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AN ACTIVE RS-449/RS-232C ADAPTER FOR RMMS

by

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PREFACE

Acknowledgment is made to Mr. Thomas McHugh, Co-op, Drexel University, for his participation in the construction, testing, and data collection and analysis on this task.

INTRODUCTION

PURPOSE.

The purpose of this activity was to develop an active adapter to interface RS-449 devices to RS-232C devices. This active adapter will be used in RMMS activities at the Technical Center and as a functional prototype for possible future procurement.

BACKGROUND.

In the Remote Maintenance Monitoring System (RMMS), data interchange circuits between the various remote sites and the Maintenance Processor Subsystem (MPS) are required. NAS MD-790 "Interface Control Document for the Remote Maintenance Monitoring System (RMMS) (ICD-1)," defines the electrical, mechanical, and data link control interfaces for these RMMS devices. NAS MD-790 states that equipment communicating with the MPS shall use the EIA RS-449 interface. Although the RS-449 interface allows the use of either balanced circuits (RS-422) or unbalanced circuits (RS-423), NAS MD-790 states that only balanced circuits (RS-422) shall be used.

For many years the industry standard interface for serial data interchange has been RS-232C, and there are many commercial devices available having RS-232C interfaces, but very few having RS-449. Thus, there is a high probability that RS-232/449 interfaces will exist in the implementation of RMMS. The need to interface RS-232C to RS-449 devices has been recognized by industry, and EIA Electronics Bulletin No. 12 defines the requirements for this interface. Several manufacturers have built 449/232C passive adapters, based on Bulletin No. 12, to provide this interface capability. FAA Technical Center Letter Report CT-82-100-13LR "Investigation of the Use of Passive Adapters for RS-449/RS-232C Interfaces" discussed tests conducted on the Amp Products Corporation "37 to 25 Position RS-449 (DTE) to RS-232C (DCE), Adapter B."

Report CT-82-100-13LR notes three potential problems with the use of the passive adapter for RS-449 to RS-232 interfaces. The first is that the passive adapter is inherently an unbalanced device and, therefore, should only be used with the unbalanced circuit (RS-423) and not with the balanced circuit (RS-422). The second potential problem is the effect of noise on the signal due to the lower output voltage of the RS-423 source (max ± 6 volts). The third potential problem is that Bulletin 12 recommends limiting the cable length to that of the RS-232C standard (50 feet). (Figure 1 gives a comparison of cable length vs. data signalling rates for the three interfaces.) Because ICD-1 specifies that only balanced circuits (RS-422) will be used, and there will probably be cable runs longer than 50 feet, an active adapter was developed, for use in RMMS activities at the FAA Technical Center, and as a functional prototype for possible future procurement.

DESIGN CONSIDERATIONS.

In interfacing RS-449 to RS-232C devices, four types of interfaces exist. These are:

RS-422 (DTE) to RS-232C (DCE)
RS-422 (DCE) to RS-232C (DTE)
RS-423 (DTE) to RS-232C (DCE) -
RS-423 (DCE) to RS-232C (DTE) -

By definition:

DTE = Data Terminal Equipment

DCE = Data Communications Equipment (MODEM)

To properly support these four interfaces, four different adapters are required. The RS-423 interfaces can be supported by passive adapters, as defined in EIA Electronics Bulletin No. 12, and implemented commercially by several manufacturers. Tests conducted at the FAA Technical Center on one commercial adapter indicated some potential problems with passive adapters. Therefore, it was decided to include all four interfaces in the active adapter design.

Since the primary purpose of this active adapter is to support experimental RMMS activities at the Technical Center, it was decided to build all four interfaces into one adapter. With this approach, fewer parts would be required than for four separate adapters. Switching and connector changes would then provide the selection of the desired interface.

Neither the RS-232C nor the RS-449 connector provide a means to bring D.C. power to associated devices, thus it was necessary to include a power supply for the active adapter.

The question of using spare pins on the RS-449/RS-232C connectors to bring power into the adapter was considered, but was rejected. There are spare pins in the RS-449/RS-232C connectors, which can be used for specific functions by the device manufacturer. However, since there is no standard assignment of these spare pins, using them for power would be a non-standard interface, and could cause problems on some devices.

ADAPTER DESCRIPTION.

The logic/wiring diagram of the active adapter is shown in figure 2. Connector 422P is the connector for the RS-422 interface, connector 423P is the connector for the RS-423 interface and the RS-232C connector is marked RS-232C. Switches S1 through S12 determine the direction of signal flow into and out of the RS-232C connector (i.e. whether the RS-232C device is the DTE or DCE). The selection of the RS-422 or RS-423 is made by S13, and S14 selects whether the 422/423 interface is the DTE or DCE. Switch S15 sets the Send Common (SC) and Receive Common (RC) grounding protocol for either DTE or DCE configurations.

For RS-423 operation, capacitors are required on the 26LS29 drivers, to provide rise and fall time waveshaping (i.e. slow down the rise and fall times). This is to minimize near end crosstalk to other circuits. The value of these capacitors was selected for the highest data rate used (9600 bps) and is 180 picofarads.

Power to the adapter is from a separate AC to DC power supply providing +5, +12, and -12 volts. The adapter has an internal regulator to provide -5 volts.

Figures 3, 4, 5, and 6 are the same as figure 2 with the addition of heavy lines to show the signal flow for each of the four interface configurations. Specifically:

Figure 3. RS-422 (DTE) to RS-232C (DCE) Signal Flow

Figure 4. RS-422 (DCE) to RS-232C (DTE) Signal Flow

Figure 5. RS-423 (DTE) to RS-232C (DCE) Signal Flow

Figure 6. RS-423 (DCE) to RS-232C (DTE) Signal Flow

If an adapter is built for one of these specific interfaces only the components having the heavy lines would be required, thus there would be a considerable saving in component costs.

In this adapter, the approach taken was to convert the RS-449 signals to TTL levels and then convert the TTL levels to RS-232C levels, which is considered a necessary approach. This approach was taken because the only available integrated circuit (IC) chips are designed to interface EIA data signal levels to standard logic levels. A much better approach would be for an IC manufacturer to make a single IC to convert RS-449 signals directly to RS-232C levels and vice versa. This would further reduce the cost and complexity of any adapters.

TEST CONDUCT.

These tests were conducted to investigate the interface from RS-422 and RS-423 sources to an RS-232C load, and not the reverse. This configuration will thus test the interface under worst case signal levels. (See Letter Report CT-82-100-13LR.) Six tests were conducted. The first three tests used the RS-423 to RS-232C interface, and the last three tests used the RS-422 to RS-232C interface. All tests used the active adapter.

Test 1. This test used the configuration shown in figure 7. The purpose of this was to determine the effects of cable length on an RS-423 to RS-232C interface. Test data is shown in table 1.

Test 2. This test used the configuration shown in figure 8. The purpose was to determine the effects of 60Hz sine wave noise on the RS-423 side of an RS423 to RS-232C interface. Capacitor C1 provides rise and fall time wave-shaping. The LM-741 operational amplifier was used to provide isolation of the noise source from the signal source and impedance matching. Test data is shown in table 2.

