Models 776 and 776H
Counters and Timers
Operating and Service Manual

WARNING

This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. As temporarily permitted by regulation it has not been tested for compliance with the limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference. Operation of this equipment in a residential area is likely to cause interference, in which case the user, at his own expense, will be required to take whatever measures may be required to correct the interference.

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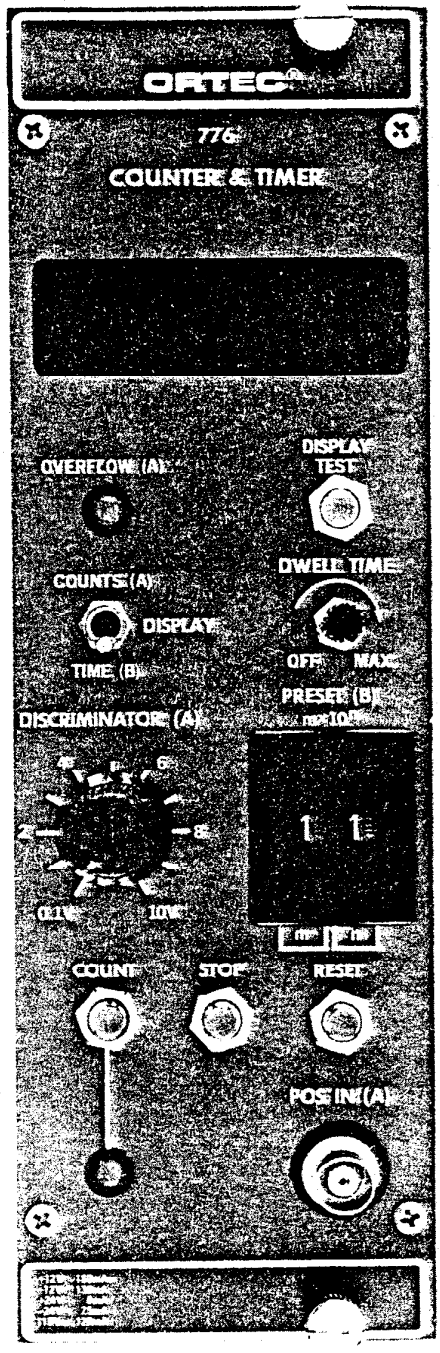
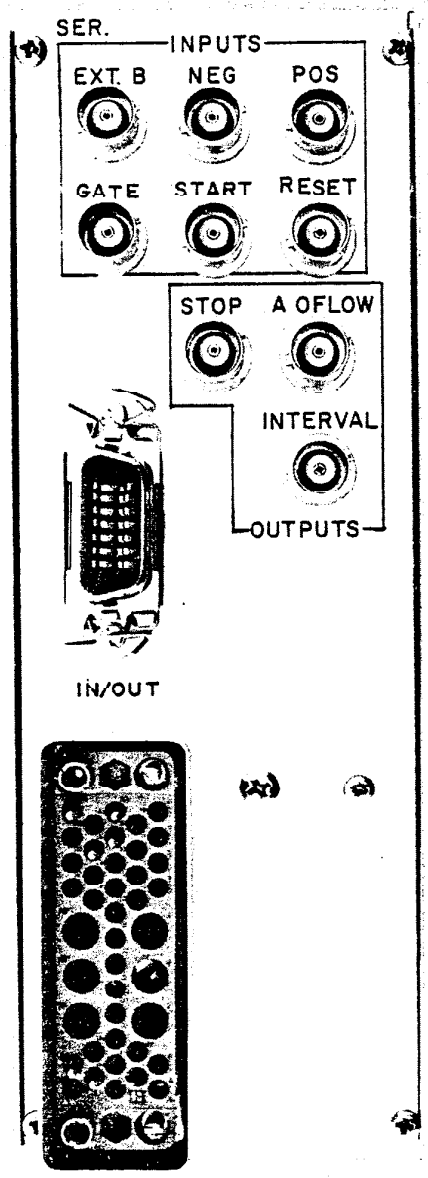
CONTENTS

ILLUSTRATIONS


ORTEC
776
COUNTER & TIMER
OVERFLOW (A)
DISPLAY TEST
COUNTS (A)
DISPLAY
TIME (B)
DWELL TIME
OFF
MAX
PRESET (B)
DISCRIMINATOR (A)
0.1V
1.0V
COUNT
STOP
RESET
POS IN (A)


