RFL Electronics Inc.

INSTRUCTION DATA

RFL 98 TMX
Programmable Telemetry Transmitter

NOTE

RFL 98 TMX modules require the use of the RFL 9800 DSP Programmer/Calibrator to set their operating parameters. Before attempting to program the RFL 98 TMX for the first time, be sure to fully read the programming instructions in this Instruction Data Sheet. Additional information on the RFL 9800 DSP Programmer/Calibrator can be found in its Instruction Data Sheet (RFL Publication No. ID 103180).

Throughout this Instruction Data sheet, specific terminals on terminal blocks or connectors are noted by the circuit symbol followed by a dash and the terminal number (TB1-1, P1-12C). IC pin numbers are noted by the device number followed by a dash and the pin number (U1-1, U1-2, etc).

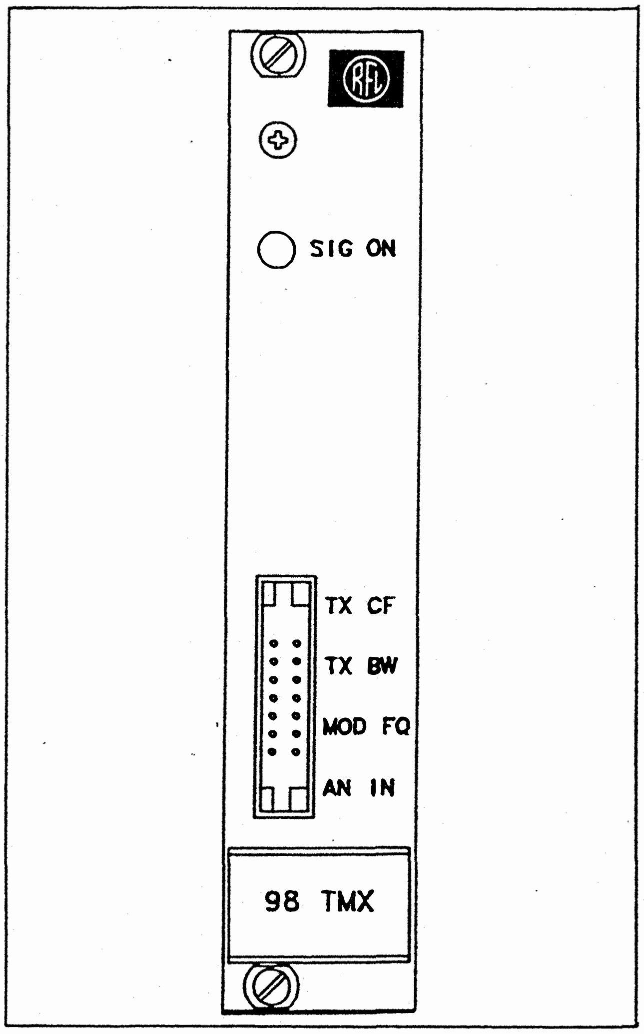

Figure 1. RFL 98 TMX Programmable Telemetry Transmitter

DESCRIPTION

The RFL 98 TMX (Fig. 1) 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 an 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

As of the date this Instruction Data Sheet was published, the following specifications apply to the RFL 98 TMX. Since the RFL 98 TMX undergoes constant refinement and improvement, these specifications are subject to change without notice.

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 600 ohms.

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.

NOTE

The output level reading on the programmer is only an approximation; it is typically 2 dB below the actual reading. Accurate settings will require the use of an external instrument to measure output levels.

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 98 TMX analog input are provided through the use of 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: See Table 1.

Table 1. Frequency characteristics, RFL 98 TMX Programmable Telemetry Transmitter

Baud Rate	Frequency Shift (Hz)	Bandwidth (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 inch).
Height: 128 mm (5.04 inches).
Depth: 248 mm (9.76 inches).

INSTALLATION

Before the RFL 98 TMX can be placed in service, it must be installed in a chassis. Installation involves inserting an RFL 98 DATA I/O module into the rear of the chassis, connecting all signal and power wiring to the I/O module, checking the settings of all jumpers, and inserting the module into the front of the chassis.

Wiring assignments for the RFL 98 DATA I/O module are given in Figure 2. Figure 3 shows the location of all controls and indicators used during installation and operation of the RFL 98 TMX; these controls and indicators are described in Table 2.

The following instructions are provided for installing RFL 98 TMX modules into existing systems; if the module was included as part of a system, installation was done at the factory. Proceed as follows:

1. Determine which module slot in the chassis the RFL 98 TMX will be installed in.

2. From the rear of the chassis, insert the RFL 98 DATA I/O module into the slot where the RFL 98 TMX module is to be installed. Push the I/O module all the way into the chassis, and then use a flat-blade screwdriver to turn the two quarter-turn fasteners to secure the I/O module in place.

3. Turn off the chassis power supply by placing the POWER switch in the OFF (down) position.

4. For all the tone/telemetry modules in the chassis to operate properly, circuit common should be tied to station ground. Check to see if a grounding jumper has been installed between TB2-3 on the I/O module for the power supply and the chassis itself; if not, connect one between TB2-3 and the closest Allen-head screw on the chassis.

5. Temporarily unplug all other modules in the chassis from their I/O modules (except the power supply) as follows:

   a. Using a flat-head screwdriver, disengage the two quarter-turn fasteners on the front of each module by pushing in and turning counterclockwise.

   b. Grasp the handle on each module and pull until the edge connector on the rear of the circuit board comes out of its mating connector on the I/O module.

      Do not pull the module completely out of the chassis; leave each module in place so they can be reinstalled later in the proper slot.

6. Using Figure 2 as a guide, connect all power and signal wiring to the RFL 98 DATA I/O module installed during step 2 above.

   Make sure all screws on terminal block TB1 are fully tightened once the wires are inserted.

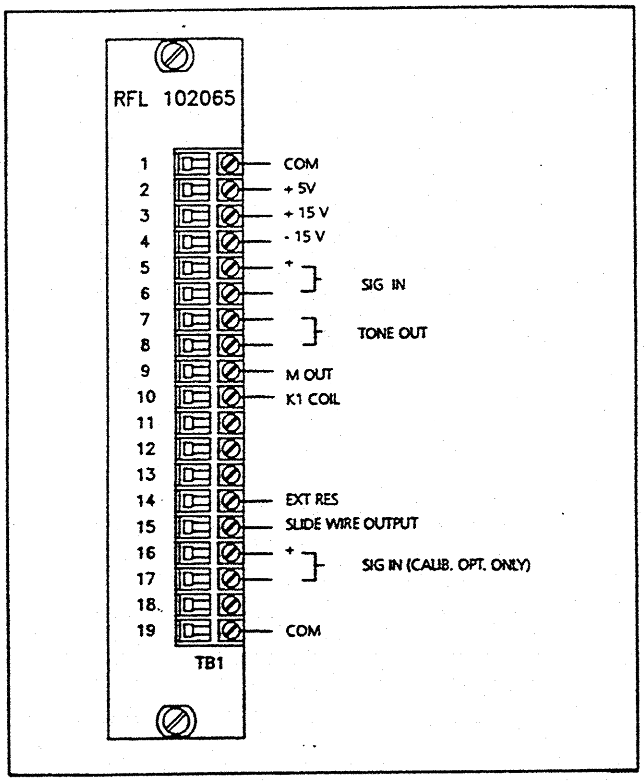

Figure 2. Wiring assignments for RFL 98 TMX modules using the RFL 98 DATA I/O 19-Point Data I/O Module

7. Using a multimeter set for dc voltage measurements, check the RFL 98 DATA I/O module for proper supply voltages as follows:

   a. Turn the chassis power supply back on by placing the POWER switch in the ON (up) position.

   b. Connect the negative multimeter lead to TB1-1 on the RFL 98 DATA I/O module.

c. Connect the positive multimeter lead to TB1-2 on the RFL 98 DATA I/O module. Note the multimeter indication.

The multimeter indication should be between +4.75 and +5.25 volts.

d. Move the positive multimeter lead to TB1-3 on the RFL 98 DATA I/O module. Note the multimeter indication.

The multimeter indication should be between +14.25 and +15.75 volts.

e. Move the positive multimeter lead to TB1-4 on the RFL 98 DATA I/O module. Note the multimeter indication.

The multimeter indication should be between -14.25 and -15.75 volts.

If the proper indications were noted during steps 7c through 7e, the chassis power supply is functioning properly and the power wiring to the RFL 98 DATA I/O module was properly done. If one or more of the voltages are not present, check for shorts or disconnected wires at all terminal blocks at the rear of the chassis; if none are found, troubleshoot the power supply, using its Instruction Data sheet as a guide.

