INSTRUCTION DATA

Dowty RFL Industries Inc. • Boonton, New Jersey

RFL Model 64A TMX TELEMETER TRANSMITTER

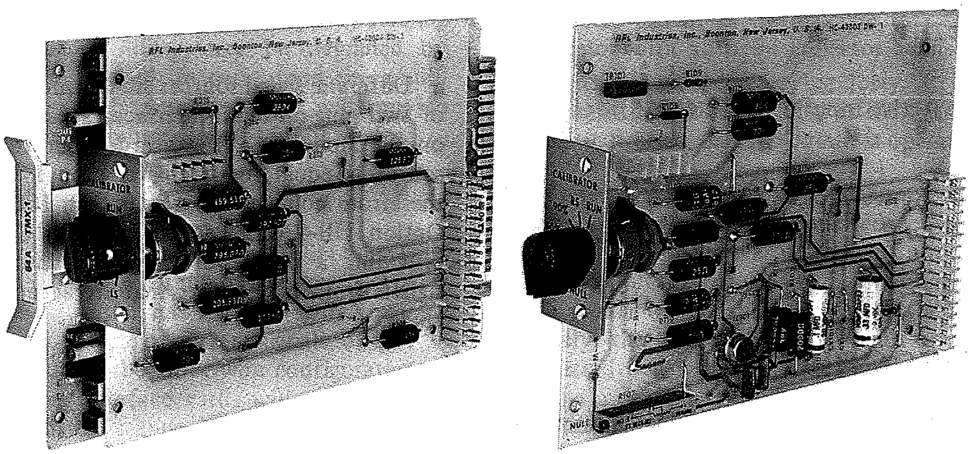

Figure 1. Model 64A TMX Telemeter Transmitter with passive input card on left, active card on right.

SPECIFICATIONS

INPUT SENSITIVITY AND RANGE

With Passive Input Card, Option HB-43035: Input sensitivity is 10,000 ohms per volt. Minimum span of input signal is 1 Vdc or 100 microamperes dc. Maximum span of input signal is 1000 Vdc, or 100 mA dc.

With Active Input Card, Option HB-43025: Input resistance is greater than 10 megohms for inputs up to +5 and -5 Vdc. For higher voltages, input resistance will depend upon maximum practical values for the input-voltage divider. Minimum span is 20 mV, maximum is 200 V.

OUTPUT CHARACTERISTICS

Frequency Range: The standard range is 10 Hz left scale (LS) to 30 Hz right scale (RS). Other ranges are available.

Voltage and Waveform: Greater than plus and minus 9 V squarewave signal into a load greater than 3000 ohms, bipolar, symmetrical about zero. Also provided is the open collector of a PNP transistor which will pull a resistive load of up to 30 mA to within 0.5 V of the V+ bus. Collector-voltage limits are V+ bus plus 0.5 V to V+ bus minus 30 V.

Accuracy: After a 48-hour burn-in and after initial calibration, and where % given is % of span, accuracy will be:

(a) With Passive Input Card
LS and RS are setable to within 0.1%. Six-month drift is less than 0.2%. Temperature coefficient is less than 0.005% per degree C. Supply-voltage coefficient is less than 0.1% per volt.

(b) With Active Input Card
Accuracy is the same as when using the passive input card, except for additional errors of 2 microvolts per degree C, plus 3 microvolts per month, plus 10 microvolts, all referred to the input.

Linearity: The linearity is within 0.1% of the best straight line between LS and RS.

SLIDEWIRE VOLTAGE

The internal, stable power supply generates plus 7 Vdc. It can supply up to 10 mA to a slidewire or other external load.

OPERATING TEMPERATURE RANGE

-30 to +70°C, ambient.

POWER REQUIREMENTS

The module requires both plus and minus 11 to 15 Vdc, with 50 mA or less from each source.

POWER SUPPLY REGULATION

Regulation required from the power supply need be no better than 1%.

DIMENSIONS

Circuit card is 4.71 inches by 8 inches by 1.5 inches wide when equipped with all options. Requires three, one-half-inch module spaces in RFL Model 68 Chassis.

DIFFERENCE BETWEEN MODELS

64A TMX
Basic unit with Passive Input Card HB-43035.

64A TMX-1
Basic unit with Passive Input Card HB-43035 and Calibrator HB-43021.

64A TMX-2
Basic unit with Active Input Card HB-43025.

64A TMX-3
Basic unit with Active Input Card HB-43025 and Calibrator HB-43015.

DESCRIPTION

The Model 64A TMX Analog Telemetering Transmitter is a specialized voltage-to-frequency converter designed to generate a squarewave output signal, the frequency of which is an analog of its input voltage or current.

For telemetering over short distances, the variable-frequency squarewave signal from the 64A TMX may be sent directly to the input of a companion telemetering receiver, such as the RFL Model 64 TMR. The output of the TMR, which is essentially a frequency-to-voltage converter, will be a dc voltage or current which is a specific and accurate fraction of the input signal to the TMX. Most frequently, the variable-frequency telemeter signal is transmitted to a distant point using a voice-frequency-carrier transmitter and receiver to send the signal over voice-grade communication circuits.

Carrier signals for telemetry channels can be frequency multiplexed with other carriers bearing either the same kind of data, or other data, including speech and telegraph. Suitable equipment for voice-frequency carrier work will be found in the RFL Series 6000 group which includes transmitters, receivers, transceivers, matching equipment, protective and control units, and suitable power supplies for a complete system with channels sufficient in number to load fully, if needed, a voice-grade circuit.

Different signal sources are accommodated with a choice of two plug-on input-interface cards which mount directly on the Model 64A TMX card. When the dc voltage of the source is equal to or greater than 1 volt, or the current therefrom equal to or greater than 100 microamperes, the Option HB-43035 Passive Interface Card will suffice by providing a choice of ranging resistors. Typical output signals from transducers that are accepted by this card include:

(a) zero-center signals in the range from ±0.5 to ±300 Vdc, or ±100 microamperes to ±100 mAdc,

(b) zero-left signals from +1 to a maximum of +300 Vdc or a minimum of +100 microamperes to a maximum of 100 mAdc,

(c) 4 to 20 mAdc,

(d) 1000-ohm slidewire, for which excitation voltage can be taken from the TMX card.

