PULSE COUNTER CARD

MODEL 69435A

OPERATING AND SERVICE MANUAL

FOR CARDS DESIGNATED RUN 1 AND ABOVE*

*For Cards above Run 1
a change page may be
included.

Hewlett-Packard

HP Part No. 69435-90001

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SECTION I
GENERAL INFORMATION

1-1 INTRODUCTION

1-2 This instruction manual contains operating and service instructions for the Pulse Counter Card, Model 69435A. This card is designed specifically for use in the 6940A Multiprogrammer and 6941A Multiprogrammer Extender Units.

1-3 DESCRIPTION

1-4 The pulse counter card consists of a bi-directional 12-bit binary counter capable of counting pulses at rates of up to 200kHz. It can also count contact closures and signals other than pulses. Pulse shaping circuits are provided to filter contact bounce or other high frequency noise from the count input signal. The main count up and count down inputs are photo-isolated and can be enabled and disabled independently. The counter card,which can count continuously in either direction, generates a carry pulse each time it counts up past its 4095-count maximum to zero and generates a borrow pulse each time it counts down past zero to 4095. When the card is used as a preset counter, this carry or borrow output can be used to generate a computer interrupt.

1-5 When installed in a multiprogrammer system, the counter card is programmed by a 16-bit word originating at a remote computer or the 6940A Multiprogrammer front panel switch register. In the output mode, a data word addressed to this card and accompanied by a data strobe loads an initial quantity into the counter or sets it to zero. When the card is addressed in the input mode, the quantity it contains is made available to the computer on the data return lines.

1-6 The quantity contained in the counter is also available at all times on 12 external counter output lines.

1-7 The 12-bit counter can be divided into three 4-bit counters or one 4-bit and one 8-bit counter by changing some jumper connections. Two additional count input circuits, complete with enable gates and provisions for filtering the count input signals, are provided for use when the counter is divided into two or three parts.

1-8 The counter card is fabricated on a 4-1/2" x 11" printed circuit card. The inner edge of the card contains a dual 24-pin (48-pin total) printed circuit plug that can mate with any connector in slot 400 through 414 of a master multiprogrammer unit or an extender. A dual 15-pin (30-pin total) printed circuit plug located at the outer edge of the card connects the count and count enable inputs and the carry, borrow, and external counter outputs.

1-9 SPECIFICATIONS

1-10 Table 1-1 provides detailed specifications for the Model 69435A.

1-11 INTERFACING

1-12 The 69435A Pulse Counter Card is automatically interfaced with its associated multiprogrammer unit when it is installed in a 400-series slot connector. Once it is assigned to a slot, the card assumes the address of that position and will receive programmed data only when the applicable unit and slot are addressed. All operating power and programmed data for the card are derived from the multiprogrammer unit.

1-13 OUTPUT CONNECTOR ASSEMBLY

1-14 One 30-pin output connector assembly (HP Part No. 5060-7934) is furnished with each pulse counter card for interfacing the card with the external system. Additional 30-pin connector assemblies may be ordered from your local Hewlett-Packard sales office. (Refer to list at the rear of manual for addresses).

1-15 ORDERING ADDITIONAL MANUALS

1-16 One manual is shipped with each order. Additional manuals may be purchased from your local Hewlett-Packard sales office. Specify the card model number and HP Part Number shown on the title page.

Table 1-1. Model 69435A, Specifications

DATA INPUT (From Computer): When addressed in the output mode, 12 bits of binary data preset counter to any value 0-4095. Logic 1 = LO.

DATA OUTPUT (To Computer): When addressed in the input mode, 12 bits of binary data carry contents of counter to computer. Logic 1 = LO.

DATA OUTPUT (External): Contents of counter available on 12 lines at external connector. Logic 1 = HI. Drive capability of each line is one TTL load.

CARRY AND BORROW OUTPUTS: Lines go HI as count is incremented above 4095, or below zero, respectively. Drive capability of each is 10 TTL loads.

MAIN COUNT UP AND COUNT DOWN INPUTS:

- Pulse Signals: Max. frequency, 200kHz; min. pulse width, 2.5μsec; max. rise time, 5μsec.
- Other Waveforms: A minor component change eliminates the max. rise time restriction (and reduces the max. frequency to about 100kHz), permitting other signal waveforms including sine waves to be counted.
- Signal Amplitudes: An input signal must be capable of turning on a photodiode which requires between 5 and 10mA of current. The input voltage limits for the main count inputs are listed in Fig. 3-3. A special input terminal can be adapted by the user for other signal amplitudes up to 100 volts. TTL pulses or contact closures can be counted if jumpers W1 and W2 are installed.
- Signal Filtering: Capacitors can be installed on the board to filter out high frequency noise or contact bounce.
- Isolation: The main count up and count down inputs are photo isolated and will withstand potential differences of up to 100Vdc or 100Vrms to chassis ground. (Isolation is lost if jumpers W1 and W2 are installed.)

AUXILIARY COUNT INPUTS (Used when card is divided into two or three counters.):

- Input Signal: Will count positive 3V to 30V pulses (the input level between pulses must be -3V to +0.5V); max. frequency, 200kHz; min. pulse width, 2.5μsec; max. rise time, 1μsec per volt.
- Signal Filtering: Capacitors can be installed on the board to filter out high frequency noise or contact bounce.
- Isolation: The auxiliary count inputs are not isolated.

COUNT ENABLE INPUTS:

- Logic Coding: TTL HI or open circuit equals enable, TTL LO or ground equals disable.
- Each count enable input line is equivalent to one TTL load.
- Max. Rise Time: Main count enable inputs, 5μsec; auxiliary count enable inputs, no rise time limitation.

OUTPUT CONNECTOR: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 5060-9658). This connector accomodates up to 30 wires with outside diameters of up to 44 mils each.

TEMPERATURE RANGE: 0° C to 70°C operating in mainframe (allows +15°C internal rise when operating in mainframe at up to +55°C ambient); -40°C to +80°C storage.

SECTION II
INSTALLATION

2-1 INITIAL INSPECTION

2-2 Before shipment, each pulse counter card is inspected for mechanical and electrical defects. As soon as the card is received, proceed as instructed in the following paragraphs.

2-3 MECHANICAL CHECK

2-4 If external damage to the shipping carton is evident, ask the carrier's agent to be present when the instrument is unpacked. Check the output card for signs of physical damage. If it is damaged, file a claim with the carrier's agent and notify Hewlett-Packard Sales and Service Office as soon as possible. If it appears to be undamaged, perform the electrical check given in the following paragraph.

2-5 ELECTRICAL CHECK

2-6 Check the electrical performance of the output card as soon as possible after receipt. Section V of this manual contains checkout procedures which will verify operation of the output cards. Refer to the inside front cover of this manual for Certification and Warranty statements.

2-7 REPACKING FOR SHIPMENT

2-8 When shipping an output card, it is recommended that the package designed for it be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the output card can be shipped. Be sure to attach a tag to the output card specifying the owner, model number, full serial number, and service required, or a brief description of the trouble.

2-9 OUTPUT CARD INSTALLATION

2-10 Output cards are installed in slots 400 through 414 of a multiprogrammer unit. To install an output card, proceed as follows:

a. Open the hinged front panel of the multiprogrammer unit by turning the recessed screw within the handle counterclockwise.

——CAUTION——

Always turn off power at the multiprogrammer before installing or removing the output card. If power is not removed, it is possible to short components in the multiprogrammer when installing or removing a card thereby causing possible damage.

b. With the extractor handle on the top and the card components on the right, slide the card into the desired output slot (400 through 414). Note that all output cards are slotted between pins 4 and 5 and all 400 series connectors of the multiprogrammer are keyed between the same points. This makes it virtually impossible to plug an output card in upside down or into any slot other than a 400 series slot.

c. Route all wiring from the output cards through the false-bottom channel and out the back of the unit to the external system

SECTION III
OPERATING INSTRUCTIONS

3-1 DATA CONNECTOR

3-2 The 69435A Pulse Counter Card is controlled by the multiprogrammer in which it is installed. Any connector in slots 400 through 414 of the multiprogrammer mainframe can supply dc operating power, address and data bits, and control signals to the card. Through this interface the counter can be present to any number in its range from 0 to 4095. The contents of the counter can also be monitored through the card's interface with the multiprogrammer. Figure 3-1 illustrates the signals present on all multiprogrammer 400-series connectors.

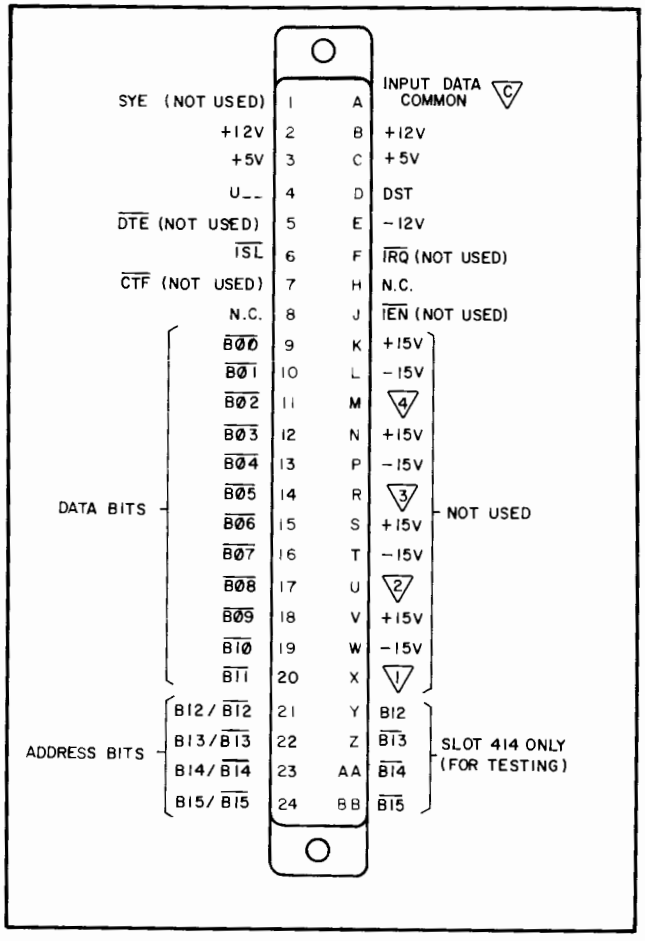


Figure 3-1. Multiprogrammer 400-Series Slot Connector

3-3 OUTPUT CONNECTOR

3-4 Pulse signals to be counted and their associated enable signals are applied through the output connector. This connector also conducts the carry and borrow outputs and has direct connections to the 12 output lines from the counter. The pin assignments of the output connector are illustrated in Figure 3-2. Paragraphs 3-5 through 3-20 describe the requirements and capabilities of these inputs and outputs.

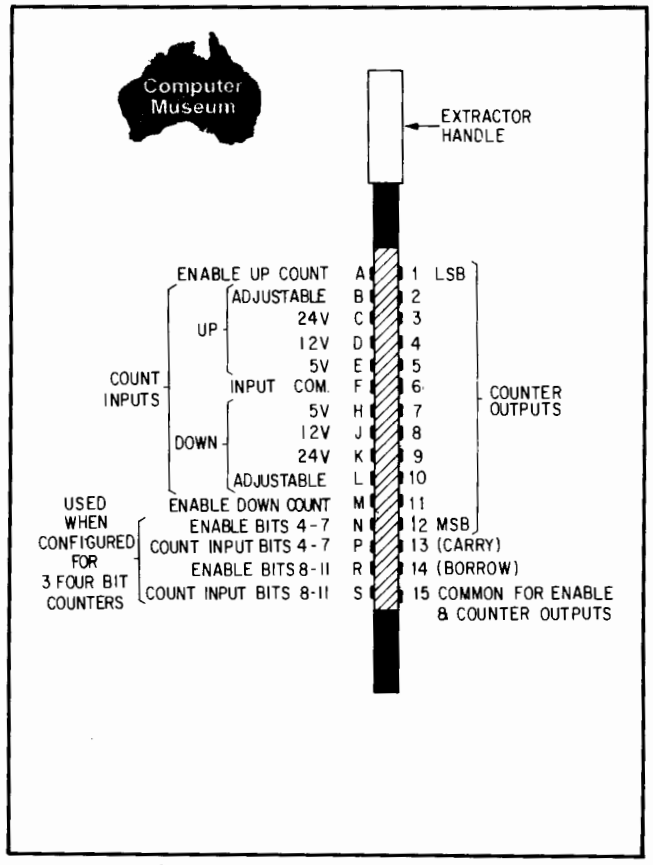


Figure 3-2. 69435A Output Connector

3-5 MAIN COUNT INPUTS

3-6 The main count inputs will operate with a wide range of input signal levels They are designed primarily for pulse inputs but other signal waveforms can be counted if the circuit is modified to accept signals with slower rise times, as described in paragraph 3-10 The inputs are isolated unless jumpers W1 and W2 are installed to permit counting TTL levels or contact closures. The counter is incremented or decremented by the trailing edge of a pulse or the closing of a pair of contacts.