8. Check the setting of factory test jumper J4. (See Figure 3 for location.)

   J4 is used for factory testing only; it must be placed in position A for proper module operation.

9. Check the setting of impedance selection jumper J5. (See Figure 3 for location.)

   J5 sets the RFL 98 TMX's output impedance. Position A sets it to 600 ohms, and position B sets it to greater than 10,000 ohms.

10. Check the settings of factory test jumpers J6, J7, and J9. (See Figure 3 for location.)

    J6, J7, and J9 are removed during factory testing; they must be in place for proper module operation.

11. Check the setting of common reference jumper J8. (See Figure 3 for location.)

    J8 determines whether the analog input (SYSTEM SIG RET, at TB1-6) is tied directly to system common, or allowed to float. If J8 is placed in position 1, SYSTEM SIG RET is grounded. SYSTEM SIG RET will float if J8 is placed in position 2. If a floating input is selected, TB1-6 should be tied to circuit common (TB1-1 or TB1-19) through a dc path of 10 MΩ or less; this will prevent offset charges from building up on the input amplifier.

NOTE

Jumpers J2 and J3 do not have to be set at this time; when the RFL 98 TMX is programmed, messages will appear on the programmer/calibrator's display telling you how to set these jumpers.

12. Push the RFL 98 TMX module all the way into the front of the chassis, and then use a flat-blade screwdriver to turn the two quarter-turn fasteners to secure the module in place.

    Make sure the connector at the rear of the module and the mating connector on the I/O module are fully engaged. Also make sure that the I/O module is properly attached to the rear of the chassis; otherwise, the RFL 98 TMX will not work properly.

The RFL 98 TMX is now installed.

PROGRAMMING

NOTE

In the normal programming mode, the **[INCR]** and **[DECR]** keys change the <u>parameter</u>, while in the dynamic set modes they will affect the programmed <u>value</u>. Parameters may be stepped through (rather than entered) with these keys.

Once the RFL 98 TMX module has been installed, it must be programmed and calibrated using the following procedure. It can also be re-programmed and/or re-calibrated any time a change in operating parameters is desired.

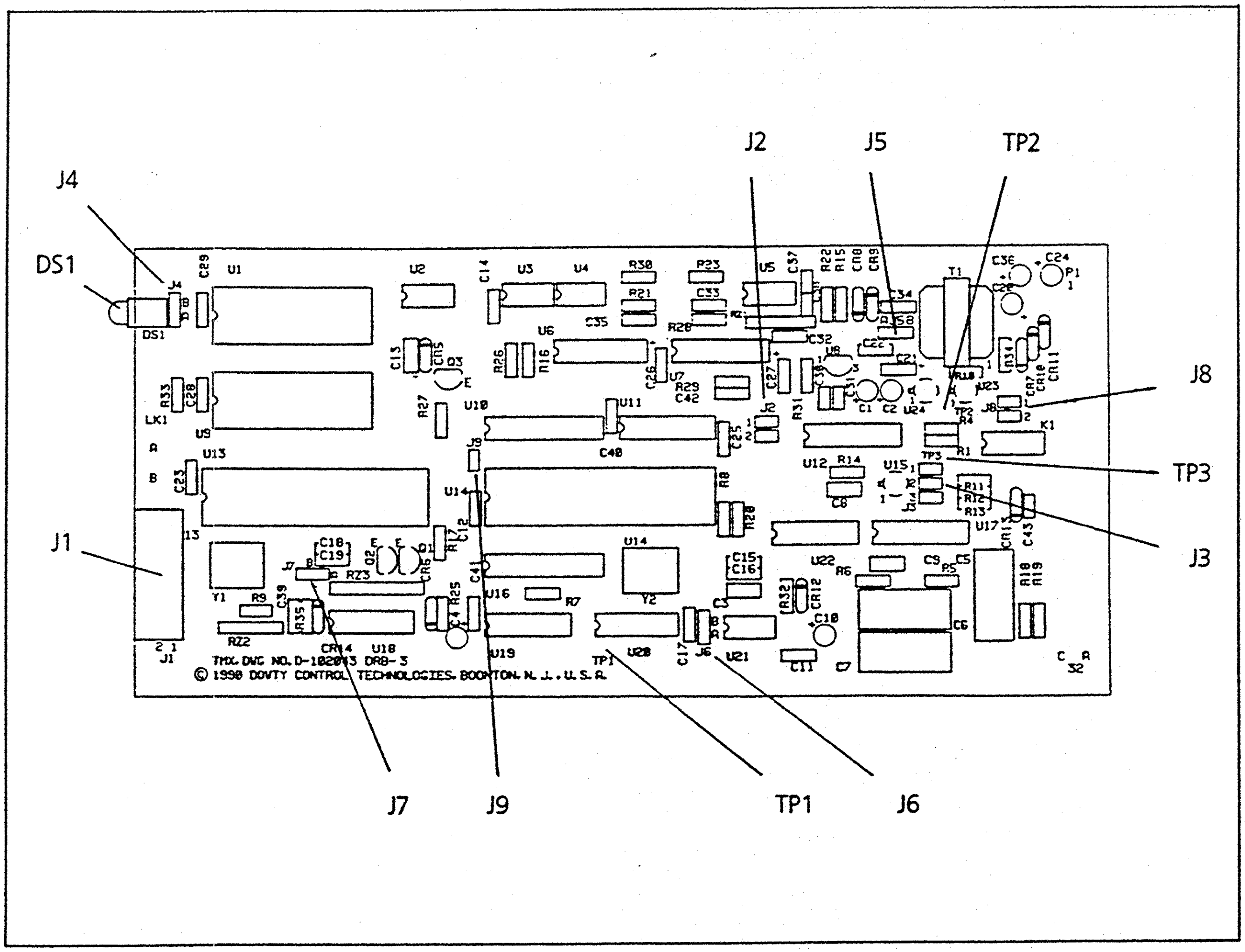

Figure 3. Controls and indicators, RFL 98 TMX Programmable Telemetry Transmitter

Table 2. Controls and indicators, RFL 98 TMX Programmable Telemetry Transmitter

Circuit Symbol	Name/Description	Function
DS1	SIG ON indicator	Flashes to indicate presence of signal being transmitted.
J1	Programmer connector	Mating connector for RFL 9800 Programmer/Calibrator.
J2	Input gain control jumper	Sets the gain of the input buffer amplifier to unity or 10. (See PROGRAMMING section.)
J3	Signal divider gain control jumper	Sets the gain of the signal divider to unity, 2 or 4. (See PROGRAMMING section.)
J4	Factory test jumper	Used during factory testing; must be in position A for proper module operation.
J5	Impedance selection jumper	Selects desired output impedance: Position A: 600Ω nominal. Position B: Greater than 10,000Ω.
J6, J7, J9	Factory test jumpers	Removed during factory testing: must be in place for proper module operation. (J6 and J7 jumpers should be in position A, and J9 jumper should be installed)
J8	Ground reference jumper	Ties SYSTEM SIG RET line to circuit common (position 1), or allows it to float (position 2).
TP1	Test turret	Digital common reference point.
TP2	Test turret	Instrumentation amplifier output (High).
TP3	Test turret	Instrumentation amplifier output (Low).

An RFL 9800 DSP Programmer/Calibrator (Part Number 103180) is required to do the programming. By only giving authorized personnel access to the programmer/calibrator, all the operating parameters can be set and unauthorized personnel cannot change them.

If the programmer used to program the RFL 98 TMX does not contain the calibrator option, an error message will be displayed if you attempt to change any of the telemetry parameters (LSCL, LSPL, RSCL or RSPL). Additional information on the RFL 9800 DSP Programmer/Calibrator can be found in its Instruction Data Sheet (RFL Publication No. ID103000).

Programming and Calibration

When programming and calibrating the RFL 98 TMX with the RFL 9800 DSP Programmer/Calibrator, four different programming modes are enabled:

- o Operational Programming
- o Calibration
- o Transmit Level Dynamic Setting
- o Output Test Level Measurement

RFL 98 TMX programming is a two-step process. First, the RFL 9800 DSP Programmer/Calibrator is used to check the present settings of each parameter, and change them if necessary. The parameters can be viewed in order, or selected parameters can be displayed by pressing the **[PAR]** key, followed by the code number for the desired parameter. (Table 4 lists all the RFL 98 TMX's parameters, and the entries that are valid for each parameter.) Once all parameters have been set, the RFL 9800 should transfer all the new parameter settings to the RFL 98 TMX as a single block of data. The RFL 98 TMX will then enter an automatic calibration mode, controlled by calibrator board inside the programmer. When calibration is complete, the RFL 98 TMX will begin to operate using the new parameter settings.