Test 3. Same as test 2 except the noise frequency was 6 KHz. Test data is shown in table 3.

Test 4. This test used the configuration shown in figure 9. The purpose was to determine the effects of cable length on an RS-422 to RS-232 interface. Test data is shown in table 4.

Test 5 and Test 6. These tests used the configuration shown in figure 10. The purpose of these tests were to determine the effects of 60Hz and 6 KHz sine wave noise on the RS-422 side of an RS-422 to RS-232 interface. Test data is shown in table 5.

TEST RESULTS.

1. The data from tests 1 and 4 indicate that cable lengths up to 1500 feet for the RS-423 configuration, and up to 4000 feet for the RS-422 configuration, cause little attenuation of signal levels, and did not contribute any errors. This is to be expected since the input impedance of an RS-449 line receiver is high (greater than 6K ohms).

2. Tests 2 and 3 showed that the 6KHz and 60Hz noise started to cause errors at approximately the same signal/noise ratio. For example, at 1200 bits per second, the signal-to-noise ratio was -0.036 dB for 60 Hz noise and -0.048 dB for 6 kHz noise.

3. Tests 5 and 6 showed that the effect of common mode noise on the signal in an RS-422 (balanced) interface is very small. The test could only be run to a noise level of 20 volts peak-to-peak to avoid possible damage to the 26LS32 receiver. At the signal levels used in these tests, the Common Mode Rejection Ratio (CMMR) was greater than 20 dB. (The specification sheet on the 26LS32 indicates a CMMR greater than 30 dB.)

DISCUSSION OF RESULTS.

1. When used with the active adapter, the RS-422 (balanced) configuration demonstrated excellent noise rejection (greater than 20 dB) and the capability to drive long lines. High common mode noise rejection is inherent in a balanced circuit and the active adapter provides proper balanced to unbalanced conversion, between the RS-422 and RS-232C devices, to maintain the noise rejection and signal integrity of this configuration.

2. When used with the active adapter, the RS-423 (unbalanced) configuration demonstrated a substantial improvement in performance over the commercial passive adapter previously tested (Letter Report CT-82-100-13LR). At the error threshold, the signal-to-noise ratio for the previously-tested passive adapter was 13.9 dB, while for the active adapter it was -0.036 dB. This improvement in performance is attributed to the RS-423 receiver having its detection threshold set near ground potential (see item 3) whereas the RS-232C receiver (used in the passive adapter tests) had a positive bias, making it more susceptible to the negative swing of line noise.

3. The small negative signal-to-noise ratio (-.036 dB) in the RS-423 interface is attributed to the RS-423 receiver (AM26LS32). This receiver has a typical 30 millivolt hysteresis about ground, therefore, the noise must exceed the signal by this amount to break this hysteresis and cause errors.

CONCLUSIONS

1. The active adapter can be used with an RS-422 (balanced) to RS-232C interface. This capability is not available in a passive adapter.
2. The active adapter will allow long cable lengths on the RS-422/423 side of the adapter. The RS-232C constraint only applies to the RS-232C side.
3. For an RS-423 interface the active adapter provides improved signal/noise performance (about 14 dB) over a passive adapter.
4. For an RS-422 interface, the Common Mode Rejection Ratio (CMMR) is better than 20 dB.
5. For a single function adapter (e.g.: RS-422 (DCE) to RS-232C (DTE)), the cost of the adapter could be reduced considerably from the four function adapter built at the FAA Technical Center and described in this report.

RECOMMENDATIONS

1. Active adapters should be used on all RS-422/RS-232C interfaces.
2. Active adapters should be used on RS-423/RS-232C interfaces operating in an electrically noisy environment.

BIBLIOGRAPHY

1. Interface Control Document for the Remote Maintenance Monitoring System (RMMS) (ICD-1). National Airspace System Document NAS-MD-790, April 17, 1981.
2. Electronic Industries Association (EIA) Standard RS-232-C, August 1969, Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange.
3. EIA Standard RS-449, November 1977, General Purpose 37-Position and 9-Position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
4. EIA Standard RS-422-A, December 1978, Electrical Characteristics of Balanced Voltage Digital Interface Circuits.
5. EIA Standard RS-423-A, December 1978, Electrical Characteristics of Unbalanced Voltage Digital Interface Circuits.
6. EIA Industrial Electronics Bulletin No. 12, November 1977, Application Notes on Interconnection Between Interface Circuits Using RS-449 and RS-232-C.
7. Investigation of the Use of Passive Adapters for RS-449/RS-232-C Interfaces. FAA Technical Center Letter Report CT-82-100-13LR, December 1981.

TABLE 1. RS-423 TO RS-232-C

BAUD RATE (bit/sec)	PATTERN (1)	CABLE LENGTH		SIGNAL LEVEL AT A (2) (volts)	ERRORS RECEIVED
		L1 (2) (feet)	L2 (2) (feet)		
9600	511	3	3	± 3.6	0 in 10E7
9600	511	50	3	± 3.6	0 in 10E7
9600	511	800	3	± 3.6	0 in 10E7
9600	511	1500	3	± 3.6	0 in 10E7
9600	511	50	50	± 3.6	0 in 10E7
9600	511	800	50	± 3.6	0 in 10E7
9600	511	1500	50	± 3.6	0 in 10E7

(1) Pattern '1:1' is alternating mark and space (1 and 0); and
 '511' is pseudo random binary sequence 511 bits long.

(2) See Figure 7. (Note- Capacitor C1 is 180 pf for Table 1)

Note: 10E7 means 10 raised to the seventh power.

TABLE 2. RS-423 to RS-232-C With 60 Hz Injected Noise

BAUD RATE (bit/sec)	PATTERN (1)	SIGNAL LEVEL AT A (2) (volts)	NOISE LEVEL AT A (2) (volts P-P)	ERRORS RECEIVED	C1 (2) (pf)
300	1:1	± 3.6 V	7.22 V PP	7 out of 10E6	4700
300	1:1	± 3.6 V	7.21 V PP	0 out of 10E6	4700
300	511	± 3.6 V	7.25 V PP	87 out of 10E6	4700
300	511	± 3.6 V	7.24 V PP	0 out of 10E6	4700
1200	1:1	± 3.6 V	7.23 V PP	4 out of 10E6	1800
1200	1:1	± 3.6 V	7.21 V PP	0 out of 10E6	1800
1200	511	± 3.6 V	7.28 V PP	109 out of 10E6	1800
1200	511	± 3.6 V	7.25 V PP	0 out of 10E6	1800
9600	1:1	± 3.6 V	7.29 V PP	26 out of 10E6	180
9600	1:1	± 3.6 V	7.26 V PP	0 out of 10E6	180
9600	511	± 3.6 V	7.25 V PP	11 out of 10E6	180
9600	511	± 3.6 V	7.24 V PP	0 out of 10E6	180

(1) See Table 1.

(2) See Figure 8.