SER.
INPUTS
EXT. B
NEG
POS
GATE
START
RESET
STOP
A OFLOW
INTERVAL
OUTPUTS
IN/OUT

ORTEC 776 AND 776H COUNTERS AND TIMERS

1. DESCRIPTION

The ORTEC 776 Counter and Timer is a dual 7-decade unit that can be used as a counter with a presettable timer or as two independent counters, one of which can be preset. The count, stop, gate, and reset control functions are common to both counting sections. The 776 can be used in any ORTEC printing system and will furnish a readout of seven digits from each of its two sections.

Section A is always used as a counter and can accept either positive or negative input signals at rates of up to 20 MHz while the unit is in a count condition. The positive input circuit includes an adjustable discriminator that can be set for any level from 100 mV through 10 V.

Section B can be used as either a timer or a counter; an internal slide switch selects the function. When it is used as a timer, the unit counts time in increments of either 0.1 s or 1 min with excellent precision based on an internal 1-MHz crystal-controlled time base. When it is used as a counter, section B accepts and counts positive input pulses at rates of up to 20 MHz. Section B is used for a preset stop control that affects both counting sections. The ranges for preset are 0.1 through 900,000 s, 1 through 9,000,000 min, or 1 through 9,000,000 counts.

The 776 is packaged as a NIM-standard double-width module. It includes all the connectors and controls for either manual or automatic operation and indicates the accumulated time or count in either section with 7-segment light-emitting diodes (LED) in a direct-reading digital display with suppression of insignificant zeros. When it is reading the contents of section B and the 0.1-s time base is used, a decimal point is included in the display.

An LED indicator at the bottom of the front panel lights to show when the 776 is in a counting condition. The counting gate, which affects both sections, is enabled when the LED is lighted. The gate is controlled by the manual Count or Stop switch, by a signal through the rear panel Gate connector, by an internal preset, and by the system preset signal through the ORTEC printing loop connector on the rear panel. The front panel Count switch normally initiates a counting interval, and this function can be duplicated remotely by a signal through the rear panel Start connector. A signal through the Gate input connector inhibits counting in both sections while it is present. Either automatic preset or the front panel Stop switch can be used to stop the counting interval. When the unit is in a stop condition, the front panel Reset switch can be pressed or a signal can be furnished through the rear panel Reset connector to reset both counting sections to zero. Reset is generated automatically when power is first applied and when power is restored after an interruption.

If the 7-decade counter in section A overflows, an LED on the front panel lights and remains lit until the next reset. At each overflow an output pulse is also furnished through the rear panel A Oflow connector that can be cascaded into another counter for an increased counting capacity.

A signal is available through the rear panel Interval connector to indicate the duration of the counting interval. If preset stop is used, there is a signal through the rear panel Stop output to indicate to any external equipment that preset has been reached and that the counting has been terminated.

The seven segments in each of the seven characters in the digital display can be tested at any time by pressing the Display Test switch on the front panel. When the switch is pressed, all seven segments in each digit should light for a reading of 8888888.

The 776H Counter and Timer operates the same as the 776 but requires a +6-V power source from the bin and power supply in which it is installed. An ORTEC 401B/402H Bin and Power Supply typically furnishes this requirement in addition to −6-V, ±12-V, ±24-V, and 115-V ac levels.

2. SPECIFICATIONS

2.1. PERFORMANCE

Count Capacity 7 decades in each of the two sections.

Counting Rate 20 MHz guaranteed, both sections.

Time Base 0.1-s or 1.0-min increments derived from 1-MHz crystal-controlled oscillator; inaccuracy, <0.0005%; temperature instability, <0.0002%/°C, 0 to 50°C.

Synchronizing Error <0.2 μs.

Pulse Pair Resolution 50 ns minimum.

Automatic Clear Generated when power is turned on initially or after a power interruption.

2.2. INDICATORS

Readout Display Contains 7 characters, 7 LED segments per character, plus decimal point.

Overflow (A) Single LED illuminated from first overflow of section A until reset.

Count Single LED illuminated when unit is in the counting condition.