Before the RFL 98 TMX can be programmed and calibrated, it must be installed in a chassis; all interconnect wiring must be in place, and the chassis power supply must be turned on. Use the following procedure to check the settings of all programmable parameters and change them if necessary. Perform all steps in the order presented, unless directed otherwise. Expected results and/or comments are indented and appear in **boldface** type.

1. Make sure the power supply in the chassis housing the RFL 98 TMX is turned on (POWER switch in the ON position).

2. Plug the RFL 9800 DSP Programmer's ribbon cable into the mating connector on the front of the RFL 98 TMX. Note the status of the programmer's display.

   The parameter display should read "RESET*".

3. Press the **[RESET]** key on the keypad.

   The parameter display should read "LSCL" (Left Scale Input), followed by a four-digit number in the variable display. If it doesn't, press the reset switch on the side of the programmer, and then press the [RESET] key again. "LSCL" will appear in the parameter display.

   If you want to check the current parameter settings or change one or more settings before calibration, perform steps 4 through 28. If you only want to re-calibrate the RFL 98 TMX without changing any of the parameter settings, go to step 29.

4. Use the programmer's keypad to enter the desired left scale input voltage.

   The left scale input voltage can be set to any value from zero to 9.999 volts, in 1-mV increments. For example, if the desired left scale input is 2.5 volts, enter "2500"; for a left scale input of 5 volts, enter "5000".

5. Press the **[ENTER]** key.

   The left scale input value will be stored in the programmer's memory. Once stored, the parameter display will read "LSPL" (Left Scale Polarity), followed by a four-digit number.

6. Use the programmer's keypad to enter the desired left scale polarity.

   To set the left scale input voltage to a positive value, enter "0001"; enter "0000" to set it to a negative value.

Table 3. Parameter numbers, parameter codes, and valid entries, RFL 98 TMX Programmable Telemetry Transmitter

#	Code	Meaning	Valid Entries [1]
1	LSCL	Left Scale Input (mVdc)	Any value from 0000 (0 mV) to 9999 (9.999 V). [2]
2	LSPL	Left Scale Polarity	0000 (negative) or 0001 (positive).
3	RSCL	Right Scale Input (mVdc)	Any value from 0000 (0 mV) to 9999 (9.999 V). [2]
4	RSPL	Right Scale Polarity	0000 (negative) or 0001 (positive).
5	LSFQ	Left Scale Frequency	Any value from 0005 (5 Hz) to 0040 (40 Hz). [3]
6	RSFQ	Right Scale Frequency	Any value from 0005 (5 Hz) to 0040 (40 Hz). [3]
7	TXBW	Transmit Bandwidth (Hz)	0050 (50 Hz), 0060 (60 Hz), or 0085 (85 Hz).
8	TXCF	Transmit Carrier Frequency (Hz)	Any carrier frequency where high and low frequencies will both be between 350 Hz and 3200 Hz. [4]
9	TXLV	Transmit Level (-dBm)	Any value between 0000 (0 dBm) and 4000 (-40 dBm), in 0.25-dB increments.
10	JMPS	Jumper Placement Data	No data entry - set jumper J2 to the position indicated by the first two digits in the variable display, and jumper J3 to the position indicated by the last two digits.
11	RUN*	RUN Mode	No data entry; press the **[ENTER]** key to transfer data from the programmer to the RFL 98 TMX and return module to RUN mode.
12	TXST	Transmitter Set Mode	Allows operator to change output level setting. Press the **[ENTER]** key once parameter code is displayed; the parameter display will start flashing. Output level can be changed by pressing **[INCR]** and **[DECR]** keys. When desired value is displayed, press **[ENTER]** key to store it.
13	OTLV	Output Test Level Mode [5]	Press **[ENTER]** key once the parameter code is displayed and flashing. **[INCR]** and **[DECR]** keys may be used to set calibrator output to 10, 50, 90, or 100 percent of voltage span. Press **[ENTER]** to go to the next parameter.
14	CALB	Calibration [5]	Automatic operation - no entry required. "CALIB" will flash on display while calibration is taking place. In about 30 seconds, calibration will be complete and the module will enter the Run mode.
15	PARA	Parameter Selection	Enter desired parameter number listed above, and then press **[ENTER]** key; the selected parameter will be displayed.

1. Press **[ENTER]** key after the desired value is displayed. "ERR" will appear on the display if the entered value is not valid.
2. The difference between the left and right scale points must be at least 100 mV. The left scale point may be offset away from zero, but the offset cannot be greater than the difference between the scale points.
3. For full accuracy, the difference between the left and right scale frequencies must be at least 20 Hz.
4. For full frequency characteristic information, refer to Table 1.
5. Can only be accessed if the RFL 9800 Programmer is equipped with the Calibrator Option.

7. Press the **[ENTER]** key.

   The left scale polarity value will be stored in the programmer's memory. Once stored, the parameter display will read "RSCL" (Right Scale Input), followed by a four-digit number.

8. Use the programmer's keypad to enter the desired right scale input voltage.

   The right scale input voltage can be set to any value from zero to 9.999 volts, in 1-mV increments. For example, if the desired right scale input is 5 volts, enter "5000"; for a right scale input of 8 volts, enter "8000".

9. Press the **[ENTER]** key.

   The right scale input value will be stored in the programmer's memory. Once stored, the parameter display will read "RSPL" (Right Scale Polarity), followed by a four-digit number.

10. Use the programmer's keypad to enter the desired right scale polarity.

    To set the right scale input voltage to a positive value, enter "0001"; enter "0000" to set it to a negative value.

11. Press the **[ENTER]** key.

    The right scale polarity value will be stored in the programmer's memory. Once stored, the parameter display will read "LSFQ" (Left Scale Frequency), followed by a four-digit number.

12. Use the programmer's keypad to enter the desired left scale frequency.

    The left scale frequency can be set to any value from 0005 (5 Hz) to 0040 (40 Hz).

13. Press the **[ENTER]** key.

    The left scale frequency value will be stored in the programmer's memory. Once stored, the parameter display will read "RSFQ" (Right Scale Frequency), followed by a four-digit number.

14. Use the programmer's keypad to enter the desired right scale frequency.

    The right scale frequency can be set to any value from 0005 (5 Hz) to 0040 (40 Hz), but it must be higher than the left scale frequency for normal operation.

    For test purposes, the left and right scale frequencies can be set to the same frequency. The modulation frequency will then be independent of the analog input signal.

15. Press the **[ENTER]** key.

    The right scale frequency value will be stored in the programmer's memory. Once stored, the parameter display will read "TXBW" (Transmit Bandwidth), followed by a four-digit number.

16. Use the programmer's keypad to enter the desired transmit bandwidth.

    Valid entries are as follows:

    0050 - 50 Hz
    0060 - 60 Hz
    0085 - 85 Hz.

17. Press the **[ENTER]** key.

    The transmit bandwidth value will be stored in the programmer's memory. Once stored, the parameter display will read "TXCF" (Transmit Carrier Frequency), followed by a four-digit number.

18. Use the programmer's keypad to enter the desired transmit carrier frequency.

    The transmit carrier frequency can be set to any value from "0300" (300 Hz) to "3200" (3200 Hz) that is compatible with the selected channel bandwidth. For example, if the transmit bandwidth has been set to 50 Hz, the carrier frequency cannot be set to 320 Hz, because the low frequency would be below 300 Hz.

19. Press the **[ENTER]** key.

    The transmit carrier frequency value will be stored in the programmer's memory. Once stored, the parameter display will read "TXLV" (Transmit Level), followed by a four-digit number.

20. Use the programmer's keypad to enter the desired transmit level.

    The transmit level is expressed in negative dBm, and may be set to any value from "0000" (0 dBm) to "4000" (-40 dBm) in 0.25-dB increments (0000, 0025, 0050, etc).

21. Press the **[ENTER]** key.

    The transmit level value will be stored in the programmer's memory. Once stored, the parameter display will read "JMPS" (Jumper Locations Output), followed by a four-digit number.

22. Note and record the number being displayed on the programmer's display.

    The first two digits of the number in the programmer's display indicate the proper setting for jumper J2, and the last two digits indicate the proper setting for jumper J3.

23. Press the **[INCR]** key until the parameter display reads "RUN*", and then press the **[ENTER]** key.
    All the parameter settings will be transferred from the programmer to the RFL 98 TMX; after about 60 seconds, the RFL 98 TMX will return to its normal operation mode. When it does, the word "RUNNING" will appear on the display.