TABLE 3. RS-423 To RS-232-C With 6KHz Injected Noise

BAUD RATE (bit/sec)	PATTERN (1)	SIGNAL LEVEL AT A (2) (volts)	NOISE LEVEL AT A (2) (volts P-P)	ERRORS RECEIVED	C1 (2) (Pf)
300	1:1	± 3.6 V	7.27 V PP	81 out of 10E6	4700
300	1:1	± 3.6 V	7.22 V PP	0 out of 10E6	4700
300	511	± 3.6 V	7.29 V PP	98 out of 10E6	4700
300	511	± 3.6 V	7.26 V PP	0 out of 10E6	4700
1200	1:1	± 3.6 V	7.24 V PP	198 out of 10E6	1800
1200	1:1	± 3.6 V	7.23 V PP	0 out of 10E6	1800
1200	511	± 3.6 V	7.28 V PP	109 out of 10E6	1800
1200	511	± 3.6 V	7.25 V PP	0 out of 10E6	1800
9600	1:1	± 3.6 V	7.27 V PP	121 out of 10E6	180
9600	1:1	± 3.6 V	7.25 V PP	0 out of 10E6	180
9600	511	± 3.6 V	7.28 V PP	5 out of 10E6	180
9600	511	± 3.6 V	7.27 V PP	0 out of 10E6	180

(1) See Table 1.

(2) See Figure 8.

TABLE 4. RS-422 to RS-232-C

BAUD RATE (bit/sec)	PATTERN (1)	CABLE LENGTH		SIGNAL LEVEL AT INPUT (volts)	ERRORS RECEIVED
		L1 (feet)	L2 (feet)		
9600	511	3	50	± 3.0	0 in 10E7
9600	511	50	50	± 3.0	0 in 10E7
9600	511	800	50	± 3.0	0 in 10E7
9600	511	1500	50	± 3.0	0 in 10E7
9600	511	4000	50	± 3.0	0 in 10E7

(1) See Table 1.

(2) See Figure 9.

TABLE 5. RS-422 TO RS-232-C With Injected Noise

BAUD RATE (bit/sec)	PATTERN (1)	INJECTED NOISE FREQUENCY (Hz)	SIGNAL LEVEL AT A (2) (volts p-p)	NOISE LEVEL AT A (2) (volts p-p)	ERRORS RECEIVED
9600	1:1	60	2.0	20	0 out of 10E7
9600	511	60	2.0	20	0 out of 10E7
9600	1:1	6000	2.0	20	0 out of 10E7
9600	511	6000	2.0	20	0 out of 10E7

(1) See Table 1.

(2) See Figure 10.

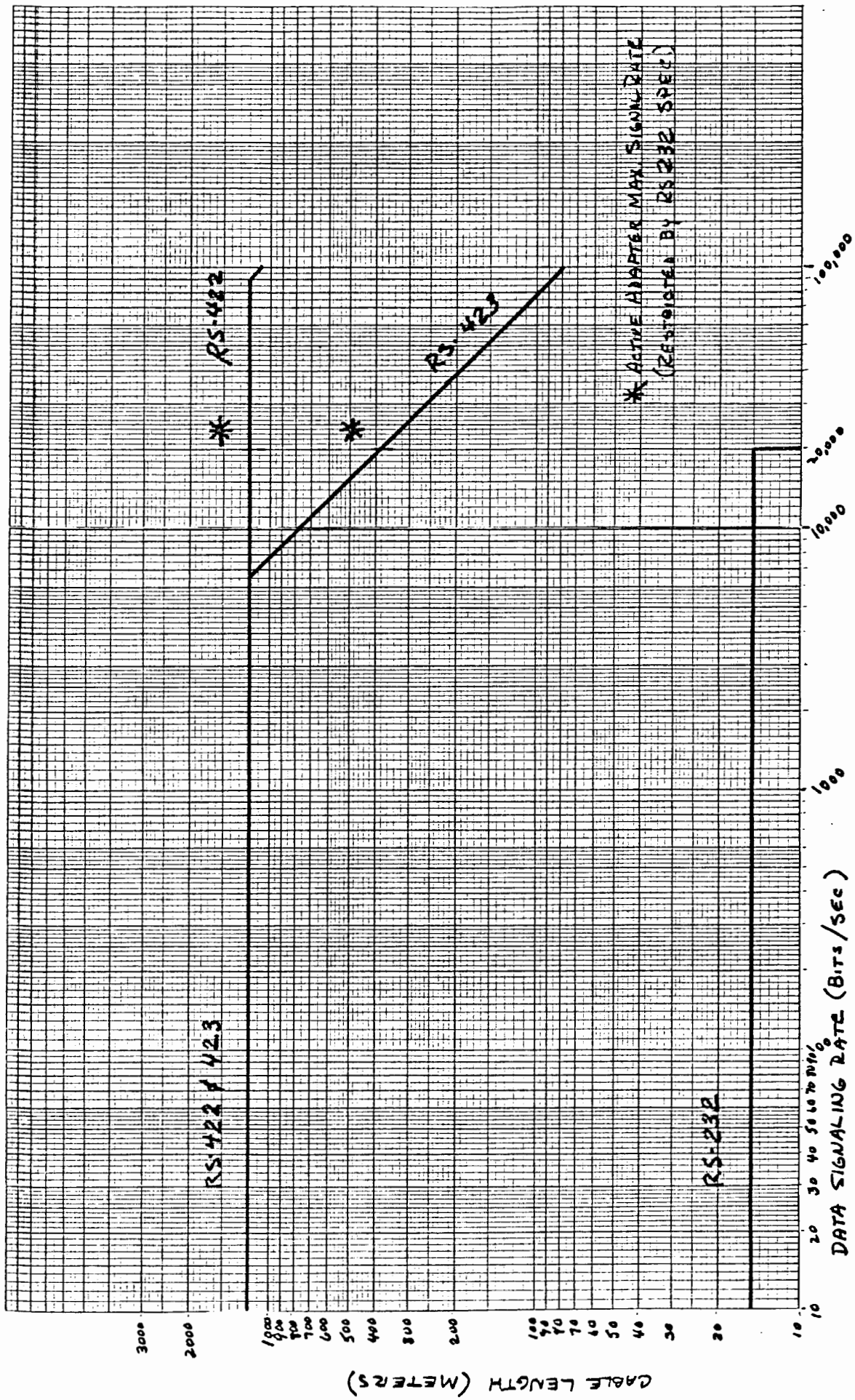


FIGURE 1. CABLE LENGTH vs. DATA RATE
(BASED ON EIA SPECIFICATIONS)