3-7 Counting Pulses The installed attenuating resistors at the 5V, 12V, and 24V inputs allow pulses to be counted that have amplitudes within the limits shown in Figure 3-3 These voltage

limits are determined by the 5 to 10mA current limits of the photodiodes in the input isolators. A pulse signal applied to these inputs or to the special input must be capable of supplying at least 5mA at its HI level, but the photodiode current must not exceed 10mA. The isolated input circuit permits counting pulses regardless of the ground reference of the source. If input pulses have an amplitude that is not usable with the 5V, 12V, or 24V inputs, the special inputs can be adapted by installing a fixed resistor and a series trimmer in spaces provided on the board. Use resistors of the proper value to provide between 5 and 10mA to turn the photodiode on. The breakdown voltage limits of 100Vdc or 100Vrms between any of these isolated input terminals and chassis ground limits the maximum input pulse amplitude to about 100 volts. As shipped from the factory (with speed-up capacitors C12 and C13 installed, but no C14 or C15 filters installed), the card will count pulses as narrow as 2.5μsec at frequencies up to 200kHz. Pulse rise times should not exceed 5 microseconds. (If the waveform to be counted has a slower rise time, see paragraph 3-10 for instructions on modifying the count input circuit).

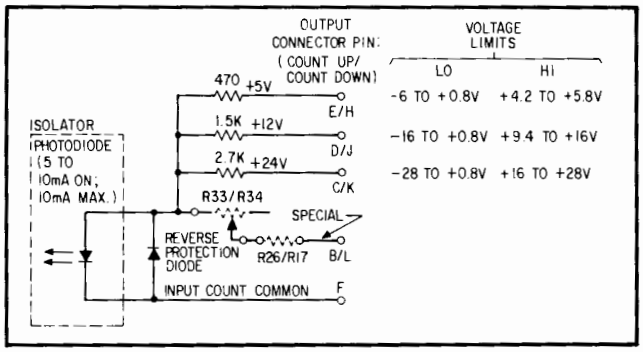


Figure 3-3. Main Count Input Receiver Circuit

3-8 Counting TTL Pulse Signals. Input pulses at TTL levels can be counted by using the 5V input terminal and installing the corresponding jumper, W1 or W2. The isolated common input terminal (output connector pin F) must be strapped to the common return for the card (pin 15) when using jumpers W1 or W2. Without the additional current provided by the jumper, a TTL signal cannot provide sufficient current to the photodiode. Figure 3-4 illustrates the TTL pulse receiver circuit. When counter cards are cascaded, the count up and count down inputs of the second (or subsequent) card are connected as shown in Figure 3-4 so that they will accept the carry and borrow outputs of the first (or previous) card.

3-9 Counting Contact Closures. The same input circuit arrangements illustrated in Figure 3-4 are used in counting the operations of a pair of relay contacts. The 5V input is used, jumper W1 or W2 is installed, and the isolated common input terminal is strapped to the common return for the card. When counting contact closures, it is necessary to filter out any noise which might be caused by contact bounce. (This noise must be filtered out before it reaches the counter or it, too, will actuate the counter.) Spaces are provided on the board for installing filter capacitors C14 and C15 for this purpose. When a filter capacitor is installed, the corresponding speed-up capacitor, C12 or C13 must be removed. The capacitance of the filter required depends on the nature of the signal and that of the noise to be filtered out. For these reasons, and because the filtering effect of a given capacitor depends on the characteristics of the transistor in the circuit, the size of the capacitor to be used must be determined experimentally for each application and for each input circuit. Monitor the waveform at TP6 or TP10; and, by substituting a capacitance decade for C15 or C14, choose the smallest capacitor value that filters out the noise effectively. The count up and count down inputs must be checked individually if both are to be used. Since the noise produced by contact bounce usually has a frequency of several kilohertz, it can be filtered out without limiting the circuit's sensitivity to contact operations at the fastest rate they are likely to be counted.

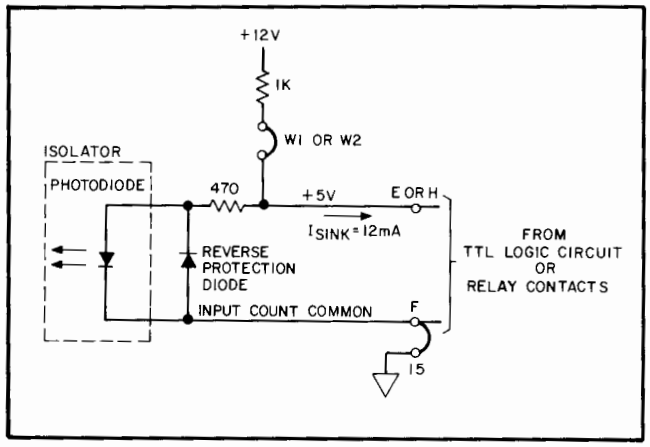


Figure 3-4 Input With W1 or W2 Connected

3-10 Counting Other Signal Waveforms. Since slow rise times can cause circuit instability and also increase the sensitivity to noise, pulse input signals must have a faster rise time than 5μsec. A waveform with a slow rise time can allow superimposed stray noise to penetrate the Schmitt trigger circuit (Z13) provided in each count input for noise suppression. If the speed up capacitors, C12 and C13, are removed and small filter capacitors installed as C14 and C15, slow rise times no longer limit the types of waveforms that can be counted. The minimum value of filter capacitor that will have this effect is the value that rejects frequencies above 100kHz. It takes approximately 30pF of capacitance to produce this degree of filtering. Within the limitations of a somewhat reduced

maximum count rate, any waveform that alternates between the required high and low input logic levels and does not reverse direction while proceeding from one to the other can be counted once the circuit has been modified in this way. Diodes CR1 and CR2 conduct to protect the photodiodes when the input voltage is reversed, so waveforms that reverse direction, such as sine waves, can be counted. If noise is present, it can be removed by a greater amount of filtering, assuming that the noise has a higher frequency than the highest expected count rate. If this relatively simple method of noise filtering is not effective, then some external means of signal conditioning will be required before the signal to be counted is applied to the card.

3-11 AUXILIARY COUNT INPUTS

3-12 One or both of the auxiliary count inputs are used when the card is configured as one 4-bit and one 8-bit counter or as three 4-bit counters. These inputs are designed to receive positive input pulses and will operate satisfactorily with pulse amplitudes ranging from +3V to +30V. Between pulses, the input level should remain between -3V and +0.5V. Unlike the main count inputs, these inputs are not isolated. The auxiliary count inputs have provisions for installing speed-up capacitors (C17 and C19) when counting pulses or for installing filter capacitors (C16 and C18) when counting noisy signals, contact closures, or pulse waveforms with rise times slower than 1μsec per volt. In choosing filter capacitor values for the auxiliary count inputs, the same considerations apply as are discussed in paragraphs 3-9 and 3-10. No speed-up capacitors are provided on the card for the auxiliary inputs. If these inputs are used for counting high frequency, fast rise time pulses, install .001μF capacitors as C17 and C19. The auxiliary count inputs have no reverse voltage protection and thus will not count sine waves. To count contact closures with an auxiliary count input, an external pull-up resistor must be used. Connect the resistor (1kΩ is suitable) between the input terminal and a +5V to 12V source, and connect the contacts between the input terminal and common pin 15.

3-13 COUNT ENABLE INPUTS

3-14 The main count up and count down inputs and the two auxiliary count inputs are enabled by an open-circuit or HI logic level and disabled by a ground or LO logic level at the corresponding count enable input line. Figure 3-5 shows the equivalent circuit of a count enable receiver. There are no rise time restrictions on the signals applied to the count enable receivers for the main count up and count down inputs, but input signals to the auxiliary count enable inputs must have a rise time faster than 5μsec. Each count enable receiver is equivalent to one TTL load.

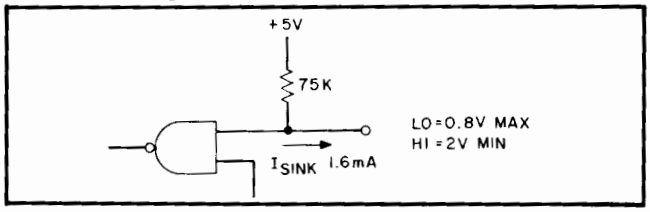


Figure 3-5. Count Enable Receiver

3-15 CARRY AND BORROW OUTPUTS

3-16 When the counter has a count of 4095 registered and an up count input pulse occurs, a positive pulse of equal duration appears at the carry output terminal Similarly, a positive borrow output pulse results when the counter is at zero and a down count input pulse occurs. The carry or borrow output pulse is coincident in time with the count pulse that generates it.

3-17 One way of using these outputs is to connect them to the count up and count down inputs of another counter card in order to cascade the two cards for a greater count capacity. Connect the carry output of the first card to the count up input of the second and the borrow output to the count down input. Use the 5V input terminals and connect the input circuits of the second card as described in paragraph 3-8. Any number of cards can be cascaded in this way.

3-18 There are several ways to use the carry or borrow output to generate a computer interrupt. The carry or borrow output can be connected to the flag input of a 69431A Digital Input Card with Option 096 or to one of the data inputs of a 69434A Event Sense Card. Another card that can be used to generate an interrupt is the 69436A Process Interrupt Card. Either an event sense card or a process interrupt card can monitor the borrow or carry outputs of up to 12 counter cards. Of these two cards, the process interrupt card has the advantage that it monitors its inputs continuously, whether the interrupt system is turned on or off. If the interrupt system is on when the borrow or carry occurs, the computer is interrupted immediately. If the interrupt system is off, an interrupt is generated the next time the interrupt system is turned on. The carry and borrow outputs of the counter card each have a drive capability of 10 TTL loads.

3-19 BIT 0-11 COUNTER OUTPUTS

3-20 The logic levels on these output lines represent the contents of the counter in positive logic form (logical one equals HI). As there are no gates between the counter and the output, this live data

The pulse counter card cannot accept count-up and count-down input pulses simultaneously. Ordinarily, only the count-up or the count-down input will be enabled at a given time, but if **both** are enabled, count-up and count-down pulses that are separated by at least 2.5 microseconds can be considered to be *non-coincident and will* be counted properly.

is available at the output terminals at all times. The counter operates synchronously (all bit changes occurring simultaneously) so that registering a pulse does not cause false count indications to appear. The drive capability of each counter output line is one TTL load.

3-21 USING AS TWO OR THREE COUNTERS

3-22 The 12-bit counter can be divided into three 4-bit counters or one 4-bit and one 8-bit counter. This is accomplished by reconfiguring jumpers W3 and/or W4 on the card. To isolate Z11 from Z12 or Z10 from Z11, remove the jumper wires between A and B, and between D and E. Then connect a jumper between C and B if the counter is to count up or between C and D if it is to count down. Connect the unused terminal, B or D, to terminal F. The signal input requirements for the auxiliary count and count enable inputs may be found in paragraphs 3-11 and 3-13.

3-23 PROGRAMMING

3-24 INTRODUCTION

3-25 Only two different operations are performed through the counter card's interface with the multiprogrammer. They are: (1) loading the counter with some initial value, or (2) reading the counter contents into the computer. Paragraph 3-26 through 3-33 describe the basic programming steps necessary to perform these two operations. Programming instructions at the system level are given in the operating and service manual for the multiprogrammer master unit.

NOTE

This discussion assumes that the reader is familiar with the functions and contents of the multiprogrammer word formats. If not, review of Section III of the 6940A instruction manual is suggested.

3-26 LOADING THE COUNTER

3-27 Presetting. Whether the counter card is used as a totalizing counter or a preset counter, it must first be preset or loaded to some initial value. As a totalizing counter it is first set to zero. Then the count input is enabled for some period of time so that the number of counts accumulated during that period is registered in the counter and can be read out into the computer when desired.

3-28 When the card is used as a preset counter, the card is preset to some value and then an output is produced at the carry or borrow output terminal when a predetermined number of input pulses have arrived at the counter.

3-29 Since the carry or borrow output is produced as the quantity registered in the counter passes from 4095 to zero or from zero to 4095, the number initially loaded into the counter determines how many pulses later the output will occur. The proper quantity to preset into the counter is the number of pulses that are to occur before the borrow output is produced. In other words, if the sixth pulse is to be gated through the borrow output, load the quantity 5 and apply input pulses to the count down input. When counting up, load the quantity 4095 reduced by the number of pulses to be produced before the carry output. Thus, if the sixth pulse is to be gated through the carry output, load 4090.

3-30 Control Word. In order to load data into the counter card, the multiprogrammer system must be placed in the output mode. This is accomplished by issuing a control word which has its input select (ISL) bit off and which contains the unit address of the master unit or extender which houses the card. (Of the five mode bits contained in a control word, only the ISL bit affects the operation of the card. However, the TME bit must not be on, for if it were, a data word addressed to this card would cause the system to become locked up due to the fact that the counter card does not return a flag.) The master unit stores and decodes the 4-bit address, causing the corresponding unit select (U__) line to go HI. This unit select line is an input to the address gates of all of the cards in the addressed unit. The last unit selection made remains in effect until a different unit is addressed by a later control word. The mode of control also remains the same until it is changed by a later control word.