24. Using a flat-blade screwdriver, push in on each of the quarter-turn fasteners on the RFL 98 TMX's front panel, and turn one quarter-turn counter clockwise to loosen.

25. Remove the RFL 98 TMX from the chassis by pulling on the module handle.

26. Check the settings of jumpers J2 and J3. (Refer to Figure 4 for their location.)
    J2 and J3 must be set as indicated by the number noted during step 22. If necessary, re-position these jumpers before proceeding to step 27.

27. Carefully align the circuit board edges with the card guides in the chassis, and gently slide the RFL 98 TMX module back into the chassis, until the 64-pin connector at the rear of the RFL 98 TMX engages the connector on the I/O module.

28. Once the RFL 98 TMX is fully seated, use a flat-bladed screwdriver to tum the two quarter-tum fasteners on the front panel of the module to secure it in place.
    The RFL 98 TMX will be on-line and ready for operation.

    If the analog input values ("LSCL", "LSPL", "RSCL", or "RSPL") were changed during steps 4 through 10 above, the RFL 98 TMX will have to be re-calibrated; perform step 29. If none of these parameters were changed and the RFL 98 TMX was previously calibrated, re-calibration is not necessary; go on to step 30.

29. Enter the calibration mode by pressing and releasing the **[INCR]** key on the programmer until the word "CALB" appears on the display, or press the **[PAR]** key followed by the **[1]** and **[4]** keys to move the programmer to parameter 14. When it does, press the **[ENTER]** key.
    A relay on the RFL 98 TMX will disconnect the analog input and substitute voltages generated by the calibrator board in the programmer for the first four parameters. These voltages are applied for several seconds to enable the RFL 98 TMX's dual-slope A/D circuits to obtain and store several readings. During this time, the programmer's display will flash the "CALB" indication. After about 30 seconds, the word "RUNNING" will appear in the programmer display.

30. Disconnect the programmer from the RFL 98 TMX.

The RFL 98 TMX is now programmed, on-line, and in its RUN mode of operation. It will operate in a normal fashion, using all the parameters that have been programmed. You can re-program it at any time by re-connecting the programmer and repeating the above programming procedure.

While the RFL 9800 DSP Programmer/Calibrator is connected to the RFL 98 TMX, several input and output signals on the RFL 98 TMX can be monitored by connecting a digital multimeter of suitable bandwidth to the test points on the side of the programmer. These signals are listed in Table 4; all signals are referenced to the GND test point.

NOTE

The test points on the RFL 9800 Programmer should be monitored with high-impedance instruments only. Because the test points are resistor-isolated, they cannot be used for current measurements.

Because of losses in the ribbon cable and noise generated by the programmer's LED display, the test points are not suitable for calibration or high-level verification. They are intended for use during troubleshooting and for coarse level adjustment or measurement.

Table 4. Programmer test point assignments

Point	Signal Name/Description
A	TONE OUT (after reconstruction filter)
B	Calibration relay coil
C	Circuit common
D	CAL INPUT (LO)
E	CAL INPUT (HI)
F	-15 Vdc
G	Modulating frequency (TTL square wave)
GND	Signal common

Dynamic Programming

The RFL 98 TMX's Transmitter Set Mode ("TXST") permits the RFL 98 TMX's transmit levels to be dynamically adjusted during normal operation. To dynamically change level adjustments, proceed as follows:

1. Make sure the power supply in the chassis housing the RFL 98 TMX is turned on (POWER switch in the ON position).

2. Plug the RFL 9800 DSP Programmer's ribbon cable into the mating connector on the front of the RFL 98 TMX. Note the status of the programmer's display.
   The parameter display should read "RESET*".

3. Press the **[RESET]** key on the keypad.
   The parameter display should read "LSCL" (Left Scale Input), followed by a four-digit number in the variable display. If it doesn't, press the reset switch on the side of the programmer, and then press the [RESET] key again. "LSCL" will appear in the parameter display.

4. Press and release the **[INCR]** key (or press the **[PAR]** key followed by the **[1]** and **[2]** keys) until the word "TXST" appears on the display. When it does, press the **[ENTER]** key.
   A four-digit number will appear in the display, indicating the current transmit level setting. The display will flash to indicate that the RFL 98 TMX is in the dynamic set mode.

5. Use the **[INCR]** or **[DECR]** keys to raise or lower the transmit level to the desired value.
   The transmit level can be varied in 0.25-dB increments.

6. When the desired transmit level value appears in the display, press the **[ENTER]** key.
   The word "RUN*" will appear in the display.

7. Press the **[ENTER]** key.
   The new transmit level value will be stored in the RFL 98 TMX's memory, and the module will return to its normal operation mode. When it does, the word "RUNNING" will appear on the display.

8. Disconnect the programmer from the RFL 98 TMX.

Output Test Level Mode

The output test level mode ("OTLV") is a method of checking the RFL 98 TMX's calibration. To enter this mode, proceed as follows:

1. Make sure the power supply in the chassis housing the RFL 98 TMX is turned on (POWER switch in the ON position).

2. Plug the RFL 9800 DSP Programmer's ribbon cable into the mating connector on the front of the RFL 98 TMX. Note the status of the programmer's display.
   The parameter display should read "RESET*".

3. Press the **[RESET]** key on the keypad.
   The parameter display should read "LSCL" (Left Scale Input), followed by a four-digit number in the variable display. If it doesn't, press the reset switch on the side of the programmer, and then press the [RESET] key again. "LSCL" will appear in the parameter display.

4. Press and release the **[INCR]** key (or press the **[PAR]** key followed by the **[1]** and **[3]** keys) until the word "OTLV" appears on the display. When it does, press the **[ENTER]** key.
   The analog input will be switched to the programmer/calibrator, and you will be able to control the output of the calibrator.

5. Use the **[INCR]** or **[DECR]** keys to change the output test level.
   There are five possible output settings:

   1. **Left Scale voltage (as set by the LSCL parameter).**
   2. **Left Scale voltage plus 10 percent of voltage span (the difference between the Left Scale and Right Scale voltages).**
   3. **Left Scale voltage plus 50 percent of voltage span.**
   4. **Left Scale voltage plus 90 percent of voltage span.**
   5. **Left Scale voltage plus 100 percent of voltage span.**

6. To make a direct measurement of the voltage generated by the RFL 98 TMX for the selected test level input, set the digital multimeter for dc voltage measurements; connect its positive lead to test point D on the side of the programmer, and the negative lead to test point E.

7. To measure the accuracy of the corresponding modulation frequencies, connect the frequency counter input leads across test points C and G on the side of the programmer (high to C, low to G).

8. Leave the "OTLV" mode by pressing [ENTER] a second time.
   The RFL 98 TMX will exit the output test level mode and return to the RUN mode.

9. Disconnect the programmer from the RFL 98 TMX.

NOTE

Do not disconnect the programmer from the RFL 98 TMX while "TXST", "OTLV", or CALIB" is being displayed; if you do, the RFL 98 TMX will not enter the RUN mode.

INPUT SCALING

The following information is provided for users who wish to modify the RFL 98 TMX's input ranges through the use of external dropping resistors.

The RFL 98 TMX is calibrated for a voltage input. If you want to use a current input, place a precision dropping resistor across terminals TB1-5 and TB1-6 on the RFL 98 DATA I/O module; this resistor can also be mounted directly to the RFL 98 DATA I/O, in the space marked "R1". Since the RFL 98 TMX's specified accuracy of ±0.05 percent applies to a full-scale voltage input, the dropping resistor should be chosen so that the RFL 98 TMX can be calibrated for a full-scale voltage corresponding to the maximum input current required.

For example, if the current range is 4 mA to 20 mA, a 100-ohm resistor can be placed across the input. The RFL 98 TMX can then be calibrated for a left scale value of 0.4 volts (LSCL = 0400, LSPL = 0001), and a right scale value of 2 volts (RSCL = 2000, RSPL = 0001).

THEORY OF OPERATION

The RFL 98 TMX Programmable Telemetry Transmitter provides coding points along the length of a data communications link. It accepts analog inputs representing analog intelligence and transforms such data into a modulated carrier; at the other end of the link, an RFL 98 TMR Programmable Telemetry Receiver will accept the modulated carrier and transform it into analog voltages or currents for subsequent processing by other equipment.

The RFL 98 TMX converts dc input voltages from -10 to +10 volts into a modulated voice-frequency carrier ranging from 5 to 40 Hz; the conversion is directly proportional to the input voltage. The conversion can be represented by the equation

$$F = a + bV$$

where

F = Modulating frequency
V = Input voltage
a, b = Computed coefficients

The computed coefficients are determined by digital signal processor (DSP) U13.