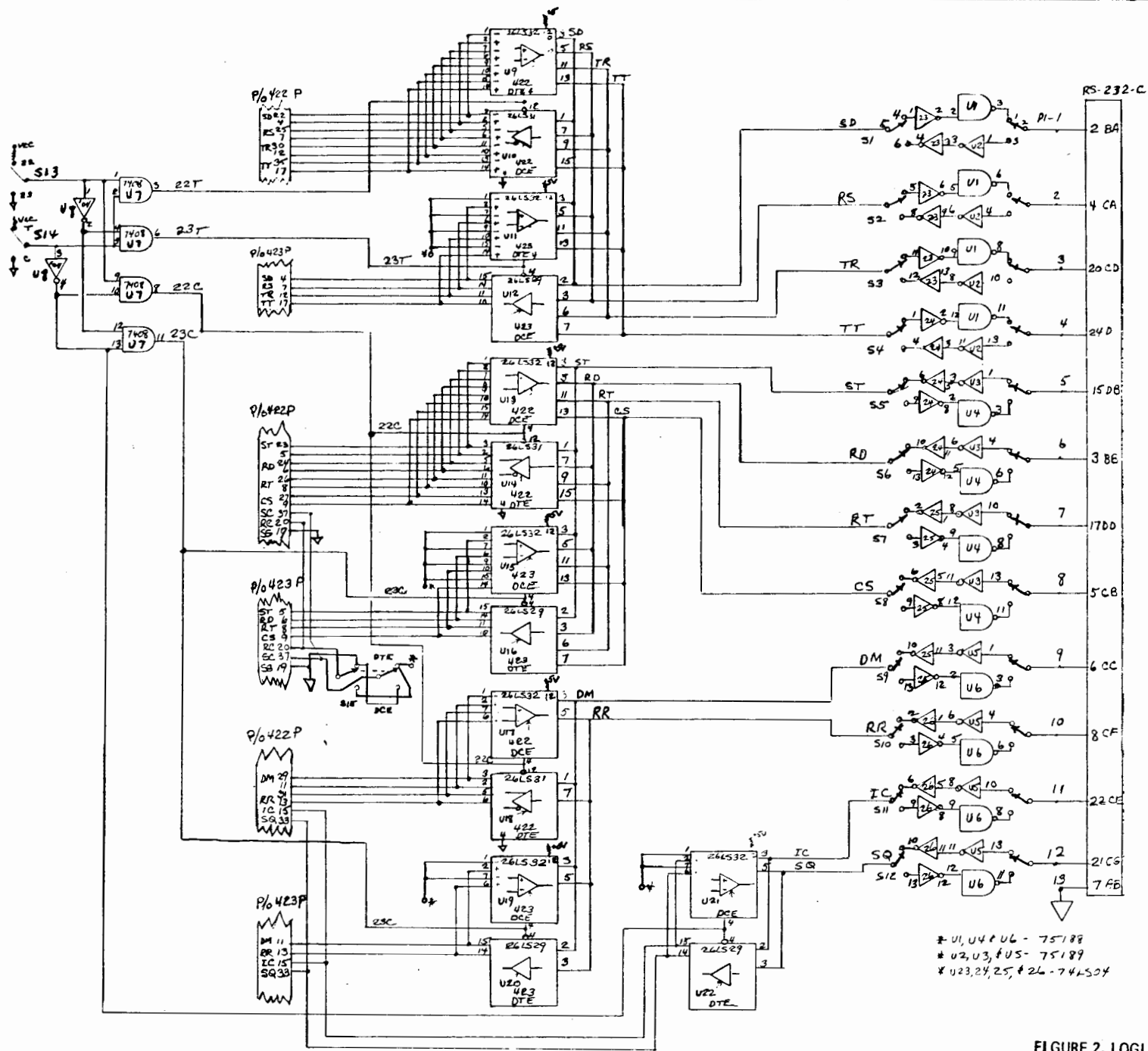


FIGURE 2. LOGIC and WIRING DIAGRAM

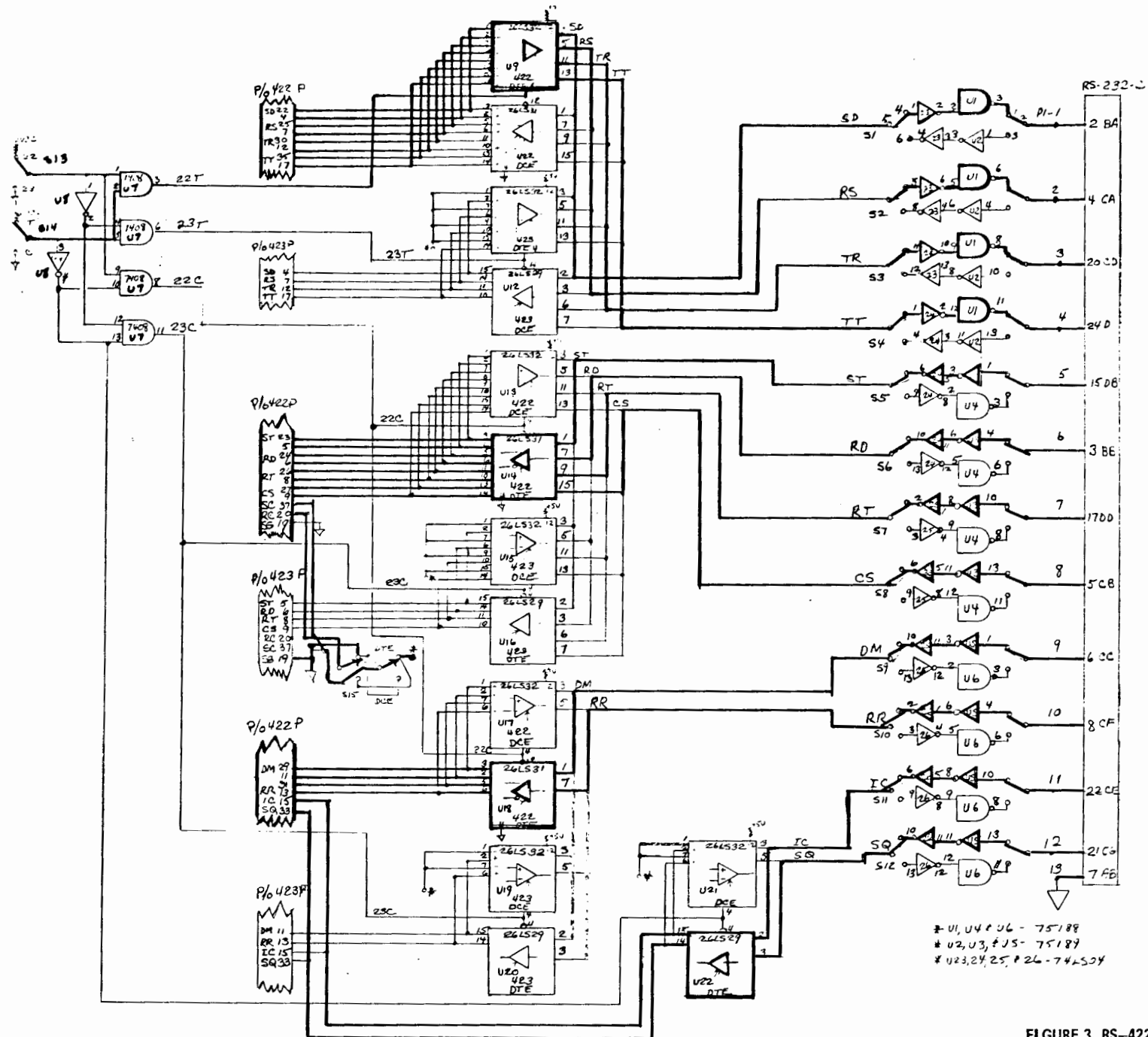


FIGURE 3. RS-422(DTE) to RS-232C(DCE)
SIGNAL FLOW