2.3. CONTROLS

Display Test Pushbutton switch illuminates all segments in all readout display characters to read 8888888 when pressed.

Reset Pushbutton switch, when depressed, resets the internal registers for both sections to zero and turns off the Overflow (A) LED.

Stop Pushbutton switch selects noncounting condition for both sections when pressed.

Count Pushbutton switch enables counting condition for both sections when pressed provided that the Gate input is not held below +2 V and the B register is not at the preset count level.

Display Toggle switch selects the register whose contents will be displayed, either Counts (A) or Time (B).

Dwell Time Single-turn control with switch at full counterclockwise setting for Off. Off inhibits recycled operation of a preset counting interval. When the control is turned clockwise away from Off, it permits recycling with a dwell time between counting intervals that can be adjusted from 0.3 to 15 s with the control.

Discriminator (A) Single-turn control adjusts the discrimination level for the Pos In (A) circuit from 100 mV to 10 V.

Preset (B) A pair of thumbwheel switches select a time (or count) level in section B for a preset stop. One switch selects m = 0 through 9 and the other selects n = 0 through 6 in an m X 10^n format. Setting m = 0 or n $\geq$ 7 disables the preset circuitry.

Time Base 3-position slide switch on printed circuit board (accessible through left side panel) selects internal time base for 1-min or 0.1-s increments or the pulse source through the rear panel Ext B connector to be counted in section B of the unit.

2.4. INPUTS

Pos In (A) Front and rear panel BNC connectors; either accepts positive unipolar or bipolar signals in the range from the adjusted Discriminator (A) level through +10 V linear, 25 V maximum. Minimum pulse width above threshold, 20 ns at a 40% duty cycle. Z_{in} = 1 kΩ to ground, dc-coupled.

Neg (A) Rear panel BNC connector accepts fast negative logic pulses, 14 mA into 50Ω. Minimum pulse width, 4 ns. 250 mV fixed threshold. Input protected to ±100 V at 10% duty cycle.

Ext B Rear panel BNC connector accepts positive unipolar or bipolar signals when side panel switch is set at Ext; $>$+3 V to count, ±25 V maximum. Pulse pair resolution, 40 ns. Z_{in} = 1 kΩ to ground, dc-coupled.

Gate Rear panel BNC connector accepts standard slow positive logic signal to control counter input gate for both sections and the front panel Count LED indicator. $\geq$+3 V or open circuit allows counting; $\leq$+1.5 V inhibits counting; 25 V maximum. Driving source must be capable of sinking 0.5 mA positive current during inhibit.

Start Rear panel BNC connector accepts standard slow positive logic signal to remotely initiate a counting condition. $\geq$+3 V to start the count condition; $\leq$+1.5 V to not start; 25 V maximum. Pulse width, $\geq$100 ns. Z_{in} = 1 kΩ to ground, dc-coupled.

Reset Rear panel BNC connector accepts standard slow positive logic signal to remotely reset both sections to an initial zero. $\geq$+3 V to reset; $\leq$+1.5 V or open to not reset; 25 V maximum. Pulse width, $\geq$100 ns. Z_{in} = 2 kΩ to ground, dc-coupled.

2.5. OUTPUTS

Stop Rear panel BNC connector furnishes a standard slow positive logic pulse at the end of each preset interval. +5 V, 0.5-μs width, through $<$10 Ω, dc-coupled.

A Oflow Rear panel BNC connector furnishes a standard slow positive logic pulse at each overflow from 9,999,999 to 0 in section A only. Nominally +5 V, 2-μs width, through $<$10Ω, dc-coupled.

Interval Rear panel BNC connector furnishes a positive signal through the duration of each counting condition interval. Nominally +5 V through $<$10Ω, dc-coupled.

2.6. PRINTING LOOP

In/Out Rear panel Amphenol type 57-40140 connector includes four common data lines and all system logic for standard ORTEC printing and/or counting system interconnections through a 772-C1 cable, included with the 776.

2.7. OPTION

776H Counter and Timer The 776H is a complete instrument that is equal in performance to the 776 and differs only in that it requires +6 V from the bin and power supply in which it is installed.