A block diagram of the RFL 98 TMX appears in Figure 4. Figure 5 on page 21 of this Instruction Data sheet is a component locator drawing for the RFL 98 TMX; its schematic appears in Figure 6 on page 19 of this Instruction Data sheet.

Input Section

The RFL 98 TMX receives its input from two sources. The first is edge connector P1, which connects to the RFL 98 DATA I/O module and accepts inputs from external equipment. The other input source is front panel connector J1, which accepts parameter setting and calibration inputs from the RFL 9800 Programmer/Calibrator. Relay K1 determines which input source is used, depending on the signal being applied to its coil through P1-17C or J1-12.

The input selected by K1 is applied to the input pins of operational amplifier U12 (U12-14 and U12-15). Dual diodes U23 and U24 provide limit protection, which prevents U12's inputs from becoming overloaded. U12 buffers and amplifies the limited input signal. U12 takes the difference between the two input levels presented to it and develops either that difference or ten times that difference, as determined by the placement of jumper J2.

Processor Section

A/D Converter. The output of the input section (U12-11) is coupled to analog-to-digital (A/D) converter U17, which furnishes the signal in digital form (including polarity data) to microcontroller U14. Dual diode U15 provides limit protection for U17's input (U17-11). The choice of divide-by-1, divide-by-2, or divide-by-4 is determined by the setting of jumper J3.

Voltage Reference. The +2.5-volt reference required by U17 is provided by voltage reference U21; this voltage is also buffered by an operational amplifier in U5 before being passed to P1-22C as the 2.5-volt reference output for slide wire applications.

Digital Signal Processor And Microprocessor. The heart of the processing section is U13, which is a Digital Signal Processor (DSP) under the control of microcontroller U14. The software that controls U13 is stored in EPROMs U1 and U9; the parameter settings that can be altered by using the RFL 9800 DSP Programmer/Calibrator are stored in U3, which is an Electrically-Eraseable Programmable Read-Only Memory (EEPROM). Data and address buses are used to pass information between these devices, the address and data outputs generated by U14 are placed in the buses by octal flip-flip U10 and octal buffer/line driver U16.

When input power is first applied, microcontroller U14 performs a check to determine if the RFL 9800 is connected to ribbon header J1 on the RFL 98 TMX's front panel. If the RFL 9800 is not connected, U14 recalls all the stored parameter values from Electrically-Eraseable Programmable Read-Only Memory (EEPROM) U3, and feeds them to U13, along with the digitized input signal. When U13 receives the microcontroller-supplied parameter values, it generates the frequency-shift output tone to be routed to the output section.

When the parameter values are in place, U13 and U14 enter their normal run routine. If the RFL 9800 is connected, U14 will initialize, but will not put the RFL 98 TMX in the RUN mode. The values stored in memory will be copied to the programmer's memory.

One of U14's output lines is used to cause SIG ON indicator DS1 to flash to indicate the presence of a signal being processed.

Control Section

The control section produces timing and sequencing signals that are used by the processing section.

RESET commands are supplied to the microcontroller by a circuit formed from transistors Q1, Q2, and Q3, timer U2, and NAND gate U19. This circuit monitors the supply voltages for proper levels and sends a RESET command to U14-9 if any of the voltages fall outside the acceptable limits. It also monitors J1-11 to issue a RESET command when a reset command is received from the RFL 9800 programmer/calibrator; external reset commands applied to P1-21C are handled in the same way.

The reset circuit also functions as a watchdog circuit. If either the microcontroller or the DSP go out of program during operation, Q3 will start timer U2; if U2 times out, a RESET command will be sent to U14-9.

A clock output from U14-30 is routed to U7-5 through four-stage ripple counter U20. This clock signal is used to control the flow of data through CODEC U7 in the output section.

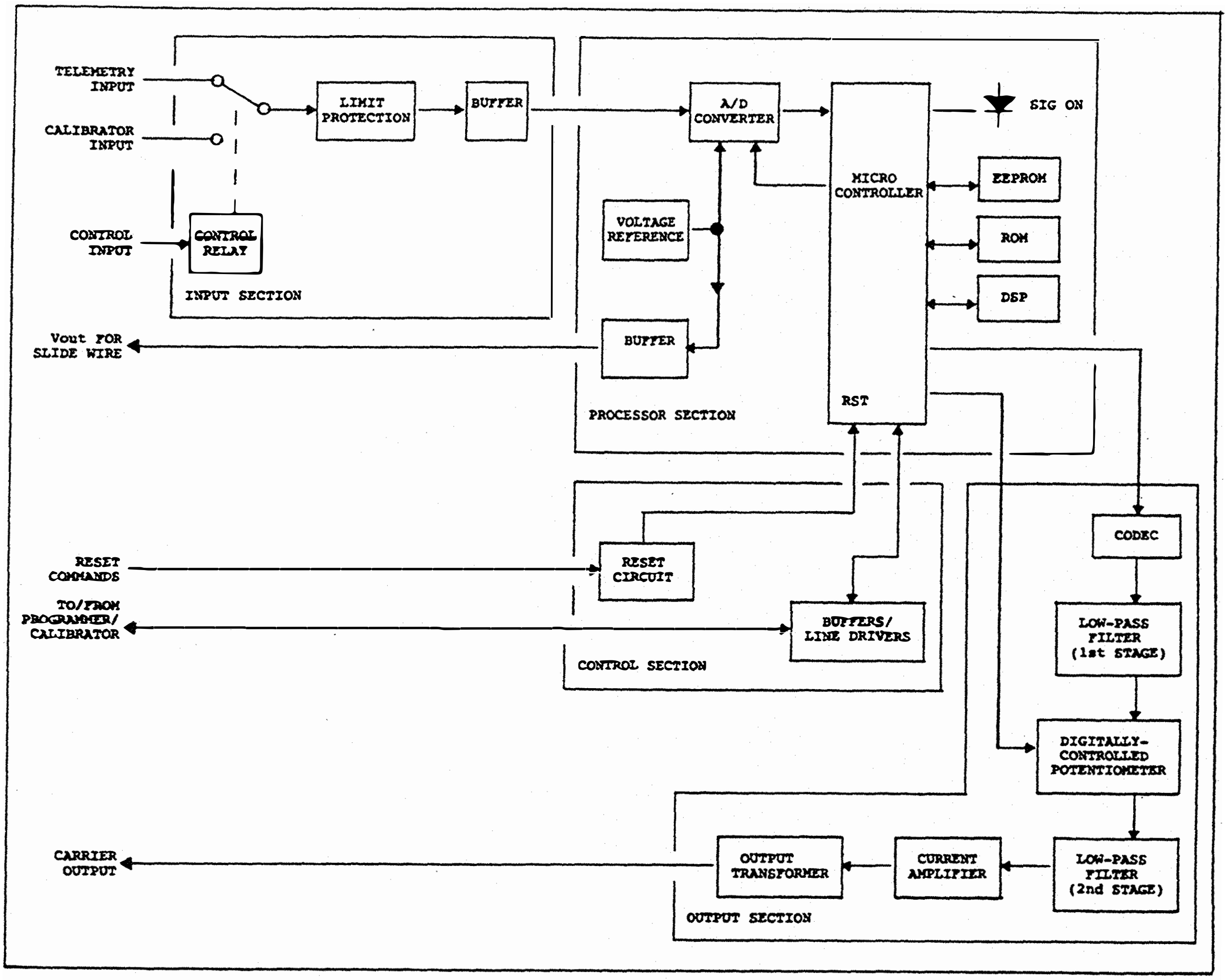

Figure 4. Block diagram, RFL 98 TMX Programmable Telemetry Transmitter

Data to be supplied to the RFL 9800 from U14 is conditioned by quad buffer/line driver U18 before being passed to front panel connector J1. The RFL 9800 echoes the parameter values it receives back to U14 for error checking. If the data does not match, the RFL 98 TMX resets and repeats the process. Every parameter is also checked to make sure its value is consistent with all the other parameter settings. This echoing process assures the transfer of accurate parameter values.

The RUN* command issued by the RFL 9800 initiates a consistency check within the programmer/calibrator before parameters are relayed to U14. It then stores the new parameter values in EEPROM U3.

If a programmer/calibrator is connected to the RFL 98 TMX during operation, the word "RESET*" will appear on its display; however, the RFL 98 TMX will remain operational and on-line until the reset switch on the RFL 9800 is pressed.