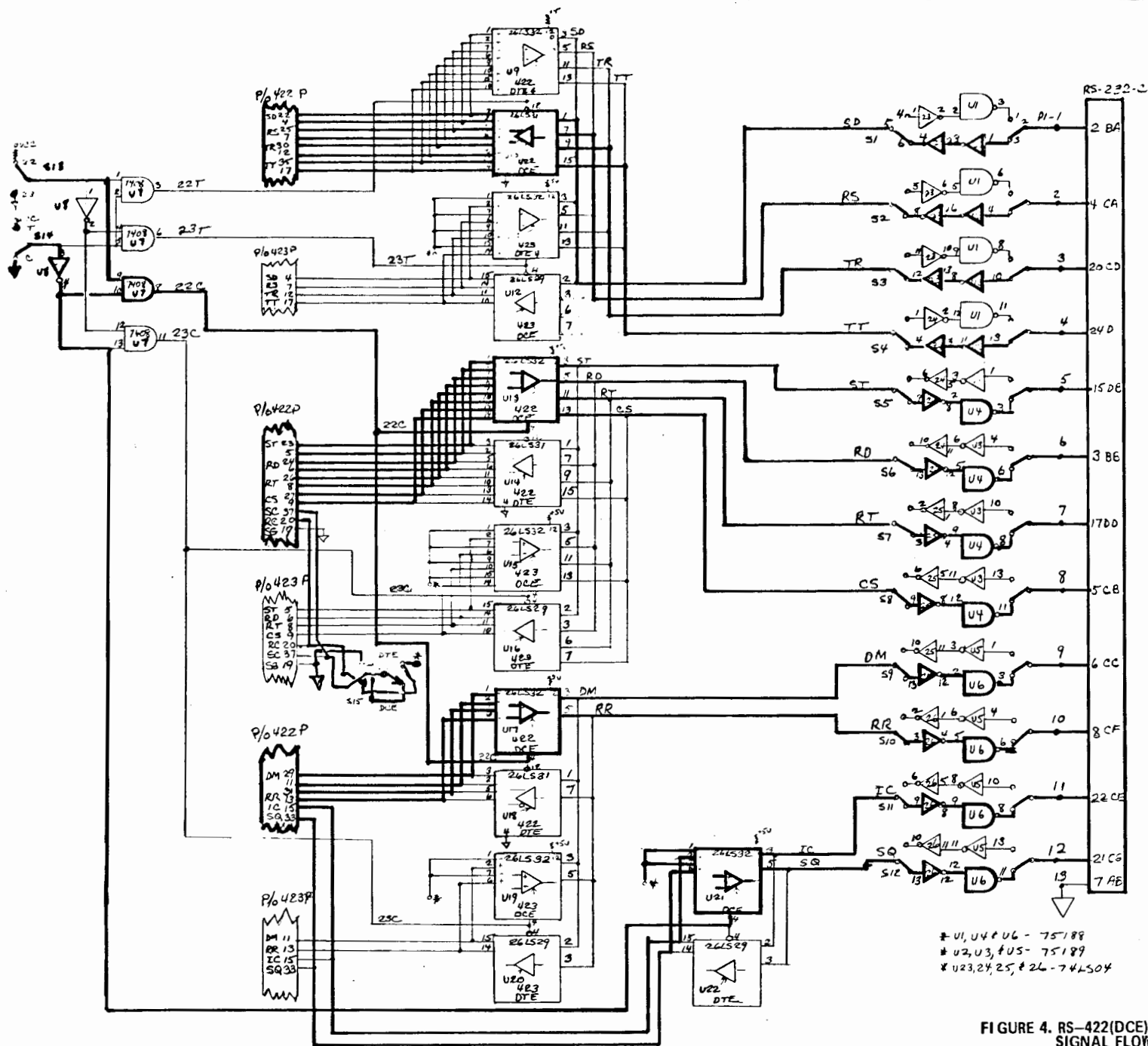


FIGURE 4. RS-422(DCE) to RS-232C(DTE)
SIGNAL FLOW

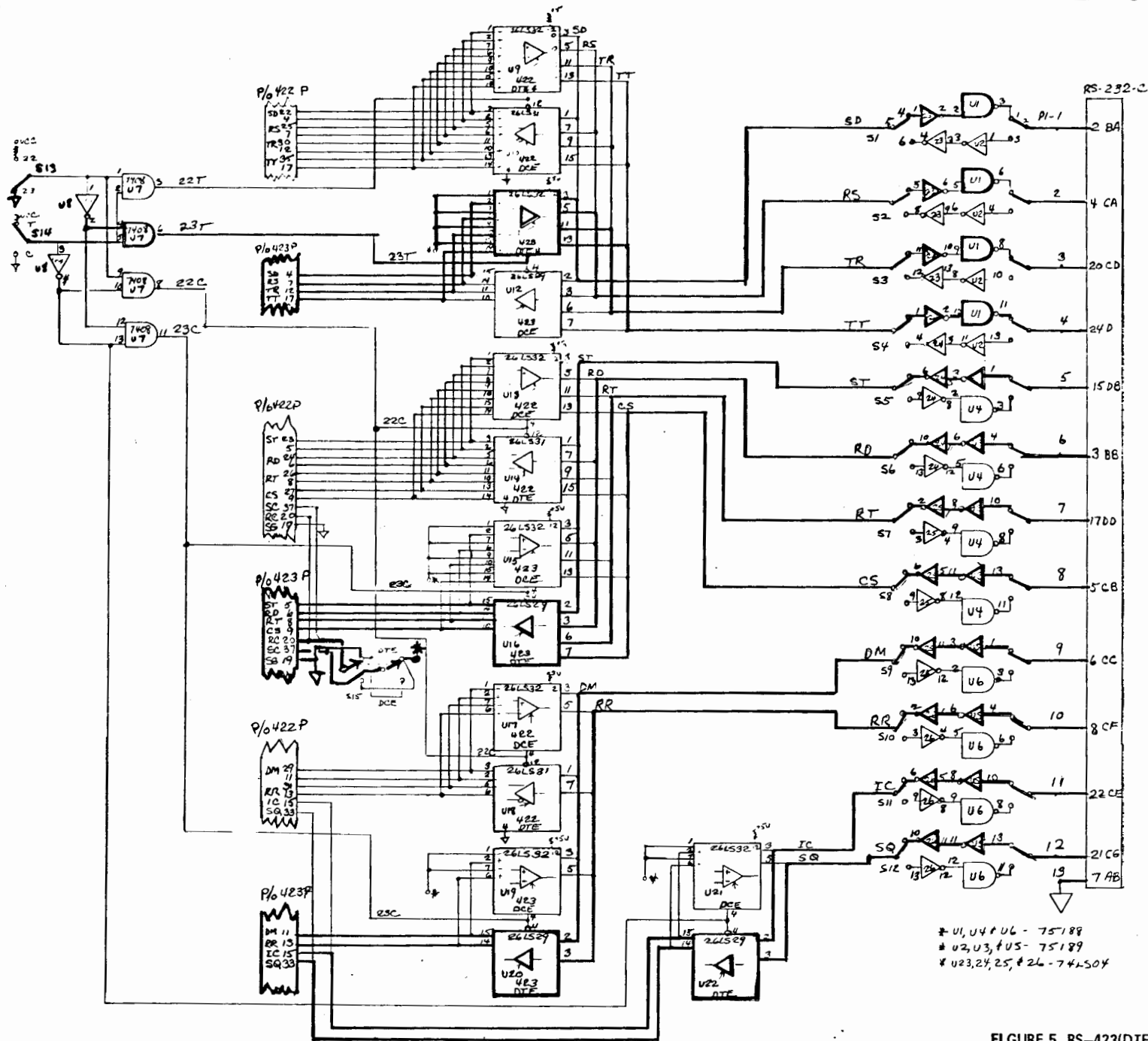


FIGURE 5. RS-423(DTE) to RS-232C(DCE)