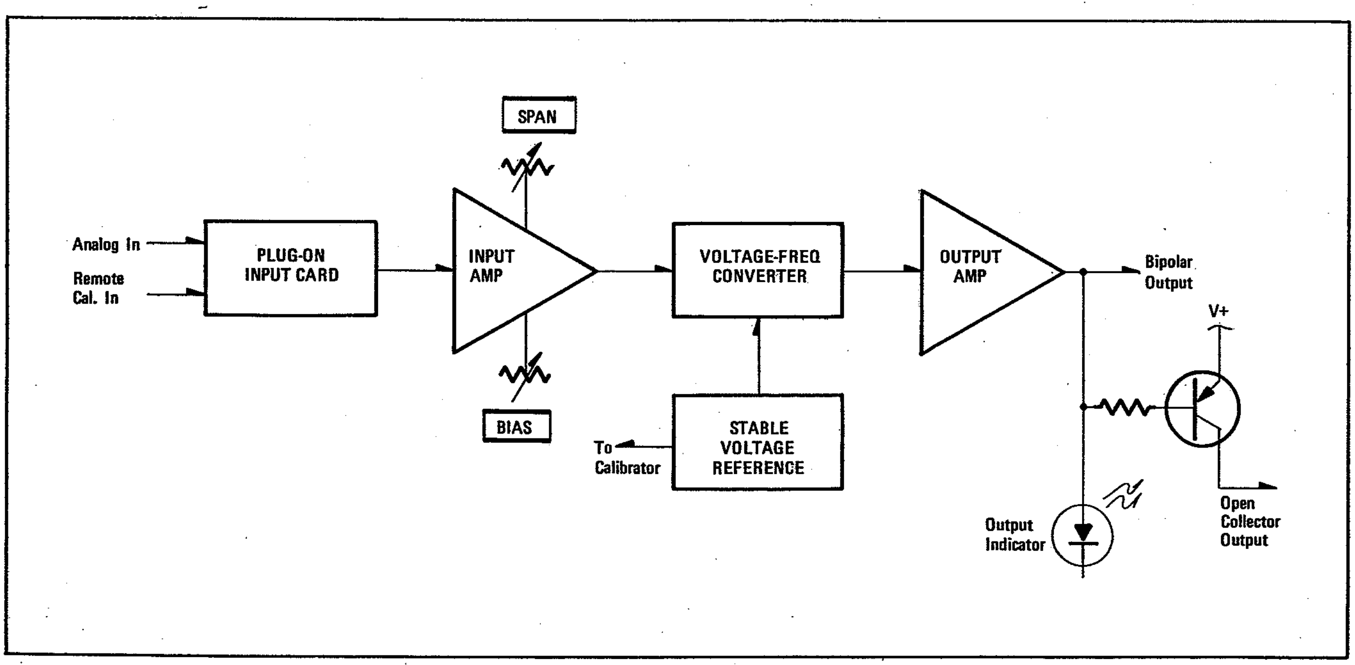

Figure 2. Block Diagram, Model 64A TMX.

The Option HB-43025 Active Interface Card replaces the passive card for conditions of low input-signal level, or where high input impedance is required. It includes an operational amplifier that makes it possible to accept input signals with a span as low as 20 mV, and it has a high input impedance.

The accuracy of a TMX will depend, in part, on the requirements placed upon the input-interface card. Accuracy will not be degraded by a passive card using only ranging resistors. Accuracy and stability may be degraded by active circuits, and will depend, in part, upon the amplification required. The cards described here will provide an interface with the most commonly used input ranges.

BLOCK DIAGRAM

The basic principle of operation of the Model 64A TMX is illustrated in the block diagram of Figure 2. Analog input signals, entering at the left of the Figure, may be either two-wire, as for voltage or current signals, or may be connected to the input in the three-wire configuration of a slidewire transducer. Interface cards will accommodate either format and, after scaling, deliver the signal to the input of an operational amplifier at the input of the basic TMX circuits. Broad adjustments of bias and span are made by selection of resistors used on the plug-in interface card. Fine adjustments are made with variable resistors to control voltage gain and offset for the input amplifier. These adjustments establish the low-frequency and the high-frequency limits of span.

A voltage-to-frequency converter, under control of the input amplifier, generates the squarewave signal whose frequency is the analog of the input signal. The design has emphasized stability with respect to temperature, humidity, time, and supply voltage; and the error in linearity is a small percentage of the specification for full-span accuracy. Monolithic operational amplifiers and CMOS logic elements are used in the v-f converter as switches, level shifters, integrators, and threshold detectors.

The output circuit uses another operational amplifier. The output signal can be taken directly from the opamp as a bipolar signal, or it may be taken through a keying transistor with an open collector available to pull a load, such as a high-speed keying relay, to the V-plus bus. A light-emitting diode, flashing at the output frequency, gives visual indication that the circuit is operating.

Reference voltages are generated internally, derived from a temperature-compensated zener diode. The stable positive and negative references not only control the accuracy of the conversion from voltage to frequency but also contribute to the accuracy of the optional calibrator. Finally, the stable reference avoids any need for a tightly regulated power supply; and standard RFL power supplies, having a 5% tolerance in output level, and 1% regulation, are adequate and recommended.

For testing the accuracy of the system, an optional calibrator may be mounted on the input card. A front-panel switch will introduce calibrating signals corresponding to left scale (LS), 10%, 50%, and 90% of span, and to right scale (RS). The three central points can be introduced into the system by remote control. This feature permits easy and frequent checking of the system by operating personnel. One three-frequency, reverse channel with three control relays is required to select the 10%, 50% and 90% points remotely.

INSTALLATION AND ADJUSTMENTS

When the Model 64A TMX is installed in an RFL chassis, or as part of a system supplied by RFL, the drawing supplied with the equipment will detail the external connections to be made. All units will have been calibrated to meet specified input and output ranges. Installation, therefore, usually will require no more than connection to signal source, communication line, and to the primary-power source. If it is desired to check the accuracy of the adjustments, then proceed to the next heading on adjustments.

Test points are provided so that the transmitter may be adjusted using only a frequency counter capable of 10-period average, and either a digital or potentiometer-bridge dc voltmeter with sensitivity of 500 microvolts and at least 0.02% accuracy. First, plus and minus seven-volt reference levels are adjusted, using R29 and R39, with the dc voltmeter connected respectively to TP3 and TP2, and referred to common. Next, with the counter connected to the output test point, TP4, the calibrator is switched between the left-scale (LS) and right-scale (RS) positions while BIAS and SPAN trimmers are adjusted for corresponding output periods of 0.1000 and 0.0333 seconds to obtain a frequency span of 10-30 Hz. The periods will, of course, be changed to fit those cases where the frequency span is different from standard.

On the active interface card, a control is available for reducing the opamp's offset to zero. To make this adjustment, the calibrator is switched to NULL, and the sensitive dc voltmeter is connected to TP101. The null trimmer is then adjusted for an output of zero volts.

PRELIMINARY ADJUSTMENTS

There may be reasons for checking the accuracy of the adjustments and if this is necessary, then the following procedure should be followed.

Internal Reference-Voltage Adjustment

A. In all the following tests, use TP1 as a common reference for the test equipment.

B. Using a DVM, monitor and adjust:

1. TP3, R29 (+7 V) for +7 V ±0.007.
2. TP2, R39 (-7 V) for -7 V ±0.007.

Frequency Calibration

A. Use a frequency counter capable of indicating 10-period average and connect to TP4.

B. Active Card HC-43003 only:

1. Connect a DVM to TP101.
   a) If strap F is omitted from this board then Terminals 16 and 17 should be jumpered for remaining Test Procedure.

   b) W/Internal Calibrator
   1. Switch S101 to NULL and adjust R107 for 0 V ±0.0001.

   c) W/O Internal Calibrator
   1. With no input voltage jumper Terminal 10 and Terminal 11 on the edge connector and adjust R107 for 0 V ±.0001. Remove the jumper.

