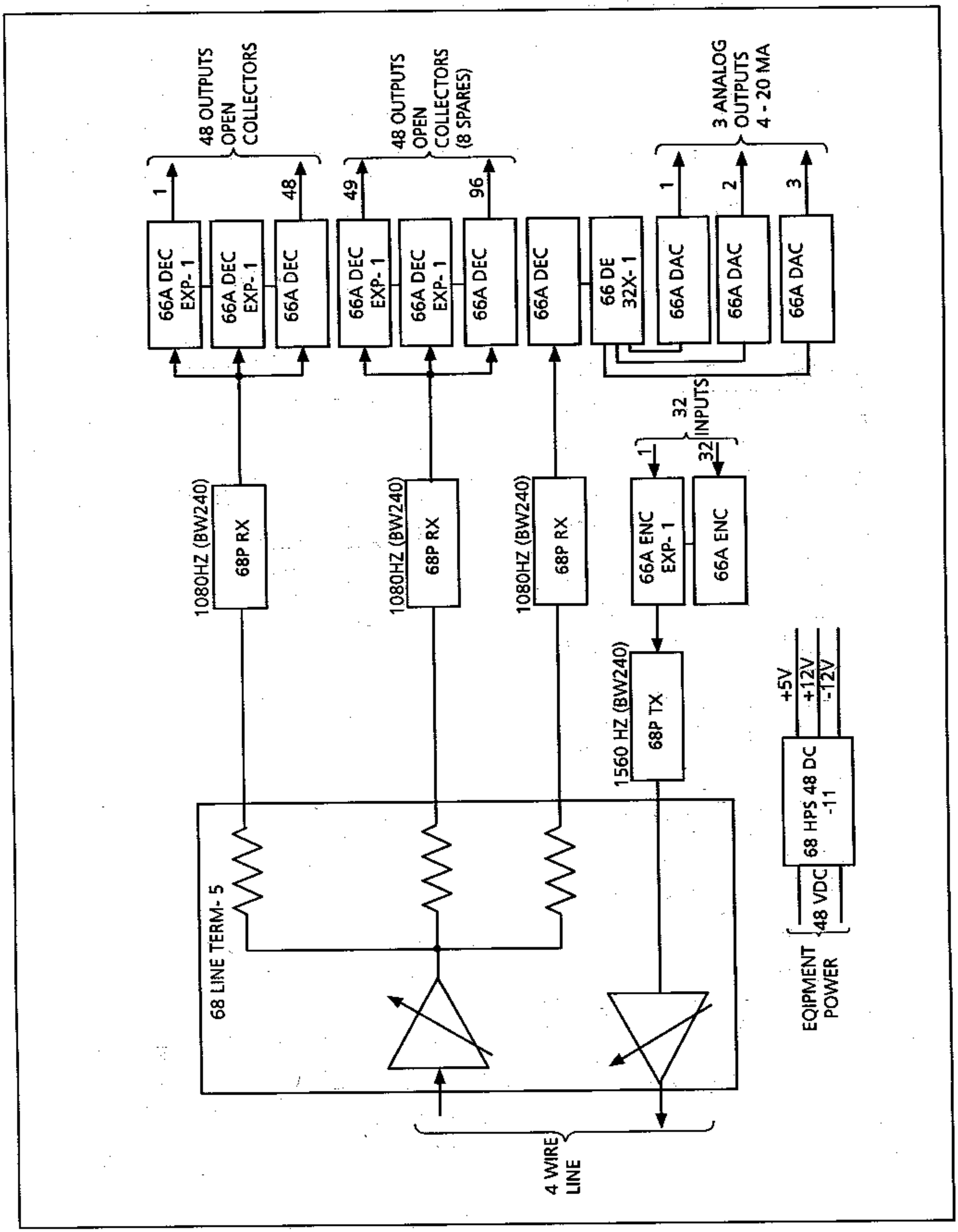


Figure 26. Master block diagram

SYSTEM 5. The system shown in Figure 27 is for simplex transmission (one direction only). It is used to monitor an unmanned pumping station in a sewerage facility. While this could have been accomplished more easily and economically with a TDM system, the customer preferred the simplicity of FDM. One other advantage is that a module failure would not cause the entire system to be inoperative. It is interesting to note the use of 3F channels wherever possible.

Other Design Considerations

Power Supplies. All modules described in this Application Guide require positive and negative voltages for operation; some also require +5 volts. These sources are available from several different power supplies. A power supply should be selected with enough current capacity to handle the requirements of all circuit modules and external loads. Current demands for all modules are shown in Chapter 5.

All ac power supplies operate from 115 or 230 Vac, 48 to 63 Hz. For installations requiring uninterruptable service, equipment may be operated from batteries that are constantly charged while ac power is present. For this application, dc-dc converters operating from 12, 24, 48, or 129 Vdc are available to power this equipment.

Packaging Considerations. RFL modules used for these systems do not make it mandatory to use a fixed number of functions, controls, or channels. Because of this, the designer is free to establish precisely the kind and size of system desired, providing for growth only when needed, and to select only the type and quantity of circuit modules necessary to create the system. This freedom extends also to the mechanical aspects of the design.

The RFL 98 CHAS is the standard chassis for the 9800 Series, and is based on a single-Euro chassis design. It is 5.25 inches high, 19 inches wide and 11.7 inches deep. This chassis also mounts in a standard 19-inch rack, as shown on page 42. The module widths of the 9800 Series vary to allow maximum density in the chassis. These widths must be considered in the layout.

The chassis utilizes I/O connectors located at the rear of the chassis slot where the module is to be installed. All interconnections are made to the I/O connector. Power must be wired from the supply to the individual modules. Input power, telephone line connections, analog inputs/outputs and contacts are left as customer connections.

Other chassis available in the RFL 9800 Series include the RFL 98A CHAS, which is rack-mounted but only 1.75 inches high (for limited rack spaces), and the self-contained, wall-mount RFL 98W CHAS chassis

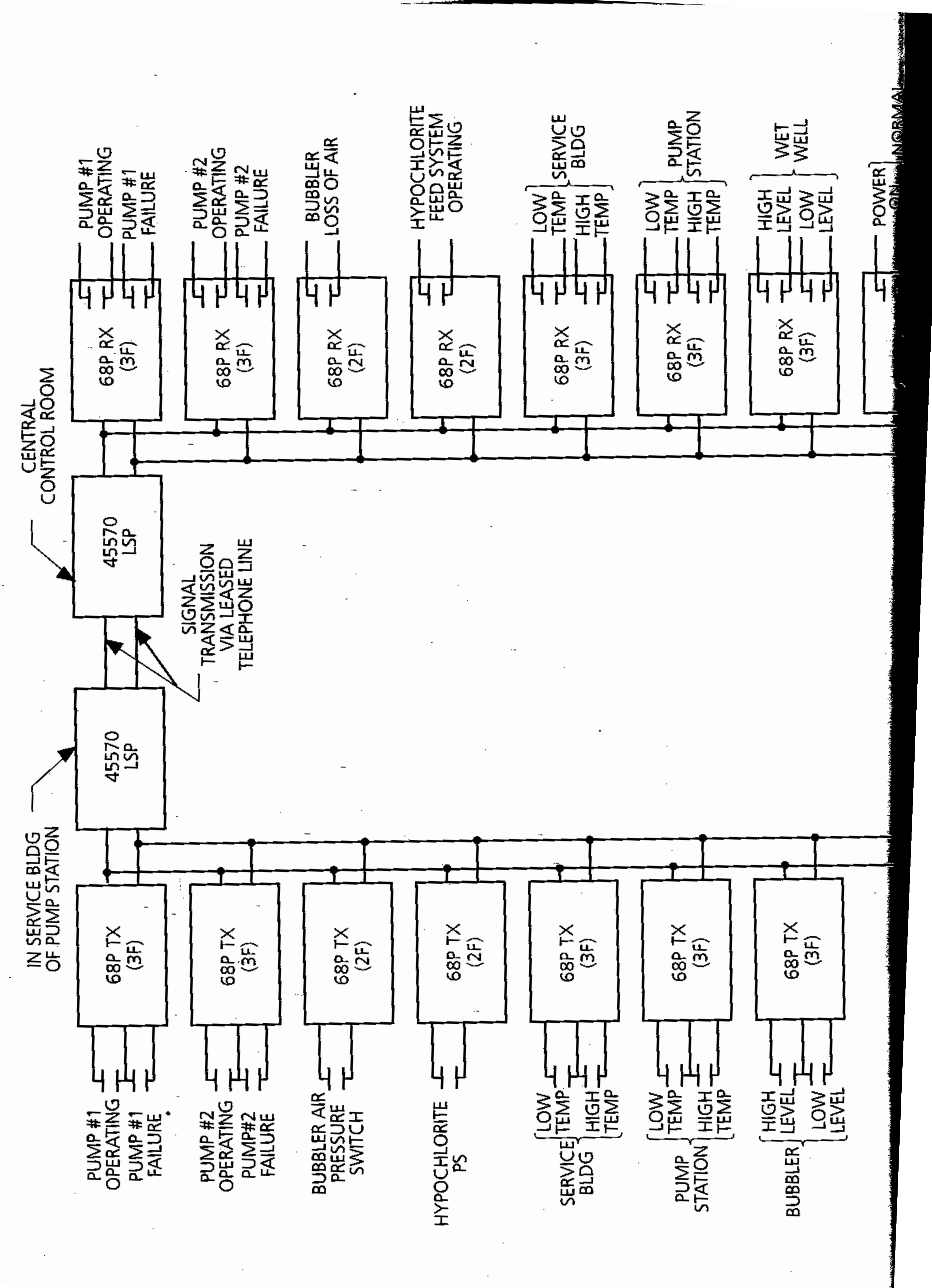
The basic enclosure for 6000 Series modules is the RFL 68 CHAS, shown on page 56. Individual circuit board modules are plugged bookshelf-style into connecting sockets in the rear. The chassis, designed to mount in a standard 19-inch relay rack, is 5.25 inches high, 19 inches wide, and 12 inches deep. It requires three rack units of a standard rack or cabinet.

The chassis contains 32 half-inch mounting spaces. Card guides and edge connectors can be placed in any slot to maximize the density of the package. The interconnect wiring for these modules is done through the edge connectors at the back plate of the chassis, and I/O connections are made through barrier-type terminal strips on the rear panel. When designing the chassis layout, attention must be paid to the widths of the modules which are in half-inch increments. Module width information is found in Chapter 5.

Generally, one power supply is used per chassis. It is usually mounted with its card set in the extreme left slot as one faces the chassis.

Other 6000 Series chassis include the RFL 68A CHAS, which is rack-mounted but only 1.75 inches high (for limited rack space), the RFL 68B CHAS, which has sixteen half-inch mounting slots, and is only twelve inches wide and the RFL 68W chassis which is a small, wall-mount, self-enclosed unit providing seven half-inch slots. Other special-purpose chassis are also available.

Accessories. Accessories such as interposing relays, interconnection terminals, impedance-matching transformers, transient and surge protectors, voltage-dropping resistors, and similar items are all available an can be mounted on accessory mounting brackets under or on the rear of these chassis. Details are available from RFL Electronics Inc.


CENTRAL CONTROL ROOM
IN SERVICE BLDG OF PUMP STATION
45570 LSP
45570 LSP
SIGNAL TRANSMISSION VIA LEASED TELEPHONE LINE
68P RX (3F)
68P RX (3F)
68P RX (2F)
68P RX (2F)
68P RX (3F)
68P RX (3F)
68P RX (3F)
68P TX (3F)
68P TX (3F)
68P TX (2F)
68P TX (2F)
68P TX (3F)
68P TX (3F)
68P TX (3F)
PUMP #1 OPERATING
PUMP #1 FAILURE
PUMP #2 OPERATING
PUMP #2 FAILURE
BUBBLER LOSS OF AIR
HYPOCHLORITE FEED SYSTEM OPERATING
LOW TEMP
HIGH TEMP
SERVICE BLDG
LOW TEMP
HIGH TEMP
PUMP STATION
HIGH LEVEL
LOW LEVEL
WET WELL
POWER ON
NORMAL
PUMP #1 OPERATING
PUMP #1 FAILURE
PUMP #2 OPERATING
PUMP#2 FAILURE
BUBBLER AIR PRESSURE SWITCH
HYPOCHLORITE PS
LOW TEMP
HIGH TEMP
SERVICE BLDG
LOW TEMP
HIGH TEMP
PUMP STATION
HIGH LEVEL
LOW LEVEL
BUBBLER