SIGNAL FLOW

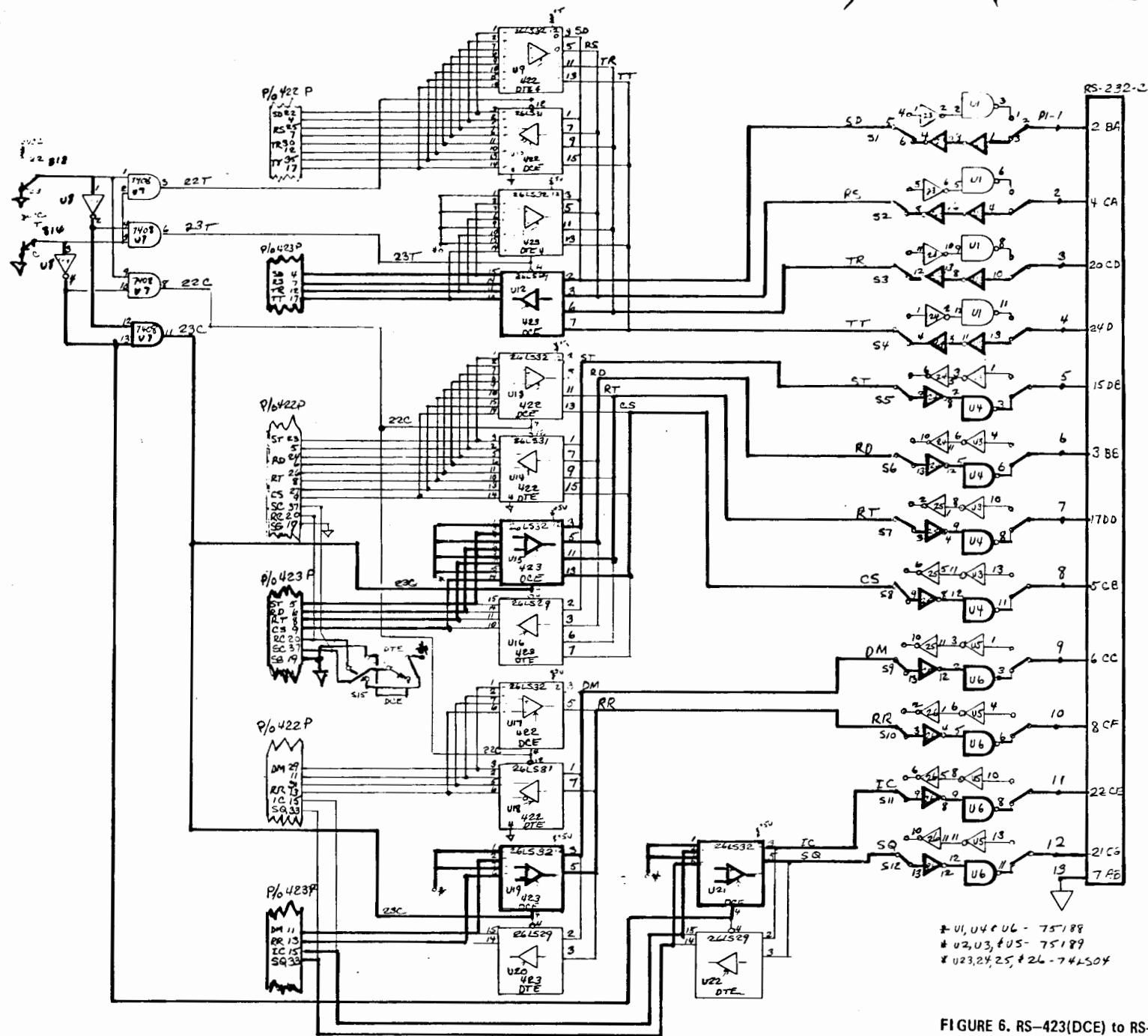


FIGURE 6. RS-422(DCE) to RS-232C(DTE)
SIGNAL FLOW

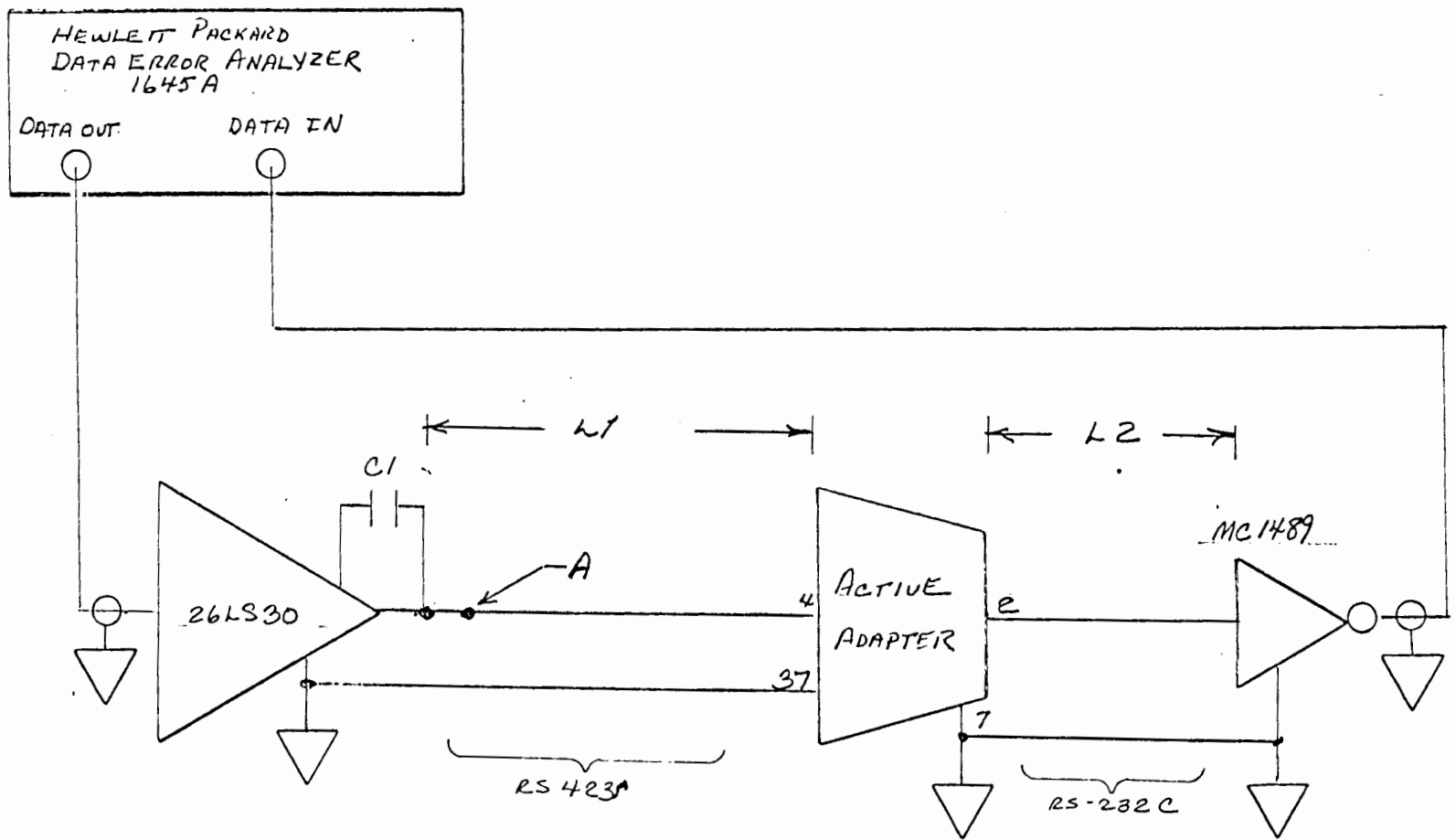