C. Active, HC-43003 or Passive HC-43004 Card

1. If the passive board doesn't have jumper A in then Terminals 16 and 17 should be jumpered for remaining Test Procedure.
2. If the card is equipped with an internal calibrator, then use it for the following steps. If not, then the proper input equivalent to R.S. or L.S. must be applied. (Refer to Sales Order).
3. Turn the switch to R. S. and adjust R7 SPAN for a period of:

   a) $\dfrac{1}{\text{R. S. frequency}}$ ±.1% of the span.

   b) Period of R. S. = $\dfrac{1}{\text{R. S.}}$

   c) Period of R. S. ±.1% of the span,

   $$= \frac{1}{\text{R. S.} \pm (\text{R. S.} - \text{L. S.})\ (.001)}$$

   d) Take calculations to seven places after decimal point.

   e) Example:
   1. R. S. = 30 Hz
      L. S. = 10 Hz
   2. Period of R. S. = $\dfrac{1}{30}$
      = .0333333
   3. Period of R. S. ±.1% of the span,

      $$= \frac{1}{30 \pm (30-10)\ (.001)}$$

      = + is .0333111
      –is .0333555
   4. Therefore, a setting within the periods of 0.0333111 and 0.0333555 must be obtained with 0.0333333 being the exact value.

4. Now, turn the switch to LS and adjust R5 (BIAS) for a period of 0.100000. Refer to and repeat test listed under C-3 but, substitute LS for RS in equations 3(a), 3(b), 3(c), and 3(e), except in 3(c) change equation

$$\frac{1}{\text{L.S.} \pm (\text{R.S.} - \text{L.S.})\ (0.001)}$$

REMOTE CALIBRATION

If the remote-calibration feature is to be used with the TMX, three relays must be provided at the TMX and wires extending to the remote-control point must be installed.

Connections for the relays are shown on Figure 4, where it is suggested that the relays may be energized by the power supply used for the TMX. In such a case, the load on the power supply will be increased by whatever current is drawn by the relay, for whatever period each relay is energized.

FUTURE CHANGES IN RANGES

Where it is desired to recalibrate the equipment for use in a different application, the following data on installation will be useful.

For installation of individual cards, the edge-connector diagram of Figure 3 is provided.

Selection of Scaling Components

Both active and passive input cards have been designed for extreme versatility in the matter of range of input voltage or current signals, and of output-frequency span. Thus, each has a group of components which must be selected to scale the input signals actually encountered to fit the standardized input characteristics of the basic TMX. Details of the selection process follow.

Tables I, II, and III have been prepared to facilitate the process of calculating the required input-circuit resistors for each of the two input boards. These tables pertain to most signal-input spans generally used; but for brevity not all possibilities are included. For spans not found, please contact RFL.

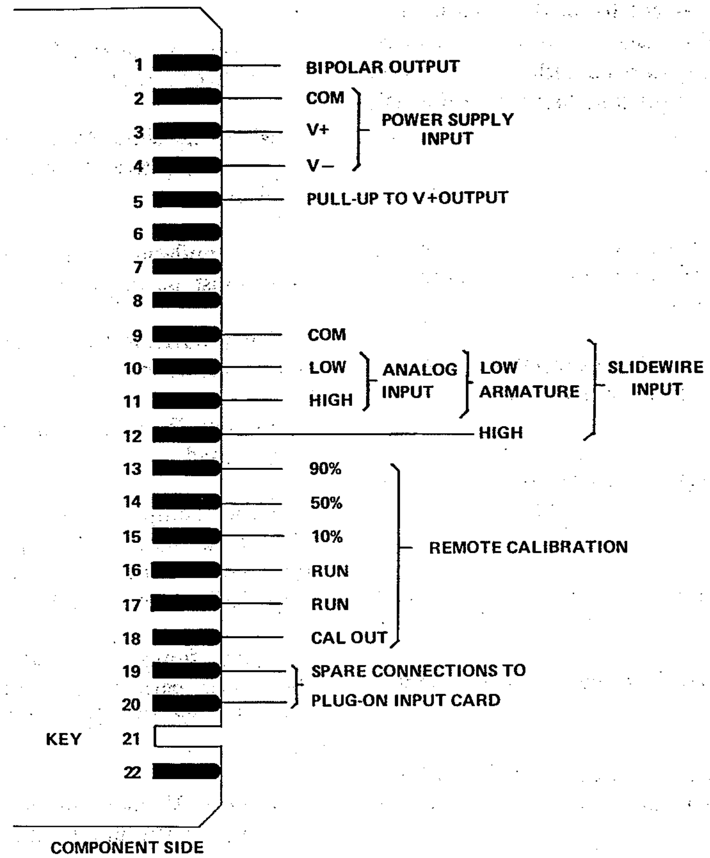

Figure 3. Connection Diagram for Model 64A TMX.

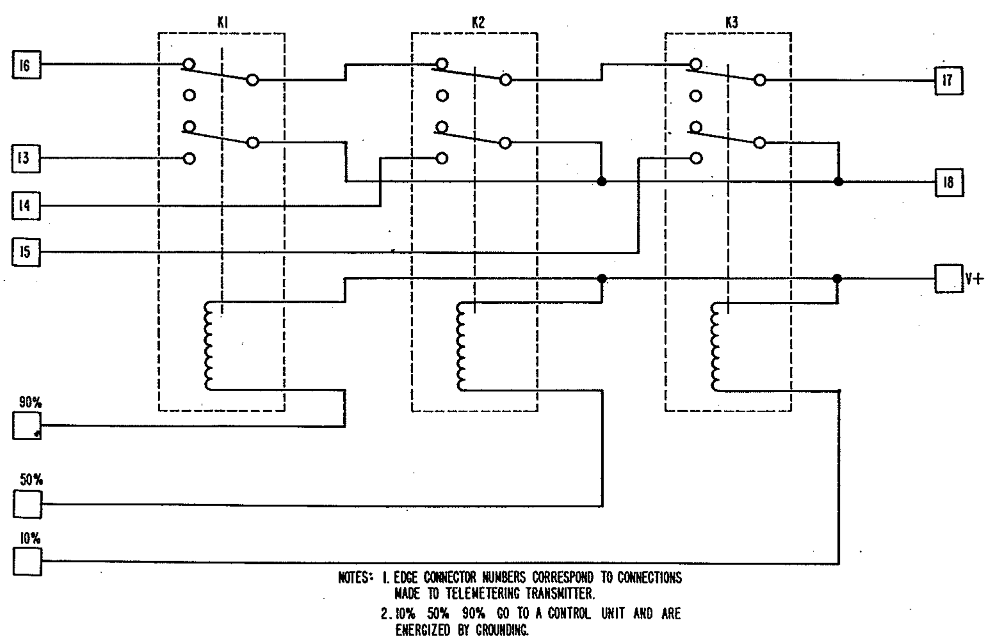

Figure 4. Connections for relays used for remotely controlling calibration input to Model 64A TMX.

To use the tables, select Table I or Table II, as appropriate, for either active of passive input circuits. In the first column, note the requirement to satisfy Equation (1), sometimes also (2), and then select the input span of interest. Then read horizontally to select either the specified resistor value or the proper equation, listed in Table III, for calculating it.

Placement of Jumpers

Main Circuit Board: Jumper A-B completes the bipolar output line to Terminal 1. Removing this jumper allows for a front-panel jack to replace it.

Jumper C-D completes the pull-up output line to Terminal 5. Removing it allows for a front-panel jack to replace it.

Jumper F-H breaks the high input line, and its removal will allow for a front-panel jack for injecting or monitoring a signal.

Circuit-point E on the board is the circuit-common point for jack usage.

Circuit-point J on the board is the analog-low input-wiring point for jack usage.