2.8. ELECTRICAL AND MECHANICAL

Power Required For the 776: +12 V, 180 mA; −12 V, 130 mA; −24 V, 25 mA; 115 V ac (50 or 60 Hz), 120 mA. An internal power supply generates the +5-V source that is required by the integrated circuits; protected by a chassis-mounted 1.5-A, type 3AG, fuse.

For the 776H: +12 V, 180 mA; −12 V, 130 mA; −24 V, 25 mA; +6 V, 1 A. Must be operated in an ORTEC 401B/402H Bin and Power Supply or equivalent.

Dimensions NIM-standard double-width module (2.70 X 8.714 in.) per TID-20893.

3. INSTALLATION

3.1. GENERAL

The 776 operates on input power that must be furnished from a NIM-standard Bin and Power Supply such as the ORTEC 401/402 Series. If any vacuum tube equipment is operated in the same rack with the 776, there must be sufficient cooling air circulating to prevent localized heating of the integrated circuitry used throughout the 776. The temperature of equipment mounted in racks can easily exceed the maximum limits of 120°F (50°C) unless precautions are taken.

3.2. CONNECTION TO POWER

Turn off the Bin Power Supply when inserting or removing any modules. The ORTEC modules are designed so that it is not possible to overload the Power Supply with even a full complement of modules in the Bin. Since, however, this may not be true when the Bin contains modules other than those of ORTEC design, the Power Supply voltages should be checked after all modules have been inserted. The 401/402 has test points on the Power Supply control panel to permit monitoring the dc voltages easily.

The 776 requires 115 V ac as one of its power inputs. Some bins and power supplies, as well as jumper cables, may not be wired to include this power. In the event that the unit fails to operate in a new installation, check the bin and/or cable to determine whether the 115-V ac circuit is included.

The 776H version requires +6 V dc at 1 A. It must be used with an ORTEC 401B/402H Bin and Power Supply or equivalent to satisfy this power requirement. No ac power is required for the 776H.

3.3. COUNTER INTERCONNECTION

The 776 Counter and Timer can be combined into a counting system that includes other ORTEC printing instruments such as 772 Counters or additional 776 modules operated as dual counters. When it is combined into a complex counting system, the modules are connected together as shown in Fig. 3.1 for an integrated system control and for a standard readout program. The In/Out connector on the rear panel of each module is used for this loop interconnection and one cable is furnished with each printing module to permit the loop to be formed. For nonprinting systems the order of interconnections is not important and the loop need not be closed, but for printing systems the order in which their data will be printed is 1 through n in sequence, as shown in Fig. 3.1. Figure 3.2 shows how the 772-C1 cable that is furnished with the 776 provides the In and Out connections separately. Normally, after the modules have been connected together in a system, one of the modules will be selected as the master for the system and the remaining modules will be slaves. The 776 module that is set for a preset time (or count) in its section B will act as the master module for the system loop for either printing or nonprinting functions. If any other modules in the system have a selector switch for master-slave-normal, each should be set at slave. If any other 776 modules are included, turn the Preset m wheel to 0 to turn off preset.

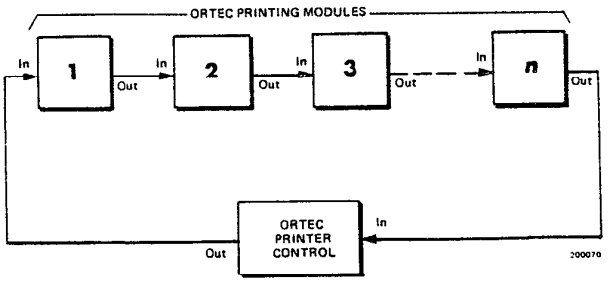


Fig. 3.1. Counter Interconnection for System Operation.

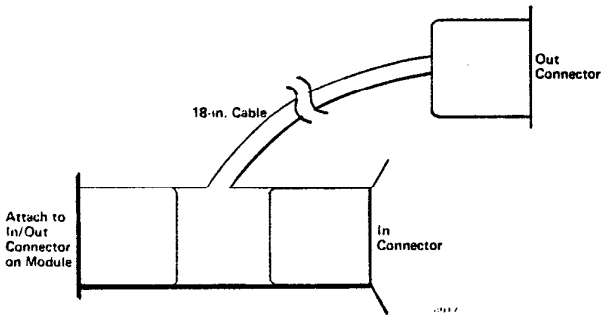


Fig. 3.2. Detail of 772-C1 Printing System Cable.