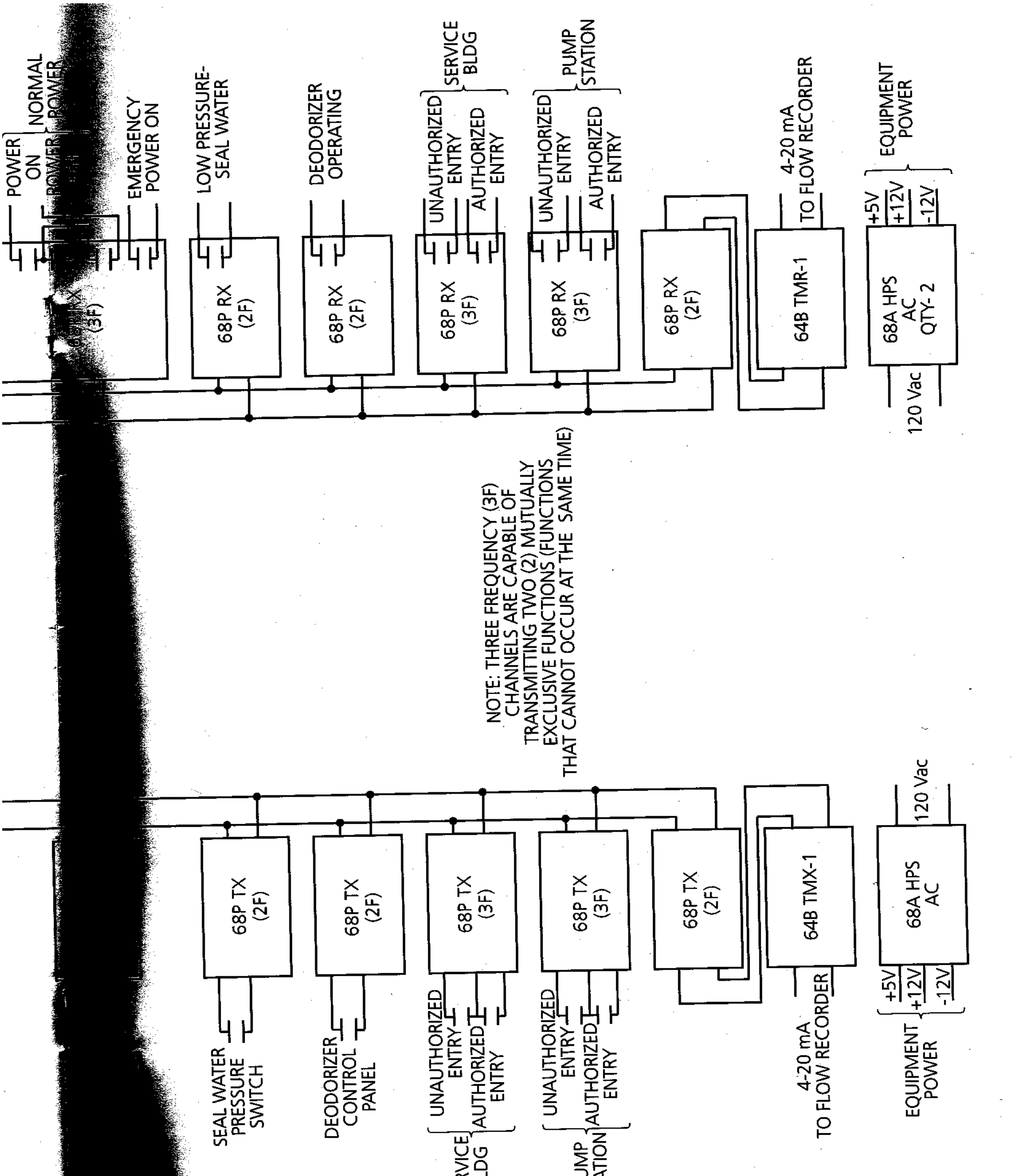


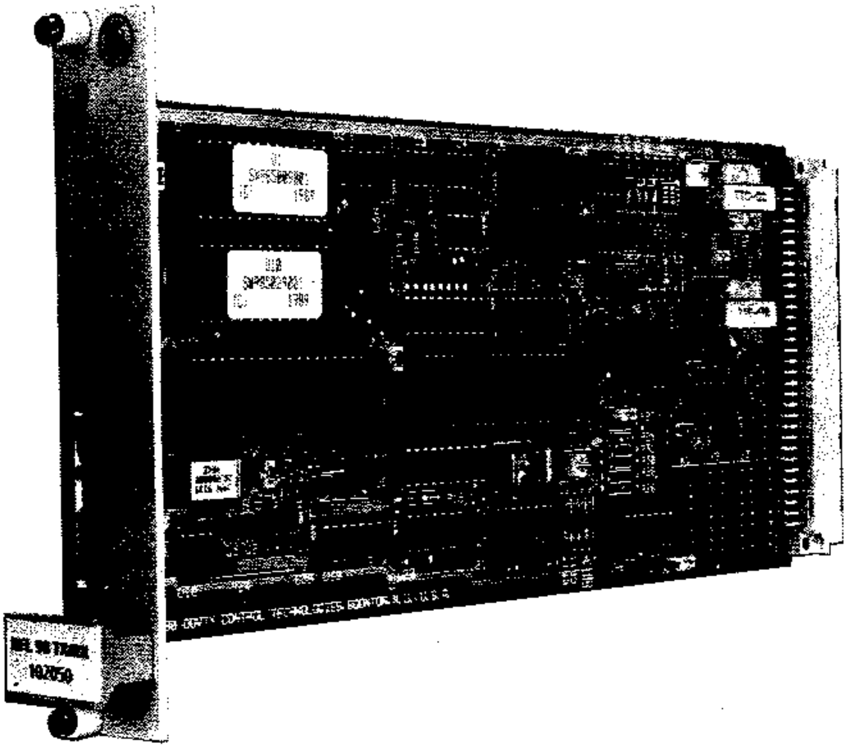
Figure 27. Simplex system for monitoring an unmanned sewerage pumping station

Chapter 5. EQUIPMENT SPECIFICATIONS

This chapter contains descriptions and technical specifications for all the major products discussed in this Application Guide. Information on other accessory modules can be obtained directly from RFL Electronics Inc. in Boonton, New Jersey.

The specifications in this chapter were applicable as of the date this Application Guide was published. Because RFL products undergo constant refinement and improvement, all specifications are subject to change without notice.

RFL 9850 TX/RX
Programmable FSK Tone Transceiver



The RFL 9850 TX/RX is a fully-programmable FSK tone transceiver. Its transmitter and receiver sections function independently of each other; each can be programmed to operate on any center frequency from 300 Hz to 3200 Hz, with frequency shifts up to 300 Hz and at speeds up to 600 baud (2F operation only).

The RFL 9850 TX/RX uses Digital Signal Processing (DSP) techniques to replace the discrete oscillators, modulators, filters, and demodulators normally used in FSK transceivers. Its operating characteristics can be changed by using the hand-held RFL 9800 Programmer to modify the software. This means its operating characteristics cannot be modified by unauthorized personnel. The RFL 9850 TX/RX can also be programmed to operate as an FSK receiver/amplifier; this provides a filtered carrier signal for measurement or use by signal-to-noise (S/N) ration detection equipment.

SPECIFICATIONS

TRANSMITTER SECTION:

Input Keying: RS-232C, MIL-STD-188, TTL, CMOS, or dry contact.

Output Impedance: Strap-selectable, 600Ω nominal or 60,000Ω minimum; isolated and balanced.

Clear-To-Send Delay: Programmable from 5 ms to 255 ms in 1-ms increments.

Carrier Level: Adjustable from -40 dBm to 0 dBm in 0.25-dB increments. Variation is less than 1.0 dB over full temperature range and power supply variation.

Spectral Purity:
Harmonic Content: 50 dB below carrier, at a carrier level of -10 dBm.
Spurious Signals At Adjacent Channels: 40 dB below carrier.

RECEIVER SECTION:

Input Impedance: Strap-selectable, 600Ω nominal, 10,000Ω nominal, or 60,000Ω minimum; transformer-isolated and balanced.

Input Sensitivity: -50 dBm to 0 dBm. The analog gain is automatically adjusted, normally providing a dynamic range of about 26.dB (10 dB of signal "headroom" and -16 dB before the carrier detect signal is lost).

Adjacent Channel Response: Adjacent channel rejection to MARK and SPACE is greater than 40 dB.

Frequency Stability: Actual center frequency is within 0.02 percent of room-temperature center frequency over full temperature range and power supply variation.

rier Detector:

Signal Times: ON time is programmable from 5 ms to 255 ms in 1-ms increments. OFF time is fixed at about 10 ms.

Hysteresis: 2 dB to 3 dB typical.

Clamping:

2F Operation: Receiver squelch and carrier detect work together to clamp receiver output to either MARK or SPACE, as programmed.

3F Operation: Receiver squelch and carrier detect work together to clamp receiver output to the center frequency.

xternal Squelch (2F Operation Only): A logic high at the SPACE input can be used to squelch (disable) the receiver section output, if desired.

ARK, SPACE, and Carrier Detect Outputs:

Open-Collector NPN Transistors (standard): Rated for 150 mA @ 30 Vdc. RS-232C outputs are also available.

Relays (optional):

Form: SPDT (Form C).

Contact Ratings: 2 amperes resistive @ 28 Vdc.

Maximum Switching Power: 60 watts resistive, 125 VA.

Maximum Switching Current: 2 amperes.

Maximum Switching Voltage: 250 Vac or 220 Vdc.

RFL 9850 TX/RX modules equipped with optional mercury-wetted relays must be mounted vertically; they cannot be installed in an RFL 98A 1U Flat-Pack Chassis. If the voltages being switched by the relays exceed 110 volts, the relays must be protected by placing a bi-directional transient suppressor across the load (JEDEC Type 1N6300CA or equivalent).

OGRAMMING CAPABILITIES:

nsmit and Receive Carrier Frequency: Adjustable in 1-Hz steps.

nsmit And Receive Bandwidth: Can be set to 50, 60, 85, 120, 240, 300, or 600 Hz.

nsmit Output Level: Adjustable from -40 dBm to 0 dBm in 0.25-dB steps.

eive Sensitivity Level: Automatically set to provide a dynamic range of about 26 dB (10 dB of "headroom" and 16 dB to carrier dropout). Automatic setting can be manually overridden if desired.

nsmit And Receive Mode Of Operation: Two-frequency (2F) up to 600 baud, or three-frequency (3F) up to 120 baud. External squelch feature is only available when operating in 2F mode.

ar-To-Send Delay: Adjustable from 5 ms to 255 ms in 1-ms increments.

Transmit And Receive MARK Polarity: Can be set to either high or low frequency. Receiver can be set to clamp high or low with loss of carrier.

Carrier Detect Delay: Adjustable from 5 ms to 255 ms in 1-ms increments.

GENERAL:

Frequency Characteristics:

Baud Rate	Freq. Shift (Hz)	Band-width (Hz)	Remarks
50	±25	50	Slow-speed control spacing
50/60/75	±30	60	CCITT R.35 and control spacing
85/110	±42.5	85	43A1/Western Electric Telegraph
100/120	±60	120	240-Hz spacing (CCITT R.37)
200/300	±120	240	480-Hz spacing (CCITT R.38A)
300	±150	300	600-Hz spacing
600	±300	600	1200-Hz spacing

Keying Modes:

Two-Frequency: Available at all bandwidths.

Three-Frequency: Available at all bandwidths up to 120 Hz.

Distortion: Less than 7 percent when operating within the stated carrier frequency range, bandwidth, and baud rate limits.

Visual Indicators: LED indicators on front panel for MARK IN, SPACE IN, MARK OUT, SPACE OUT, and RS-232 signals RTS, CTS, and CD.

Operating Temperature: -30°C to +70°C (-22°F to +158°F).

Relative Humidity: 95 percent maximum, non-condensing @ 40°C.

Input Power Requirements:

+5-Volt Supply: 200 mA typical; add 100 mA when using RFL 9800 DSP Programmer.

+15-Volt Supply:

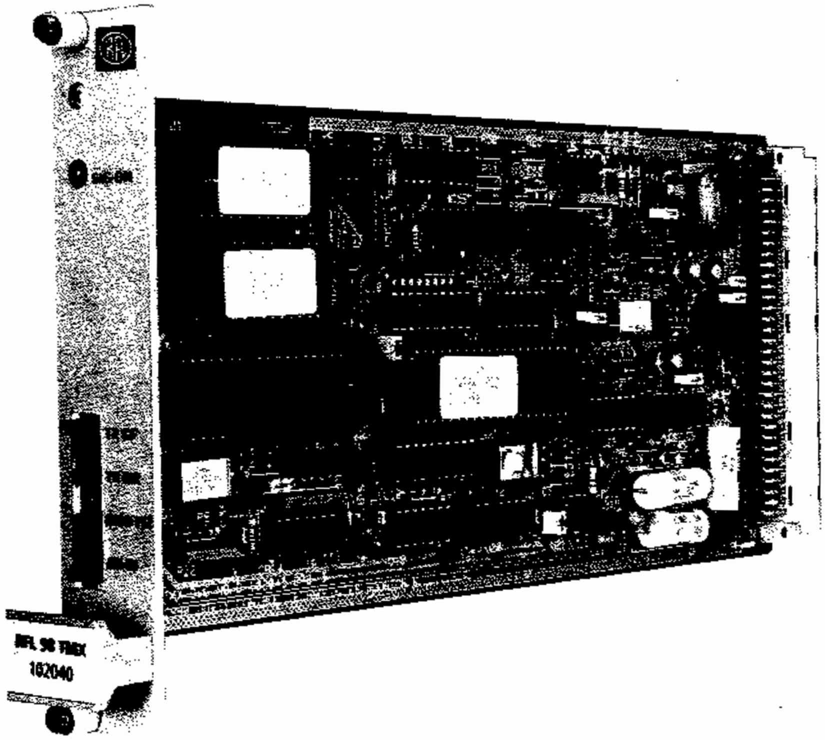
With Relays: 80 mA typical.

Without Relays: 40 mA typical.

-15-Volt Supply: 40 mA typical.

Dimensions: 25.4 mm wide x 128 mm high x 248 mm deep; occupies six horizontal units (6E) in a Single-Euro (3U) chassis.

RFL 98 TMX Programmable Telemetry Transmitter



The RFL 98 TMX is a programmable telemetry transmitting module, capable of operating within wide input and output parameter ranges. It uses Digital Signal Processing (DSP) techniques to produce telemetry signals having greater stability than conventional analog telemetry devices. The operating characteristics of the RFL 98 TMX can be changed by using the RFL 9800 Programmer/Calibrator, which plugs into a dedicated connector on the front of the module.

RFL 98 TMX modules are designed for use in a RFL 9800 Series chassis. Each module requires five horizontal units (5E) of chassis space. Power and data connections are made through an RFL 98 DATA I/O 19-point I/O module, which is installed in the chassis directly behind the module.

SPECIFICATIONS

INPUT:

Voltage Span: 100 mV (min) to 10.0 V (max).

Maximum Differential Voltage: 10.0 V.

Maximum Voltage: 10.0 V, from either differential input to common.

Impedance: Greater than 5.0 MΩ, for both differential and common mode.

Maximum Span Offset: Equal to voltage span.

Common-Mode Voltage Rejection: 80 dB (min).

Accuracy (@ +25°C):
For Voltage Spans Greater Than 250 mV: ±0.05 percent of the Left or Right Scale voltage, whichever absolute value is the greatest.
For Voltage Spans Less Than 250 mV: ±0.05 percent of the Left or Right Scale voltage (whichever absolute value is the greatest), ±0.125 mV.
Effect Of Power Supply Variations On Accuracy: 0.01 percent maximum.

Drift: 0.003 percent/°C over operating temperature range. Six-month drift for identical input value and identical temperature is 0.01 percent maximum.

OUTPUT:

Capacity: 0 dBm ±1.0 dB terminated in 600Ω.

Adjustment Range: -40 dBm to 0 dBm in 0.25-dB increments. Variation is less than 1.0 dB over full temperature range and power supply variation.

Spectral Purity:

Harmonic Content: 50 dB below carrier, at a carrier level of -10 dBm.

Spurious Signals At Adjacent Channels: 40 dB below carrier.

Transmit Carrier Frequency Range: 300 Hz to 3200 Hz, adjustable in 1-Hz increments.

Bandwidths: 50, 60, or 85 Hz.

Frequency Stability: Actual center frequency is within 0.02 percent of room-temperature center frequency over full temperature and power supply variation.

Modulating Frequency Range: 5 Hz minimum to 40 Hz maximum.

Modulating Frequency Span: 20 Hz minimum to 35 Hz maximum.

Output Impedance: 600Ω nominal or greater than 10,000Ω, jumper-selectable.

Calibration: Provisions for calibrating the RFL 98 TMX analog input are provided by the RFL 9800 DSP Programmer/Calibrator. Output level checking is also provided at Left Scale, 10 percent, 50 percent, 90 percent, and 100 percent of the span.

Frequency Characteristics:

Baud Rate	Freq. Shift (Hz)	Band-width (Hz)	Remarks
50	±25	50	Slow-speed control spacing
50/60/75	±30	60	CCITT R.35 and control spacing
85	±42.5	85	43A1/Western Electric Telegraph

GENERAL:

Environmental Requirements:

Operating Temperature: -30°C to +70°C.

Humidity: Up to 95 percent non-condensing with all voltages on and a temperature of 40°C.

Input Power Requirements:

+5-Volt Input: +4.75 to +5.25 volts @ 120 mA.

+15-Volt Input: +14.25 to +15.75 volts @ 20 mA.

-15-Volt Input: -14.25 to -15.75 volts @ 20 mA.

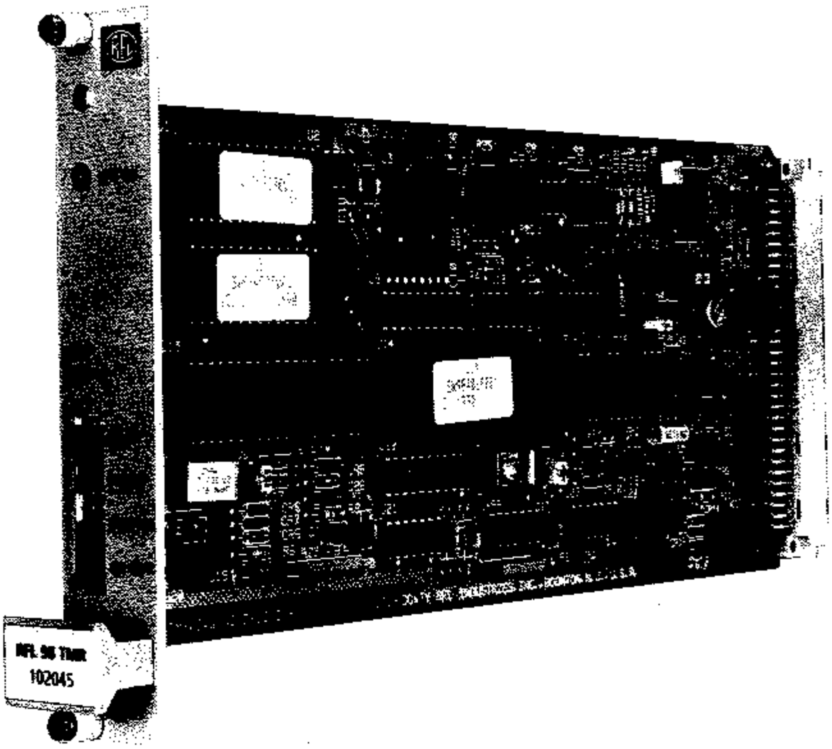
Dimensions:

Width: 25.4 mm (1.0 inch).