3-31 Data Word. After a control word has put the system into the output mode and selected the multiprogrammer unit which contains the card, the card is addressed by a data word consisting of the 12 bits of data to be loaded into the counter (bits 0-11) and a 4-bit slot address (bits 12-15). Although both the true and complemented forms of the slot address bits are represented in Figure 3-1 (e.g. B12 and $\overline{B12}$), only one of the two states is present on each of the four slot address lines of a particular card slot. Each card slot in a multiprogrammer is distinctively coded by its connections to the slot address lines. For example, if the card is installed in slot 405, then bits B12 (1), $\overline{B13}$ (2), B14 (4), and $\overline{B15}$ (8) will be connected to the card's address lines, and all four lines will be HI when slot 405 is addressed. Approximately 3μsec after the data word containing the four slot address and 12 data bits is gated, the mainframe sends a data

strobe (DST) pulse to the accessory card slots. On the addressed counter card, this data strobe generates a load pulse which loads the 12 data bits into the counter.

3-32 READING THE COUNT

3-33 To read the contents of the counter into the computer, address the unit containing the counter card with a control word that has its ISL bit on to put the system into the input mode. (Do not set the TME bit or the system will become locked up because the card does not return a flag.) Once in the input mode, all that is necessary to make the counter contents available to the computer on the return data bus is to address the card with an address word. An address word consists of just the slot address in bit positions 12 through 15. No data strobe is required. The data remains available to the computer input for as long as the card remains addressed.

3-34 SAMPLE HP ASSEMBLY LANGUAGE PROGRAMMING

3-35 The following paragraphs provide simple examples of HP Assembly Language programs for a 69435A Counter Card. In the first example, an initial count is loaded into the card; and in the second, the count registered by the card is read into the computer. In both of these operations the state of SYE (system enable) is optional as it has no effect on the counter card. SYE is programmed on in the examples to enable other cards that may need to have it on. TME must never be programmed on while addressing the counter card because that would cause the multiprogrammer to become locked up waiting for the card to return a flag, as this card does not return one.

3-36 The sample programs are for illustration purposes and do not reflect the most efficient way in which to program the multiprogrammer. For instance, the program continually tests if the multiprogrammer is ready for another word by sensing its computer I/O card flag. The computer s interrupt system could be utilized for this function by allowing the multiprogrammer program to be called via the interrupt system when the multiprogrammer is ready. Thus, the computer can be gainfully employed pursuing other system functions rather than tied up completely by the multiprogrammer channel.

3-37 OUTPUT COUNT TO CARD

```
                Instruction                          Function

OTCW1   17ØØ43₈
COUNT   1ØØØØØ₈

                    (Select Output Mode)
        LDA OTCW1           Load A Reg. with 17ØØ43₈; control word to set SYE
                            and select unit Ø3.
Start:  OTA nn              Output control word to multiprogrammer.
        NOP                 Wait for output lines to settle.
        NOP
        NOP
        NOP
        STC nn, C           Set multiprogrammer Gate, clear multiprogrammer
                            Flag (on computer I/O card).
        SFS nn              Check if multiprogrammer ready for next word (I/O)
                            card Flag set).
        JMP *-1             Wait until ready.
                    (Output Count to Card)
        LDA COUNT           Ready. Load A Reg. with data word for 69435A;
                            assuming card in slot 08 (10₈) and loading zero,
                            word is 1ØØØØØ₈.
        OTA nn              Output data word to 69435A.
        NOP                 Wait for output lines to settle.
        NOP
        NOP
        NOP
        STC nn, C           Set multiprogrammer Gate, clear Flag.
        SFS nn              Check if multiprogrammer ready for next word.
        JMP *-1             Wait until ready.
```

3-38 READ COUNT FROM CARD

	Instruction		Function
INCW1	$17Ø243_8$		
CARD	$1ØØØØØ_8$		
		(Select Input Mode)	
Start:	LDA INCW1		Load A Reg. with $17Ø243_8$; control word to set SYE and ISL and select unit Ø3.
	OTA nn		Output control word to multiprogrammer.
	NOP		Wait for output to settle.
	NOP		
	NOP		
	NOP		
	STC nn, C		Set multiprogrammer Gate, clear Flag.
	SFS nn		Check if multiprogrammer ready for next word.
	JMP *-1		Wait until ready.
		(Input Data From Card)	
	LDA CARD		Load A Reg. with address word for 69435A; $1ØØØØØ_8$; card in slot 08 (10_8).
	OTA nn		Output address word to card.
	NOP		Wait for input data lines to settle.
	NOP		
	NOP		
	NOP		
	LIB nn		Load external data word into B Reg.

Note: "nn" in all instructions that address the multiprogrammer must be equal to the select code assigned to the multiprogrammer. The select code can be in the range: $07_8 <$ select code $\leq 77_8$.

NOTE

The Sample HP Assembly Language Program on p. 3-5, 3-6, will result in an erroneous reading if the card is read at the instant the count is being updated. One solution is to take two or more readings and determine if they are reasonable or externally inhibit the count during read conditions.

SECTION IV
PRINCIPLES OF OPERATION

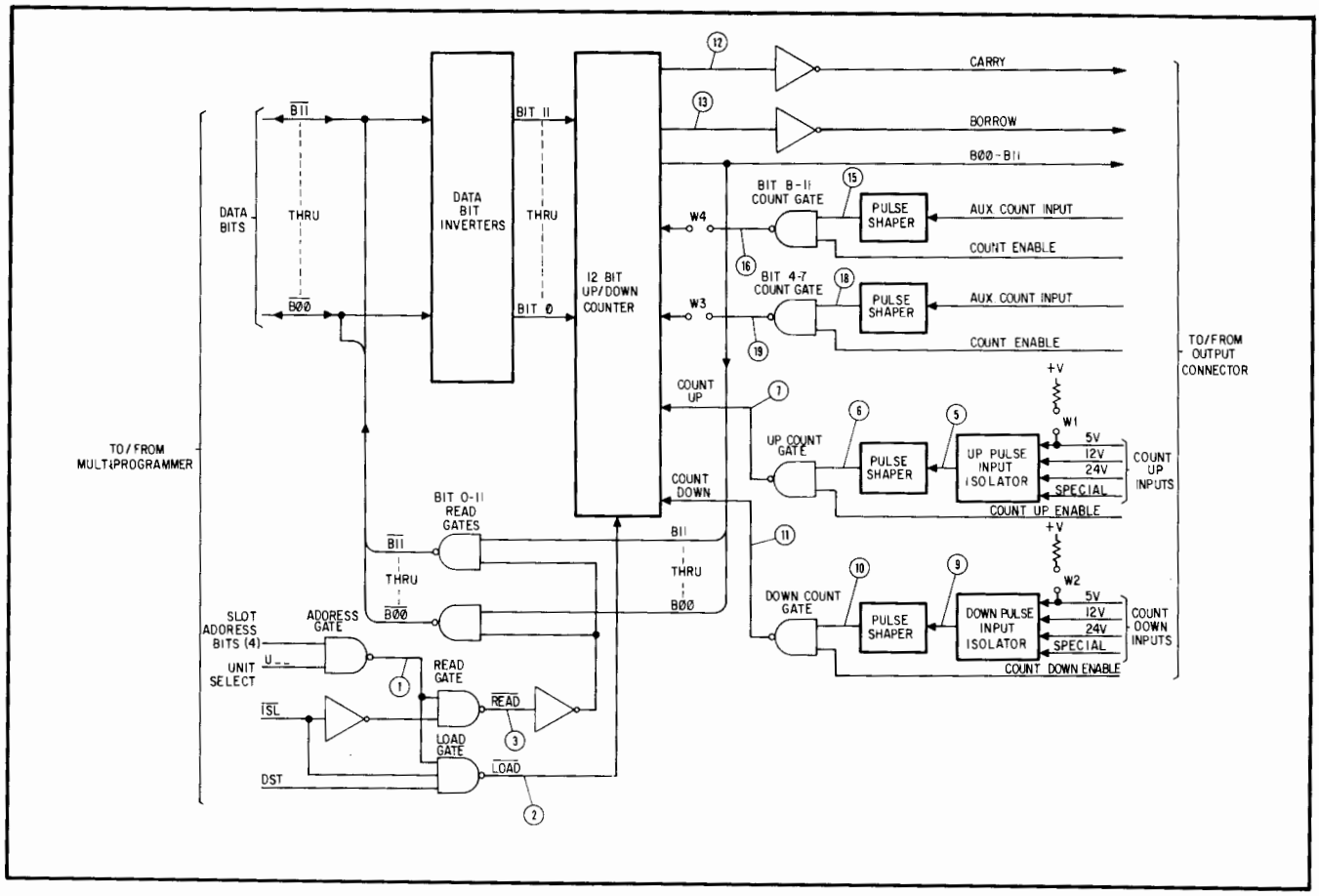


Figure 4-1. Pulse Counter Card, Simplified Block Diagram

4-1 INTRODUCTION

4-2 This section covers the principles of operation of the Model 69435A Pulse Counter Card. Throughout this discussion refer to the simplified block diagram of Figure 4-1 and to the schematic diagram (Figure 7-1).

4-3 CIRCUIT DESCRIPTION

4-4 The pulse counter card contains a bidirectional 12-bit binary counter and circuits which isolate it electrically from the source of the pulses being counted. The count up and count down inputs to the counter have separate input isolators and pulse shapers to condition input signals and gates to allow the counter to be turned on and off by an external enable signal. The input isolators are equipped to receive input pulses with 5V, 12V, and 24V nominal levels. With jumpers W1 and W2 connected, contact closures or pulses from a TTL output can be counted using the 5V input terminals. The special input terminals can be adapted by the user for other input pulse amplitudes.

4-5 Since it is a 12-bit counter, the card has a capacity of 4095 counts. When pulses are being applied to one of the count up inputs and the count is at 4095, the next input pulse to occur recycles the count to zero and is transmitted through the counter to appear as an output carry pulse with a duration equal to that of the input pulse (see Figure 4-2). Subsequent input pulses continue to increment the counter. When counting down, the counter operates similarly. When the count is at zero, the next pulse recycles the count to 4095 and is transmitted to the borrow

output terminal. Subsequent pulses continue decrementing from 4095. The carry and borrow output pulses can be used as inputs to another counter card to provide a greater counting capability (over 16 million counts using two cards) or they can be used to generate an alarm signal or a computer interrupt at some predetermined count. Counter cards are cascaded by connecting the W1 or W2 jumper of the second card and driving its 5V count up or count down input from the carry or borrow output, respectively, of the first card.

4-6 The 12-bit counter can be divided into three 4-bit counters or one 4-bit and one 8-bit counter by changing some jumper connections. When the card is used as three 4-bit counters, the input circuits described above drive bits 0-3 and two auxiliary input circuits are connected to drive bits 4-7 and 8-11. These auxiliary circuits lack isolated inputs and cannot be made to count bidirectionally under program control but must be strapped individually to count either up or down.

4-7 The count and count enable input lines and the carry and borrow outputs discussed so far all terminate at the card's output connector. Twelve lines from the counter outputs also terminate there to permit the contents of the counter to be read externally at any time. These complete the card s external interface.

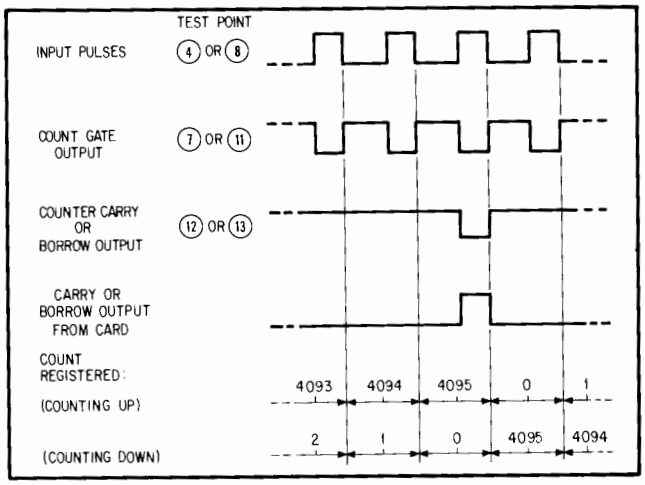


Figure 4-2. Carry and Borrow Pulse Timing

4-8 Through the interface between the card and the multiprogrammer, the counter can be preset to any number from 0 to 4095 or its contents can be read into the computer. The two basic ways of using the counter card are as a totalizing counter card as a preset counter. When the card is used as a totalizing counter it is first preset to zero. Then the pulses that occur while the count enable signal is present are counted so that their quantity can be read into the computer. As a preset counter, some predetermined number is loaded into the counter so that a carry or borrow output pulse is generated a certain number of input pulses later.