3.4. SIGNAL CONNECTIONS

Section A Input Positive pulses can be furnished through either the front panel Pos In (A) connector or the rear panel Pos (A) connector. These two connectors are ***not isolated*** from each other, so signals from two sources should not be connected simultaneously to the two input connectors. The input circuit in the 776 is dc-coupled to eliminate baseline shifts associated with changing counting rates. For signals with an average dc level greater than ±25 V, external capacitive coupling must be provided by the user. For dc levels below ±25 V, connection to the input can be made safely without damage to the 776. However, for the counter to respond to any signals through the input circuit, the signals must rise from below the adjusted discriminator threshold through its level, which is set in the range 0.1 through 10 V, and should not have any transients at or around the threshold level.

NIM-standard fast negative logic pulses can be furnished through the Neg (A) connector on the rear panel. The input impedance is 50Ω and is the proper termination for this type of signal. Use matching 50Ω cable for the interconnection to prevent spurious oscillations, which would otherwise be counted as input pulses.

Section B Input When the internal slide switch selects either 0.1-s or 1-min time base increments for section B, the pulses that are counted originate internally and no external connections are required. An internal 1-MHz crystal-controlled oscillator is counted down to provide each input pulse to the counting register The countdown is 100,000 oscillator cycles for each output at 0.1-s intervals or is 60,000,000 oscillator cycles for each output at 1-min intervals.

When the slide switch is set at Ext, positive logic pulses can be furnished through the rear panel Ext B connector. The pulses can originate in an external time base and occur at regular intervals or can be pulses that occur at random times. The minimum pulse pair resolution is 50 ns. Each signal to be counted must rise from below +1.5 V to above +3 V with fast rise time and without any transients at or around +3 V.

Gate Input The gate input signal, if it is to be used, can be connected to the 776 at the rear panel Gate BNC. When there is no input connection, the gate is enabled. When there is a connection and the 776 is set for a counting condition, the gate is disabled when the input circuit furnishes +1.5 V or less to the unit; the driving circuit must be capable of sinking 0.5 mA from the gate circuit. The gate circuit permits counting when the gate input is at +3 V or greater or is open-circuited.

Start Input A remote start input signal can be used to initiate the counting condition in the 776. It provides the same control as that described for the result of pressing the front panel Count switch. It has no effect except when the 776 is in a stop condition, provided by either a preset condition or a manual stop control. The input signal must rise from below +1.5 V to above +3 V with fast rise time.

Stop Output A NIM-standard slow positive logic pulse is furnished through this connector when the counting condition in the 776 is stopped by preset only. It can be used to indicate the termination of a counting interval to any external equipment.

A Oflow Output Each time the section A register overflows at 10^7 counts, a NIM-standard slow positive logic pulse is furnished through this connector. It can be used as the input to another counter in order to increase the total counting capacity. The output is +5 V, 2 μs wide.

Interval An interval output is available through the rear panel Interval BNC connector. This output is at nominally +5 V whenever the 776 is in a counting condition, and changes to a nominal 0 V when counting is inhibited. The output is dc-coupled. Z_o <10Ω.

In/Out System Connector Signals An adapter cable, 772-C1, is furnished with the 776 to attach to the In/Out connector and to make separate connectors available for the In and Out system interconnections. The signals at the In and Out connectors are listed in Table 3.1. The physical

Table 3.1

In Connector		Out Connector	
Pin	**Description**	**Pin**	**Description**
1	Data 1	1	Data 1
2	Data 2	2	Data 2
3	Data 4	3	Data 4
4	Data 8	4	Data 8
5	Print	5	Print
6	Print Advance	6	Print Advance
7	Previous Module Finished	7	This Module Finished
8	System Gate	8	System Gate
9	System Preset	9	System Preset
10	System Reset	10	System Reset
11	Ground	11	Ground
12	432 Off	12	432 Off
13	Spare	13	Spare
14	This Module Printing	14	This Module Printing

details of the 772-C1 cable are shown in Fig. 3.2; the system In connector is located on the opposite end of the connector block from the portion that attaches to the In/Out connector on the rear of the module, and the Out connector is on the remote end of the 18-in. multiwire cable that extends to the next module in the loop.