Height: 128 mm (5.04 inches).

Depth: 248 mm (9.76 inches).

RFL 98 TMR Programmable Telemetry Receiver



The RFL 98 TMR is a programmable telemetry receiving module, capable of operating within wide input and output parameter ranges. It uses Digital Signal Processing (DSP) techniques to produce telemetry signals having greater stability than conventional analog telemetry devices. The RFL 98 TMR's operating characteristics can be changed by using the RFL 9800 Programmer/Calibrator, which plugs into a dedicated connector on the front panel.

RFL 98 TMR modules are designed for use in any RFL 9800 Series chassis. Each module requires five horizontal units (5E) of chassis space. Power and data connections are made through an RFL 98 DATA I/O 19-point I/O module, which is installed in the chassis directly behind the module.

SPECIFICATIONS

Input Sensitivity: -50 dBm to 0 dBm. The receiver gain is automatically adjusted, normally providing a dynamic range of about 26 dB (10 dB of signal "headroom" and -16 dB before the signal is lost).

Bandwidths: 50, 60, and 85 Hz.

Frequency Stability: Actual center frequency is within 0.02 percent of room-temperature center frequency over full temperature and power supply variation.

Receive Carrier Frequencies: 300 to 3200 Hz, adjustable in 1-Hz steps.

Input Modulating Frequencies: Selectable between 5 Hz to 40 Hz. All specifications are obtainable with a minimum input frequency span of 20 Hz.

Response Speed: When an RFL 9840 TMX and an RFL 98 TMR operate in a back-to-back configuration, response time is less than one second to settle to within 5 percent of the correct value.

Accuracy (@ 25°C): ±0.05 percent of full-scale value (50, 20, or 5 mA).

Stability: Less than 0.003 percent of the full-scale value/°C over full operating temperature range.

Six-Month Drift: Less than 0.01 percent of full-scale value over full temperature range.

Input Impedance: 600Ω nominal, 10,000Ω nominal or 60,000Ω minimum (jumper-selectable).

Outputs:

Primary: Capable of being bipolar. Current output is capable of a 50-mA maximum span @ 10 volts maximum. Current output is jumper-selectable at 5 mA, 20 mA, or 50 mA full-scale. Provision is made for sinking a constant current from an external voltage source of up to +24 Vdc.

Auxiliary Output: Capable of driving a 5-mA maximum span @ 5 volts maximum.

Loss Of Signal Mode: DPDT relay output for loss of telemetry signal. Relay contacts are rated for 1.0 A @ 28 Vdc or 0.5 A @ 115 Vac; the contact sets are connected in parallel for increased capacity. Upon loss of signal, analog output reverts to full left scale, zero volts, or the last valid signal level. Loss of signal detection occurs within 2 cycles of the lowest modulating frequency used. Return to normal operation upon detection of telemetry signal takes about 4 seconds.

Output Span: 1 mA to 50 mA.

Maximum Output Offset (applies to Left Scale reference): Equal to output span.

Output Impedance: 10,000Ω minimum for current output.

Calibration: Provisions for calibrating the RFL 98 TMR's analog output are provided by the RFL 9800 DSP Programmer/Calibrator. Output level checking is also provided at Left Scale, 10 percent, 50 percent, 90 percent, and 100 percent of the span.

Frequency Characteristics:

Baud Rate	Freq. Shift (Hz)	Band-width (Hz)	Remarks
50	±25	50	Slow-speed control spacing
50/60/75	±30	60	CCITT R.35 and control spacing
85	±42.5	85	43A1/Western Electric Telegraph

Environmental Requirements:

Operating Temperature: -30°C to +70°C.

Humidity: up to 95 percent non-condensing with all voltages on and a temperature of 40°C.

Input Power Requirements:

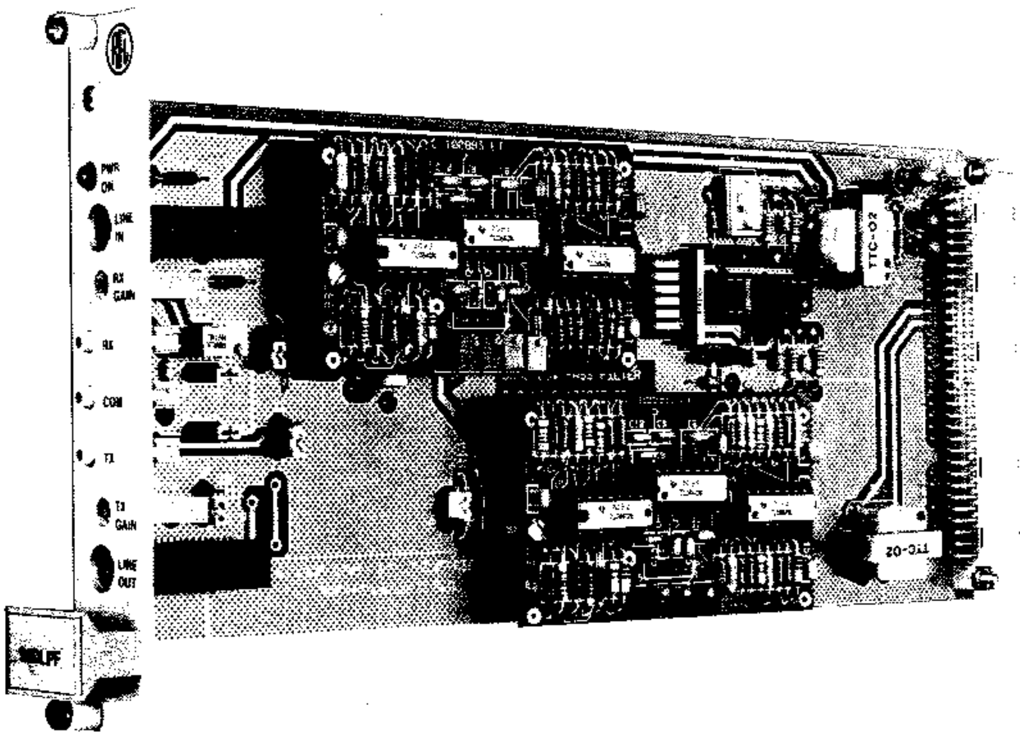
+5-Volt Input: +4.75 to +5.25 volts @ 120 mA

+15-Volt Input: +14.25 to +15.75 volts @ 35 mA.

-15-Volt Input: -14.25 to -15.75 volts @ 35 mA.

Dimensions: 25.4 mm wide x 128 mm high x 248 mm deep.

RFL 9820 DLPF Dual Low-Pass Filter



The RFL 9820 DLPF Dual Low-Pass Filter is designed for use with the RFL 9850 TX/RX Programmable FSK Tone Transceiver. It operates in a speech-plus mode to limit speech to the lower portion of the normal telephone voice-frequency spectrum; this allows tone signals to be transmitted and received in the upper portion of the frequency spectrum.

The RFL 9820 DLPF contains two low-pass filters, which permit bi-directional speech transmission. Since speech quality is related to the frequency spectrum used, the module is available in six standard cutoff frequencies, ranging from 1800 Hz to 3000 Hz.

The RFL 9820 DLPF also contains a high-pass filter, which will limit the speech energy entering the receiver section of the RFL 9850 TX/RX module. In speech-plus systems, the peak speech level is normally at a slightly higher level than the average tone level. By removing most of the speech energy, the high-pass filter enables the tone receiver to operate with a higher sensitivity (input gain). This eliminates the danger of overloading the receiver front end, and improves the signal-to-noise ratio and dynamic range of the tone system. The high-pass filter cutoff frequency is programmable, and is normally selected to be slightly below the low-pass cutoff frequency to provide maximum utilization of the telephone frequency spectrum.

SPECIFICATIONS

LOW-PASS FILTER:

Standard Cutoff Frequencies: 1800, 2000, 2200, 2400, 2700, and 3000 Hz.

Maximum Passband Ripple: 0.5 dB (from 300 Hz to 98 percent of cutoff frequency).

Maximum Loss at Cutoff: 1.5 dB.

Minimum Stopband Attenuation: 60 dB.

Stopband Edge/Passband Edge Ratio: Less than 1.05.

Input/Output Impedances:
- Line Side: 600Ω or more than 60,000Ω; determined by jumper settings.
- Equipment Side:
  - Input Impedance:
    - Four-Wire: Greater than 60,000Ω.
    - Two-Wire: 600Ω to 900Ω nominal.
  - Output Impedance (four-wire): 600Ω to 900Ω.

aximum Signal Levels:
Input: +7 dBm (either direction).
Output: 0 dBm (either direction).

aximum Gain: 30 dB, either direction; separate controls on front panel for transmit and receive gain.

GH-PASS FILTER:

andard Cutoff Frequencies: Programmable between 1768 and 3254 Hz (6-position DIP switch).

aximum Passband Ripple: $\pm$0.5 dB (cutoff to 3400 Hz).

inimum Stopband Attenuation: 43 dB.

ssband Edge/Stopband Edge Ratio: 1.302.

Passband Gain at 3000 Hz: $\pm$0.5 dB.

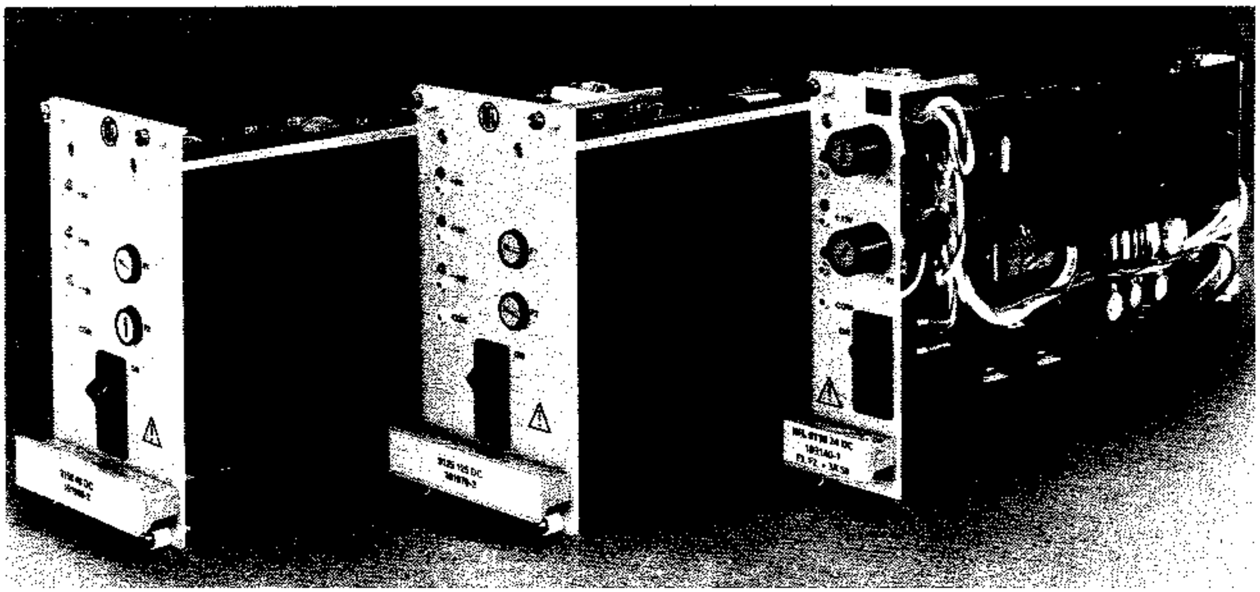
GENERAL:

Environmental Requirements:
Operating Temperature: -30°C to +70°C (-22°C to +158°C).
Humidity: Up to 95 percent non-condensing, with all voltages on and a temperature of +40°C (+104°F).

Input Power Requirements:
+5-Volt Input: +4.25 to +5.25 volts @ 10 mA
+15-Volt Input: +14.25 to +15.75 volts @ 60 mA.
-15-Volt Input: -14.25 to -15.75 volts @ 70 mA.

Dimensions: 25.4 mm wide, 128 mm high, and 248 mm deep; occupies five horizontal units (5E) in a single-Euro (3U) chassis.

Power Supply Modules For 9800 Series Equipment
RFL 9110 **PS (10-Watt)
RFL 9125 **PS (25-Watt)
RFL 9150 **PS (50-Watt)



Three different power supply modules are available for use with RFL 9800 Series equipment: the RFL 9110 **PS, which supplies 10 watts of output power for installations with only a few modules; the RFL 9125 **PS, with 25 watts of output power for medium-size installations; and the RFL 9150 **PS, which can provide 50 watts of output power for larger installations. They can be installed vertically in RFL 98 CHAS 3U Single-Euro or RFL 98W CHAS Wall-Mount Chassis; in addition, RFL 9110 **PS modules can be installed horizontally in the RFL 98A CHAS 1U Flat-Pack Chassis.

Each power supply module provides three regulated outputs: +5, +15, and -15 volts. Switching regulators are used for high efficiency. All outputs have overvoltage protection and short circuit protection; in addition, the entire power supply will shut down if the ambient temperature exceeds a pre-established limit.

RFL 9110 **PS, 9125 **PS, and 9150 **PS power supply modules are available in a wide range of ac and dc input voltages to suit virtually all applications. The following table summarizes the differences between the various models.

Model Number	Assembly Number	Input Voltage Range	Output Power
RFL 9110 24DCPS	103140-1	19 to 29 Vdc	10 W
RFL 9110 48DCPS	103140-2	38 to 58 Vdc	10 W
RFL 9110 125DCPS	103140-3	103 to 150 Vdc	10 W
RFL 9110 110ACPS	103145-1	108 to 132 Vac	10 W
RFL 9110 220ACPS	103145-2	216 to 264 Vac	10 W
RFL 9125 24DCPS	101970-1	19.2 to 28.8 Vdc	25 W
RFL 9125 48DCPS	101970-2	38.4 to 57.6 Vdc	25 W
RFL 9125 125DCPS	101970-3	100 to 150 Vdc	25 W
RFL 9125 250DCPS	101970-4	200 to 300 Vdc	25 W
RFL 9125 110ACPS	101975-1	99 to 121 Vac	25 W
RFL 9125 220ACPS	101975-2	198 to 242 Vac	25 W
RFL 9150 24DCPS	101980-1	19.2 to 28.8 Vdc	50 W
RFL 9150 48DCPS	101980-2	38.4 to 57.6 Vdc	50 W
RFL 9150 125DCPS	101980-3	100 to 150 Vdc	50 W
RFL 9150 250DCPS	101980-4	200 to 300 Vdc	50 W
RFL 9150 110ACPS	101985-1	99 to 121 Vac	50 W
RFL 9150 220ACPS	101985-2	198 to 242 Vac	50 W

SPECIFICATIONS

RFL 9110 **PS SUPPLIES:

Input Voltage: Dependent upon model. (See table.)