4-9 To load data into the counter, the multiprogrammer or extender in which the card is installed must first be selected by a control word which has its input select (ISL) bit off. (Refer to Section III of the 6940A manual for an explanation of control and data words.) The unit address of that control word is decoded in the multiprogrammer to produce a HI unit select (U__) bit at the address gate input. The HI logic level at the card's $\overline{\text{ISL}}$ input disables the read gate and enables the load gate. The control word is followed by a data word which contains the address of the slot in which the card is installed (bits 12-15) and the data to be loaded into the counter (bits 0-11). When the slot containing this card is addressed, the four slot address bits go HI to enable the address gate. When a data strobe (DST) pulse arrives 3μsec later, the pulse produced by the load gate loads the 12 data bits into the counter.

4-10 To make the contents of the counter available at the multiprogrammer backplane, a control word must be programmed that selects the multiprogrammer or extender in which the card is installed and also has its ISL bit on. The control word is followed by an address word which selects the slot containing the counter card. When the slot address bits of the address word enable the address gate, its output enables the read gate, which in turn enables the bit 0-11 read gates. These gates make the data available at the card's common input/output lines. No data strobe is required for a read operation. The read gates are enabled for as long as the card remains addressed and ISL is on.

SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 This section contains preventive maintenance instructions, a checkout procedure, and troubleshooting procedures for the Pulse Counter Card, Model 69435A.

5-3 TEST EQUIPMENT REQUIRED

5-4 The test instruments required for maintenance of this card are listed in Table 5-1. The multiprogrammer in which the card is installed, as well as all other test instruments, are assumed to be functioning properly at the outset of testing.

5-5 PREVENTIVE MAINTENANCE

5-6 The only preventive maintenance necessary is to keep the printed circuit connector contact fingers clean. A nonabrasive eraser, such as a "Pink Pearl" or a plastic eraser, should be lightly rubbed over the contact fingers to remove any film or foreign matter.

5-7 CHECKOUT PROCEDURE

5-8 This procedure can be used to check the operation of pulse counter cards when they are first received, and as an aid in isolating trouble to a general circuit area if a malfunction is noted during operation. If the card fails a test, make certain that it was programmed correctly and all test instrument controls were set correctly before beginning to troubleshoot. Also check that the multiprogrammer SYE interlock jumper (pins 18 and 19 of the data input connector) is in place before testing. Perform the checkout procedure with the card plugged into an extender in any 400-series slot of a multiprogrammer unit.

PROGRAMMING CHECK

1. At the multiprogrammer front panel switch register, program a control word addressed to the

Table 5-1. Test Equipment Required

TYPE	CHARACTERISTICS	USE	RECOMMENDED MODEL
Oscilloscope	Bandwidth: dc to 50MHz Sensitivity: 20mV/div.	Checkout and general troubleshooting	HP Model 180A with 1804A and 1821A plug-ins
Multimeter	10Ω to 1MΩ, ±5% 0.1V to 100V, ±2%	General troubleshooting	HP 427A
Logic Probe	Impedance: 25kΩ. Trigger thresholds: 2.0V and 0.8V, nominal. Min. pulse width: 10nsec	Logic circuit troubleshooting	HP 10525T
Electronic Counter	Frequency and totalizing modes with 0-200 kHz range. DC coupled input	Checkout and troubleshooting	HP 5326C
Pulse Generator (two required)	Rep. rate to 200kHz, free-running and manually-triggered modes, synchronous gating	Checkout and troubleshooting	HP 8003A

appropriate unit and having all of its mode control bits off. Touch LOAD OUTPUT to gate this control word.

2. Address the counter card with a data word having the bit pattern 101010101010 in bit positions 11 through 0. Touch LOAD OUTPUT.

3. With a logic probe, check the logic levels at pins 1 through 12 of the output connector. The even-numbered pins should be at a HI logic level and the odd pins should be LO.

4. Address the unit with a control word having the ISL bit (bit 7) on. Touch LOAD OUTPUT.

5. Program an address word with the address of the counter card slot in bit positions 12 through 15. The bit pattern programmed in step (2) should reappear on the switch register.

6. Repeat steps (1) through (5) except use the complement (010101010101) of the bit pattern used in step (2). This time the odd-numbered output connector pins should be HI.

NOTE

In order to complete the remainder of the checkout procedure, the pulse counter card must have its jumpers in the same positions as when it was shipped from the factory (see schematic notes 3 and 4). If filter capacitors C14, C15, C16, or C18 have been installed, they must be removed while checking the card.

COUNTING CHECKS: PREPARATION

7. Connect the test setup shown in Figure 5-1. The card is still installed on an extender in a multiprogrammer mainframe. When it is manually triggered, pulse generator 1 provides a 25 to 30msec enabling gate to pulse generator 2. (Pulse generator 2 must have synchronous gating so that the last pulse is completed even if the gate ends during the pulse.) When the preparations in steps (8) through (11) have been made, pulse generator 2 will supply a 200kHz burst of between 5000 and 6000 pulses to the high speed electronic counter and the 69435A Counter Card connected in parallel, permitting the card's counter accuracy to be checked at its maximum count frequency. The output of pulse generator 2 is connected first to the +5V count up input (the input is on pin E, common is on F). The count enable inputs are left disconnected (enabled) at this time.

8. Set the controls of pulse generators 1 and 2 to the initial settings shown in Figure 5-1. Select the NORMAL (free running) operating mode on pulse generator 2.

9. Select the frequency measuring function on the electronic counter and set the repetition rate of pulse generator 2 to approximately 200kHz.

10. Observe the output of pulse generator 2 on an oscilloscope and set its pulse width control for a symmetrical square wave output (2.5μsec pulses) and its output amplitude to 5 volts.

11. Switch pulse generator 2 to the GATED mode and switch the electronic counter to the totalizing (START) mode. Reset the counter and then manually trigger pulse generator 1. If the counter registers between 5000 and 6000 counts, the test preparation is complete. If the count registered is outside this range, readjust the pulse generator 1 pulse width, reset the counter, and trigger the pulse generator again. Repeat the adjustment until the pulse train consists of between 5000 and 6000 pulses.

UP COUNT CHECK

12. Load a count of zero into the 69435A Counter Card as follows:

a. Address the unit with a control word having its mode control bits off. Touch LOAD OUTPUT.

b. Address the card slot with a data word with all zeros programmed in bit positions

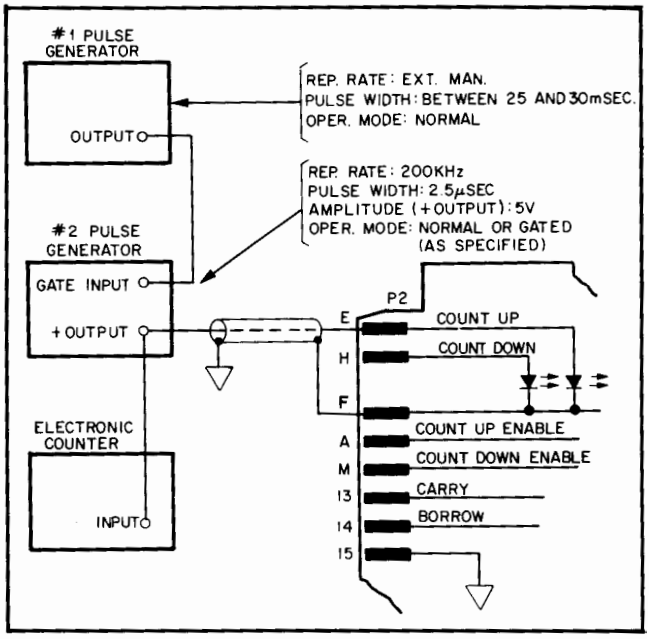


Figure 5-1. Checkout Procedure-Initial Setup

0 through 11. Touch LOAD OUTPUT.

13. Switch the 69435A Counter Card to the read mode as follows:

a. Address the unit with a control word having its ISL bit (bit 7) on. Touch LOAD OUTPUT.
b. Address the card slot with an address word consisting of the slot address in bit positions 12 through 15. (It is not necessary to touch LOAD OUTPUT.) Now, in this mode, the switch register displays the contents of the counter continuously.

14. Reset the electronic counter and then manually trigger pulse generator 1 once. Record the decimal count registered by the electronic counter and the binary count indicated at the multiprogrammer switch register. The decimal count should be between 5000 and 6000. Convert the binary count registered by the card to decimal form.

15. Since the capacity of the card is 4095 counts, it will have cycled beyond 4095 and partly into a second count cycle. If the card has operated properly, its count will equal 4096 less than the total registered by the electronic counter.

COUNT UP ENABLE CHECK

16. To check the count up enable input:

a. Switch pulse generator 2 from the GATED to the NORMAL mode. The counter card is now counting at a 200kHz rate. The data lamps of the switch register will be out or dim.
b. Connect a momentary short from the count up enable input (pin A) to common pin 15. While the short is connected, the data lamps of the switch register will display some steady bit pattern.
c. Disconnect the short connected in (b) above and return pulse generator 2 to the GATED mode.

CARRY PULSE CHECK

17. Disconnect the electronic counter from the output of pulse generator 2 and connect the carry output of the 69435A Counter Card to the counter input. (The carry output is on pin 13 and common is on 15.)

18. Switch pulse generator 2 to the manually triggered mode so that it will produce a single 2.5μsec pulse each time it is triggered.

19. Load the quantity 4093 into the counter card. (Follow the instructions of step (12) except use the bit pattern 111111111101 in bit positions 11 through 0 of the data word.)

20. The electronic counter should be in the totalizing (START) mode. Reset the electronic counter.

21. Monitor the indication on the electronic counter and manually trigger pulse generator 2 three times. The electronic counter should register one count (the carry pulse) on the third trigger.

NOTE

The following steps use the same techniques to check the down count and count down enable inputs and the borrow output of the card.

22. Disconnect the electronic counter from the carry output of the counter card and reconnect the counter to the output of pulse generator 2.

23. Disconnect the output of pulse generator 2 from the count up input of the card and connect pulse generator 2 to the +5V count down input (input is on pin H, common is on F).

24. Repeat the portions of steps (8) through (11) that are necessary to restore the original test equipment control settings.

DOWN COUNT CHECK

25. Preset the counter card to zero and switch to the read mode by repeating steps (12) and (13).

26. Apply a burst of pulses to the electronic counter and the counter card in parallel by repeating step (14). If the card has operated properly, its count will equal the difference between 8192 and the quantity registered by the electronic counter.

DOWN COUNT ENABLE CHECK

27. To check the count down enable input, repeat the instructions of step (16), substituting the count down enable input (pin M) for the count up enable input.

BORROW PULSE CHECK

28. Repeat steps (17) and (18), substituting the borrow output (pin 14) for the carry output.

29. Load the quantity 2 into the counter card. (Follow the instructions of step (12) except use the bit pattern 000000000010 in bit positions 11

through 0 of the data word).

30. The electronic counter should be in the totalizing (START) mode. Reset the electronic counter.

31. Monitor the indication on the electronic counter and manually trigger pulse generator 2 three times. The electronic counter should register one count (the borrow pulse) on the third trigger.

AUXILIARY COUNT INPUT CHECK

32. Apply a 200kHz +5V square wave to the bit 4-7 auxiliary count input (pin P and common pin 15 of the output connector). Leave the bit 4-7 count enable input line open (pin N).

33. Check with an oscilloscope for the presence of the 200kHz square wave which should appear at Z14-6.

34. While observing the waveform at Z14-6, ground the bit 4-7 count enable input line to common pin 15. Pin Z14-6 should go to a HI logic level while pin N is grounded.

35. Test the bit 8-11 auxiliary count input using the same method as in steps (32) through (34) above. Apply the square wave input to pin S and monitor Z14-3. The count enable input is pin R.

5-9 TROUBLESHOOTING

5-10 Figures 5-2, 5-3, and 5-4 provide troubleshooting procedures for the count, load, and read functions of a pulse counter card. If data fails to appear at pins 1-12 of the output connector immediately on being loaded into the counter, follow the steps of Figure 5-2. Figure 5-3 locates faults which prevent reading the contents of the counter back to the multiprogrammer, and Figure 5-4 troubleshoots the count input circuits and tests the counting function of the counter IC's.

5-11 If a defective component is found in the course of troubleshooting, be sure to turn off power at the multiprogrammer and remove the output card from the extender before attempting replacement. When installing an IC, be sure that the notch or dot on the IC is at the same end as the bevel on the IC socket.