Output Section

The signal data produced by microcontroller U14 is fed to coder/decoder (CODEC) U7. U7's output (a ragged sine wave at U7-2) is smoothed by two-stage low-pass filter U6. Digitally-controlled potentiometer U4 is connected between the stages of U6 and sets the output level, as determined by the PT3.5 output of the microcontroller (U14-15). After filtering, the now-smooth analog signal is routed to current amplifier U5; diodes CR8 and CR9 clamp U5's output to a safe level. U5's output is coupled by capacitor C34 to transformer T1; T1's impedance is controlled by jumper J5. From there, it is coupled to edge connector terminals P1-12C and P1-11C through transformer T1.

Table 5. Replaceable parts, RFL 98 TMX Programmable Telemetry Transmitter
Assembly No. 102040

Circuit Symbol (See Figs. 5 & 6.)	Description	Part Number
	CAPACITORS	
C1,2,4	Capacitor,tantalum,1µF,10%,35V,Kemet T368A105K035AS or equiv.	1007 1692
C3,8,9,11,12,14,17,22, 23,25,39-42	Capacitor,X7R ceramic,0.1µF,10%,50V,AVX SA305C104KAA or equiv.	0130 51041
C5,6	Capacitor,polypropylene,0.1µF,2%,100V,F-Dyne PPA-11-.1-100-2 or equiv.	0105 55
C7	Capacitor,metallized polypropylene,0.47µF,5%,100V,Wesco 32MPL or equiv.	1007 1690
C10	Capacitor,tantalum,10µF,10%,20V,Kemet T362B106K020AS or equiv.	1007 1465
C13	Capacitor,tantalum,1µF,20%,35V,Kemet T322B105M035AS or equiv.	1007 496
C15,16,18,19	Capacitor,ceramic,27pF,5%,100V,AVX SA101A270JAA or equiv.	0125 12705
C20,36	Capacitor,tantalum,6.8µF,20%,25V,Sprague 196D685X0025JA1 or equiv.	1007 1669
C21	Capacitor,tantalum,0.33µF,10%,35V,Kemet T322A334K035AS or equiv.	1007 1281
C24	Capacitor,tantalum,22µF,20%,16V,Sprague 199D226X0016DB1 or equiv.	1007 1569
C26,27	Capacitor,tantalum,4.7µF,20%,20V,Kemet T322B475M020AS or equiv.	1007 711
C28,29,35	Capacitor,X7R ceramic,0.01µF,10%,50V,AVX SA105C103KAA or equiv.	0130 51031
C30,31,37,38,43	Capacitor,ceramic,0.1µF,GMV,50V,Centralab CY20C104P or equiv.	1007 1366
C32	Capacitor,ceramic,0.056µF,10%,50V,AVX SR205C563KAA or equiv.	1007 1647
C33	Capacitor,ceramic,47pF,5%,100V,AVX SA101A470JAA or equiv.	0125 14705
C34	Capacitor,ceramic,1µF,10%,50V,Type CK06	0110 6
	RESISTORS	
R1,4,14,29	Resistor,metal film,10KΩ,1%,1/4W, Type RN1/4	0410 1384
R2,3,21,22,24,29	Not used.	
R5	Resistor,metal film,127KΩ,1%,1/4W, Type RN1/4	0410 1490
R6	Resistor,metal film,100Ω,1%,1/4W, Type RN1/4	0410 1192
R7	Resistor,metal film,20KΩ,1%,1/4W, Type RN1/4	0410 1413
R8,9,17,28	Resistor,metal film,100KΩ,1%,1/4W, Type RN1/4	0410 1480
R10	Resistor,metal film,604Ω,1%,1/4W, Type RN1/4	0410 1267
R11-13	Resistors, matched set	30693
R15	Resistor,metal film,402Ω,1%,1/4W, Type RN1/4	0410 1250
R16	Resistor,metal film,1.5KΩ,1%,1/4W, Type RN1/4	0410 1305
R18,19,20,23	Resistor,zero-ohm,1/4-watt size,Corning OMA07 or equiv.	1510 2217

Table 5. Replaceable parts, RFL 98 TMX Programmable Telemetry Transmitter - continued.

Circuit Symbol (See Figs. 5 & 6.)	Description	Part Number
	RESISTORS - continued.	
R25	Resistor,metal film,2.21MΩ,1%,1/4W, Type RN1/4	0410 1609
R26,27	Resistor,metal film,2.8KΩ,1%,1/4W, Type RN1/4	0410 1331
R30	Resistor,composition,5.1Ω,5%,1/4W, Allen-Bradley CB Series or equiv.	1009 932
R31	Resistor,composition,30Ω,5%,1/4W, Allen-Bradley CB Series or equiv.	1009 828
R32	Resistor,metal film,4.99KΩ,1%,1/4W, Type RN1/4	0410 1355
R33	Resistor,metal film,681Ω,1%,1/4W, Type RN1/4	0410 1272
R34	Resistor,metal film,243Ω,1%,1/4W, Type RN1/4	0410 1229
R35	Resistor,metal film,3.01KΩ,1%,1/4W, Type RN1/4	0410 1334
RZ1	Resistor network,three 100KΩ 2% resistors,0.75W total,6-pin SIP, Bourns 4306R-102-104 or equiv.	96959
RZ2	Resistor network,three 10KΩ 2% resistors,0.75W total,6-pin SIP, Bourns 4306R-102-103 or equiv.	98446
RZ3	Resistor network,four 5.6KΩ 2% resistors,1W total,8-pin SIP, Bourns 4308R-102-562 or equiv.	30263
	SEMICONDUCTORS	
CR1-4	Not used.	
CR5,8,9,13,14	Diode,silicon,1N914B or 1N4448	26482
CR6	Diode,Zener,3.3V,5%,250mW,DO-35 package,1N4620	96871
CR7,10	Diode,Zener,17V,10%,500mW,DO-35 case,1N5247	98447
CR11	Transient suppressor,5.8 WVdc,600W,General Instrument P6KE6.8A or equiv.	30694
CR12	Diode,Schottky,1A,20V,1N5817	30150
DS1	Light-emitting diode,green,right-angle PC mount,Industrial Devices 5300H5 or equiv.	32567
Q1,2	Transistor,NPN,TO-92 case,2N3903	21562
Q3	Transistor,PNP,TO-92 case,2N3905	21564
U1,9	EPROM,8K x 8,UV-eraseable	Contact factory
U2	MOS timer,8-pin DIP,General Electric/Intersil ICM7555IPA or equiv.	0615 328
U3	EPROM,1024-bit (64 x 16),electrically-erasable,serial read/write,8-pin DIP, International CMOS Technology 93C46P or equiv.	0630 43
U4	MOS digitally-controlled potentiometer,8-pin DIP,Xicor X9104P or equiv.	0615 295
U5	Linear operational amplifier,JFET input,8-pin DIP,Texas Instruments TL082CP or equiv.	0620 155
U6	MOS PCM transmit/receive filter,16-pin DIP,Samsung KT3040JML or equiv.	0615 352

Table 5. Replaceable parts, RFL 98 TMX Programmable Telemetry Transmitter - continued.

Circuit Symbol (See Figs. 5 & 6.)	Description	Part Number
	SEMICONDUCTORS - continued.	
U7	Serial 13-bit linear CODEC,16-pin DIP,Motorola MC145402 or equiv.	0625 19
U8	Linear voltage regulator,-5-volt,3-terminal TO-92 package, National Semiconductor LM79L05ACZ or equiv.	0620 210
U10	MOS octal tri-state D-type flip-flop,20-pin DIP,Motorola MC74HC574N or equiv.	0615 298
U11	MOS 8-bit latch/3-to-8 line decoder,16-pin DIP, National Semiconductor MM74HC259N or equiv.	0615 288
U12	Linear operational amplifier,16-pin hermetic DIP,Burr-Brown INA102CG or equiv.	0620 302
U13	MOS digital signal processor,40-pin DIP,Texas Instruments TMS320C10NL or equiv.	0615 300
U14	MOS microcontroller,40-pin DIP,Intel D87C51 or equiv.	0615 299
U15,23,24	Diode,dual low-leakage,5A peak @ 20V,TO-71 case,Siliconix DPAD5 or equiv.	99056
U16	MOS octal tri-state non-inverting buffer/line driver,20-pin DIP, National Semiconductor MM74HC541N or equiv.	0615 297
U17	Dual-slope integrating converter,microprocessor-controlled,16-pin ceramic DIP, Teledyne Semiconductor TSC500AIJE or equiv.	0625 21
U18	MOS quad buffer/line driver,14-pin DIP,Signetics 74HC125N or equiv.	0615 292
U19	MOS quad 2-input NAND gate,14-pin DIP,Motorola MC74HC132N or equiv.	0615 306
U20	MOS 4-stage binary ripple counter,14-pin DIP,Motorola MC74HC93N or equiv.	0615 305
U21	Linear voltage reference,2.5-Vdc,8-pin ceramic DIP,Precision Monolithics REF-43F2 or equiv.	0620 301
U22	MOS dual J-K flip-flop,14-pin DIP,National Semiconductor MM74HC107N or equiv.	0615 153
	MISCELLANEOUS COMPONENTS	
K1	Relay,DPDT,PC-mount,12-volt/1028Ω coil,140 mW,Aromat TQ2E-12V or equiv.	98439
T1	Transformer,telephone-coupling,600Ω,Microtran T1104 or equiv.	90221
Y1	Crystal,quartz,20.0 MHz	99215 4
Y2	Crystal,quartz,12.0 MHz	99215 3
. . .	Shorting bar,single,Molex 90059-0009 or equiv.	98306