Passive Input Board: Jumper A is used when the optional calibrator is used and when the remote calibration is not used.

Jumper B is used when no calibration features are present.

Active Input Board: Jumpers A, B, C, D, and E determine the mode of operation of the optional Calibrator, as follows:

When the simulation is zero-center between equal positive and negative values, Jumpers A, C, and D must be in place.

For simulation from zero to a positive value, Jumper B, only, must be in place.

For simulation from a negative value to zero, Jumper E, only, must be in place.

Jumper F must be in place when remote calibration is not used.

Either Jumper H or Jumper J is used, depending upon whether a negative or a positive return for offset-adjustment potentiometer R107 is desired. For example, for the Type 05CJ opamp, use J; for the Type 741, use H.

Either Jumper K or Jumper L is used for completing the offset path to the proper pin of the opamp. For example, for the Type 05CJ, use K, for the Type 741, use L.

Jumper M must be in place when no Calibrator is included on the input card.

TABLE I

ACTIVE–INPUT BOARD, ASSEMBLY HC-43003
EQUATIONS FOR CALCULATING INPUT–CIRCUIT RESISTORS

INPUT Must satisfy Eq (1) for all cases	IC101 Type	R101	R102	R103	R104	R105	R106	R107	R108	R110	R111	JUMPERS
$V_R < 0.5$ volt	0C5J	Short	Open	1K	(104)	2K	(106a)	20K	(108)	(110a)	(111)	J and K are shorted
V_R from 0.5 thru 1.0 volt	0C5J	Short	Open	1K	(104)	2K	(106b)	20K	(108)	(110b)	(111)	
V_R from 1.0 thru 5.0 volts	741	Short	Open	1K	1K	Open	2K	10K	(108)	(110c)	(111)	H and L are shorted
$V_R > 5.0$ volts	741	(101)	5K	1K	1K	Open	(106c)	10K	(108)	(110d)	(111)	

CALIBRATOR For cases where $V_R > 0$		R112	R113	R114	R115	R116	R117	R118	R119	JUMPERS A	B	C	D	E
$V_L < 0$	$V_R > 5$	Open	(113a)	500 Ω	2K Ω	2K Ω	500 Ω	(118a)	Open	Short	Open	Short if $V_L = -V_R$	Short	Open
	$(V_L + 0.35) \leqslant V_R \leqslant 5$	Open	(113b)	500 Ω	2K Ω	2K Ω	500 Ω	(118b)	Open	Short	Open		Short	Open
	$V_R < (V_L + 0.35)$	500 Ω	(113c)	500 Ω	2K Ω	2K Ω	500 Ω	(118b)	500 Ω	Short	Open		Short	Open
$V_L \geqslant 0$	$V_R > 5$	Open	(113a)	500 Ω	2K Ω	2K Ω	500 Ω	(118c)	Open	Open	Short	Open	Short	Open
	$(V_L + 0.35) \leqslant V_R \leqslant 5$	Open	(113b)	500 Ω	2K Ω	2K Ω	500 Ω	(118c)	Open	Open	Short	Open	Short	Open
	$V_R \leqslant (V_L + 0.35)$	500 Ω	(113c)	500 Ω	2K Ω	2K Ω	500 Ω	(118c)	500 Ω	Open	Short	Open	Short	Open

TABLE II

PASSIVE–INPUT BOARD, ASSEMBLY HC-43004
EQUATIONS FOR CALCULATING INPUT–CIRCUIT RESISTORS

INPUT Must satisfy Eq (1) in all cases	R209	R210	R211	R212	R213	R215	R_N
VOLTAGE INPUT $V_R \leqslant 15$ volts	(209a)	(210a)	Open	Short	Open	(215a)	—
CURRENT INPUT: Must satisfy Eq (1) and (2) $f_R > 20$ and $I_R \leqslant 2$ mA	(209b)	(210b)	(211b)	Short	Open	(215b)	(R_N)
$f_R > 20$ and $I_R > 2$ mA	(209c)	(210b)	(211c)	(209c)	(211c)	(215b)	(R_N)

TABLE III

DEFINITIONS AND EQUATIONS FOR CALCULATING INPUT–CIRCUIT RESISTORS

SYMBOL	DEFINITION
V_L or I_L	Input voltage or current for left scale, in volts or amperes.
V_R or I_R	Input voltage or current for right scale, in volts or amperes.
f_L	Output frequency for left scale, Hz.
f_R	Output frequency for right scale, Hz.
R_N	Input resistance, ohms.

EQUATION NUMBER	APPLICABLE EQUATION
(1)	$0 \leqslant \frac{f_L V_R - f_R V_L}{V_R - V_L}$ OR $0 \leqslant \frac{f_L I_R - f_R I_L}{I_R - I_L}$ If (1) equals zero, then R111 (active card) and R210 (passive card) are infinite (open).
(2)	$I_R - I_L \geqslant 5(f_R - f_L)\, 10^{-6}$
(101)	$R101 = 1000\,(V_R - 5)$ ohms
(104)	$R104 = \frac{2000\,(R106)}{2000 + R106} - 1000$ ohms
(106a)	$R106 = 2000\left(\frac{1}{V_R} - 1\right)$ ohms
(106b)	$R106 = 1000\left(\frac{5}{V_R} - 2\right)$ ohms
(106c)	$R106 = \frac{5000\,(R101)}{5000 + R101} + 2000$ ohms
(108)	$R108 = 900 + \frac{1}{(2 \times 10^{-5}) + \frac{1}{R111} + \frac{1}{R110}}$ ohms
(110a)	$R110 = \frac{1 - \frac{V_L}{V_R}}{(5 \times 10^{-6})\,(f_R - f_L)}$ ohms
(110b)	$R110 = \frac{2.5\left(1 - \frac{V_L}{V_R}\right)}{(5 \times 10^{-6})\,(f_R - f_L)}$ ohms
(110c)	$R110 = \frac{V_R - V_L}{(5 \times 10^{-6})\,(f_R - f_L)}$ ohms
(110d)	$R110 = \frac{1 - \frac{V_L}{V_R}}{10^{-6}\,(f_R - f_L)}$ ohms
(111)	$R111 = \frac{1.4\,(V_R - V_L)\,10^6}{f_L V_R - f_R V_L}$ ohms
(113a)	$R113 = \frac{2000\,V_R}{V_R - V_L}$ ohms
(113b)	$R113 = \frac{5000\,(7 - V_R)}{V_R - V_L}$ ohms
(113c)	$R113 = \frac{5000\,(7 - V_R)}{11\,V_R - V_L}$ ohms
(118a)	$R118 = \frac{5000\,(V_L + 1.4\,V_R)}{V_R - V_L}$ ohms
(118b)	$R118 = \frac{5000\,(V_L + 7)}{V_R - 11\,V_L}$ ohms
(118c)	$R118 = \frac{5000\,V_L}{V_R - V_L}$ ohms
(209a)	$R209 = \frac{V_R - V_L}{5\,(f_R - f_L)\,10^{-6}}$ ohms
(209b)	$R209 = \frac{2 \times 10^5}{(f_R - f_L)\left(\frac{I_R}{I_R - I_L}\right)}$ ohms
(209c)	$R209 = R212 = \frac{10^5}{(f_R - f_L)\left(\frac{I_R}{I_R - I_L}\right)}$ ohms
(210a)	$R210 = \frac{1.4\,(V_R - V_L)\,10^6}{f_L V_R - f_R V_L}$ ohms
(210b)	$R210 = \frac{1.4\,(I_R - I_L)\,10^6}{f_L I_R - f_R I_L}$ ohms
(211b)	$R211 = \frac{R209}{\frac{I_R - I_L}{5\,(f_R - f_L)\,10^{-6}} - 1}$ ohms
(211c)	$R211 = R213 = \frac{R209}{\sqrt{2\left(\frac{I_R - I_L}{f_R - f_L}\right)10^5 + 1.25} - 1.5}$ ohms
(215a)	$R215 = 900 + \frac{1}{(2 \times 10^5) + \frac{1}{R210} + \frac{1}{R209 + A}}$ ohms where $A = \frac{R212 \;\; R213}{R212 + R213}$
(215b)	$R215 = 900 + \frac{1}{2 \times 10^{-5} + \frac{1}{R210} + \frac{1}{R209 + \frac{1}{\frac{1}{R213} + \frac{1}{R211 + R212}}}}$ ohms
R_N	$R_N = \frac{1}{\frac{1}{R211} + \frac{1}{R212 + \frac{1}{\frac{1}{R213} + \frac{1}{R209}}}}$ ohms