FIGURE 7. RS-423 to RS-232C TEST CONFIGURATION

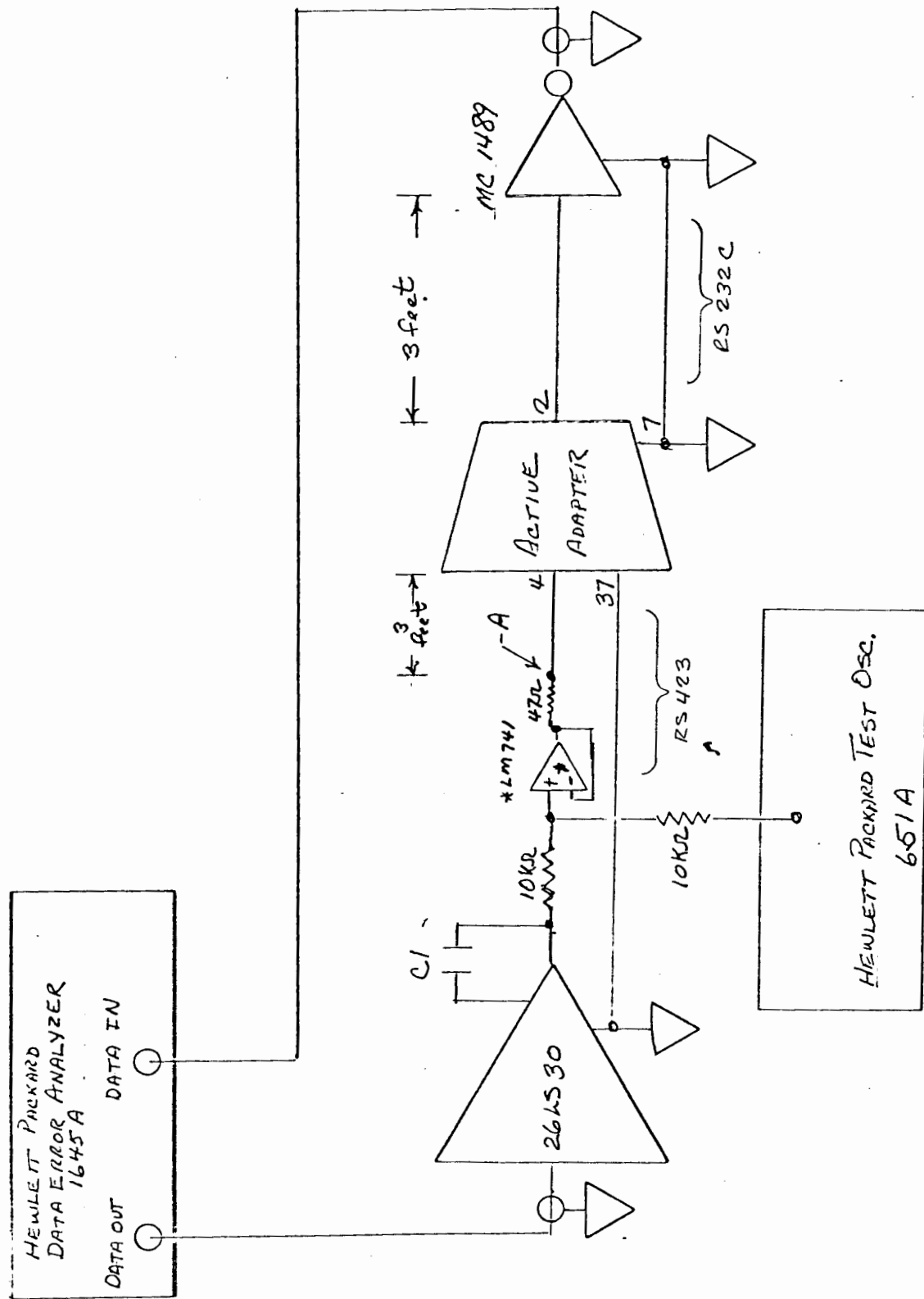


FIGURE 8. RS-232 to RS-232C TEST CONFIGURATION with INJECTED NOISE

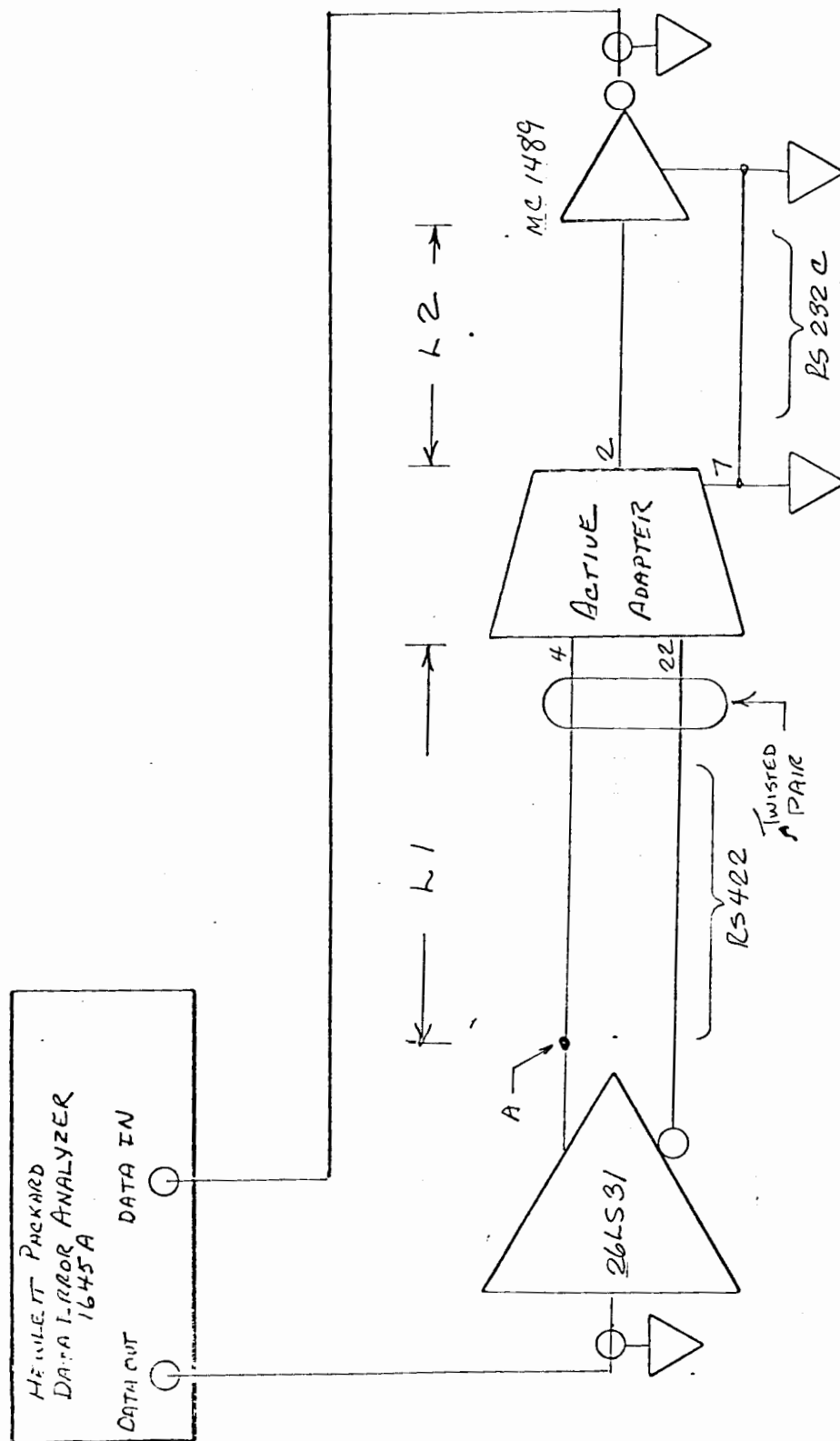