Pin 7 on the In/Out connector is the previous-module-finished (PMF) signal from pin 7 of the In connector. Pin 13 on the In/Out connector is the this-module-finished (TMF) output to pin 7 of the Out connector. All the remaining pins are wired point-to-point between all three connectors in the cable.

The functions of signals through the 14 pins of the In/Out connector are as follows:

Pins 1–4 – Data Lines Transfer the four bits of each digit from the assigned instrument to the 432A or 777 Printout Control. Each instrument includes an isolated program control that drives these common lines only during its turn for printing.

Pin 5 – Print Prepares the instrument for data transfer during printing.

Pin 6 – Print Advance Advances the scanner in each instrument for readout of each of its digits during printing.

Pin 7 – Previous Module Finished Starts the actual data transfer from an instrument at its turn to be printed.

Pin 8 – System Gate Carries a gate-off signal to all instruments set for slave operation in the system loop. The signal originates in a master instrument, and this is, logically, the 776. When it has a gate input, the gate signal is imposed on the system gate line.

Pin 9 – System Preset Carries a preset signal to all instruments in the system loop. A preset condition gates off all modules in the system.

Pin 10 – System Reset Carries a reset signal to all instruments in the system loop except any that may be set for normal. This signal originates in a master module or in the Printout Control.

Pin 11 – Ground Carries a common zero potential line to all modules in the system loop.

Pin 12 – 432 Off Carries an inhibit signal to the dwell time circuit of the 776. Dwell time between recycled counting intervals is controlled by the Printout Control that is included in the system loop to permit all data to be printed before the system can be returned to a counting condition.

Pin 13 – This Module Finished Signals the next instrument in the printing loop to start its data transfer.

Pin 14 – This Module Printing Grounded by the 776 during its printout operation to signal that the data words contain seven digits each.

4. OPERATING INSTRUCTIONS

4.1. FRONT PANEL CONTROLS AND INDICATORS

The following functions are indicated on and controllable from the front panel:

Count Manually initiates a counting condition for both sections of the 776.

Stop Manually terminates a counting condition for both sections of the 776.

Reset Manually resets the contents of the registers in both sections of the 776.

Count LED Indicates the condition of the input gate and the counting condition. When it glows, the 776 is able to count in both sections. When it is dark, the 776 is inhibited from counting.

Preset (B) Two digital thumbwheel switches permit selection of a preset count level in section B. The switch at the left, marked m, selects any single significant digit, 1 through 9. When this switch is set at 0, the preset function is turned off. The switch at the right, marked n, selects a power of 10 for a multiplier factor applied to the selected significant digit; usable settings are 0 through 6. For example, when m is set at 4 and n is set at 3, a preset stop at 4×10^3 (4000) counts is selected in section B. The counts can be 400.0 s, 4000 min, or 4000 external input counts, depending on the setting of the internal slide switch.

Discriminator (A) When the section A counter is used to count positive input pulses, they must have an amplitude that exceeds the adjusted level set with this control in order to be counted. The discriminator threshold level adjustment range is 100 mV (just above normal system electronic noise) to 10 V.

Dwell Time This single-turn control has an Off switch setting at full counterclockwise that turns off the recycling program. When the control is advanced and the switch is turned on, the 776 can recycle its counting periods to preset stop and will include a dwell time between counting cycles. The range of dwell time is 0.3 to 15 s, selected as the control is turned through its range.

Display A toggle switch selects either the section A or section B contents for the digital display at any time except during a printing cycle.

Display Test Pushbutton switch lights all segments of all seven characters for a reading of 8888888.

Overflow (A) An LED lights if the section A counting register exceeds its capacity of 9,999,999 counts and remains lighted until the unit is reset.

4.2. INITIAL OPERATION

1. Set the slide switch, accessible through the left side panel, at 0.1 Sec. This will select operation of the section B counter as a timer with 0.1-s increments.

2. Install the 776 in a 401/402 series Bin and Power Supply or equivalent and turn on the power.

3. Set the Display switch at Time (B).

4. Press Stop and then press Reset. The display should now indicate that the contents of section B are zero; the display reads 0.0.

5. Set the Display switch at Counts (A). The display should now indicate that the contents of section A are also zero; the display reads 0 (with no decimal point). Return the Display switch to Time (B).