THEORY OF OPERATION

GENERAL

Figures 5, 6, and 7 are schematics of the wiring of the two available input cards and of the basic TMX. The system requires that either one or the other of the two input cards be used as an interface between the source of signal to be transmitted and the basic voltage-to-frequency converter which is the Transmitter.

TRANSMITTER

Input DC Amplifier

An analog-signal current is supplied to the inverting input of opamp IC1 through the input card. CR1 and CR2 are not normally driven into conduction, and they protect the opamp against damage from high-voltage transients. The gain of IC1 is established by feedback through R6 in series with SPAN control R7. The amplifier's offset-voltage error, as well as errors originating in the input card may be trimmed out by BIAS control R5. If, for example, the TMX is to develop a telemetering signal with a span from 10 to 30 Hz, then an input signal with a corresponding span of 50 to 150 microamperes will cause an output-voltage span of −2.5 to −7.5 volts at the output of IC1.

Voltage-to-Frequency Converter

IC9A and IC9B, connected in parallel, and IC9C and IC9D, also connected in parallel, are FET switches alternately turned on and off by an R-S flip-flop consisting of IC10A and IC10B. When IC9A & B is switched on and IC9C & D switched off, the output of IC1 is simultaneously applied to both the inverting and the non-inverting inputs of opamp IC2. IC2 then operates in the non-inverting unity-gain mode, and its output will be equal in magnitude and polarity to the output of IC1. If the positions of the switches are reversed, so that IC9C & D is conducting, then IC2 operates as a unity-gain inverting amplifier. Its output level will still equal the magnitude of that from IC1, but the polarity will be reversed.

IC3 is a precision integrator. Its output voltage will move to create a positive- or a negative-going ramp, depending upon the polarity of drive signal received from IC2, and the slope of the ramp signal will depend upon the magnitude of the output signal from IC2 which is, of course, proportional to the magnitude of the analog input signal.

Operational amplifiers IC4 and IC5 are threshold detectors, each referenced to a precisely controlled stable voltage. The output of IC4 is normally negative, but it will swing positive when the output of IC3 exceeds the reference voltage of +7 Vdc. The output of IC5 is normally negative, but it will go positive when the output of IC3 exceeds its reference voltage of −7 Vdc. The output of IC3 is a linear triangular wave. When it swings to +7 volts, the resulting positive pulse from the output of IC4 sets the R-S flip-flop which switches on IC9C & D and switches off IC9A & B. The output of IC3 now moves in a negative direction and, when it reaches −7 volts, the output pulse from IC5 resets the R-S flip-flop and so once again changes the setting of the switches of IC9. Because the time required for the output of IC3 to reach the magnitude of the reference voltage depends upon the magnitude of the input signal, the period (and, thus, the frequency) of the squarewave output from IC4 and IC5 is a function of the magnitude of the input signal. The voltage-to-frequency conversion so effected is linear and accurate over its range.

The output signals from IC10A and IC10B are each a squarewave. IC10B drives buffer IC10C to control CR12, the LED output indicator. This indicator will flash at a rate equal to the output frequency. The output of IC10A drives opamp IC8, used as a buffer. The output of IC8 is a bipolar squarewave suitable for keying the data-input circuit of an RFL voice-frequency carrier transmitter. Buffer amplifier Q3, driven by IC8, will pull a load up to the V+ bus. This open-collector output will drive the coil of a mercury-wetted relay, or it may be used to drive CMOS logic or other suitable loads.

Precision Reference Source

As shown on Figure 5, opamps IC6 and IC7, with zener diode CR10, form the basic elements of a precision reference source delivering +7 and −7 Vdc. The source operates as follows:

When power is first applied, the base of Q2 is pulled positive by the voltage divider of R30 and R31 through CR9. The emitter of Q2 is thereby held positive and drives the inverting input of IC6. As the output of IC6 goes negative, the output of emitter follower Q1 also goes negative. This pulls the inverting input of IC7 negative and its output positive. CR8 then conducts to cut off CR9, the anode of which is held at a somewhat lower voltage by R30 and R31. The emitter load of Q2 is formed by divider R23, R29, and R32; and the arm of R29 rises to the zener voltage, 6.4 volts, and causes CR10 to conduct. The circuit stabilizes at a voltage that causes about 4 mA to pass through CR10.

One output voltage from the circuit is adjusted to +7 Vdc by R29; the other is adjusted to −7 Vdc by R39. Because of the stiff negative feedback around IC6 and IC7, this circuit maintains a constant current through the reference diode, CR10, and so maintains constant output voltage over a wide range of dc-supply voltage. IC6 and IC7 are capable of only limited output current. Their outputs, therefore, are buffered by Q1 and Q2, each of which is capable of supplying stable reference current up to 30 mA.

Passive Input Card

The schematic of the circuit for the passive input card is shown in Figure 6. The card is designed to carry whatever passive components may be necessary to scale a voltage source, a current source, or the output of a slidewire to the standardized input requirements of the basic TMX. As an option, a calibrator also may be added to this card, and options for local control, remote control, or both are available with the calibrator.

Referring to Figure 6, the junction of R209 and R210 is the source of input signal to the inverting input of IC1, which is at virtual ground. R210 is selected to supply a bias current that offsets the input to a current that will generate a frequency corresponding to LS, usually 10 Hz. R209, similarly, is selected to supply a current which, when summed with the bias current, will create an output frequency corresponding to RS, usually 30 Hz.

Consider the case where the frequency span extends over a range of three to one (10 to 30 Hz), while the range of input voltage is zero to one volt. Thus an infinite voltage range must control a frequency range of three to one. An input of 50 microamperes to the inverting terminal of IC1 corresponds to an output of 10 Hz, and 150 microamperes will cause an output of 30 Hz. Under these conditions, R210 is selected to draw 50 microamperes from the +7-volt bus. Next, R209 is selected so that the input current through R209 will be 100 microamperes for a 1-volt input, to give a total of 150 microamperes at the input of IC1 for a frequency of 30 Hz. R209 and R210 can be changed in value to accommodate other input ranges.