Output Voltages And Currents:
+5-Volt Output: +4.75 to +5.25 volts @ 1.2 A.
+15-Volt Output: +14.25 to +15.75 volts @ 0.5 A.
-15-Volt Output: -14.25 to -15.75 volts @ 0.2 A.

Output Ripple (any output): Less than 100 mVp-p, below 10 MHz.

Minimum Loading Requirement: 10 percent.

Overtemperature Protection: Shutdown will occur between +90°C and +100°C (+194°F and +212°F).

Undervoltage Protection: Supply will not be damaged by input voltages below the minimum specified; the supply may or may not operate.

Overvoltage Protection: Supply will shut down if the 5-volt output rises to 6.25 volts, or if either 15-volt output rises to 18.75 volts.

Overload Protection: Supply may shut down if load currents exceed 125 percent of the stated maximum rating for all three outputs.

Input-To-Output Isolation:
Ac-Input Supplies: 1500 Vrms for one minute.
Dc-Input Supplies: 2500 Vdc for one minute; SWC capabilities as noted in ANSI/IEEE C.37-90-198X.

Environmental Requirements:
Temperature: -30°C to +70°C (-22°F to +158°F).
Relative Humidity: 90 percent (non-condensing), at temperatures up to +43°C (+109°F).

Dimensions: 5.1 inches x 1.4 inches x 9.75 inches (130 mm x 38.1 mm x 248 mm); occupies one dedicated module space in a 1U flat-pack chassis, or six horizontal positions (6E) in a single-Euro chassis.

RFL 9125 **PS AND RFL 9150 **PS SUPPLIES:

Input Voltage: Dependent upon model. (See table.)

Output Voltages And Currents:
RFL 9125 **PS Supplies:
+5-Volt Supply: +4.75 to +5.25 volts @ 3 A
+15-Volt Supply: +14.25 to +15.75 volts @ 1.2 A
-15-Volt Supply: -14.25 to -15.75 volts @ 0.5 A
RFL 9150 **PS Supplies:
+5-Volt Supply: +4.75 to +5.25 volts @ 6 A
+15-Volt Supply: +14.25 to +15.75 volts @ 1.5 A
-15-Volt Supply: -14.25 to -15.75 volts @ 1.5 A

Total Output Power:
RFL 9125 **PS Supplies: 25 watts maximum.
RFL 9150 **PS Supplies: 50 watts maximum.

Minimum Loading Requirement: 5 percent.

Efficiency: Greater than 65 percent at full load.

Output Ripple:
5-Volt Supply: 0.1 Vp-p maximum.
15-Volt Supplies: 0.4 Vp-p maximum.

Temperature Protection:
Input Converter: Shutdown will occur between +90°C and +105°C (+194°F and +221°F).
Output Converter: Shutdown will occur between +100°C and +110°C (+212°F and +230°F).

Undervoltage Protection: Supply will not be damaged by input voltages below the minimum specified; the supply may or may not operate.

Overvoltage Protection: Supply will shut down if the 5-volt output rises to +7 volts, or if either 15-volt output rises to 20 volts. To restart, the main power switch must be manually cycled.

Overload Protection:
+5-Volt Supply: 11 amperes maximum.
+15-Volt Supply: 9 amperes maximum.
-15-Volt Supply: 6 amperes maximum.

All three supplies will shut down if load currents exceed the above limits. To restart, main power switch must be manually cycled. When used with some Dowty products, automatic restart may occur.

Isolation: Circuit common is isolated from chassis ground by at least 2500 Vdc.

Surge Withstand Capability: Meets the requirements of ANSI/IEEE C37.90.1.198X.

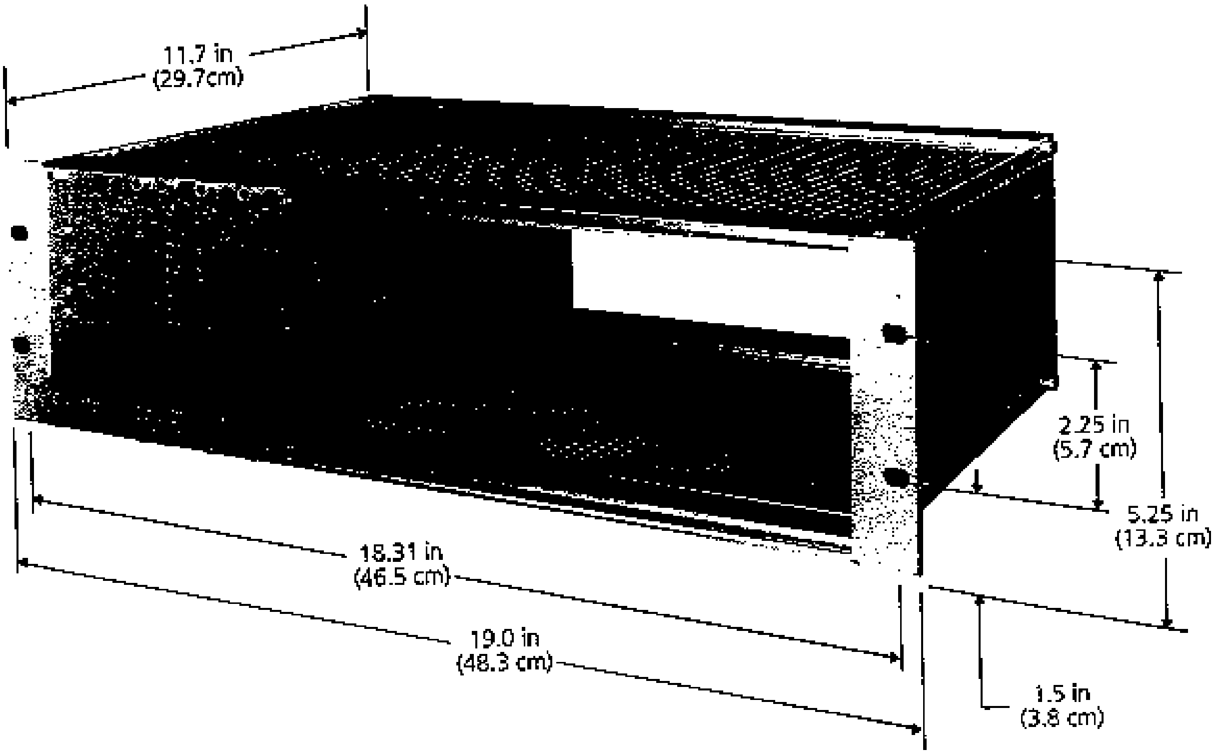
Environmental Requirements:
Temperature:
Operating: -30°C to +70°C (-22°F to +158°F).
Storage: -40°C to +70°C (-40°F to +158°F).
Survival: -40°C to +70°C (-40°F to +158°F); supply may not meet specifications, but it must not suffer damage while operating over this range.
Relative Humidity: 95 percent maximum (non-condensing), for up to 96 hours at temperatures up to +56°C (+133°F).
Altitude: 10,000 feet (3050 meters).

Dimensions: 5.1 inches x 2.8 inches x 8.8 inches (130 mm x 71 mm x 225 mm); occupies twelve horizontal positions (12E) in a single-Euro chassis.

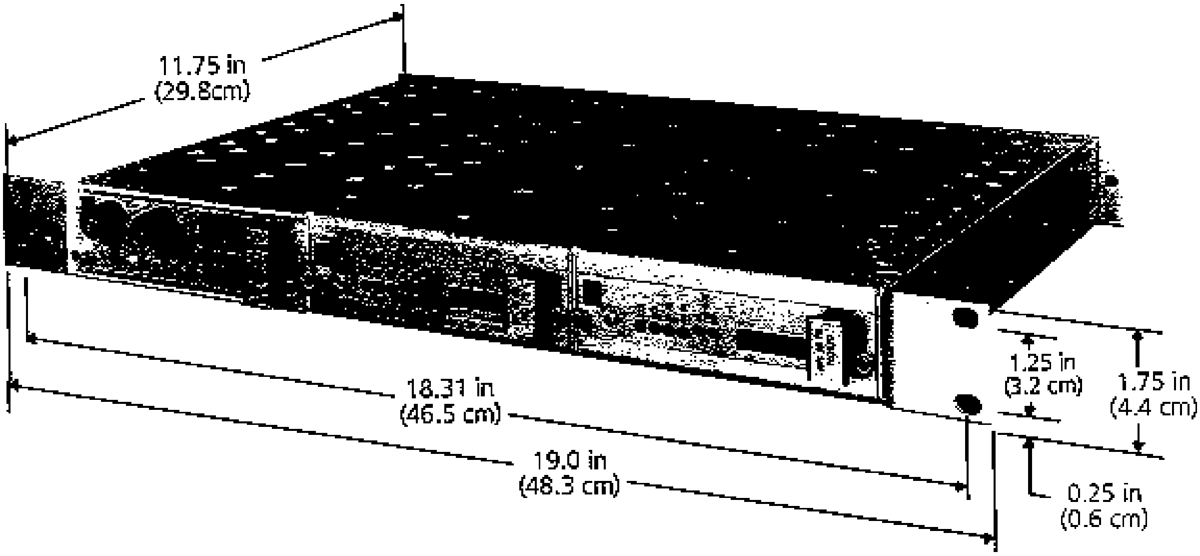
Chassis For RFL 9800 Series Equipment

Several chassis are available for housing RFL 9800 Series equipment. The circuit board modules are inserted into the chassis from the front, and secured in place by quarter-turn fasteners on the front panels. I/O modules with mating connectors for each circuit board module are mounted at the rear of the chassis, and all interconnect wiring between modules and external equipment are made using terminal blocks and connectors on the I/O modules.

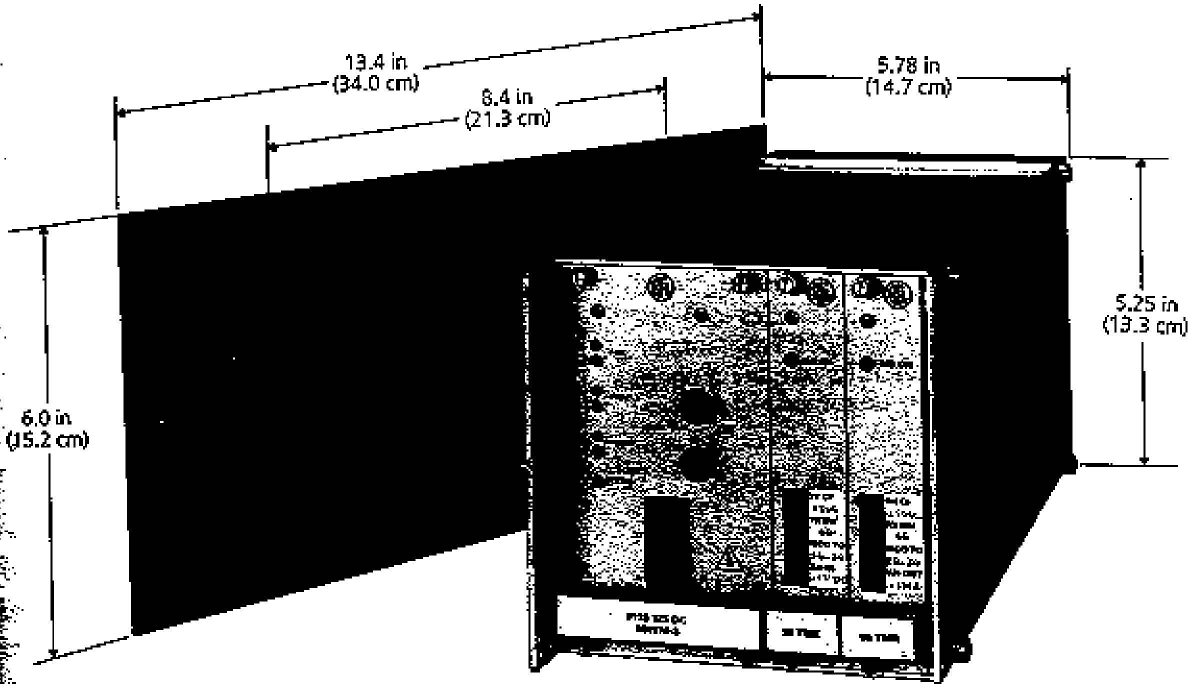
The following illustrations provide mounting dimensions for the standard RFL 9800 Series chassis. If necessary, special chassis can be provided on special order.



RFL 98 CHAS 3U Rack-Mount Chassis

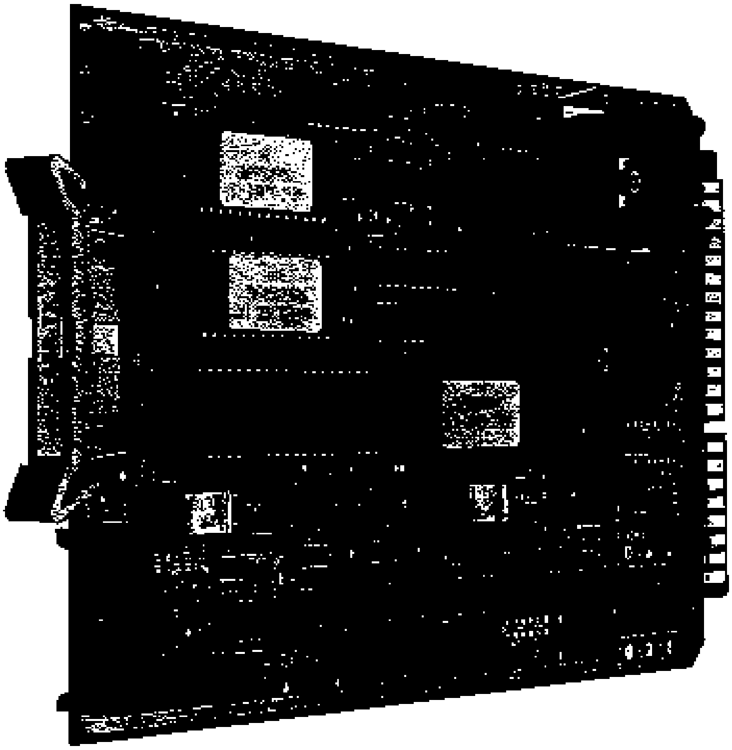


98A CHAS 1U Flat-Pack Chassis



98W CHAS Wall-Mount Chassis

RFL 68P TX Programmable FSK Tone Transmitter



The RFL 68P TX is a fully-programmable FSK tone transmitter. It can be programmed to operate on any standard center frequency from 300 Hz to 3200 Hz, with frequency shifts up to 300 Hz and at speeds up to 600 baud (2F operation only). The RFL 68P TX uses Digital Signal Processing (DSP) techniques to replace the discrete oscillators, modulators, and filters normally used in FSK transmitters.

The RFL 68P TX's operating characteristics can be changed by using the hand-held RFL 9800 Programmer to modify the software. This means its operating characteristics cannot be modified by unauthorized personnel.

SPECIFICATIONS

Input Keying: RS-232C, MIL-STD-188, TTL, CMOS, dry contact, or optically-isolated.

Transmit Carrier Frequency: Adjustable in 1-Hz steps; can be set to any frequency where the high and low shift frequencies will both be between 300 Hz and 3200 Hz.

Transmit Bandwidth: Can be set to 50, 60, 85, 120, 240, 300, or 600 Hz.

Transmit Output Level: Adjustable from -40 dBm to 0 dBm in 0.25-dB steps. Variation is less than 1.0 dB over full temperature range and power supply variation.

Frequency Stability: Within 0.02 percent of center frequency at +70°F (+21°C).