6. Press Display Test. The display should read 888888.8 and should return to 0.0 when the switch is released.

7. Press the Count switch. The count indicator should light and the timer in section B should start counting time in 0.1-s increments. Press the Stop switch; the light should go out and the timer should stop counting time. Press Count again.

8. Ground the Gate input connector on the rear panel. Observe that counting stops and that the count indicator is not lighted. Remove the ground and restore the counting condition.

9. With the two thumbwheel switches select some random preset number that is greater than the accumulated time indication. Observe that the unit stops counting time at the preset level and that the Count indicator light goes out at the preset stop.

10. Turn off power for the bin and power supply and remove the 776 from the bin.

11. Set the side panel slide switch at Min (for timer operation with 1-min intervals).

12. Return the 776 to the bin and turn on power again. Note that it is automatically reset to 0 when power is restored. There is no decimal point for timer operation with 1-min increments.

13. Since the unit has been reset, the preset condition of step 9 is removed and the unit should count time in 1-min increments.

14. Turn off power for the bin and power supply and remove the 776 from the bin.

15. Set the side panel slide switch at Ext.

16. Return the 776 to the bin and turn on power again. It should be reset automatically to 0.

17. Check the operation of section B as a counter. Provide positive logic pulses through the Ext B connector on the rear panel.

18. Press Count to start counting the input pulses into section B. Check the functions of the Stop switch, the Gate input, and the Preset thumbwheel switches as outlined for the timer mode of operation.

19. Turn off power for the bin and power supply and remove the 776 from the bin.

20. Set the side panel slide switch at 0.1 Sec.

21. Return the 776 to the bin and turn on power again. It should be reset automatically to 0.0.

22. Furnish positive pulses through either the front or rear panel Pos (A) input connector. Set the Discriminator control at 0.1 V. Set the Display switch at Counts (A).

23. Press Count to start counting pulses into section A. The timer in section B is operating simultaneously and will stop counting if it is allowed to reach preset.

24. Check the functions of the Stop switch, the Gate input, and the Preset time control.

25. While section A is counting input pulses, advance the Discriminator control toward 10 V. The unit stops counting input pulses when the input pulse amplitude no longer exceeds the adjusted discriminator level, and will start counting again when the discriminator level is decreased. If the input pulses are not all the same amplitude, the discriminator control can be adjusted to permit counting of only those with greater amplitudes.

26. Remove the Pos (A) input connection. Furnish a source of NIM-standard negative logic signals to the Neg input connector on the rear panel.

27. Press Stop and Reset.

28. Press Count to start counting pulses into section A.

The timer in section B is operating simultaneously and will stop counting if it is allowed to reach preset.

29. Permit the unit to count input pulses until it overflows. The Overflow LED should light when the contents of section A overflow from 9999999 to 0. The input pulse rate can be increased up to 20 MHz to accelerate this test.

30. Turn the Dwell Time control clockwise about 1/3 of a turn beyond its switched Off setting.

31. Permit the unit to operate until there is a preset time stop. Check that section A stops counting at the preset time, that the count indicator light goes out, and that the unit remains in this condition for a few seconds.

At the end of the dwell time the unit resets to zero and starts counting again. This continues until manual stop, preset stop, or a gate input interrupts the counting process.

After the 776 Count condition has been established with its front panel switch or by the equivalent signal through the rear panel Start connector, the program can be continued indefinitely. That is, the unit can be turned off by preset or gate and then returned to a counting condition either with or without reset. Normally, gate is used to interrupt an accumulating program, after which the gate can be released and the accumulation can proceed from the point of interruption. Preset is used to terminate a counting period and to signal this fact to an external accessory such as a printer; reset is used to start a new accumulation cycle. With Dwell Time at Off, reset must be furnished from an external printer, by a signal through the rear panel Reset connector, or by use of the manual Reset switch on the front panel. With Dwell Time turned on, its circuit measures time from preset and generates an internal reset to terminate the dwell time interval after 0.3 to 15 s.

If the front panel Stop switch is pressed, the only way to start counting again is to press the front panel Count switch or to furnish a signal through the rear panel Start connector.