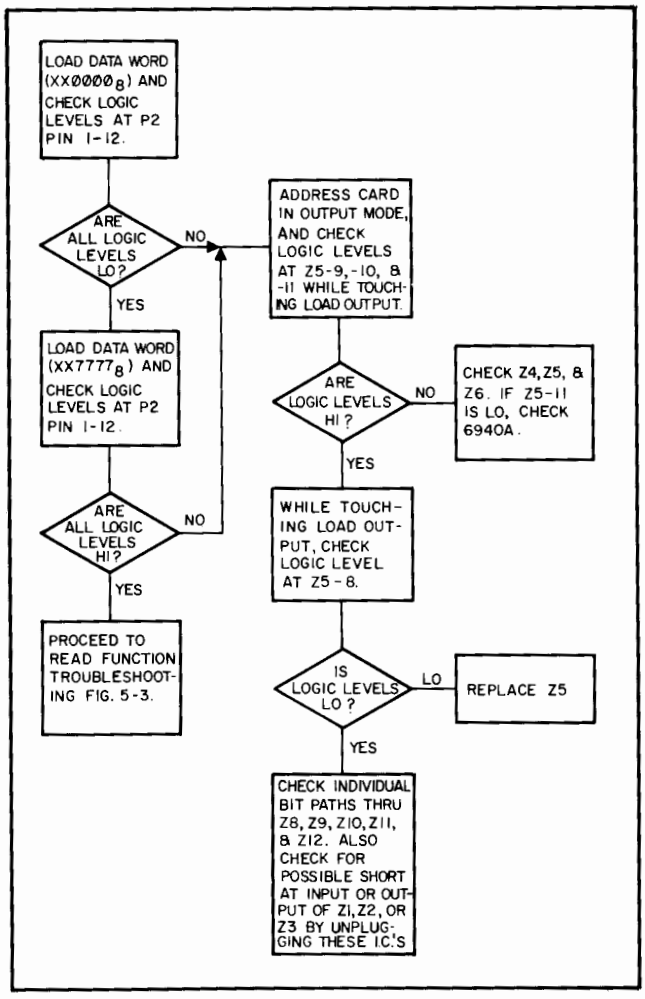


Figure 5-2. Load Function Troubleshooting

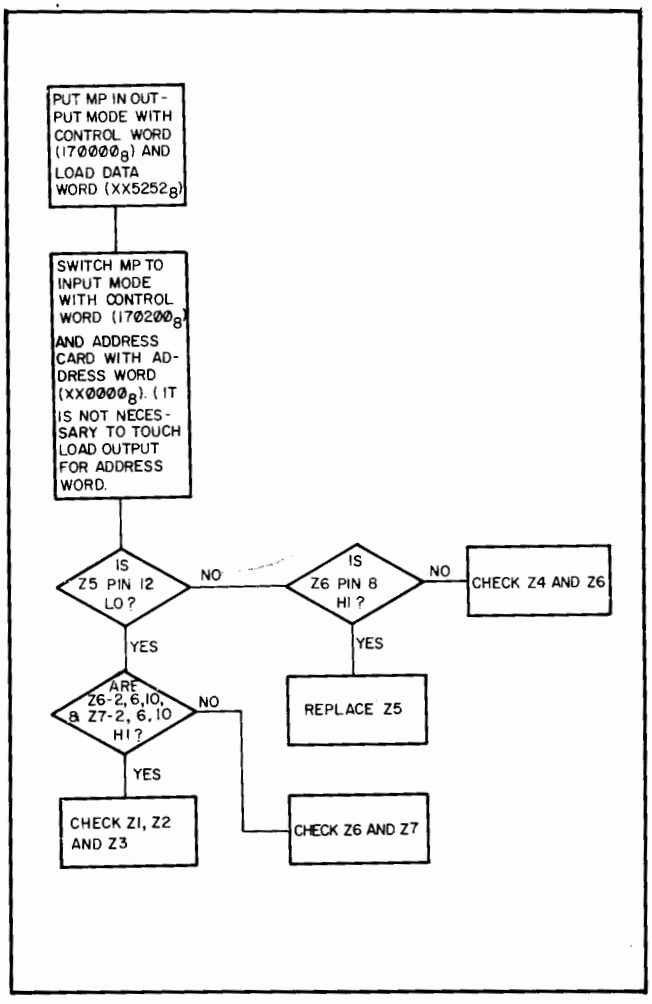


Figure 5-3. Read Function Troubleshooting

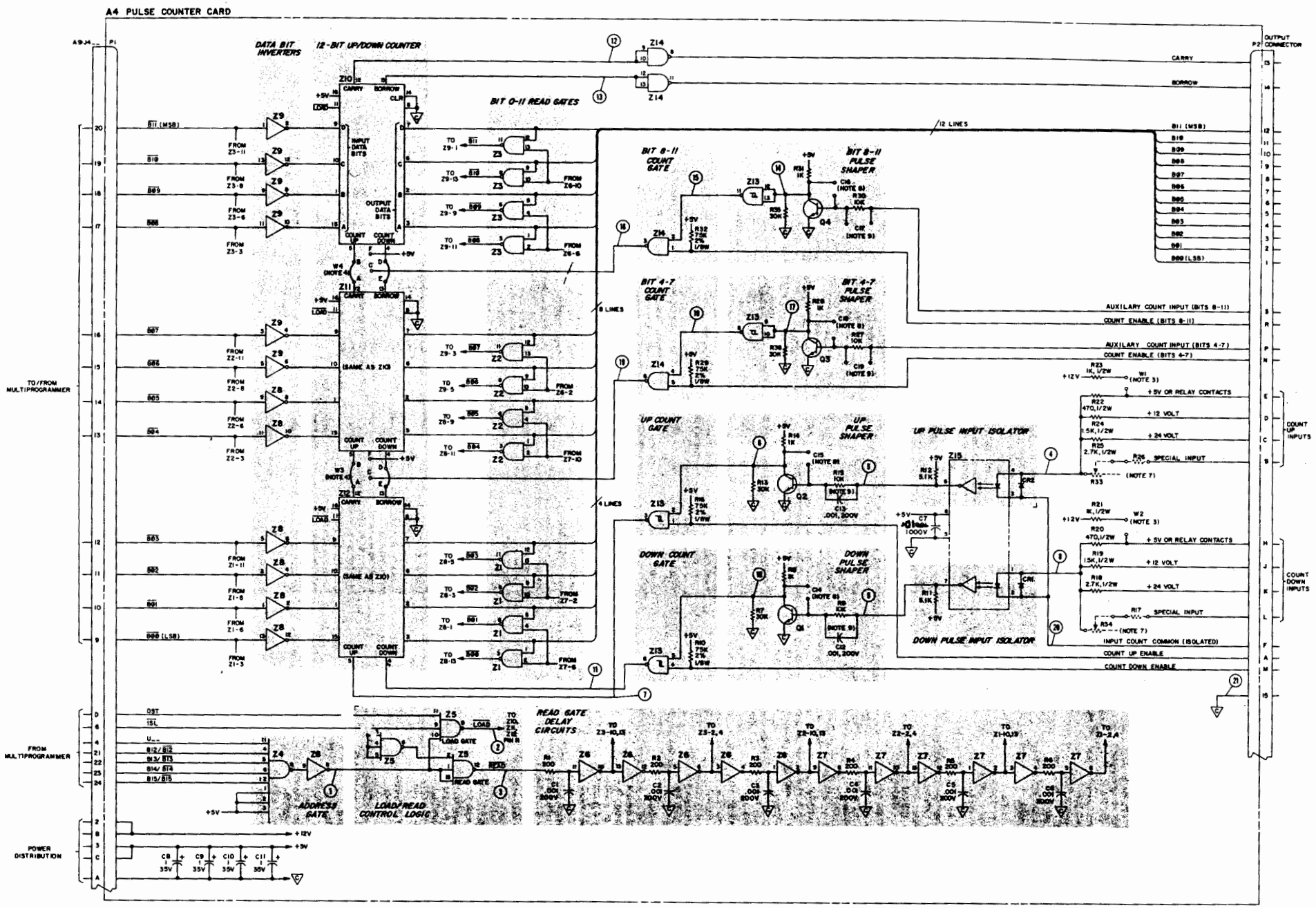


Figure 7-1. Pulse Counter Card, Schematic Diagram

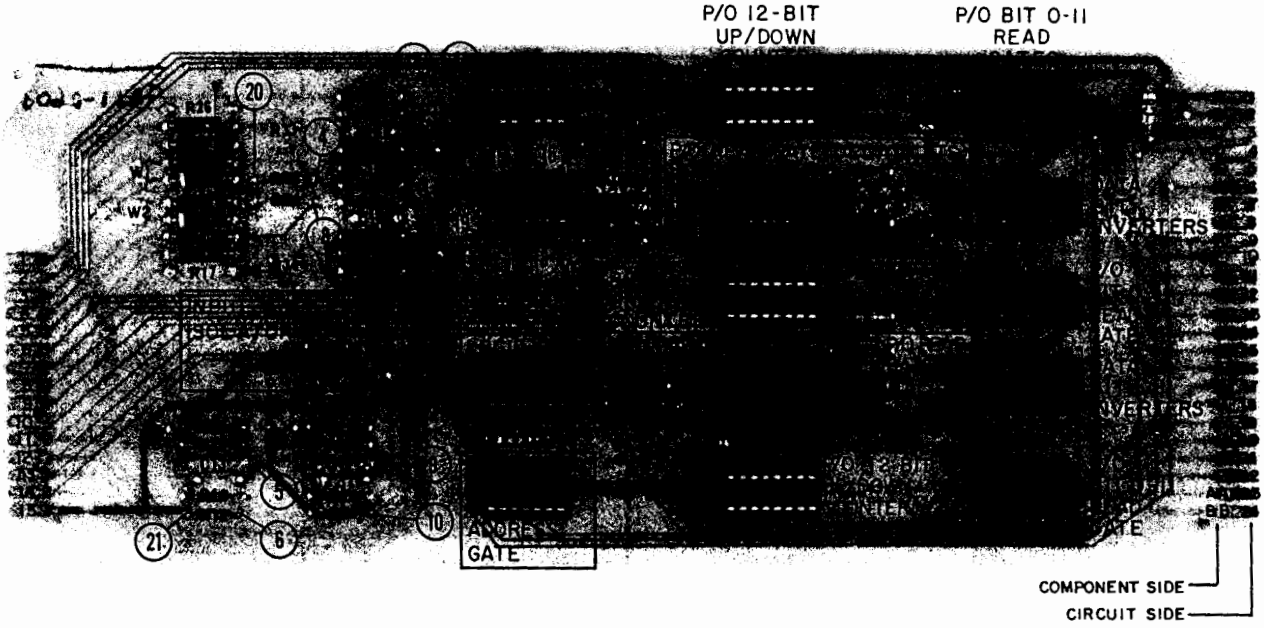
SECTION VII
CIRCUIT DIAGRAMS

7-1 COMPONENT LOCATION ILLUSTRATION

7-2 The component location illustration for the Model 69435A is given below. The illustration shows the physical location and reference designations for parts mounted on the printed circuit card.

7-3 SCHEMATIC DIAGRAM

7-4 The schematic diagram of the Model 69435A is presented on Figure 7-1. The test points (circled numbers) shown on the schematic diagrams correspond to the test points on the component location illustration.



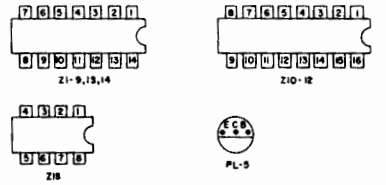
Pulse Counter Card, Component Locations

SCHEMATIC NOTES

1. ALL RESISTORS ARE IN OHMS, 1/4W 5%, UNLESS OTHERWISE INDICATED.
2. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE INDICATED.
3. WITH JUMPERS W1 AND W2 LEFT OPEN (AS SUPPLIED), THE +5V INPUTS WILL ACCEPT +5V PULSES FROM A SOURCE CAPABLE OF SUPPLYING A MINIMUM OF 5mA. INSTALLING W1 AND W2 AND TYING COMMON PIN F TO COMMON PIN 15 ENABLES THE +5V INPUTS TO OPERATE FROM RELAY CONTACTS OR TTL LOGIC LEVELS. (REFER TO SECTION III).
4. JUMPERS W3 AND W4 ALLOW THE 12-BIT COUNTER TO BE DIVIDED INTO ONE 4-BIT AND ONE 8-BIT OR THREE 4-BIT COUNTERS. AS SUPPLIED FROM THE FACTORY, A IS CONNECTED TO B, AND D TO E. (REFER TO SECTION III).
5. THE +5V V_{CC} AND COMMON CONNECTIONS TO IC'S ARE AS FOLLOWS:

IC	+5V	C
Z1-9, 13, 14	PIN 14	PIN 7
Z10-12	PIN 16	PIN 8
Z15	PIN 8	PIN 5

6. PIN LOCATIONS FOR IC'S AND TRANSISTORS USED ON THIS CARD ARE SHOWN BELOW



7. RESISTORS R17, 26, 35 AND 34 ARE NOT PROVIDED, BUT MAY BE INSTALLED BY THE USER TO ADAPT THE SPECIAL COUNT INPUTS FOR SIGNAL AMPLITUDES THAT ARE NOT SUITABLE FOR THE OTHER INPUT TERMINALS. (REFER TO SECTION III).
8. CAPACITORS C14, 15, 16 AND 18 ARE NOT PROVIDED, BUT MAY BE INSTALLED FOR THE PURPOSE OF FILTERING CONTACT BOUNCE OR OTHER HIGH FREQUENCY NOISE FROM THE SIGNAL TO BE COUNTED. THE PROPER VALUE MUST BE DETERMINED EXPERIMENTALLY. (REFER TO SECTION III).
9. CAPACITORS C12 AND C13 ARE SPEED-UP CAPACITORS WHICH EXTEND THE UPPER FREQUENCY LIMIT FOR PULSE SIGNALS. IF THE AUXILIART COUNT INPUTS ARE USED FOR PULSE SIGNALS, INSTALL .001μF SPEED-UP CAPACITORS C17 AND C18 IN THE SPACES PROVIDED. SPEED-UP CAPACITORS SHOULD BE REMOVED IF THE ASSOCIATED FILTER CAPACITOR IS INSTALLED. (REFER TO SECTION III).