Frequency Characteristics:

Baud Rate	Freq. Shift (Hz)	Band-width (Hz)	Remarks
50	±25	50	Slow-speed control spacing
50/60/75	±30	60	CCITT R.35 and control spacing
85/110	±42.5	85	43A1/Western Electric Telegraph
100/120	±60	120	240-Hz spacing (CCITT R.37)
200/300	±120	240	480-Hz spacing (CCITT R.38A)
300	±150	300	600-Hz spacing
600	±300	600	1200-Hz spacing

Output Impedance: Strap-selectable, 600Ω nominal or 60,000Ω minimum, isolated and balanced.

Spectral Purity:
- Harmonic Content: 50 dB below carrier, at a carrier level of -10 dBm.
- Spurious Signals At Adjacent Channels: 40 dB below carrier.

Distortion: Less than 7 percent when operating within the stated carrier frequency range, bandwidth, and baud rate limits.

Keying Modes:
- Two-Frequency (2F): Available at all bandwidths, at speeds up to 600 baud.
- Three-Frequency (3F): Available at all bandwidths up to 120 Hz, at speeds up to 120 baud.

Clear-To-Send Delay: Programmable from 5 ms to 255 ms in 1-ms increments.

Transmit MARK Polarity: Can be set to either high or low frequency.

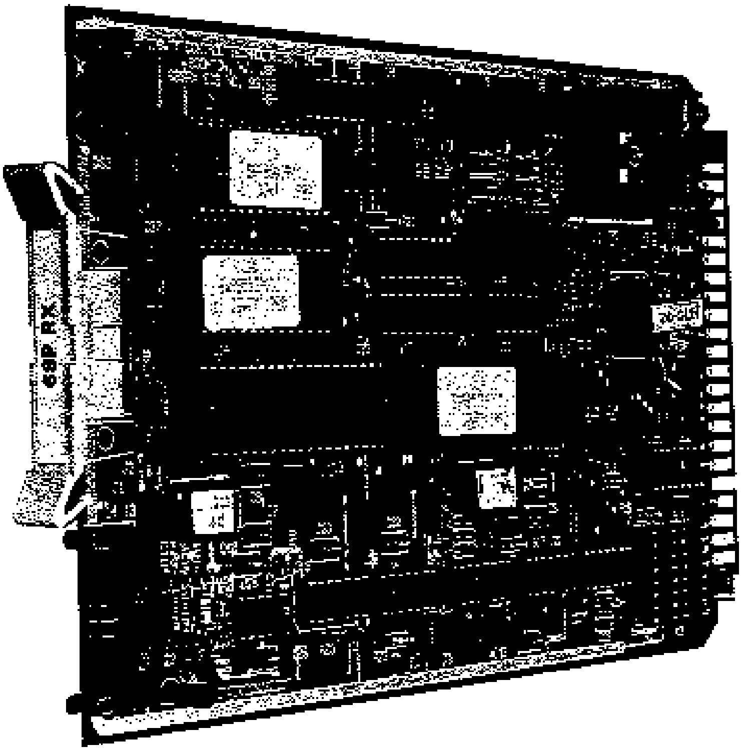
Visual Indicators: LED indicators on front panel for MARK IN, SPACE IN, and RS-232 signals RTS and CTS.

Environmental Requirements:
- Operating Temperature: -30°C to +70°C (-22°F to +158°F).
- Relative Humidity: 95 percent maximum, non-condensing @ 40°C.

Input Power Requirements:
- With internal +5-Volt Supply Connection:
  - +12-Volt Supply: 200 mA typical; add 100 mA when using RFL 9800 DSP Programmer/Calibrator.
  - -12-Volt Supply: 25 mA typical.
- With External +5-Volt Supply:
  - +5-Volt Supply: 225 mA typical; add 100 mA when using RFL 9800 DSP Programmer/Calibrator.
  - +12-Volt Supply: 40 mA typical.
  - -12-Volt Supply: 25 mA typical.

Dimensions: 4.713 inches high x 8.00 inches long x 0.75 inches wide (120 mm x 203 mm x 19 mm), excluding module handle; occupies two module slots in chassis.

RFL 68P RX Programmable FSK Tone Receiver



The RFL 68P RX is a fully-programmable FSK tone receiver. It can be programmed to operate on any standard center frequency from 300 Hz to 3200 Hz, with frequency shifts up to 300 Hz and at speeds up to 600 baud (2F operation only). The RFL 68P RX uses Digital Signal Processing (DSP) techniques to replace the discrete filters and demodulators normally used in FSK receivers.

The RFL 68P RX's operating characteristics can be changed by using the hand-held RFL 9800 Programmer to modify the software. This means its operating characteristics cannot be modified by unauthorized personnel.

SPECIFICATIONS

Receive Carrier Frequency: Adjustable in 1-Hz steps; can be set to any frequency where the high and low shift frequencies will both be between 300 Hz and 3200 Hz.

Receive Bandwidth: Can be set to 50, 60, 85, 120, 240, 300, or 600 Hz.

Receive Mode Of Operation:
Two-frequency (2F): Up to 600 baud.
Three-frequency (3F): Up to 120 baud.

Input Impedance: Strap-selectable, 600Ω nominal, 10,000Ω nominal, or 60,000Ω minimum; transformer-isolated and balanced.

Input Sensitivity: -50 dBm to 0 dBm. The receiver gain is automatically adjusted, normally providing a dynamic range of about 26 dB (10 dB of signal "headroom" and -16 dB before the carrier detect signal is lost). Automatic setting can be manually overridden if desired.

Distortion: Less than 7 percent end-to-end, when operating within the stated carrier frequency range, bandwidth, and baud rate limits.

Adjacent Channel Response: Adjacent channel rejection to MARK and SPACE is greater than 40 dB.

Frequency Characteristics:

Baud Rate	Freq. Shift (Hz)	Band-width (Hz)	Remarks
50	±25	50	Slow-speed control spacing
50/60/75	±30	60	CCITT R.35 and control spacing
85/110	±42.5	85	43A1/Western Electric Telegraph
100/120	±60	120	240-Hz spacing (CCITT R.37)
200/300	±120	240	480-Hz spacing (CCITT R.38A)
300	±150	300	600-Hz spacing
600	±300	600	1200-Hz spacing

Frequency Stability: Actual center frequency is within 0.02 percent of room-temperature center frequency over full temperature range and power supply variation.

Visual Indicators: LED indicators on front panel for MARK OUT, SPACE OUT, and CD (Carrier Detect).

Receive MARK Polarity: Can be set to either high or low frequency. Receiver can be set to clamp high or low with loss of carrier.

Carrier Detector:

- Signal Times: ON time is programmable from 5 ms to 255 ms in 1-ms increments. OFF time is fixed at about 10 ms.
- Hysteresis: 2 dB to 3 dB typical.
- Clamping:
  - 2F Operation: Receiver squelch and carrier detect work together to clamp receiver output to either MARK or SPACE, as programmed.
  - 3F Operation: Receiver squelch and carrier detect work together to clamp receiver output to the center frequency.
- Delay: Adjustable from 5 ms to 255 ms in 1-ms increments.

MARK, SPACE, and Carrier Detect Outputs:

- Open-Collector NPN Transistors (standard): Rated for 150 mA @ 30 Vdc; RS-232C outputs are also available.
- Relays (optional):
  - Form:
    - Dry Contact: DPDT (dual Form C).
    - Mercury-Wetted (MARK and SPACE outputs only): SPDT (Form C).
  - Contact Ratings: 2 amperes resistive @ 28 Vdc.
  - Maximum Switching Power: 60 watts resistive, 125 VA.
  - Maximum Switching Current: 2 amperes.
  - Maximum Switching Voltage: 250 Vac or 220 Vdc.

Environmental Requirements:

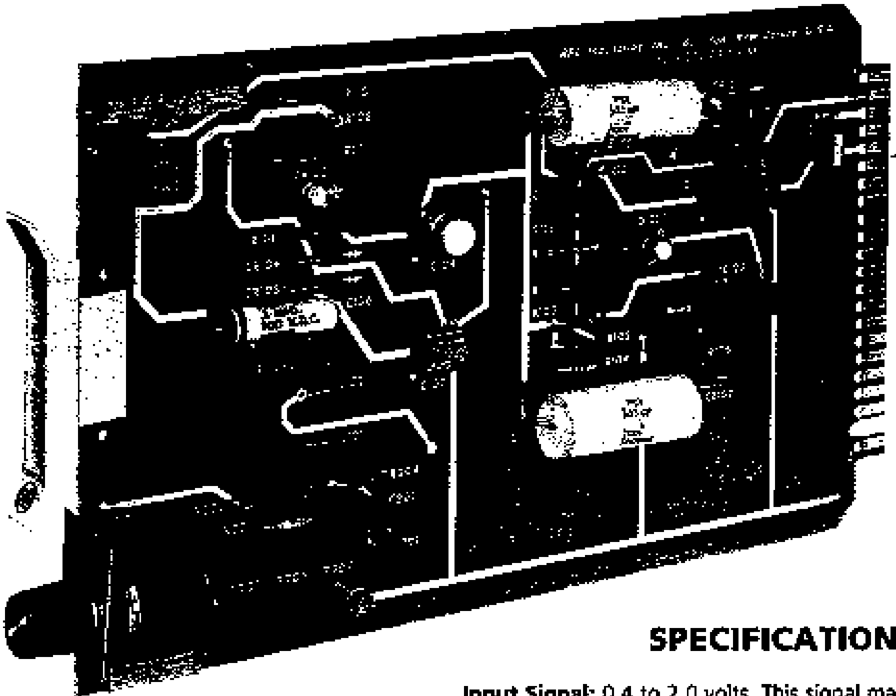
- Operating Temperature: -30°C to +70°C (-22°F to +158°F).
- Relative Humidity: 95 percent maximum, non-condensing @ 40°C.

Input Power Requirements:

- With Internal +5-Volt Supply Connection:
  - +12-Volt Supply: 200 mA typical; add 100 mA when using RFL 9800 DSP Programmer/Calibrator.
  - -12-Volt Supply: 25 mA typical.
- With External +5-Volt Supply:
  - +5-Volt Supply: 225 mA typical; add 100 mA when using RFL 9800 DSP Programmer/Calibrator.
  - +12-Volt Supply: 40 mA typical.
  - -12-Volt Supply: 25 mA typical.

Dimensions: 4.713 inches high x 8.00 inches long x 0.75 inches wide (120 mm x 203 mm x 19 mm), excluding module handle; occupies two module slots in chassis.

RFL 64B TMX Analog Telemetry Transmitter



The RFL 64B TMX Analog Telemetry Transmitter is used to convert the voltage or current generated by an analog transducer into a variable-frequency audio tone. The audio tone is usually used to key an FS tone transmitter (such as the RFL 68B FSTX), for multiplexing with other signals on a communications network. Current inputs are converted to a voltage with a resistor, so they may be used as an input to the transmitter.

Test points are provided along the front edge of the RFL 64B TMX for maintenance and adjustment. An optional calibrator can be added so the RFL 64B TMX can be keyed precisely to the 10, 50, or 90-percent points of its range.

RFL 64B TMX Ordering Information Telemetry Module	Telemetry Transmitter	Calibrator Option	FSK Tone Transmitter Option 44845	Application
64B TMX	•			*Standard input (4 - 20, 10 - 50 mA, etc.)
64B TMX-1	•	•		*Standard, but including Calibrator
64B TMX-2	•		•	Standard input but including Tone Transmitter
64B TMX-3	•	•	•	Standard input, but including Calibrator and Tone Transmitter

*NOTE: Specify input range (4 - 20 mA, 10 - 50 mA, 1 - 5 Volts, etc.)

SPECIFICATIONS

Input Signal: 0.4 to 2.0 volts. This signal may be developed across an external shunt resistor when current sources are used.

Input Impedance: 5 MΩ minimum; 10 MΩ typical.

Output Signal: Square wave; 5 to 20 Hz, 12 Vp-p.

Accuracy: ±0.15 percent of full span at +20°C (+68°F), when used back-to-back with RFL 64B TMR.

±0.5 percent of full span from -3°C to +47°C (+27°F to +117°F), when used back-to-back with RFL 64B TMR.

±1.0 percent of full span from -30°C to +70°C (-22°F to +158°F), when used back-to-back with RFL 64B TMR.

Settling Time: 1.5 seconds to 90 percent of full span, when operated back-to-back with RFL 64B TMX.

FS Transmitter (optional):

Center Frequency: 300 to 3500 Hz.

Bandwidth: 120-Hz spacings standard; other spacings available on special order.

Frequency Tolerance And Drift: ±0.25 percent over the specified temperature range.

Output Level: Adjustable from -40 dBm to -3 dBm.

Harmonic Content: At least 50 dB below fundamental.

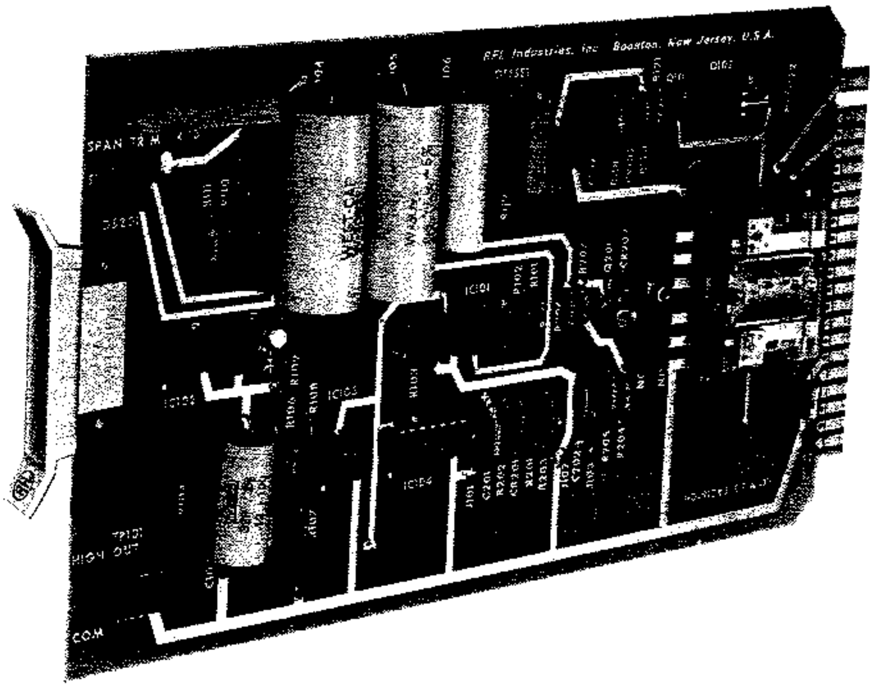
Output Impedance: 600Ω nominal within the band, with a rising impedance out of band. The two-section output filter is balanced.

Operating Temperature: -30°C to +70°C (-22°F to +158°F).

Input Power Requirements: +12 volts @ 10 mA; add an additional 10 mA when equipped with the optional FS transmitter.

Dimensions: 4.713 inches high x 8.00 inches long x 0.75 inches wide (120 mm x 203 mm x 19 mm), excluding module handle; occupies two module slots in chassis. If equipped with the optional tone transmitter, three module spaces are required.

RFL 64B TMR Analog Telemetry Receiver



...FL 64B TMR is the complement for the ...4B TMX Analog Telemetry Transmitter; it converts ...iable-frequency audio tones it receives back into ...es or currents. The audio tone is usually supplied ...ultiplexing FS tone receiver, (such as the RFL 68B ...An optional signal-loss circuit is also available.

SPECIFICATIONS

...equency: 5 to 25 Hz squarewave, +6 volts minimum, refer-...d to common.