The voltage divider of R212 and R213 is added when the voltage span is greater than 30 volts. If the input signal is from a current source, then shunt resistor R211 is added to develop a voltage drop, proportional to the signal, which is then processed through R209 like any other voltage input.

If the transducer is a slidewire, then voltage for the slidewire is taken from the +7-volt reference bus. In this case, it is passed through a transient filter consisting of R214 and C201. The arm of the slidewire drives the "input-high" line, and the voltage from the arm drives R209. The output frequency of the TMX will be proportional to the voltage sensed by the arm of the slidewire.

When the input card is equipped with a calibrator, and when its switch is set at RUN, the input of IC1 is connected directly to the signal-input junction of R209 and R210. In any other position of the switch, the output of the precision voltage divider, comprised of R201 through R206, is connected to the input through R207. Using the calibrator switch, the calibrator may be set successively to drive the TMX output to frequencies corresponding to RS, 90, 50, or 10% of scale, and to LS. Accuracy of the calibrator is assured by supplying it from a stable reference bus, and by the use of precision resistors in the divider.

Remote-calibration lines appear at the edge connector of the circuit card for the basic TMX. They can be connected to three relays, operated by a three-frequency control system, to force the TMX into the calibrating mode. Details are given in the Installation Section of this Manual. For this application, Jumpers A and B are removed from the input card. With the switch in the RUN position, and with all three remote-control relays de-energized, relay contacts connect J2-4 to J2-5, thereby completing the signal path. When one of the relays is energized, this connection is broken and the corresponding tap from the calibrator is connected to the input of IC1 through R208.

Active Input Card

The schematic of the circuit of the active input card is given in Figure 7. Input voltage at J2-10 passes through Jumper M, or through the switch of the optional calibrator, to a transient-protection network consisting of R103, C104, CR101, CR102, and R104 to the non-inverting input of operational amplifier IC101. If the magnitude of the input signal exceeds the common-mode range of IC101, voltage divider R101 and R102 is added.

IC101 may be operated as a unity-gain follower when high input resistance is the only requirement. It may also be operated with gain, in which case the gain is set with feedback resistors R105 and R106. The output of IC101 drives the input of IC1 through span resistor R110, and the voltage range is offset to fall within the frequency span of the TMX by choice of R111.

The optional calibrator consists of resistors R112 through R119, plus a control switch. When the switch is set to RUN, the input signal is connected to IC10; or the switch may be used to move the input of IC101 through the range of calibration-input voltages available. Both +7 volts and −7 volts are available for powering the calibrator. When a positive, unipolar input signal is used, Jumpers B and D are installed and Jumpers A, C, and E are omitted. For a negative, unipolar application, Jumpers A and E are installed with B and D omitted. When the calibrator switch is set to the NULL position, the input of IC101 is grounded, and the offset error of the opamp may be nulled by adjusting R107 for zero output voltage, as measured at TP101.

Like the passive input card, calibration of the active input card also may be remote controlled. Jumpers F and M are removed and installation and application are as discussed in the preceding section on the passive input card.

Table 4.
Replaceable Parts

Circuit Symbol (See Figures 5-7)	Description	Part Number
	Model 64A TMX Telemeter Transmitter - Assembly No. HB-43020	
	CAPACITORS	
C1, 6	Capacitor, polyester, 0.01µf, 10%, 100V, Cornell-Dubilier WMF-1S1 or equiv.	1007 642
C2, 4	Capacitor, mica, 10pf, 5%, 300V, Electro-Motive DM-10 or equiv.	1080 336
C5	Capacitor, mica, 150pf, 5%, 100V, Electro-Motive DM-10 or equiv.	1080 386
C7, 8	Capacitor, tantalum, 1µf, 20%, 35V, Kemet T322B105M035AS or equiv.	1007 496
C9-12	Capacitor, ceramic, 0.47µf, +80 -20%, 50V, Murata RE50-474M or equiv.	1007 939
C13	Capacitor, mica, 100pf, 10%, 100V, Electro-Motive DM10D101K0100WV4CR or equiv.	1080 328
C14	Capacitor, mica, 30pf, 5%, 100V, Electro-Motive DM-10-300J or equiv.	1080 391
	RESISTORS	
R1, 15-18, 35, 42	Resistor, metal film, 1K, 1%, ¼W, Type RN¼	0410 1288
R2, 37	Resistor, metal film, 221 ohm, 1%, ¼W, Type RN¼	0410 1225
R3	Resistor, metal film, 100 ohm, 1%, ¼W, Type RN¼	0410 1192
R4	Resistor, metal film, 100K, 1%, ¼W, Type RN¼	0410 1480
R5	Resistor, variable, cermet, 20K, 10%, ¾W, Beckman 78PR20K or equiv.	43047
R6	Resistor, wire-wound, 47.5K, .1%, .3W, ±10PPM/°C, Charles T. Gamble Type 1608AL or equiv.	1780 107
R7	Resistor, variable, cermet, 5K, 10%, ¾W, Beckman 78PR5K or equiv.	43048
R8, 9, 24, 25	Resistor, wire-wound, 4.99K, .1%, .3W, ±10PPM/°C, Charles T. Gamble Type 1608AL or equiv.	1780 105
R10, 11, 26	Resistor, metal film, 2.49K, 1%, ¼W, Type RN¼	0410 1326
R13	Resistor, metal film, 4.99K, 1%, ¼W, Type RN¼	0410 1355
R14	Resistor, metal film, 54.9K, 1%, ¼W, Type RN¼	0410 1455
R19, 22, 36	Resistor, metal film, 6.81K, 1%, ¼W, Type RN¼	0410 1368
R20, 21, 31	Resistor, metal film, 10K, 1%, ¼W, Type RN¼	0410 1384
R23	Resistor, wire-wound, 12 ohm, 1%, .3W, Charles T. Gamble Type 1608AL or equiv.	1780 103
R27, 41	Resistor, metal film, 1.5K, 1%, ¼W, Type RN¼	0410 1305
R28	Resistor, metal film, 1.74K, 1%, ¼W, Type RN¼	0410 1311
R29, 39	Resistor, variable, cermet, 50 ohm, 20%, ¾W Beckman 78PR50 or equiv.	43049
R30	Resistor, metal film, 33.2K, 1%, ¼W, Type RN¼	0410 1434
R32	Resistor, wire-wound, 487 ohm, 1%, .3W, ±10PPM/°C, Charles T. Gamble Type 1608AL or equiv.	1780 104
R33	Resistor, metal film, 2.21K, 1%, ¼W, Type RN¼	0410 1321
R34	Resistor, metal film, 15K, 1%, ¼W, Type RN¼	0410 1401
R38	Resistor, metal film, 475 ohm, 1%, ¼W, Type RN¼	0410 1257
R40	Resistor, metal film, 4.75K, 1%, ¼W, Type RN¼	0410 1353
	RESISTOR/CAPACITOR NETWORK	
C3/R12	Resistor/capacitor network: Resistor- 50K, .1%, 1/3W wire-wound; Capacitor- 0.1µf, 2%, 100V polystyrene; Electronic Concepts 110-2196 or equiv.	43194
	SEMICONDUCTORS	
CR1-9, 11, 13, 14	Diode, silicon, 1N914B or 1N4448	26482
CR10	Diode, encapsulated assembly containing 1N4583A	26926
CR12	Light-emitting diode, Dialight 550-0102 or equiv.	39568
IC1	Operational amplifier, National Semiconductor LM308H or equiv.	0620 34
IC2	Operational amplifier, 8-pin TO-5 package, Analog Devices AD518J or equiv.	0620 107
IC3-5, 8	Operational amplifier, National Semiconductor LM301AH or equiv.	0620 27
IC6, 7	Operational amplifier, high-performance, National Semiconductor LM307H or equiv.	0620 87
IC9	MOS quad bilateral switch, RCA CD4016BE or equiv.	0615 15
IC10	MOS quad 2-input NOR gate, RCA CD4001BE or equiv.	0615 3
Q1, 3	Transistor, PNP, 2N2907A, TO-18 package	37439
Q2	Transistor, NPN, 2N2222A, TO-18 package	37445