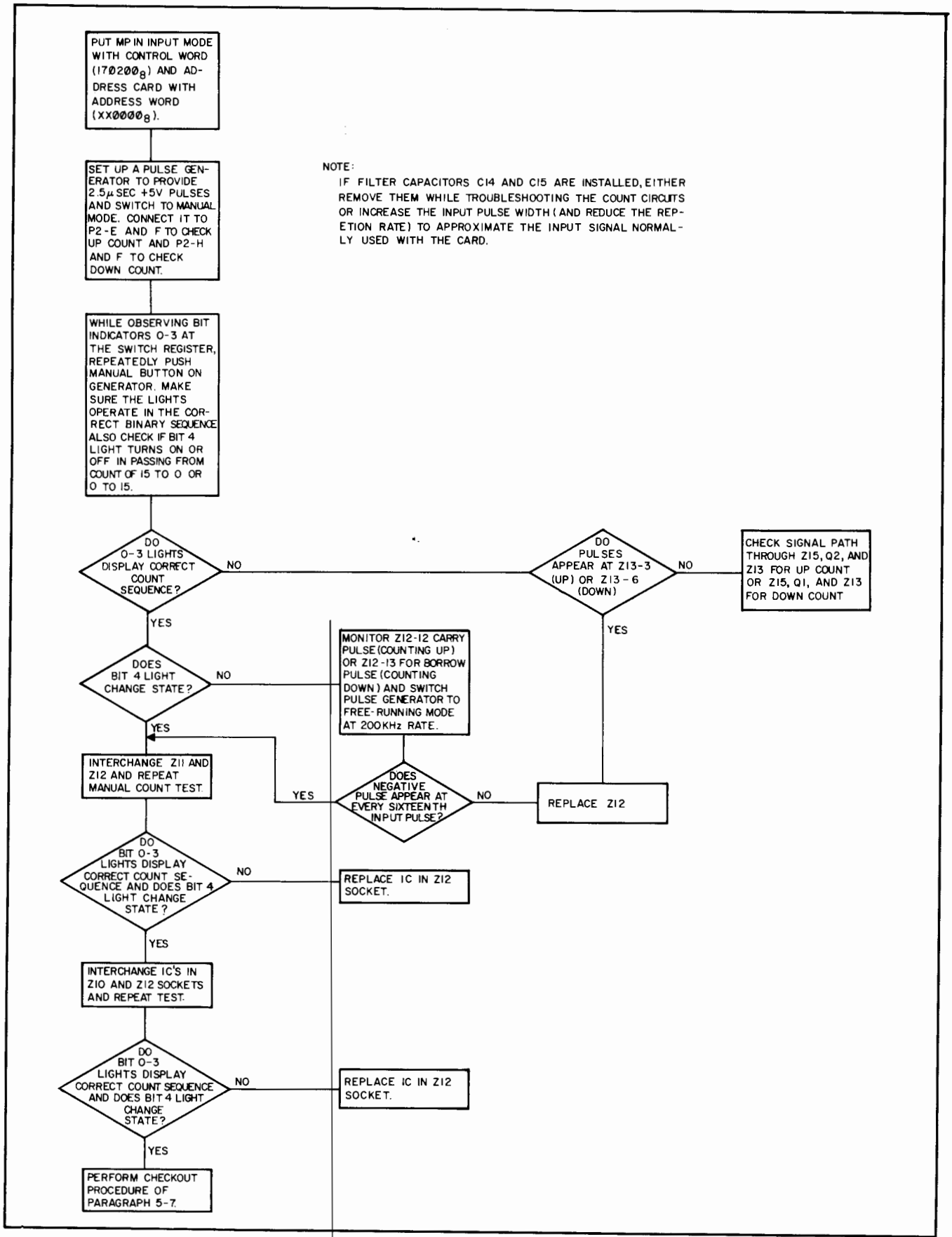


Figure 5-4. Count Function Troubleshooting

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-4 lists parts in alphanumeric order by reference designators and provides the following information:

a. Reference Designators. Refer to Table 6-1.

b. Description. Refer to Table 6-2 for abbreviations.

c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.

d. Manufacturer's Part Number or Type.

e. Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.

f. Hewlett-Packard Part Number.

g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 6-4, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

A	= assembly	E	= miscellaneous electronic part
B	= blower (fan)	F	= fuse
C	= capacitor	J	= jack, jumper
CB	= circuit breaker	K	= relay
CR	= diode	L	= inductor
DS	= device, signaling (lamp)	M	= meter

Table 6-1. Reference Designators (Continued)

P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
Q	= transistor	VR	= zener diode
R	= resistor	X	= socket
S	= switch	Z	= integrated circuit or network
T	= transformer		
TB	= terminal block		
TS	= thermal switch		

Table 6-2. Description Abbreviations

A	= ampere	mfr	= manufacturer
ac	= alternating current	mod.	= modular or modified
assy.	= assembly	mtg	= mounting
bd	= board	n	= nano = 10^{-9}
bkt	= bracket	NC	= normally closed
°C	= degree Centigrade	NO	= normally open
cd	= card	NP	= nickel-plated
coef	= coefficient	Ω	= ohm
comp	= composition	obd	= order by description
CRT	= cathode-ray tube	OD	= outside diameter
CT	= center-tapped	p	= pico = 10^{-12}
dc	= direct current	P.C.	= printed circuit
DPDT	= double pole, double throw	pot.	= potentiometer
DPST	= double pole, single throw	p-p	= peak-to-peak
elect	= electrolytic	ppm	= parts per million
encap	= encapsulated	pvr	= peak reverse voltage
F	= farad	rect	= rectifier
°F	= degree Farenheit	rms	= root mean square
fxd	= fixed	Si	= silicon
Ge	= germanium	SPDT	= single pole, double throw
H	= Henry	SPST	= single pole, single throw
Hz	= Hertz	SS	= small signal
IC	= integrated circuit	T	= slow-blow
ID	= inside diameter	tan.	= tantulum
incnd	= incandescent	Ti	= titanium
k	= kilo = 10^{3}	V	= volt
m	= milli = 10^{-3}	var	= variable
M	= mega = 10^{6}	ww	= wirewound
μ	= micro = 10^{-6}	W	= Watt
met.	= metal		

Table 6-3. Code List of Manufacturers

CODE NO.	MANUFACTURER	ADDRESS
00629	EBY Sales Co., Inc.	Jamaica, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00853	Sangamo Electric Co. S. Carolina Div.	Pickens, S.C.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Semiconductor-Components Div.	Dallas, Texas
01686	RCL Electronics, Inc.	Manchester, N.H.
01930	Amerock Corp.	Rockford, Ill.
02107	Sparta Mfg. Co.	Dover, Ohio
02114	Ferroxcube Corp.	Saugerties, N.Y.
02606	Fenwal Laboratories	Morton Grove, Ill.
02660	Amphenol Corp.	Broadview, Ill.
02735	Radio Corp. of America, Solid State and Receiving Tube Div.	Somerville, N.J.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co. Inc.	Cedar Knolls, N.J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04072	ADC Electronics, Inc.	Harbor City, Calif.
04213	Caddell & Burns Mfg. Co. Inc.	Mineola, N.Y.
04404	*Hewlett-Packard Co. Palo Alto Div.	Palo Alto, Calif.
04713	Motorola Semiconductor Prod. Inc.	Phoenix, Arizona
05277	Westinghouse Electric Corp. Semiconductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	Grand Junction, Colo.
05820	Wakefield Engr. Inc.	Wakefield, Mass.
06001	General Elect. Co. Electronic Capacitor & Battery Dept.	Irmo, S.C.
06004	Bassik Div. Stewart-Warner Corp.	Bridgeport, Conn.
06486	IRC Div. of TRW Inc. Semiconductor Plant	Lynn, Mass.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co.	Penacook, N.H.
06666	General Devices Co. Inc.	Indianapolis, Ind.
06751	Semcor Div. Components, Inc.	Phoenix, Arizona
06776	Robinson Nugent, Inc.	New Albany, Ind.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07263	Fairchild Camera and Instrument Corp. Semiconductor Div.	Mountain View, Calif.
07387	Birtcher Corp., The	Los Angeles, Calif.
07397	Sylvania Electric Prod. Inc. Sylvania Electronic Systems Western Div.	Mountain View, Calif.
07716	IRC Div. of TRW Inc. Burlington Plant	Burlington, Iowa
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Co. Components Div. Semiconductor Operation	Mountain View, Calif.
08484	Breeze Corporations, Inc.	Union, N.J.
08530	Reliance Mica Corp.	Brooklyn, N.Y.
08717	Sloan Company, The	Sun Valley, Calif.
08730	Vemaline Products Co. Inc.	Wyckoff, N.J.
08806	General Elect. Co. Miniature Lamp Dept.	Cleveland, Ohio
08863	Nylomatic Corp.	Norrisville, Pa.
08919	RCH Supply Co.	Vernon, Calif.
09021	Airco Speer Electronic Components	Bradford, Pa.
09182	*Hewlett-Packard Co. New Jersey Div.	Rockaway, N.J.
09213	General Elect. Co. Semiconductor Prod. Dept.	Buffalo, N.Y.
09214	General Elect. Co. Semiconductor Prod. Dept.	Auburn, N.Y.
09353	C & K Components Inc.	Newton, Mass.
09922	Burndy Corp.	Norwalk, Conn.
11115	Wagner Electric Corp. Tung-Sol Div.	Bloomfield, N.J.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of Cal. Inc.	So. Pasadena, Calif.
11502	IRC Div. of TRW Inc. Boone Plant	Boone, N.C.
11711	General Instrument Corp Rectifier Div.	Newark, N.J.
12136	Philadelphia Handle Co. Inc.	Camden, N.J.
12615	U.S. Terminals, Inc.	Cincinnati, Ohio
12617	Hamlin Inc.	Lake Mills, Wisconsin
12697	Clarostat Mfg. Co. Inc.	Dover, N.H.
13103	Thermalloy Co.	Dallas, Texas
14493	*Hewlett-Packard Co. Loveland Div.	Loveland, Colo.
14655	Cornell-Dubilier Electronics Div. Federal Pacific Electric Co.	Newark, N.J.
14936	General Instrument Corp. Semiconductor Prod. Group	Hicksville, N.Y.
15801	Fenwal Elect.	Framingham, Mass.
16299	Corning Glass Works, Electronic Components Div.	Raleigh, N.C.

*Use Code 28480 assigned to Hewlett-Packard Co., Palo Alto, California

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
16758	Delco Radio Div. of General Motors Corp.	Kokomo, Ind.
17545	Atlantic Semiconductors, Inc.	Asbury Park, N.J.
17803	Fairchild Camera and Instrument Corp Semiconductor Div. Transducer Plant	Mountain View, Calif.
17870	Daven Div. Thomas A. Edison Industries McGraw-Edison Co.	Orange, N.J.
18324	Signetics Corp.	Sunnyvale, Calif.
19315	Bendix Corp. The Navigation and Control Div.	Teterboro, N.J.
19701	Electra/Midland Corp.	Mineral Wells, Texas
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp. Electronics Div.	Mountain View, Calif.
22753	UID Electronics Corp.	Hollywood, Fla.
23936	Pamotor, Inc.	Pampa, Texas
24446	General Electric Co.	Schenectady, N.Y.
24455	General Electric Co. Lamp Div. of Consumer Prod. Group	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	LTV Electrosystems Inc Memcor/Components Operations	Huntington, Ind.
26982	Dynacool Mfg. Co. Inc.	Saugerties, N.Y.
27014	National Semiconductor Corp.	Santa Clara, Calif.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
28875	IMC Magnetics Corp. New Hampshire Div.	Rochester, N.H.
31514	SAE Advance Packaging, Inc.	Santa Ana, Calif.
31827	Budwig Mfg. Co.	Ramona, Calif.
33173	G.E. Co. Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
43334	New Departure-Hyatt Bearings Div. General Motors Corp.	Sandusky, Ohio
44655	Ohmite Manufacturing Co.	Skokie, Ill.
46384	Penn Engr. and Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
49956	Raytheon Co.	Lexington, Mass.
55026	Simpson Electric Co. Div. of American Gage and Machine Co.	Chicago, Ill.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
58849	Syntron Div. of FMC Corp.	Homer City, Pa.
59730	Thomas and Betts Co.	Philadelphia, Pa.
61637	Union Carbide Corp.	New York, N.Y.
63743	Ward Leonard Electric Co.	Mt. Vernon, N.Y.