...urrent: 4 to 20 mA standard, adjustable up to 10 to 50 mA ...mum. A ratio of 5:1 for maximum to minimum current must ...aintained.

Accuracy: ±0.15 percent of full span at +20°C (+68°F), when used back-to-back with RFL 64B TMX.

±0.5 percent of full span from -3°C to +47°C (+27°F to +117°F), when used back-to-back with RFL 64B TMX.

±1.0 percent of full span from -30°C to +70°C (-22°F to +158°F), when used back-to-back with RFL 64B TMX.

Speed Of Response: 1.5 seconds to within 10 percent of full span, when measured back-to-back with RFL 64B TMX.

Operating Temperature: -30°C to +70°C (-22°F to +158°F).

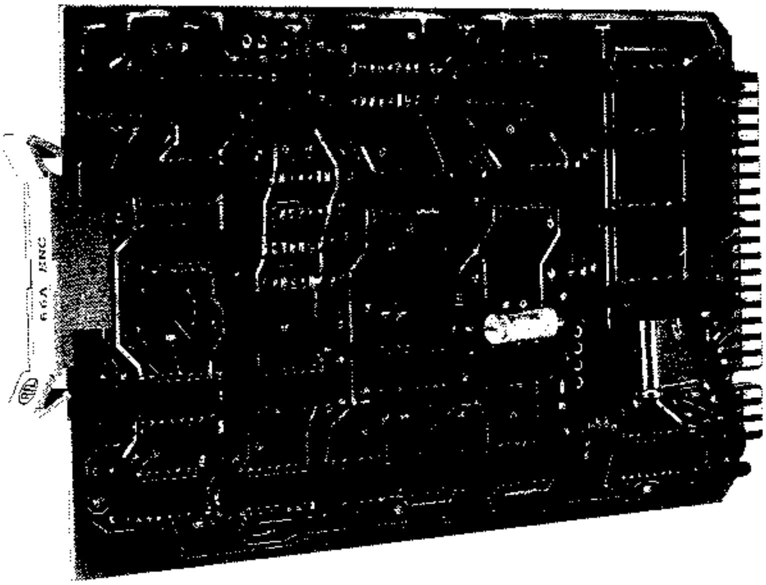
Input Power Requirements: +12 volts @ 35 mA; add an additional 35 mA when equipped with optional Signal Failure Alarm.

Dimensions: 4.713 inches high x 8.00 inches long x 0.75 inches wide (120 mm x 203 mm x 19 mm), excluding module handle; occupies two module slots in chassis.

RFL 64B TMR Ordering Information Telemetry Module	Telemetry Receiver	Signal-Loss Relay Option	Application
64B TMR	●		*Current Output
64B TMR-1	●	●	*Current Output with Signal-Loss Circuit

*NOTE: Specify output voltage or current range required, such as 4 - 20 mA, 10 - 50 mA, 1 - 5 Volts, etc.

RFL 66A ENC Encoder Controller And RFL 66A ENC EXP Encoder Expander



The RFL 66A ENC Encoder Controller develops a serial data code, representing the status of its sixteen data input points. This code can be used to key an FS tone transmitter (such as the RFL 68B FSTX), for multiplexing with other signals on a communications network. At the receiving end, the code is reconverted into sixteen points by an RFL 66A DEC Decoder Controller.

RFL 66A ENC EXP Encoder Expander boards can be used to increase the number of inputs, in groups of 16 (16, 32, 48, etc).

SPECIFICATIONS

Number Of Input Data Bits: Sixteen standard; can be expanded in groups of 16 (up to a maximum of 64 double scan or 144 singlescan bits) by adding RFL 66A ENC EXP Encoder Expanders.

Output Circuits: Open-collector or contact closure to common (or ground) is standard; closure to V+ is also available.

Data Rate: 60 baud standard; rates from 35 to 1600 baud can be provided by jumper settings or component changes.

Code: Each message word begins with a header, and contains two parity bits and sixteen data bits. Doublescan is standard; singlescan is optional.

Security: Multiple parity and doublescan are standard; doublescan can be omitted by changing a jumper.

Scan Time (at 60 baud):
Doublescan: 1.1 seconds (66 bits).
Singlescan: 0.57 second (34 bits).

Output: The output circuits produce CMOS-compatible, 12-volt pulses, suitable for keying an FSK receiver, or other compatible line interfacing unit. They can also be used with the optional metallic-line driver.

LED Indicator: One; flashes to show that the encoder is active.

FS Transmitter (optional):
Center Frequency: 300 to 3500 Hz.
Bandwidth: 120-Hz spacings standard; other spacings available on special order.
Frequency Tolerance And Drift: ±0.25 percent over the specified temperature range.
Output Level: Adjustable from -40 dBm to -3 dBm.
Harmonic Content: At least 50 dB below fundamental.
Output Impedance: 600Ω nominal within the band, with a rising impedance out of band. The two-section output filter is balanced.
Change-Of-State Detector: Provides for detection of input point changes of state. Input signal changes occurring within 4 ms of each other will not be detected as a change of state.

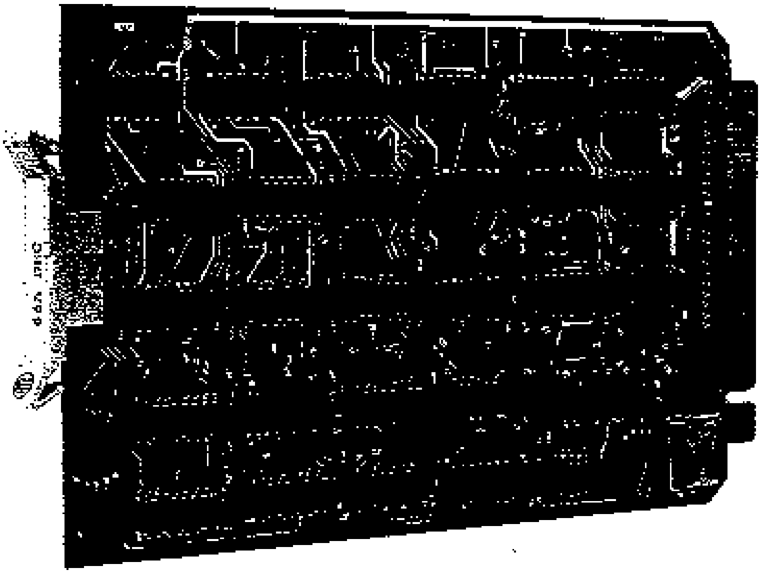
Metallic Line Driver (optional):
Maximum Usable Rate: 600 baud.
Maximum Total Loop Resistance: 400Ω.

Operating Temperature: -30°C to +70°C (-22°F to +158°F).

Input Power Requirements: +11 to +13 volts @ 30 mA, with all inputs connected to common. Add 10 mA when equipped with the optional FS transmitter; the optional metallic line driver requires an additional 10 mA.

Dimensions: 4.713 inches high x 8.00 inches long x 0.75 inches wide (120 mm x 203 mm x 19 mm), excluding module handle; occupies two module slots in chassis. If equipped with the optional FS transmitter or the metallic line driver, three module spaces are required.

RFL 66A DEC Decoder Controller
And RFL 66A DEC EXP Decoder Expander



The RFL 66A DEC Decoder Controller accepts the serial data code produced by an RFL 66A ENC Encoder Controller, and develops a parallel-data output corresponding to the status of the RFL 66A ENC's inputs. The serial data code is usually received from an FS tone receiver (such as the RFL 68B FSRX), which serves as the interface with the communications medium. RFL 66A EXP Decoder Expander boards can be used to increase the number of outputs, in groups of 16 (16, 32, 48, etc).

SPECIFICATIONS

Input: The input circuits are CMOS-compatible, and they will respond to output signals from an FSK receiver. They can also be used with the optional metallic-line receiver.

Data Rate: 60 baud standard; rates from 35 to 1600 baud can be provided by jumper settings or component changes.

Code: Each message word begins with a header, and contains two parity bits and sixteen data bits. Doublescan is singlescan is optional.

Scan Time (at 60 baud):
Doublescan: 1.1 seconds (66 bits).
Singlescan: 0.57 second (34 bits).

Number Of Output Data Bits: Sixteen standard; can be expanded in groups of 16 (up to a maximum of 64 doublescan or 144 singlescan bits) by adding RFL 66A DEC EXP-1 Decoder Expanders.

Output Circuits: Open-collector outputs to common will sink a maximum of 120 mA, and will withstand 50 Vdc simultaneously at all outputs. Optional output relay mountings are available, and optional pull-up resistors can be included.

Security: Parity and doublescan are standard; singlescan is optional. A supervisory lamp and an open-collector closure to common will indicate a scan failure. As an option, the outputs can be set to go to the non-conducting state if a scan failure occurs.

LED Indicators: Two: one for data release, and one for scan failure.

Power Turn-On: During power turn-on, outputs are set to the non-conducting state.

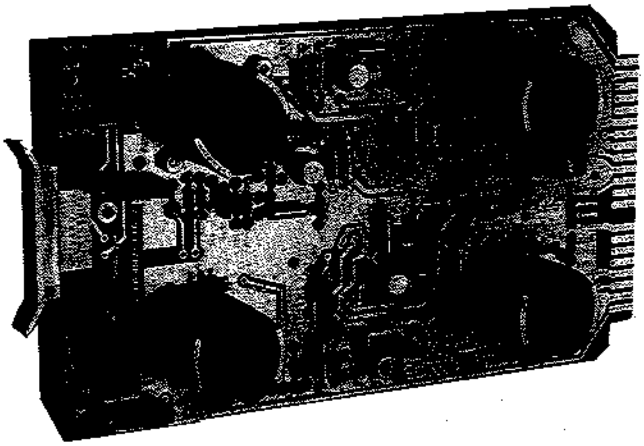
Metallic Line Receiver (optional):
Maximum Usable Rate: 600 baud.
Maximum Total Line Resistance: 400Ω.

Operating Temperature: -30°C to +70°C (-22°F to +158°F).

Input Power Requirements: +11 to +13 volts @ 30 mA, with all outputs open. Add 10 mA when equipped with the optional metallic line receiver.

Dimensions: 4.713 inches high x 8.00 inches long x 0.75 inches wide (120 mm x 203 mm x 19 mm), excluding module handle; occupies two module slots in chassis.

RFL 68 AF DUAL AMP-1 Audio Amplifier



The RFL 68 AF DUAL AMP-1 Dual Audio Amplifier Module contains two fully-independent audio amplifiers. Each amplifier is divided into two parts: an input amplifier equipped with an input isolation transformer, and an output amplifier equipped with an output isolation transformer. Each amplifier is equipped with a gain control. Many different application requirements and operating levels are possible by positioning jumpers on the circuit board and arranging the external connections.

The RFL 68 AF DUAL AMP-1 can be used as a general-purpose amplifier and combiner for audio signals. A "T" pad can also be added to the output of each amplifier, with its attenuation set to fit the needs of the application.

SPECIFICATIONS

Input And Output Impedance: 600Ω, balanced or unbalanced, with or without transformers. Return loss is greater than 20 dB from 300 Hz to 400 Hz.

Frequency Response (with transformers): Within 0.5 dB of 1000-Hz reference from 300 to 4000 Hz.

Gain: Continuously adjustable from -30 dB to +30 dB, using jumpers to set the range of a multi-turn potentiometer.

Maximum Output Level: +10 dBm, with an input supply voltage of ±12 volts. Output must be derated if supply voltage falls below ±12 volts.

Total Harmonic Distortion:
200 Hz To 500 Hz: Less than 1.5 percent @ +10 dBm.
500 Hz To 4000 Hz: Less than 0.2 percent @ +10 dBm.

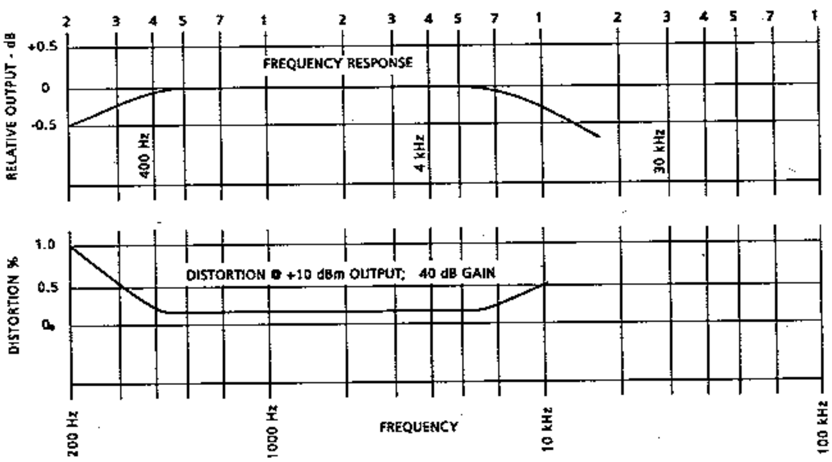
Output Noise: Less than -65 dB from 200 Hz to 4000 Hz.

Crosstalk: Coupling between amplifiers is less than -70 dB from 300 Hz to 400 Hz.

Operating Temperature: -30°C to +70°C (-22°F to +158°F).

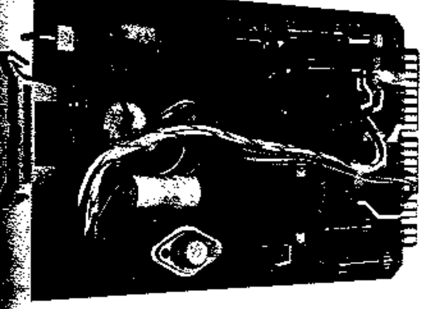
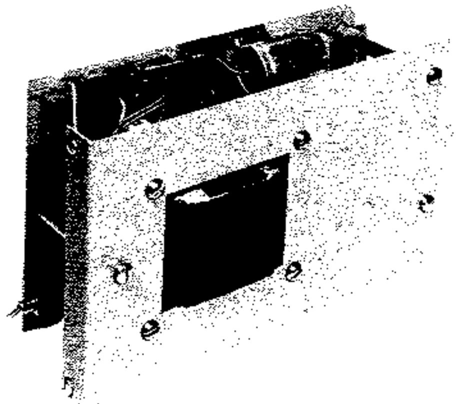
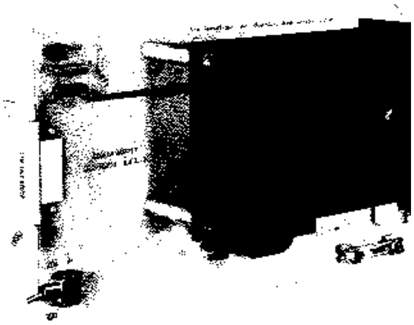
Input Power Requirements:
+12-Volt Supply: +11 to +15 volts @ 60 mA.
-12-Volt Supply: -11 to -15 volts @ 60 mA.
Required Supply Regulation: 5 percent minimum.

Dimensions: 4.713 inches high x 8.00 inches long x 1.5 inches wide (120 mm x 203 mm x 38 mm), excluding module handle; occupies three module slots in chassis.



Because RFL™ and Hubbell® have a policy of continuous product improvement, we reserve the right to change designs and specifications without notice.