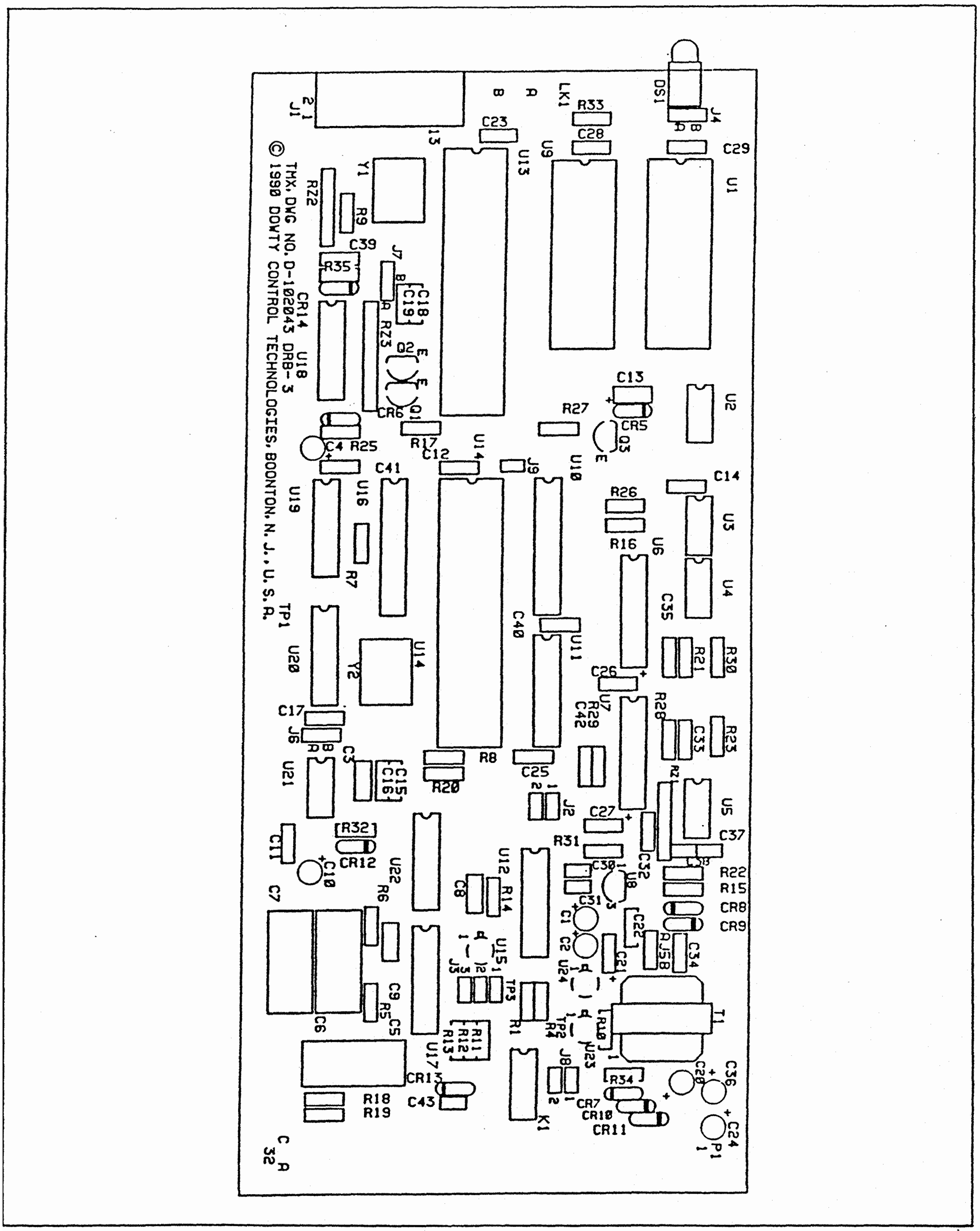

Figure 5. Component locator drawing, RFL 98 TMX Programmable Telemetry Transmitter (Assembly No. 102040; Drawing No. D-102043, Rev. E)

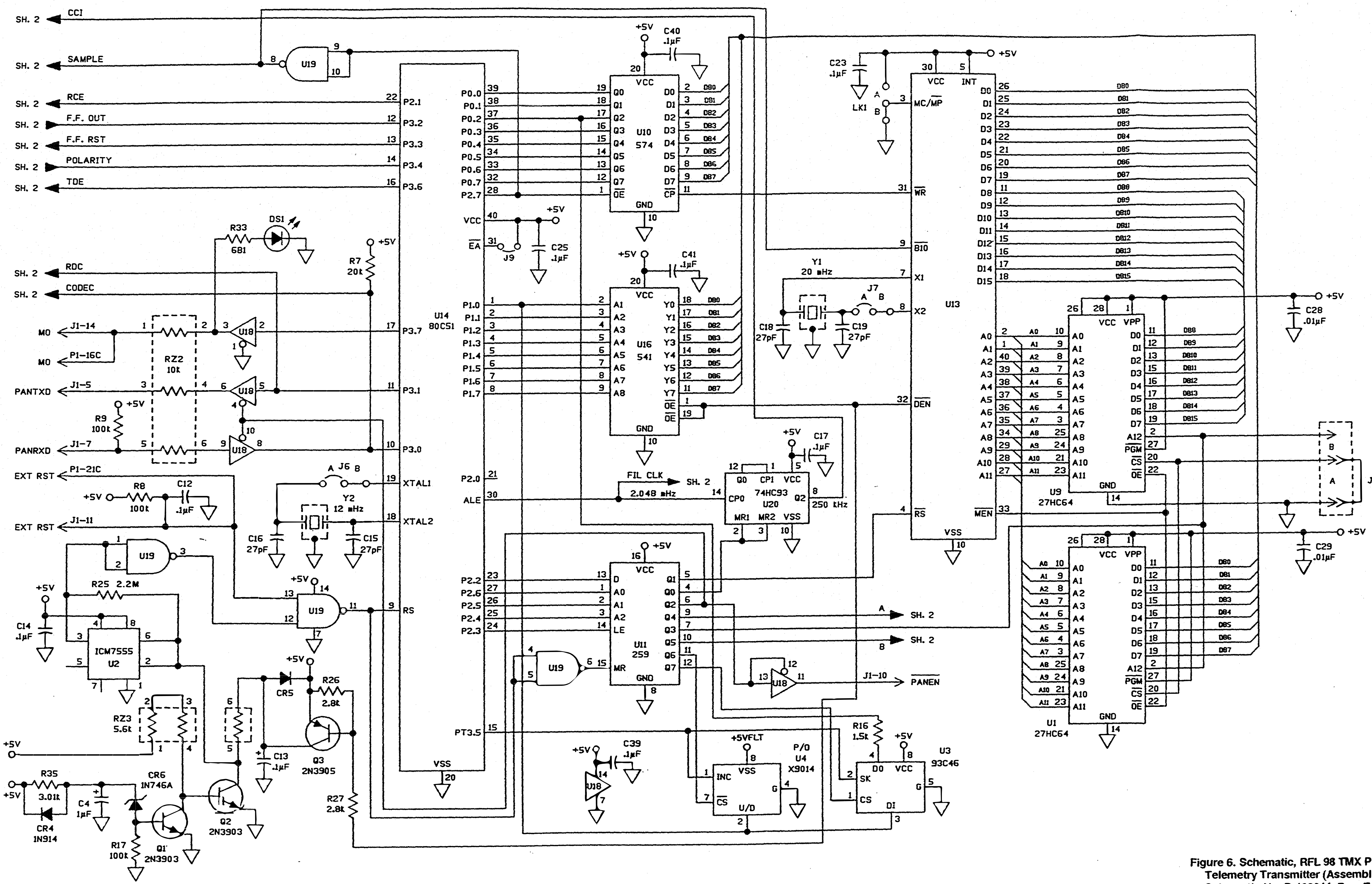

Figure 6. Schematic, RFL 98 TMX Programmable Telemetry Transmitter (Assembly No. 102040; Schematic No. D-102044, Rev. E – Sheet 1 of 2)