FIGURE 9. RS-422 to RS-232C TEST CONFIGURATION

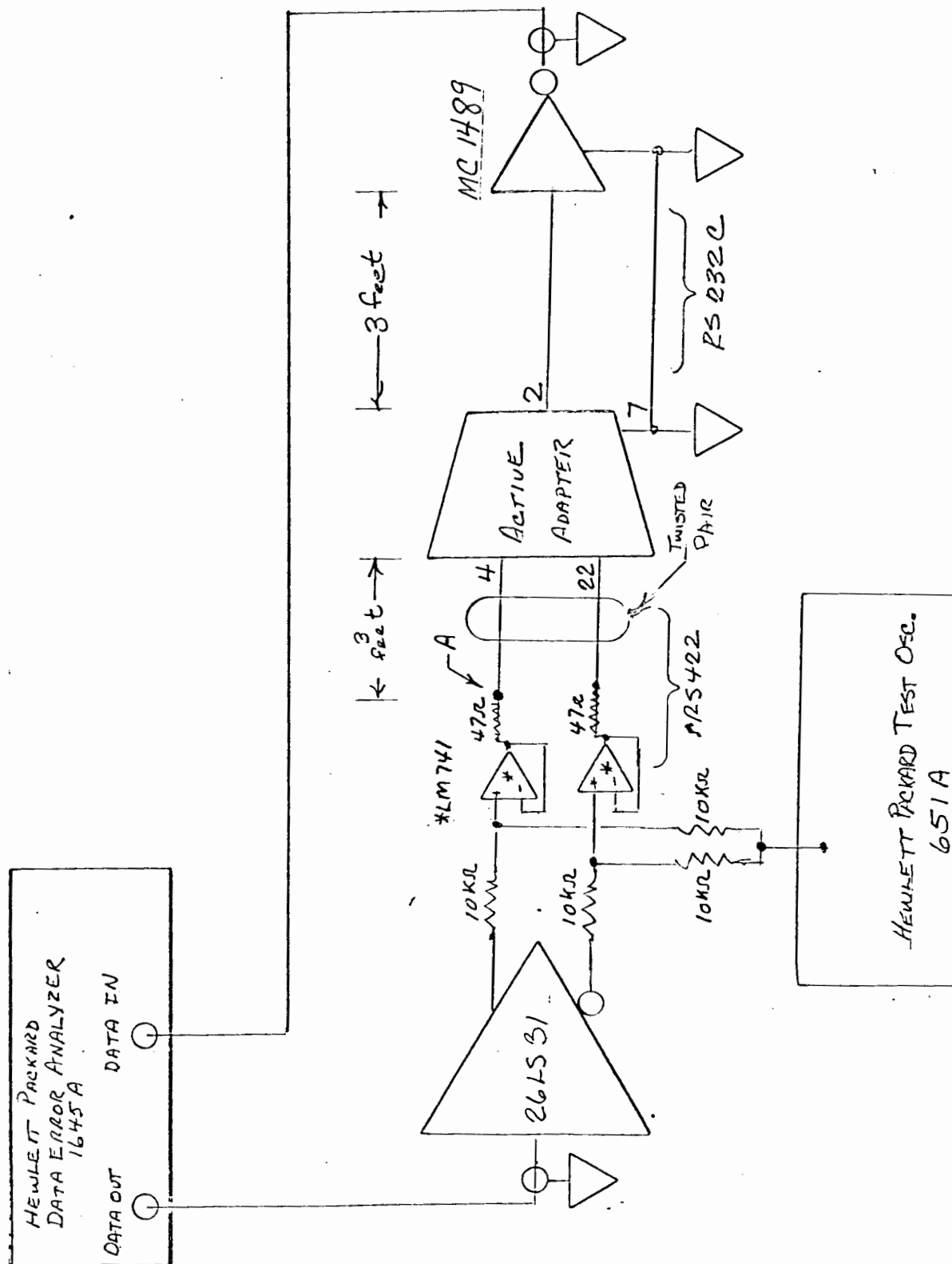


FIGURE 10. RS-422 to RS-232C TEST CONFIGURATION with INJECTED NOISE