Power Supplies For 6000 Series Equipment

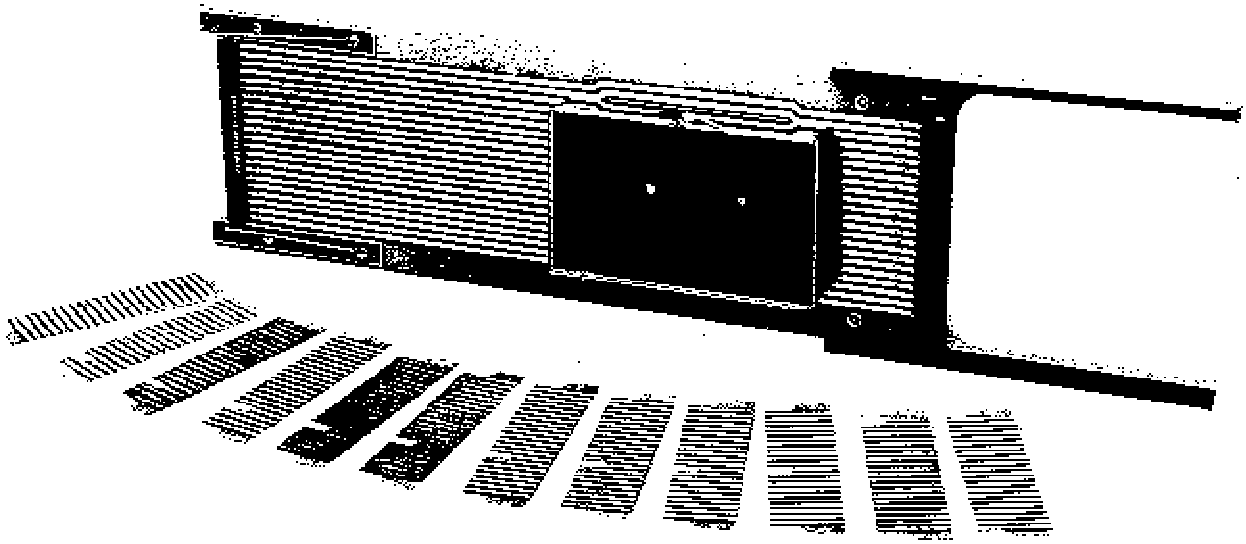
Several different power supply modules are available for use with Series 6000 equipment. Ac supplies are available for operation from 115 or 230 Vac lines, at 50 or 60 Hz; dc-dc converter supplies can operate from 24, 48, or 129-volt dc sources.

The following table summarized the different Series 6000 power supplies that are available. All supplies provide bipolar 12-volt regulated outputs, except for the RFL 68B PS AC, which provides a single +12-volt regulated output, with an additional +24-volt regulated output optional. Most supplies also provide unregulated outputs, and 10-kHz outputs that are used to drive isolation ciurcuits on some RFL circuit board modules.

Model Number	Nominal Input Voltage	Maximum Power Consumption	Regulated Output Current mA (1)	Overvoltage Protection	Module Spaces Required	External Regulator Required? (2)
RFL 68 HPS 24DC-1	24 Vdc (3)	24 watts	1000	Standard	3	Yes
RFL 68 HPS 48DC-1	48 Vdc (3)	24 watts	1000	Standard	3	Yes
RFL 68 HPS 129DC-1	129 Vdc (3)	24 watts	1000	Standard	3	Yes
RFL 68 PS AC-1 (4)	115/230 Vac	15 watts	250	Standard	3	No
RFL 68A HPS AC-1	115 Vac	65 watts	1000	Standard	5	Yes
RFL 68A HPS AC-3	230 Vac	65 watts	1000	Standard	5	Yes
RFL 68B PS AC (4)	115/230 Vac	1/4 A (115 V) 1/8 A (230 V)	(5)	Not available	4	No
RFL 68B PS AC-2	115 Vac	1/4 A	(6)	Not available	4	No

(1) Unless otherwise specified, this is the output current from each of two independent 12-volt output circuits.
(2) The RFL 68 REG External Regulator is a separate unit from the power supply, but it is always required (except when ordering spare or replacement modules).
(3) Maximum allowable ripple is 1.5 Vrms.
(4) Specify if supply is to be adjusted for 115 or 230 Vac, so proper fuse can be supplied.
(5) This supply provides a single +12-volt, 500-mA regulated output.
(6) This supply provides a +12-volt, 500-mA regulated output, and a +24-volt, 50-mA regulated output.

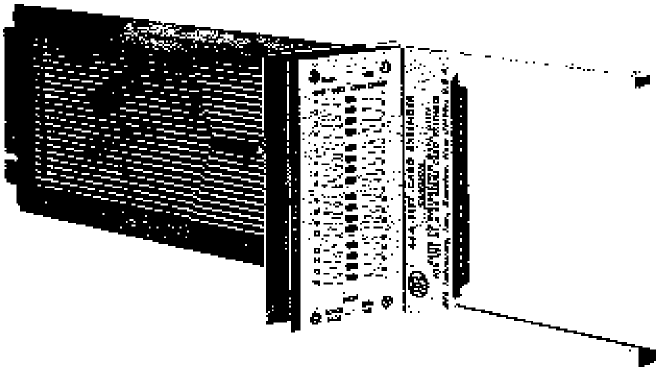
RFL 68 EXT Universal Card Extender



The RFL 68 EXT Universal Card Extender can be used to gain access to the sides of 6000 Series circuit board modules while they are connected to the power supply and the other circuit board modules in a chassis. Use of the RFL 68 EXT simplifies adjustment, maintenance, and troubleshooting.

A storage box fastened to the side of the RFL 68 EXT by two plastic rivets contains all the adapters illustrated above. These adapters match the extender with an indexing key in any of the 22 possible positions. If necessary, the storage box can be removed by pushing the center pins out of the rivets.

RFL 66A TEST EXT Test Extender



The RFL 66A TEST EXT Test Extender is a diagnostic tool for use with the RFL 66A ENC Encoder Controller, Encoder Expander, RFL 66A ENC RFL 66A DEC Decoder Controller and the RFL 66A DEC Decoder Expander. Means are provided to force input data while in the FORCE DATA mode with an encoder, and monitor decoder outputs while in the GEN USE mode. Any data terminal can be isolated from the rear-panel edge connector.

Chassis For 6000 Series Equipment

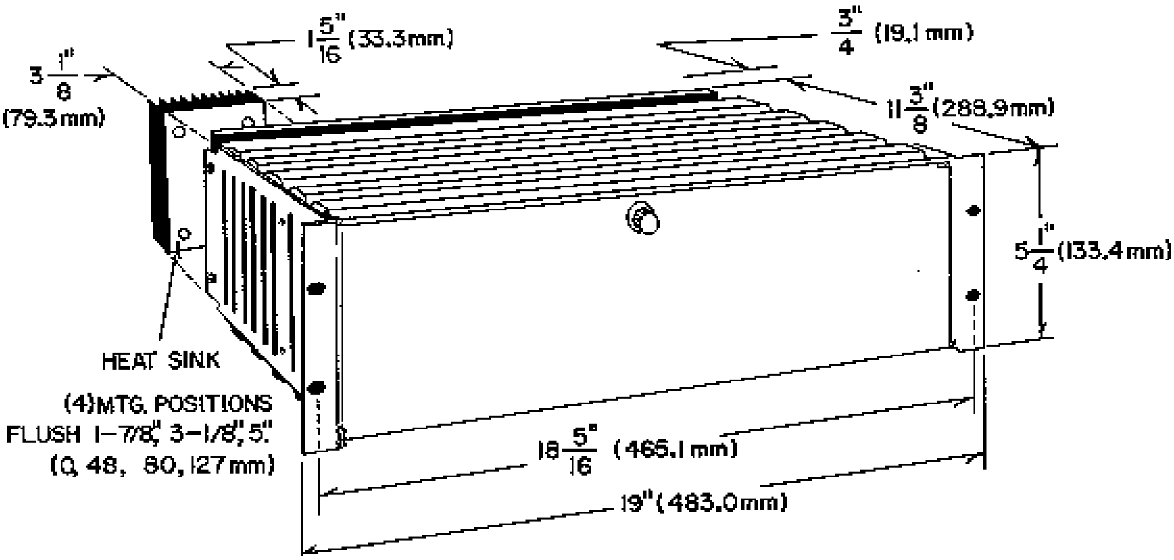
eral chassis are available for housing 6000 Series pment. The circuit board modules are inserted into chassis from the front. Mating connectors for the dules are mounted toward the rear of the chassis, discrete wiring is used to make connections be- en the mating connectors and the terminal blocks e rear panel of the chassis, which are used to make ections to external equipment.

The following table describes the standard 6000 Series chassis; the illustrations on the next two pages provide mounting dimensions. If necessary, special chassis can be provided on special order.

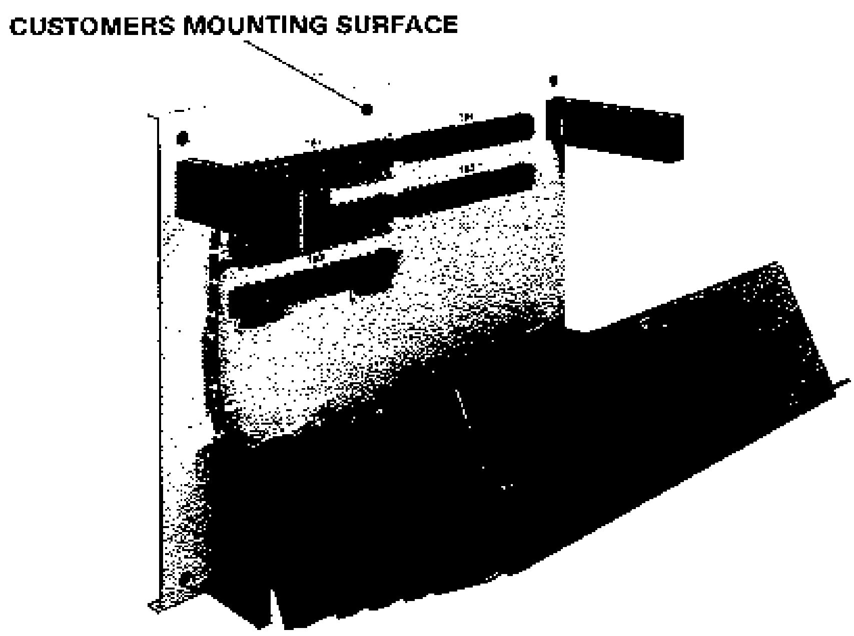
ameter	RFL 68 CHAS	RFL 68A CHAS	RFL 68B CHAS	RFL 68W CHAS	RFL 68M CHAS, RFL 68S CHAS
odule Spaces	32	3	18	(1)	1
-Inch Rack Mounting?	Yes	Yes	No	No	No
all/Tilt Bracket	P/N 48470	No	P/N 48470	Self-Contained	Wall Or Panel
ctory Wiring Available?	Yes	Yes	Yes	(1)	(2)
sk Mount Option?	Yes	No	Yes	No	No
aximum Number Of Terminal Blocks	14	3	7	5	1
rmal Power Supply	RFL 68 HPS DC-1 or RFL 68A HPS AC-1	RFL 68 PS DC-1 or RFL 68 PS AC-1	RFL 68 HPS DC-1 oı RFL 68A HPS AC-1	RFL 68B PS AC or RFL 68B PS AC-2	Included
eight	5.25 in (13.3 cm)	1.75 in (4.4 cm)	5.25 in (13.3 cm)	7.50 in (19.1 cm)	3.60 in (9.1 cm)
idth	19 in (48.3 cm)	19 in (48.3 cm)	10.25 in (26.0 cm)	11.5 in (29.2 cm)	4.98 in (12.7 cm)
epth	12.0 in (30.5 cm)	12.0 in (30.5 cm)	12.0 in (30.5 cm)	5.38 in (13.7 cm)	9.70 in (23.4 cm)

The RFL 68W CHAS can house 4 one-inch-wide circuit cards, plus a power supply module. It can be wired at the factory to accept two transmitters (RFL 68B FS TX or RFL 64B TMX), two receivers (RFL 68B FS RX or RFL 64B TMR), and the power supply (RFL 68B PS AC or RFL 68B PS AC-2).

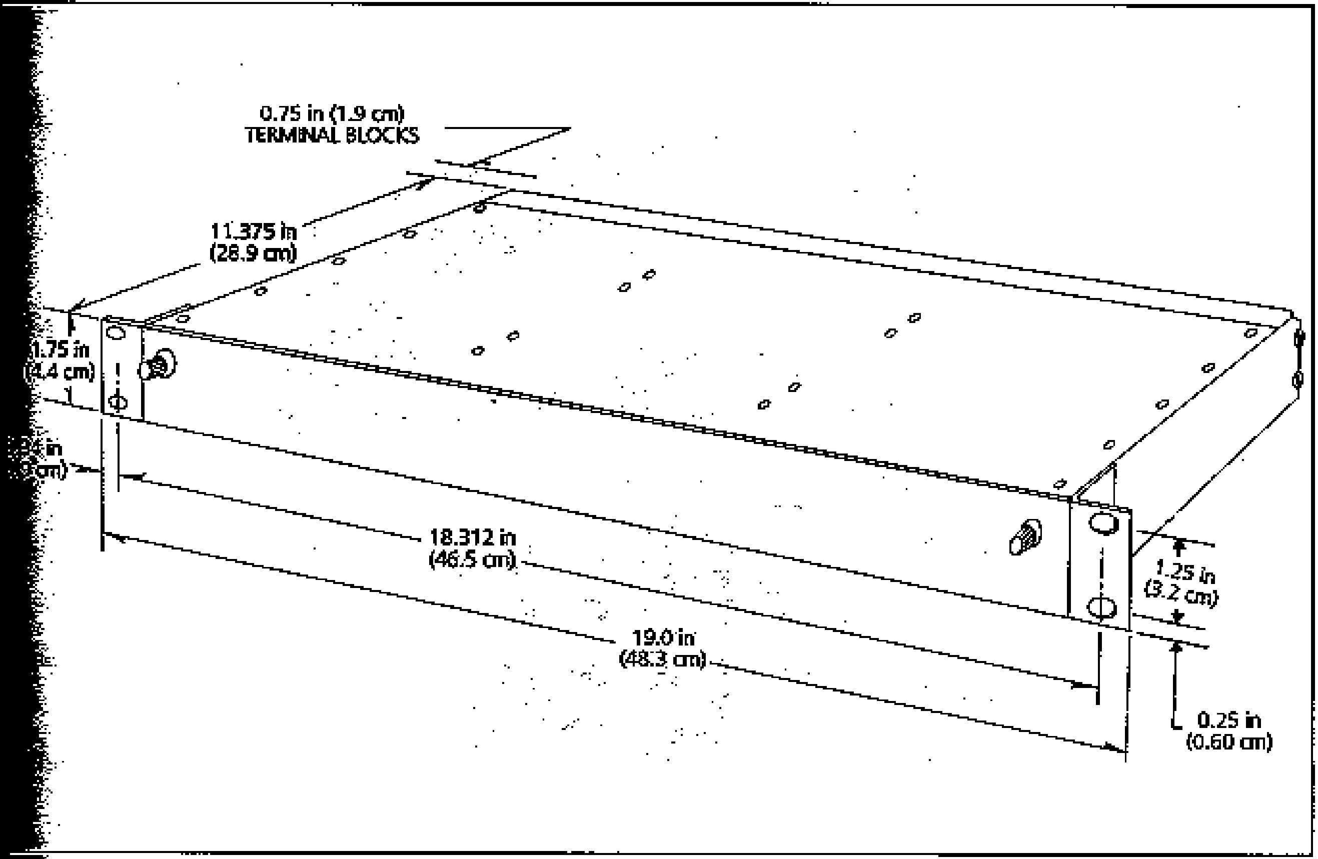
The RFL 68M CHAS chassis is wired at the factory to accept one RFL 66A ENC-4 module. The RFL 68S CHAS chassis is strapped at the factory to either accept one RFL 68B FS TX transmitter, or one RFL 68B FS RX receiver.