Table 4.
Replaceable Parts - continued

Circuit Symbol (See Figures 5-7)	Description	Part Number
	Model 64A TMX Telemeter Transmitter - continued	
	MISCELLANEOUS COMPONENTS	
JA-B, C-D, H-F	Resistor, zero-ohm, Corning OMA07 or equiv.	1510 2217
TP1	Test jack, black, E.F. Johnson 105-2203-101 or equiv.	38116 3
TP2	Test jack, purple, E.F. Johnson 105-2212-101 or equiv.	38116 10
TP3	Test jack, red, E.F. Johnson 105-2202-101 or equiv.	38116 2
TP4	Test jack, yellow, E.F. Johnson 105-2207-101 or equiv.	38116 8
	ACTIVE INPUT CARD OPTION - Assembly No. HB-43025	
	CAPACITORS	
C101	Capacitor, polyester, 0.1μf, 10%, 100V, Cornell-Dubilier WMF-1P1 or equiv.	1007 624
C102, 103	Capacitor, ceramic, 0.47μf, +80 -20%, 50V, Murata RE50-474M or equiv.	1007-939
C104	Capacitor, polyester, 0.33μf, 10%, 50V, Cornell-Dubilier WMF-05P33 or equiv.	1007 1300
	RESISTORS	
R101, 102, 105, 110, 111	Resistor, wirewound, value selected at factory	Contact factory
R103, 104, 106, 108	Resistor, metal film, value selected at factory	Contact factory
R107	Resistor, variable cermet, value dependent upon calculations in Table 1, 10%, ¾W:	
	20K – Beckman Helipot 78PR20K or equiv.	43047
	10K – Beckman Helipot 78PR10K or equiv.	31041
R109	Resistor, metal film, 221 ohm, 1%, ¼W, Type RN¼	0410 1225
	SEMICONDUCTORS	
CR101, 102	Diode, silicon, 1N914B or 1N4448	26482
IC101	Operational amplifier, device selected for desired input characteristics:	
	For low-voltage input, Precision Monolithics 05CJ or equiv.	0620 114
	For high-impedance input, National Semiconductor LM741CH or equiv.	0620 16
	MISCELLANEOUS COMPONENTS	
TP101	Test jack, blue, E.F. Johnson 105-2210-101 or equiv.	38116 7
TP102	Test jack, brown, E.F. Johnson 105-2208-101 or equiv.	38116 4
	PASSIVE INPUT CARD OPTION – Assembly No. HB-43035	
C201	Capacitor, tantalum, 15μf, 20%, 20V, Kemet T322D156M020AS or equiv.	1007 716
R209-213	Resistor, wirewound, value selected at factory	Contact factory
R214	Resistor, metal film, 10 ohm, 1%, ¼W, Type RN60D	1510 1015
R215	Resistor, metal film, value selected at factory, 1%, ¼W, Type RN60D	Contact factory
TP201	Test jack, brown, E.F. Johnson 105-2208-101 or equiv.	38116 4
	ACTIVE INPUT CALIBRATOR OPTION – Assembly No. HB-43021	
R201	Resistor, wirewound, 469.51 ohm, 0.02%, 0.3W, ±10ppm/^{o}C, C.T. Gamble Type 1608AL or equiv.	1780 194
R202	Resistor, wirewound, 192.90 ohm, 0.02%, 0.3W, ±10ppm/^{o}C, C. T. Gamble Type 1608AL or equiv.	1780 195
R203	Resistor, wirewound, 795.07 ohm, 0.02%, 0.3W, ±10ppm/^{o}C, C.T. Gamble Type 1608AL or equiv.	1780 196
R204	Resistor, wirewound, 818.65 ohm, 0.02%, 0.3W, ±10ppm/^{o}C, C. T. Gamble Type 1608AL or equiv.	1780 197
R205	Resistor, wirewound, 205.83 ohm, 0.02%, 0.3W, ±10ppm/^{o}C, C. T. Gamble Type 1608AL or equiv.	1780 198
R206	Resistor, wirewound, 1.018K, 0.02%, 0.3W, ±10ppm/^{o}C, C.T. Gamble Type 1608AL or equiv.	1780 199
R207, 208	Resistor, wirewound, 40K, 0.02%, 0.3W, ±10ppm/^{o}C, C.T. Gamble Type 1608AL or equiv.	1780 200
S201	Switch, rotary, single-deck, 2-pole, 6-position, Grayhill 71AF30-01-2-6S or equiv.	43196
	PASSIVE INPUT CALIBRATOR OPTION – Assembly No. HB-43015	
R112-119	Resistor, wirewound, value selected at factory	Contact factory
S101	Switch, rotary, single-deck, 1-pole, 7-position, Grayhill 71AF30-01-1-7S or equiv.	43195