CODE NO.	MANUFACTURER	ADDRESS
70563	Amperite Co. Inc.	Union City, N.J.
70901	Beemer Engrg. Co.	Fort Washington, Pa.
70903	Belden Corp.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionic Corp.	Cambridge, Mass.
71400	Bussmann Mfg. Div. of McGraw & Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	I.T.T. Cannon Electric Inc.	Los Angeles, Calif.
71590	Globe-Union Inc. Centralab Div.	Milwaukee, Wis.
71700	General Cable Corp. Cornish Wire Co. Div.	Williamstown, Mass.
71707	Coto Coil Co. Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co. Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72699	General Instrument Corp.	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72962	Elastic Stop Nut Div. of Amerace Esna Corp.	Union, N.J.
72982	Erie Technological Products Inc.	Erie, Pa.
73096	Hart Mfg. Co.	Hartford, Conn.
73138	Beckman Instruments Inc. Helipot Div.	Fullerton, Calif.
73168	Fenwal, Inc.	Ashland, Mass.
73293	Hughes Aircraft Co. Electron Dynamics Div.	Torrance, Calif.
73445	Amperex Electronic Corp.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Products, Inc.	Chicago, Ill.
74193	Heinemann Electric Co.	Trenton, N.J.
74545	Hubbell Harvey Inc.	Bridgeport, Conn.
74868	Amphenol Corp. Amphenol RF Div.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	IRC Div. of TRW, Inc.	Philadelphia, Pa.
75183	*Howard B. Jones Div. of Cinch Mfg. Corp.	New York, N.Y.
75376	Kurz and Kasch, Inc.	Dayton, Ohio
75382	Kilka Electric Corp.	Mt. Vernon, N.Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76381	Minnesota Mining and Mfg. Co.	St. Paul, Minn.
76385	Minor Rubber Co. Inc.	Bloomfield, N.J.
76487	James Millen Mfg. Co. Inc.	Malden, Mass.
76493	J.W. Miller Co.	Compton, Calif.

*Use Code 71785 assigned to Cinch Mfg. Co., Chicago, Ill.

Table 6-3. Code List of Manufacturers (Continued)

Computer Museum

CODE NO.	MANUFACTURER	ADDRESS
76530	Cinch	City of Industry, Calif.
76854	Oak Mfg. Co. Div. of Oak Electro/Netics Corp.	Crystal Lake, Ill.
77068	Bendix Corp., Electrodynamics Div.	No. Hollywood, Calif.
77122	Palnut Co.	Mountainside, N.J.
77147	Patton-MacGuyer Co.	Providence, R.I.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine and Foundry Co. Potter and Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Illinois Tool Works Inc. Shakeproof Div.	Elgin, Ill.
78452	Everlock Chicago, Inc.	Chicago, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Div. San Fernando Electric Mfg. Co. Inc.	Newburgh, N.Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78584	Stewart Stamping Corp.	Yonkers, N.Y.
79136	Waldes Kohinoor, Inc.	L.I.C., N.Y.
79307	Whitehead Metals Inc.	New York, N.Y.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Co.	Mt. Kisco, N.Y.
80031	Mepco Div. of Sessions Clock Co.	Morristown, N.J.
80294	Bourns, Inc.	Riverside, Calif.
81042	Howard Industries Div. of Msl Ind. Inc.	Racine, Wisc.
81073	Grayhill, Inc.	La Grange, Ill.
81483	International Rectifier Corp.	El Segundo, Calif.
81751	Columbus Electronics Corp.	Yonkers, N.Y.
82099	Goodyear Sundries & Mechanical Co. Inc.	New York, N.Y.
82142	Airco Speer Electronic Components	Du Bois, Pa.
82219	Sylvania Electric Products Inc. Electronic Tube Div. Receiving Tube Operations	Emporium, Pa.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls Inc. Control Products Group	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp. Electric Power Div.	Eatontown, N.J.
83330	Herman H. Smith, Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Div. of Amerace Esna Corp.	Brookfield, Mass.
83508	Grant Pulley and Hardware Co.	West Nyack, N.Y.
83594	Burroughs Corp. Electronic Components Div.	Plainfield, N.J.
83835	U.S. Radium Corp.	Morristown, N.J.
83877	Yardeny Laboratories, Inc.	New York, N.Y.
84171	Arco Electronics, Inc.	Great Neck, N.Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
86684	RCA Corp. Electronic Components	Harrison, N.J.
86838	Rummel Fibre Co.	Newark, N.J.
87034	Marco & Oak Industries a Div. of Oak Electro/netics Corp.	Anaheim, Calif.
87216	Philco Corp. Lansdale Div.	Lansdale, Pa.
87585	Stockwell Rubber Co. Inc.	Philadelphia, Pa.
87929	Tower-Olschan Corp.	Bridgeport, Conn.
88140	Cutler-Hammer Inc. Power Distribution and Control Div. Lincoln Plant	Lincoln, Ill.
88245	Litton Precision Products Inc, USECO Div. Litton Industries	Van Nuys, Calif.
90634	Gulton Industries Inc.	Metuchen, N.J.
90763	United-Car Inc.	Chicago, Ill.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell Inc. Div. Micro Switch	Freeport, Ill.
92825	Whitso, Inc.	Schiller Pk., Ill.
93332	Sylvania Electric Prod. Inc. Semiconductor Prod. Div.	Woburn, Mass.
93410	Essex Wire Corp. Stemco Controls Div.	Mansfield, Ohio
94144	Raytheon Co. Components Div. Ind. Components Oper.	Quincy, Mass.
94154	Wagner Electric Corp. Tung-Sol Div.	Livingston, N.J.
94222	Southco Inc.	Lester, Pa.
95263	Leecraft Mfg. Co. Inc.	L.I.C., N.Y.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95712	Bendix Corp. Microwave Devices Div.	Franklin, Ind.
95987	Weckesser Co. Inc.	Chicago, Ill.
96791	Amphenol Corp. Amphenol Controls Div.	Janesville, Wis.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97702	IMC Magnetics Corp. Eastern Div.	Westbury, N.Y.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98410	ETC Inc.	Cleveland, Ohio
98978	International Electronic Research Corp.	Burbank, Calif.
99934	Renbrandt, Inc.	Boston, Mass.

Table 6-4. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
69435A-A4	Pulse Counter Card				69435-60020	
A4C1-6	fxd, mylar . 001μF 200Vdc	8	292P10292-PTS	56289	0160-0153	2
C7	fxd, cer. .01 μF 1000Vdc	1	C067B102E1022526	56289	0150-0093	1
C8-11	fxd, elect. 1μF 35Vdc	4	150D105X9035A2	56289	0180-0291	1
C12, 13	fxd, mylar . 001μF 200Vdc		292P10292-PTS	56289	0160-0153	
C14-19	NOT SUPPLIED					
CR1, 2	Diode 180Vdc 200mA	2	SG3396	03877	1901-0033	2
Q1-4	SS NPN Si	4	SKA1124	01295	1854-0071	4
R1-6	fxd, comp 200Ω 5% 1/4W	6	CB-2015	01121	0683-2015	1
R7	fxd, comp 30K 5% 1/4W	4	CB-3035	01121	0683-3035	1
R8	fxd, comp 1K 5% 1/4W	4	CB-1025	01121	0683-1025	1
R9	fxd, comp 10K 5% 1/4W	4	CB-1035	01121	0683-1035	1
R10	fxd, met film 75K 2% 1/8W	4	Type MF4C, T-O	19701	0757-0969	1
R11, 12	fxd, comp 5.1K 5% 1/4W	2	CB-5125	01121	0683-5125	1
R13	fxd, comp 30K 5% 1/4W		CB-3035	01121	0683-3035	
R14	fxd, comp 1K 5% 1/4W		CB-1025	01121	0683-1025	
R15	fxd, comp 10K 5% 1/4W		CB-1035	01121	0683-1035	
R16	fxd, met film 75K 2% 1/8W		Type MF4C, T-O	19701	0757-0969	
R17	NOT SUPPLIED					
R18	fxd, comp 2.7K 5% 1/2W	2	EB-2725	01121	0686-2725	1
R19	fxd, comp 1.5K 5% 1/2W	2	EB-1525	01121	0686-1525	1
R20	fxd, comp 470Ω 5% 1/2W	2	EB-4715	01121	0686-4715	1
R21	fxd, comp 1K 5% 1/2W	2	EB-1025	01121	0686-1025	1
R22	fxd, comp 470Ω 5% 1/2W		EB-4715	01121	0686-4715	
R23	fxd, comp 1K 5% 1/2W		EB-1025	01121	0686-1025	
R24	fxd, comp 1.5K 5% 1/2W		EB-1525	01121	0686-1525	
R25	fxd, comp 2.7K 5% 1/2W		EB-2725	01121	0686-2725	
R26	NOT SUPPLIED					
R27	fxd, comp 10K 5% 1/4W		CB-1035	01121	0683-1035	
R28	fxd, comp 1K 5% 1/4W		CB-1025	01121	0683-1025	
R29	fxd, met film 75K 2% 1/8W		Type MF4C, T-O	19701	0757-0969	
R30	fxd, comp 10K 5% 1/4W		CB-1035	01121	0683-1035	
R31	fxd, comp 1K 5% 1/4W		CB-1025	01121	0683-1025	
R32	fxd, met film 75K 2% 1/8W		Type MF4C, T-O	19701	0757-0969	
R33, 34	NOT SUPPLIED					
R35, 36	fxd, comp 30K 5% 1/4W		CB-3035	01121	0683-3035	
Z1-3	Quad 2-input NAND(open collector)IC	3	SN23354	01295	1820-0621	3
Z4	8-input NAND IC	1	SN4345	01295	1820-0070	1
Z5	Triple 3-input NAND IC	1	SD12953	27014	1820-0587	1
Z6-9	Hex inverter IC	4	DM74L04N	27014	1820-0586	3
Z10-12	4-bit binary up/down counter IC	3	SN18953	01295	1820-0912	3
Z13	Quad 2-input NAND Schmitt trigger IC	1	SN42152	01295	1820-1056	1
Z14	Quad 2-input NAND IC	1	SN4342	01295	1820-0054	1
Z15	Dual photo-isolator	1		28480	1990-0461	1

Table 6-4. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	MECHANICAL PARTS					
	IC Socket, 16-pin (Z10-12)	3	ICN-163-53W	06776	1200-0507	
	IC Socket, 14-pin (Z1-9, 13, 14)	11	ICN-143-53W	06776	1200-0508	
	Extractor Handle (marked)	1		28480	69435-80001	
	Connector Assembly, Data Output	1			5060-9658	1
	Connector 2X15(30) pin		251-15-30-261	71785	1251-0159	
	Hood Assembly, Right			28480	5060-7981	
	Hood, Right			28480	4040-0233	
	Insert, threaded 4-40			28480	0590-1017	
	Insert, threaded 2-56	3		28480	0590-1018	
	Hood, Left			28480	4040-0232	
	Clamp, Cable			28480	1400-0714	
	Carton, foam lined			28480	9211-2603	

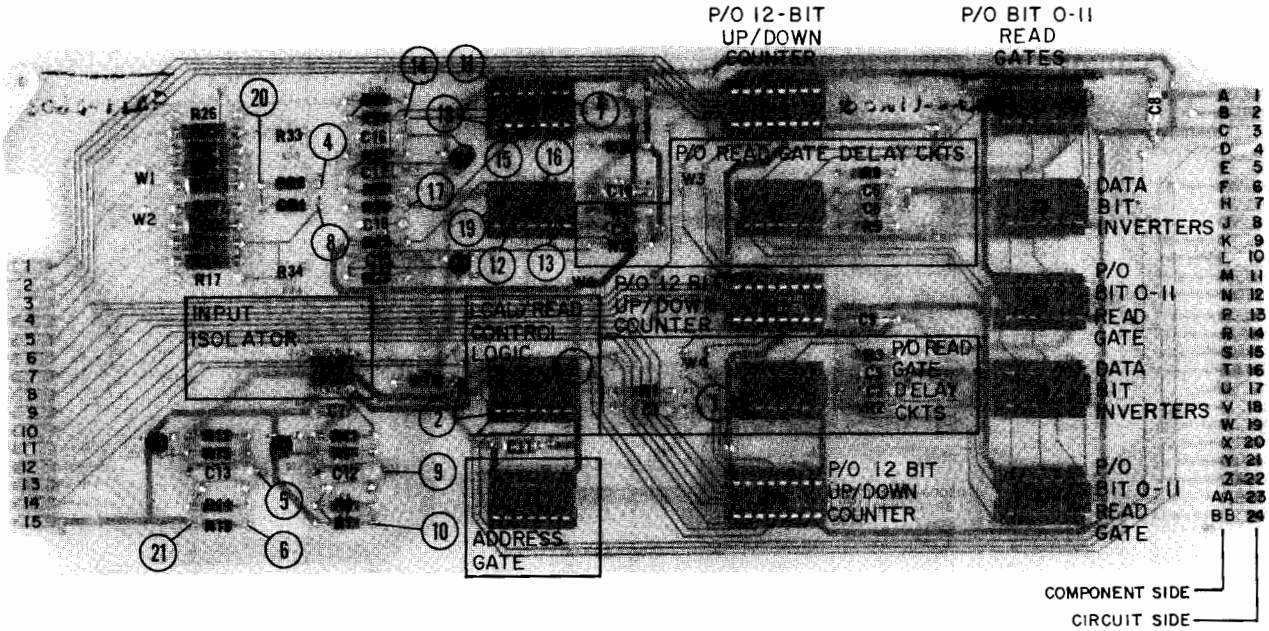
SECTION VII
CIRCUIT DIAGRAMS

7-1 COMPONENT LOCATION ILLUSTRATION

7-2 The component location illustration for the Model 69435A is given below. The illustration shows the physical location and reference designations for parts mounted on the printed circuit card.