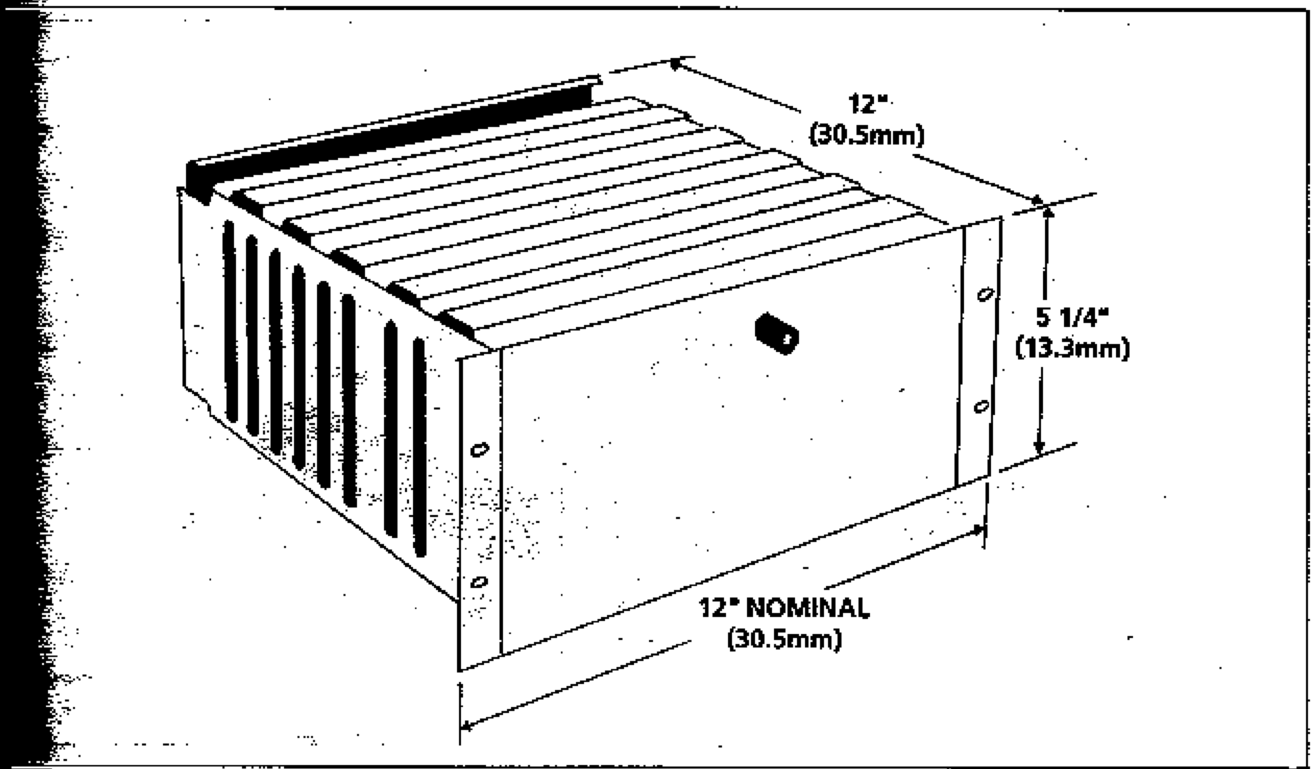
RFL 68 CHAS 3U Rack-Mount Chassis



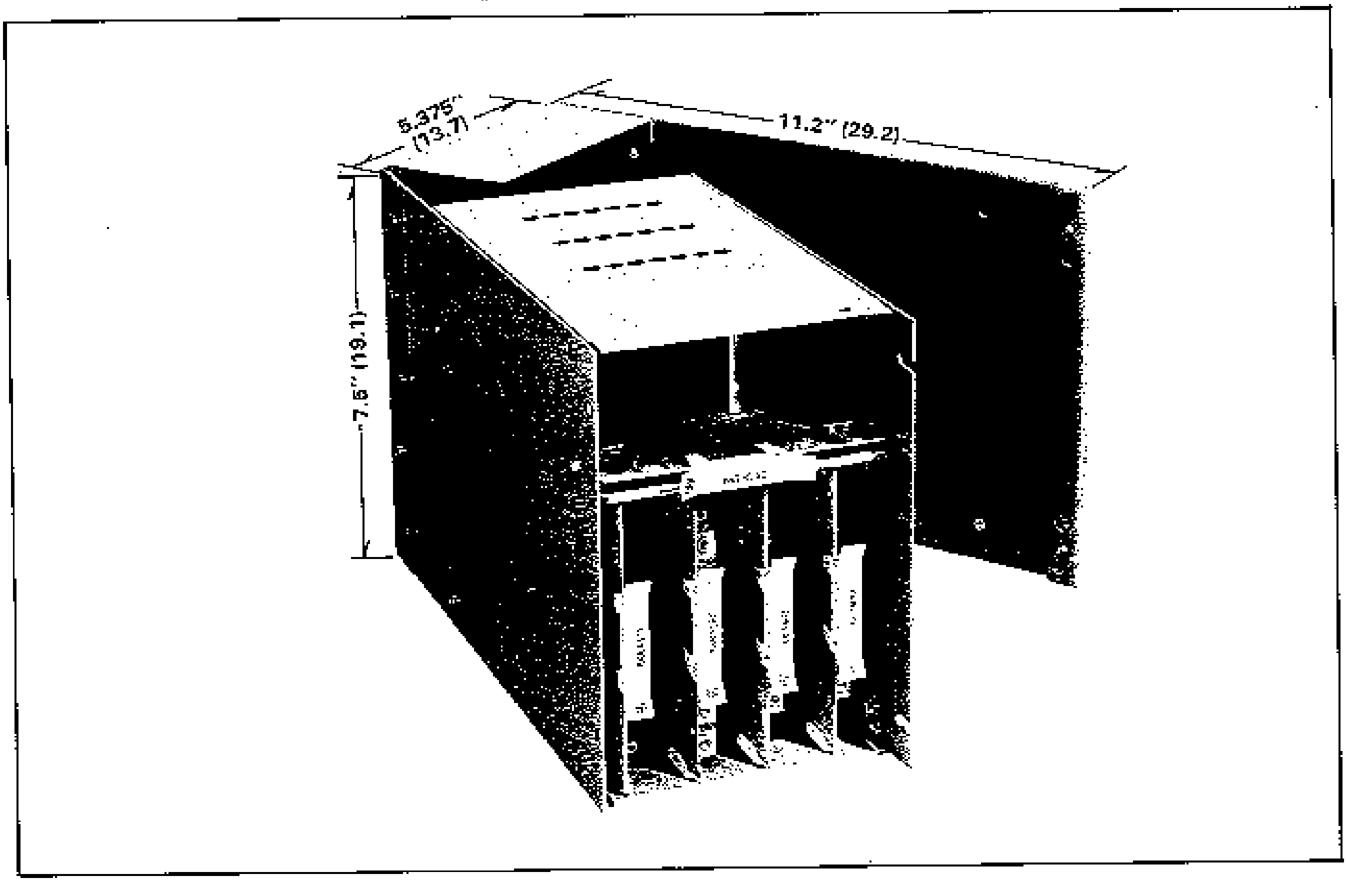
RFL 68 CHAS with tilt bracket



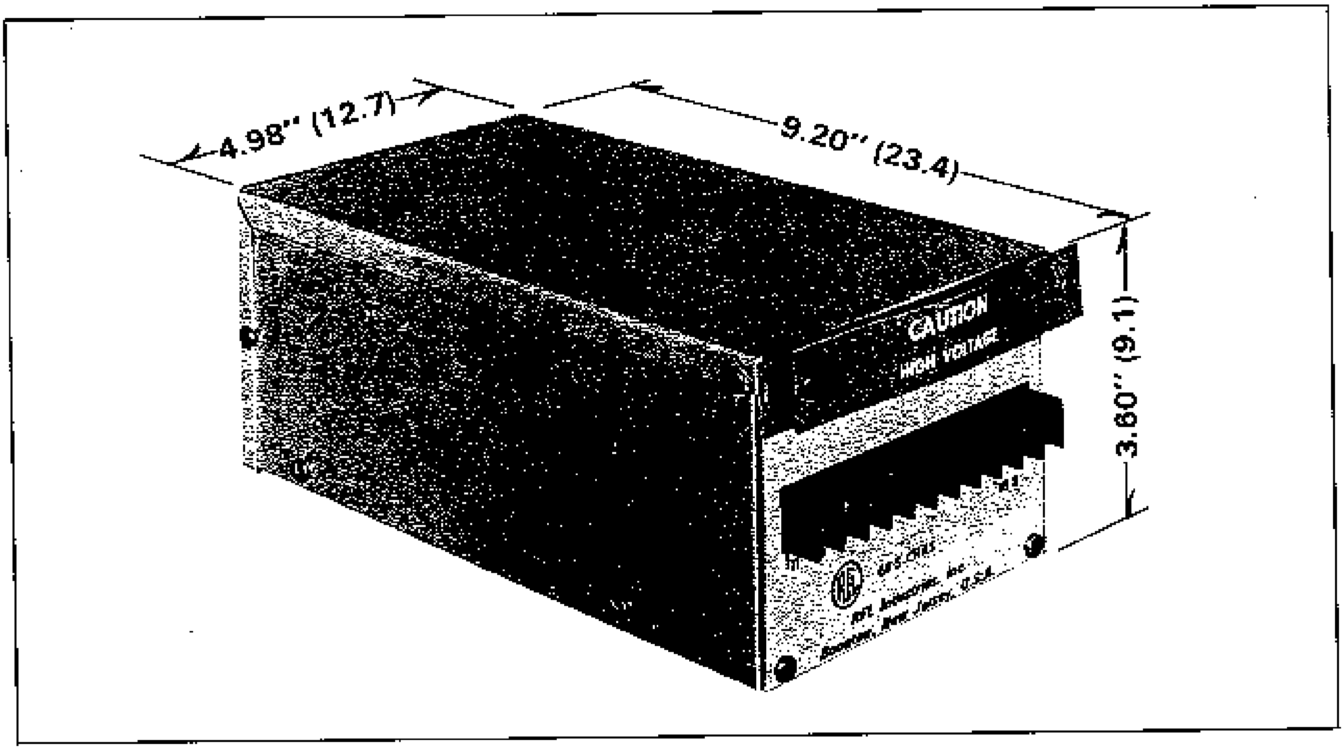
68A CHAS 1U Flat-Pack Chassis



68B CHAS Wall-Mount Chassis



RFL 68W CHAS Wall-Mount Chassis



RFL 68S CHAS Single-Module Chassis (RFL 68M CHAS is similar in appearance)

GLOSSARY OF TERMS

A/D
Analog-to-digital conversion.

Address
A sequence of bits, a character, or a group of characters that identifies a function, a network station, user, or application.

Amplitude Modulation (AM).
Transmission method in which variations in the voltage or current of a carrier signal determine encoded information.

Analog
Continuously-variable as opposed to discretely-variable.

Attenuation
A general term used to denote a decrease in magnitude from one point to another.

Bandwidth
The difference between the highest and lowest frequencies of a transmission channel, expressed in Hz.

Baud
A measurement of the signaling speed of a data transmission device.

Binary
Digital system with two states (1 and 0), in contrast with octal, decimal, and hexadecimal.

Bit
A binary digit; the representation of a signal, wave, or state as either a binary one or zero.

Bit Rate
The number of bits (binary digits) transmitted in a given time interval (usually a second).

BCD
A digital system that uses binary codes to represent decimal digits.

Carrier
A continuous frequency capable of being modulated or impressed with a second data-carrying signal.

Central Office (CO)
The building where common carriers terminate customer circuits, and where the switching equipment that interconnects those circuits is located.

Circuit Impedance
A nominal impedance for transmission testing purposes for which a circuit is designed.

Common Carrier
A private data communications utility company or a government organization that furnishes communications services to the general public and that is usually regulated by state, local, or federal agencies.

Conditioning
The "tuning" or addition of equipment to improve the transmission characteristics or quality of a voice-grade line so that it can be used for data transmission.

Crosstalk
Unwanted transference of electrical energy from one transmission medium or channel to another (usually adjacent) medium or channel.

Data Access Arrangement (DAA)
Device or circuitry that is required to allow attachment of privately owned data terminal equipment (DTE) and communication equipment to the telephone network.

dB, Decibel
Comparative (logarithmic) measure of signal power. +10 dB represents a gain of 10:1; -3 dB represents a 50 percent loss of power.

dBm
Absolute measure of signal power where 0 dBm is equal to one milliwatt.

Dedicated Line
A nonswitched channel; also called a "private line."

Digital
Discretely variable, as opposed to continuously variable. Data characters are coded in discrete, separate pulses or signal levels.

Distortion
Unwanted changes in signal or signal shape that occur during transmission between two points.

Frequency Division Multiplexing (FDM)
Technique for sharing a transmission channel, wherein carrier signals of different frequencies are transmitted simultaneously.

Frequency Modulation (FM)
Method of encoding a carrier wave by varying the frequency of the transmitted signal.

FSK
Frequency-shift keying; modulation technique whereby two different tones represent either the "0" or the "1" state of binary information.

Full Duplex (FDX)
Operation of a data communication line where transmissions are possible in both directions at the same time between devices at each end.

Half Duplex (HDX)
Operational mode of a communications line whereby transmission occurs in both directions but only in one direction at a time. Transmission directions may be alternately switched to accommodate two-way data flow.

Hertz (Hz)
A measure of frequency or bandwidth equal to one cycle per second.

Interface
A shared boundary defined by common physical interconnection characteristics, signal characteristics, and meanings of interchanged signals.

Leased Line
A telephone line reserved for the exclusive use of a leasing customer, without interchange switching arrangements.

Linearity
The property of a transmission medium or of an item of equipment that allows it to carry signals without introducing distortion.

Link
Communications circuit or transmission path connecting two points.

Loading
Adding inductance to a transmission line to minimize amplitude distortion; generally accomplished with loading coils.

MARK
In data communications, represents a binary "1".

Multiplexing
The division of a composite signal among several channels.

Noise
Random electrical signals, generated by circuit components or by natural disturbances, that corrupt the data by introducing errors.

Off-Hook
In telephony, condition indicating the active state of a subscriber's telephone circuit; a line that signals a central office that a user requires service; opposite of on-hook.

On-Hook
Deactivated condition of a subscriber's telephone circuit, in which the telephone or circuit is not in use; opposite of off-hook.

Optical Fiber
One of the glass strands, each of which is an independent circuit, in a fiber optic cable.

Repeater
A device used to extend transmission ranges/distances by restoring signals to their original size or shape.

Signal-to-Noise (S/N) Ratio
Relationship of the magnitude of a transmission signal to the noise of its channel; measurement of signal strength compared to error-inducing noise; given in decibels.

Simplex Transmission
Transmission in only one direction.

SPACE
In data communications, represents a binary "0".

Telco
An Americanism; short for telephone company.

Telemetry
Transmission of coded analog data (often real-time parameters) from a remote site.

Time-Division Multiplexing (TDM)
Interleaving digital data from many signals onto one or two serial communication links by dividing channel capacity into time slices.

Transceiver
Generic term describing a device that can both transmit and receive.

Trunk
A dedicated aggregate telephone circuit connecting two switching centers, central offices, or data concentration devices.

Twisted Pair
A pair of insulated copper conductors that are twisted around each other, mainly to cancel the effects of electrical noise. Typical of standard telephone wiring; unshielded twisted pair contains no outside wraparound conductor.

White Noise
The noise energy which is uniformly distributed over the frequency band. It is used in the evaluation of systems on a theoretical basis.

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