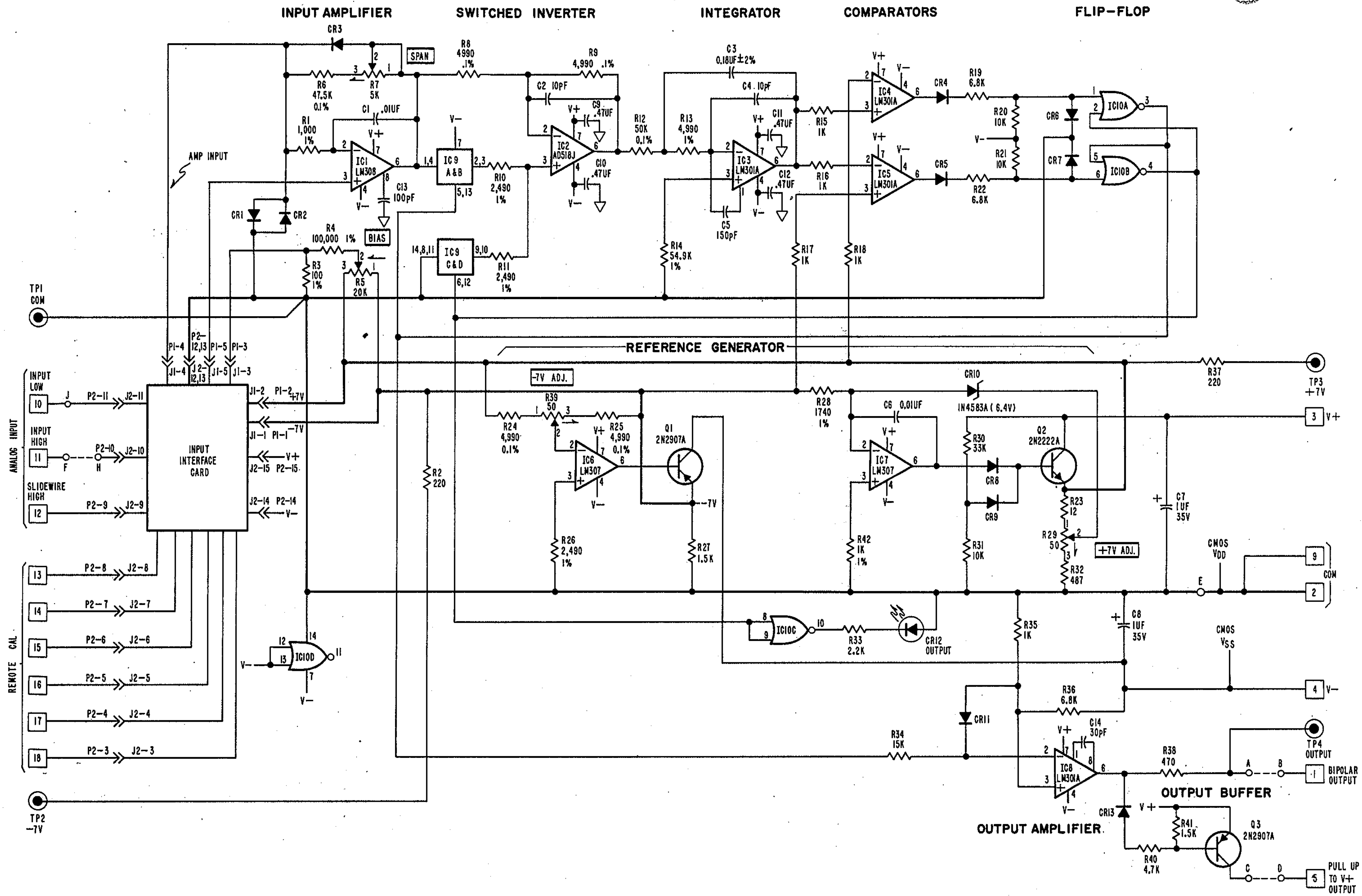

Figure 5. Schematic of circuit of basic transmitter, Model 64A TMX. A plug-on input card, either active or passive is required to interface the transmitter with the source of signal.

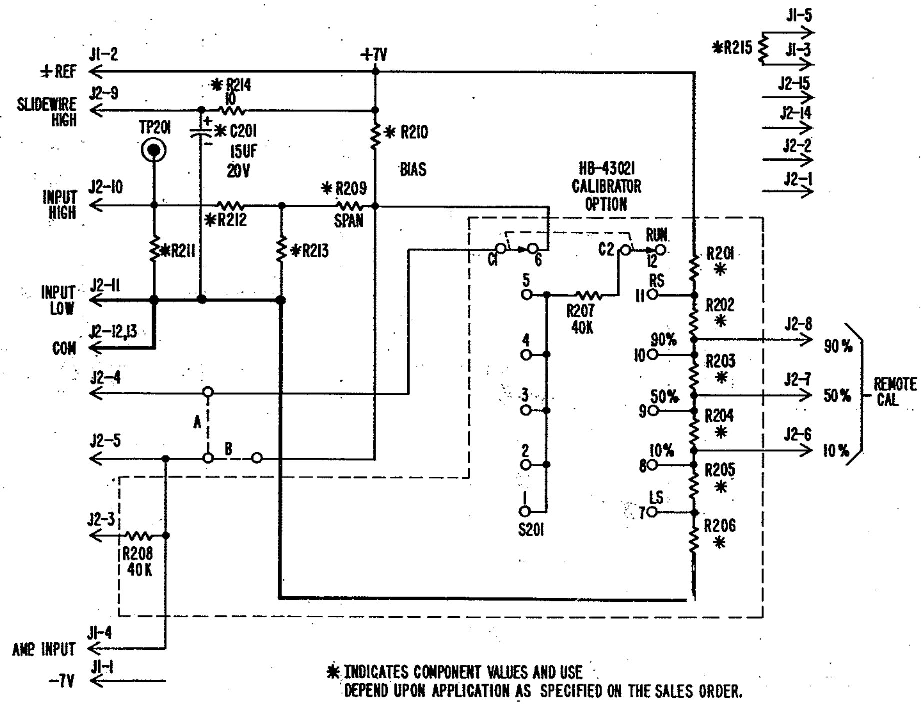

Figure 6. Schematic of circuit of plug-on Passive Input Card, used for high-level input signals (HC-43008).

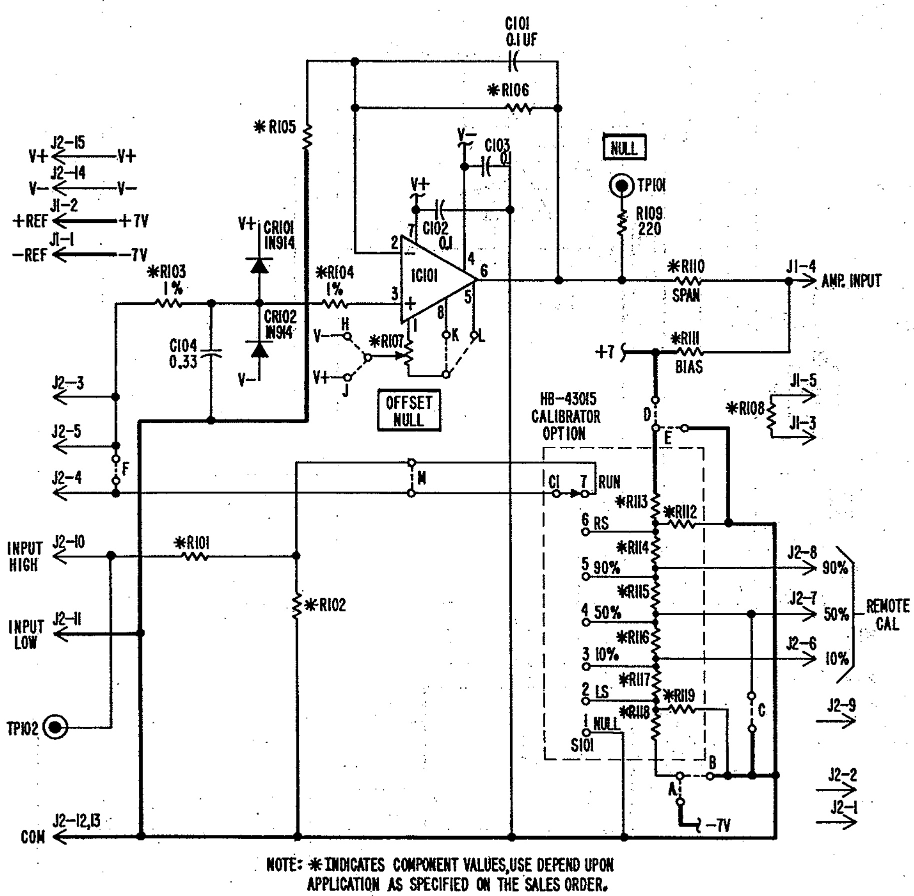

Figure 7. Schematic of circuit of plug-on Active Input Card, used with input signals of low level, or with signals from a high source impedance (HD-43009).

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