7-3 SCHEMATIC DIAGRAM

7-4 The schematic diagram of the Model 69435A is presented on Figure 7-1. The test points (circled numbers) shown on the schematic diagrams correspond to the test points on the component location illustration.



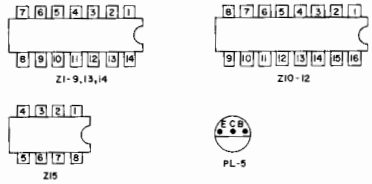
Pulse Counter Card, Component Locations

SCHEMATIC NOTES

1. ALL RESISTORS ARE IN OHMS, 1/4W 5%, UNLESS OTHERWISE INDICATED.
2. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE INDICATED.
3. WITH JUMPERS W1 AND W2 LEFT OPEN (AS SUPPLIED), THE +5V INPUTS WILL ACCEPT +5V PULSES FROM A SOURCE CAPABLE OF SUPPLYING A MINIMUM OF 5mA. INSTALLING W1 AND W2 AND TYING COMMON PIN F TO COMMON PIN 15 ENABLES THE +5V INPUTS TO OPERATE FROM RELAY CONTACTS OR TTL LOGIC LEVELS. (REFER TO SECTION III).
4. JUMPERS W3 AND W4 ALLOW THE 12-BIT COUNTER TO BE DIVIDED INTO ONE 4-BIT AND ONE 8-BIT OR THREE 4-BIT COUNTERS. AS SUPPLIED FROM THE FACTORY, A IS CONNECTED TO B, AND D TO E. (REFER TO SECTION III).
5. THE +5V V_{CC} AND COMMON CONNECTIONS TO IC'S ARE AS FOLLOWS:

IC	+5V	C
Z1-9, 13,14	PIN 14	PIN 7
Z10-12	PIN 16	PIN 8
Z15	PIN 8	PIN 5

6. PIN LOCATIONS FOR IC'S AND TRANSISTORS USED ON THIS CARD ARE SHOWN BELOW



7. RESISTORS R17, 26, 33 AND 34 ARE NOT PROVIDED, BUT MAY BE INSTALLED BY THE USER TO ADAPT THE SPECIAL COUNT INPUTS FOR SIGNAL AMPLITUDES THAT ARE NOT SUITABLE FOR THE OTHER INPUT TERMINALS. (REFER TO SECTION III).
8. CAPACITORS C14, 15, 16 AND 18 ARE NOT PROVIDED, BUT MAY BE INSTALLED FOR THE PURPOSE OF FILTERING CONTACT BOUNCE OR OTHER HIGH FREQUENCY NOISE FROM THE SIGNAL TO BE COUNTED. THE PROPER VALUE MUST BE DETERMINED EXPERIMENTALLY. (REFER TO SECTION III).
9. CAPACITORS C12 AND C13 ARE SPEED-UP CAPACITORS WHICH EXTEND THE UPPER FREQUENCY LIMIT FOR PULSE SIGNALS. IF THE AUXILIARY COUNT INPUTS ARE USED FOR PULSE SIGNALS, INSTALL .001μF SPEED-UP CAPACITORS C17 AND C18 IN THE SPACES PROVIDED. SPEED-UP CAPACITORS SHOULD BE REMOVED IF THE ASSOCIATED FILTER CAPACITOR IS INSTALLED. (REFER TO SECTION III).

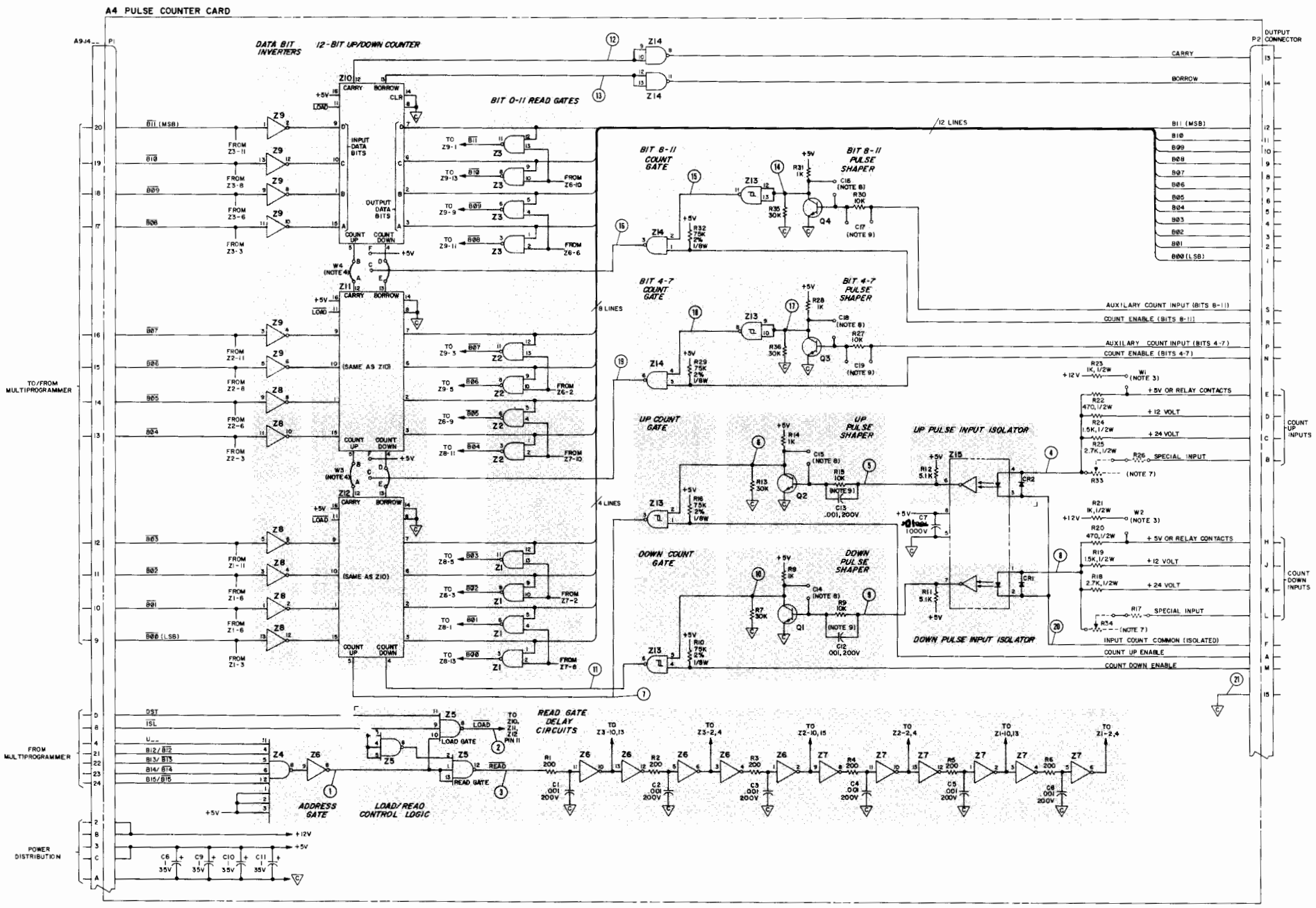


Figure 7-1. Pulse Counter Card, Schematic Diagram

SALES OFFICES

Arranged alphabetically by country

ANGOLA
Telectra
Empresa Técnica de Equipamentos Eléctricos, S.A.R.L.
R. Barbosa Rodrigues, 41-1°DT.°
Caixa Postal, 6487
Luanda
Tel: 35515/6

ARGENTINA
Hewlett-Packard Argentina S.A.
Santa Fe 2035, Martinez
6140 **Buenos Aires**
Tel: 792-1239, 798-6086
Telex: 122443 AR CIGY

Biotron S.A.C.I.y M.
Avde. Paseo Colon 221
9 piso
1399 **Buenos Aires**
Tel: 30-4846/1851/8384
34-9356/0460/4551
Telex: (33) 17595 BIO AR

AUSTRALIA

AUSTRALIA CAPITAL TERR.
Hewlett-Packard Australia Pty. Ltd.
121 Wollongong Street
Fyshwick, 2609
Tel: 804244
Telex: 62650

NEW SOUTH WALES
Hewlett-Packard Australia Pty. Ltd.
31 Bridge Street
Pymble, 2073
Tel: 4496566
Telex: 21561

QUEENSLAND
Hewlett Packard Australia Pty. Ltd.
5th Floor
Teachers Union Building
495-499 Boundary Street
Spring Hill, 4000
Tel: 2291544

SOUTH AUSTRALIA
Hewlett-Packard Australia Pty. Ltd.
153 Greenhill Road
Parkside, 5063
Tel: 2725911
Telex: 82536

VICTORIA
Hewlett-Packard Australia Pty. Ltd.
31-41 Joseph Street
Blackburn, 3130
Tel: 89-6351
Telex: 31024 MELB

WESTERN AUSTRALIA
Hewlett-Packard Australia Pty. Ltd.
141 Stirling Highway
Nedlands, 6009
Tel: 3865455
Telex: 93859

AUSTRIA
Hewlett-Packard Ges.m.b.H.
Wehlistrasse 29
P.O. Box 7
A-1205 **Vienna**
Tel: 35-16-21-0
Telex: 13582/135066

Hewlett-Packard Gas.m.b.H.
Wehlistrasse, 29
A-1205 **Wien**
Tel: 35-16-21
Telex: 135066

BAHRAIN
Medical Only
Wael Pharmacy
P.O. Box 848
Bahrain
Tel: 54886, 56123
Telex: 8550 WAEL GJ

Al Hamidiya Trading and Contracting
P.O. Box 20074
Manama
Tel: 259978, 259958
Telex: 8895 KALDIA GJ

BANGLADESH
The General Electric Co. of Bangladesh Ltd.
Magnet House 72
Dilkusha Commercial Area
Motijheil, Decca 2
Tel: 252415, 252419
Telex: 734

BELGIUM
Hewlett-Packard Benelux S.A./N.V.
Avenue du Col-Vert, 1, (Groenkraaglaan)
B-1170 **Brussels**
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Telex: 23-494 paloben bru

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Alameda Rio Negro, 750
Alphaville
06400 **Barueri** SP
Tel: 429-3222

Hewlett-Packard do Brasil i.e.C. Ltda.
Rua Padre Chagas, 32
90000-**Pôrto Alegre**-RS
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Av. Epitacio Pessoa, 4664
22471-**Rio de Janeiro**-RJ
Tel: 286-0237
Telex: 021-21905 HPBR-BR

CANADA

ALBERTA
Hewlett-Packard (Canada) Ltd.
11620A - 168th Street
Edmonton T5M 3T9
Tel: (403) 452-3670
TWX: 610-831-2431

Hewlett-Packard (Canada) Ltd.
210, 7220 Fisher St. S.E.
Calgary T2H 2H8
Tel: (403) 253-2713
TWX: 610-821-6141

BRITISH COLUMBIA
Hewlett-Packard (Canada) Ltd.
10691 Shellbridge Way
Richmond V6X 2W7
Tel: (604) 270-2277
TWX: 610-925-5059

MANITOBA
Hewlett-Packard (Canada) Ltd.
380-550 Century St.
St. James,
Winnipeg R3H 0Y1
Tel: (204) 786-6701
TWX: 610-671-3531

NOVA SCOTIA
Hewlett-Packard (Canada) Ltd.
P.O. Box 931
800 Windmill Road
Dartmouth B3B 1L1
Tel: (902) 469-7820
TWX: 610-271-4482

ONTARIO
Hewlett-Packard (Canada) Ltd.
1020 Morrison Dr.
Ottawa K2H 8K7
Tel: (613) 820-6483
TWX: 610-563-1636

Hewlett-Packard (Canada) Ltd.
6877 Goreway Drive
Mississauga L4V 1M8
Tel: (416) 678-9430
TWX: 610-492-4246

Hewlett-Packard (Canada) Ltd.
552 Newbold Street
London N6E 2S5
Tel: (519) 686-9181
TWX: 610-352-1201

QUEBEC
Hewlett-Packard (Canada) Ltd.
275 Hymus Blvd.
Pointe Claire H9R 1G7
Tel: (514) 697-4232
TWX: 610-422-3022

FOR CANADIAN AREAS NOT LISTED:
Contact Hewlett-Packard (Canada) Ltd. in **Mississauga.**

CHILE
Jorge Calcagni y Cia. Ltda.
Arturo Burhle 065
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