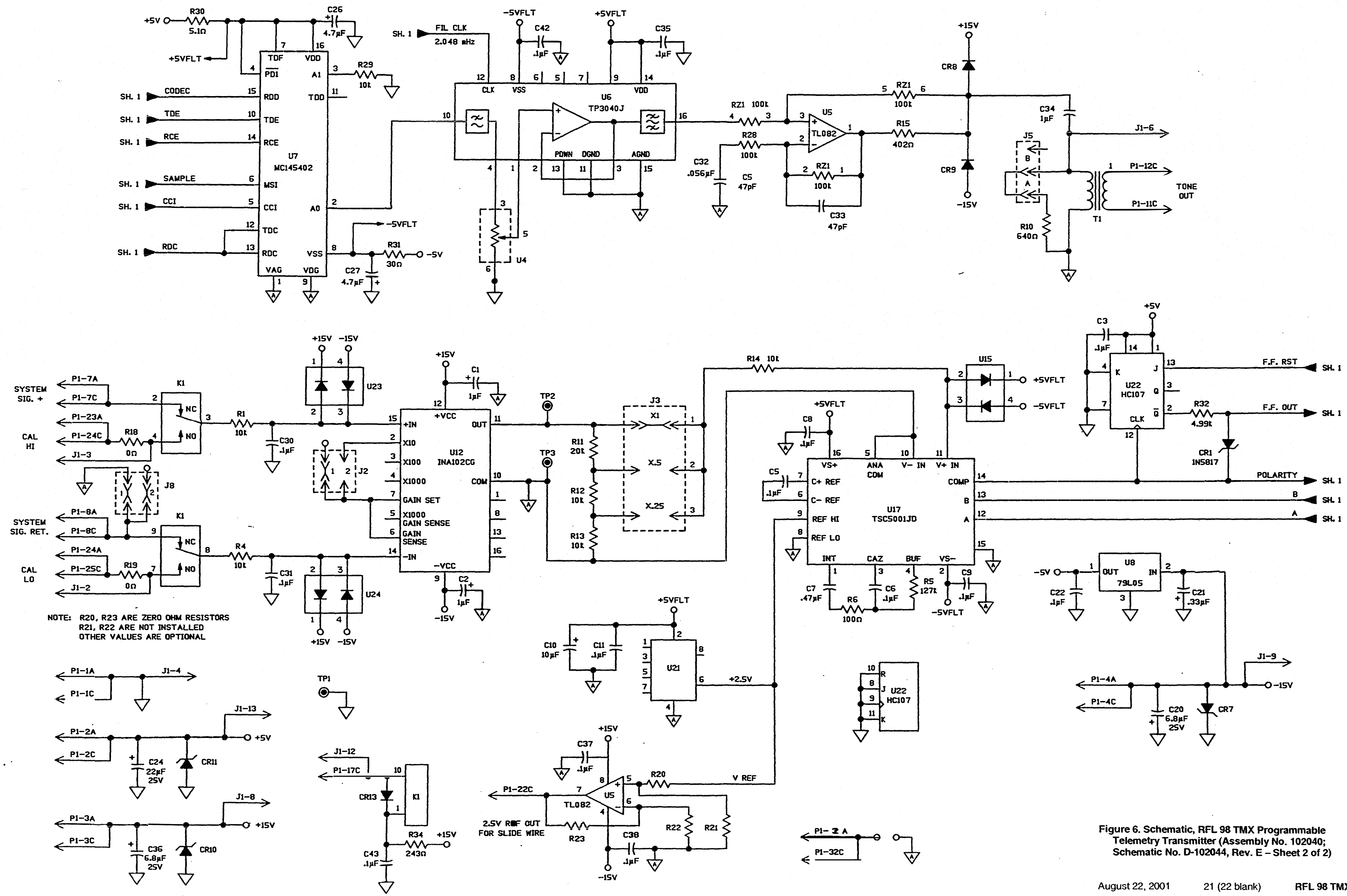

Figure 6. Schematic, RFL 98 TMX Programmable Telemetry Transmitter (Assembly No. 102040; Schematic No. D-102044, Rev. E – Sheet 2 of 2)

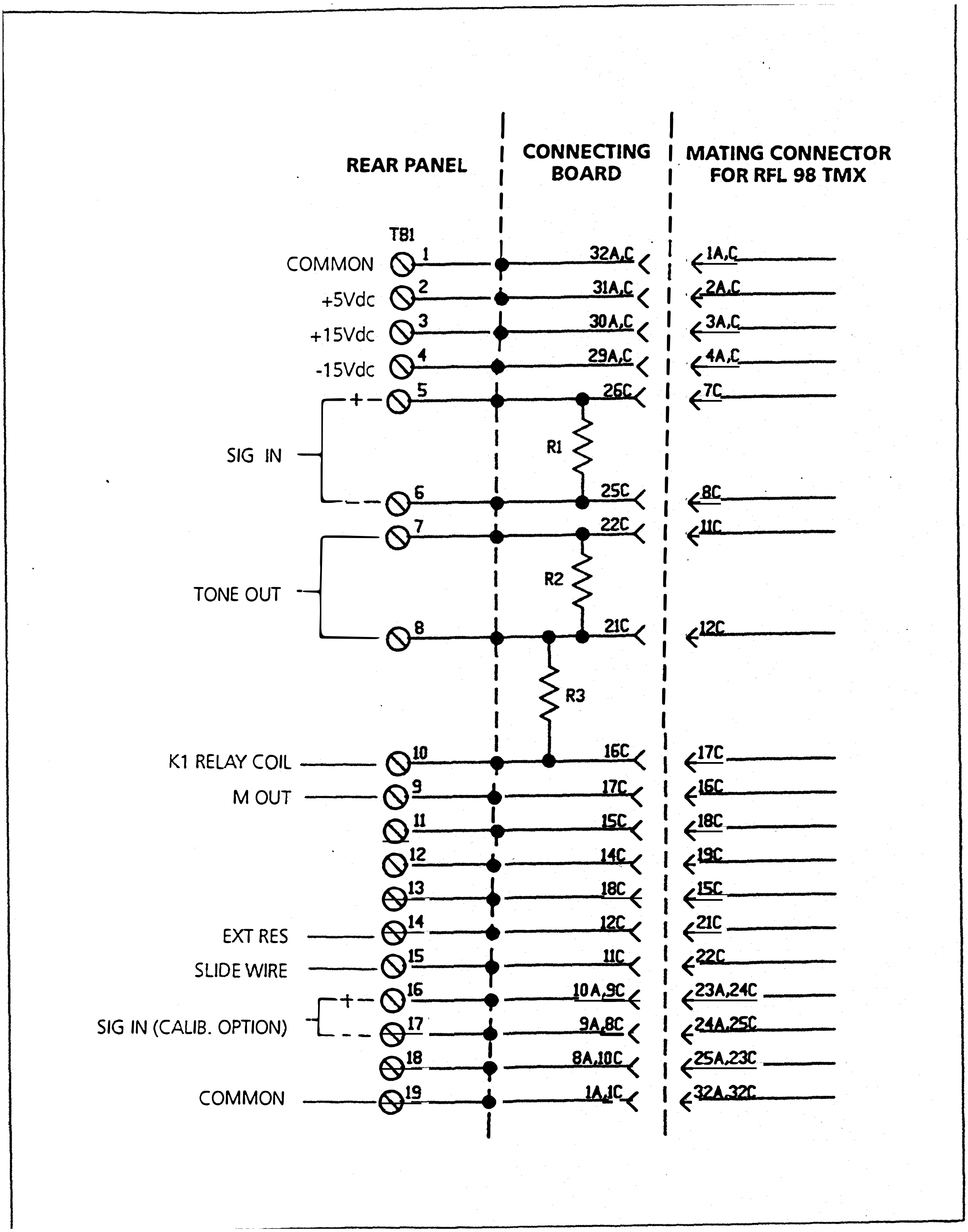

Figure 7. Schematic, RFL 98 DATA I/O 19-Point Data I/O Module (Assembly No. 102065; Schematic No. B-102069, Rev. C)

NOTICE

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