4.3. COUNTER/TIMER OPERATION

Connect the source of pulses to be counted to an input in the A section of the 776. Set the side panel slide switch at either Min or 0.1 Sec to select an appropriate time base. Set the Preset m and n digital switches for an appropriate time interval for counting. Set the Dwell Time control at Off to stop after one cycle or turn it on to select a recycled counting operation. Press Reset; the cycle can start if the 776 is in a counting condition and there is no gate input or it can be started either by pressing Count on the front panel or by removing the ground signal on the gate input. At preset stop use the Display toggle switch to read the contents of both registers or, assuming that the contents of the B register will always reflect the preset count level, to read the contents of the A register with the switch set at Counts (A).

4.4. SETUP FOR 776 AS PART OF A COUNTING SYSTEM

Operate the 776 as a single module, according to the procedure in Section 4.3. Then connect it as a part of a system loop according to the information in Fig. 3.1. If the system data are to be printed automatically by an ORTEC 777 Line Printer or ORTEC 222 (modified Teletype® 33 ASR), the sequence of modules in the system loop determines the sequence in which their data will be printed. For a nonprinting system the sequential arrangement of modules is unimportant but the system control cables must interconnect all modules in the system.

The 776 that has been set for a preset stop in its section B will be the functional system master, and the other 776 modules in the system must have preset turned off for normal operation. After they have been started, the modules in the system will all stop counting at the preset in the 776 and will be reset to start counting again at the end of reset in the 776. Gate control can be used to interrupt counting in the master 776 and in any module in the loop that is set for slave operation, but the system gate control is not accepted from the common line by any other 776 that may be included in the loop. Common gating for two or more 776 modules must be extended between their rear panel Gate connectors.

4.5. OPERATION AS A FREQUENCY METER

Use the basic setup of Section 4.3 and set the side panel slide switch at 0.1 Sec. Set the Preset switches for m = 1 and n = 1, and preset stop will occur after 1 s of counting. Connect the pulse source into section A. Set the Dwell Time control on for a short dwell interval. Set the Display switch at Counts (A). At the end of each 1-s counting interval the average count rate of pulses into the A section is available on the digital display and/or for printout.

4.6. OPERATION AS A FREQUENCY RATIO COUNTER

Operation as a frequency ratio counter involves the use of external counts into both sections of the 776. Set the side panel slide switch at Ext. The count rate of pulses into section A will be compared to the count rate into section B, and the preset controls can be set to select the basis for comparison. For example, with m = 1 and n = 4, each counting interval will accumulate a significant number of counts in section A per 10,000 counts in section B.

4.7. OPERATION AS A HIGH-CAPACITY SINGLE COUNTER

Connect the signal to be counted as the section A input and connect from A Oflow to Ext B on the rear panel. Set the side panel slide switch at Ext. With the knowledge that each count into section B represents 10^7 input counts into

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section A, preset can be used at any level from 1 X 10^7 through 9 X 10^{13}. If preset is not used, the counting capacity is $10^{14} - 1$ (99,999,999,999,999). Timing control can be furnished as a gate input.

4.8. PRINTING SYSTEMS

Interconnect the modules of the printing system as shown in Fig. 3.1. Any number of modules, from a single 776 to 50 ORTEC printing instruments, can be included in the loop, together with a 777 Line Printer or a 432A Printout Control with a 222 Teletype. When data are printed for the 776, it will include all seven digits for section A (followed by a space on the 222 or a line advance in the 777) and then all seven digits for section B. Some of the characteristics of its counters and of the printing system are described here, although a more detailed description will be found in the instruction manual for the 777 or the 432A, whichever is used.

Upon command the 776 provides the data stored in its counting registers to the printer control in a serial-by-character format. The data are fed in groups of four bits per character, one following another at a rate determined by the printer. Each group of four bits is a digit in a 1-2-4-8 BCD code, with logic 1 being about +6 V and logic 0 about 0 V. The transfer of data starts with the most significant digit in section A and proceeds sequentially through the least significant digit in section B. A Teletype space or a Line Printer line advance separates the data for the two sections. Figure 4.1 shows the sequence of events to print a total count of 7058491, assuming this to be the accumulation in either of the sections at printing time. As a note of explanation, the print command signal originates in the printer control and can be furnished manually, by remote control, or by a preset signal from any printing module in the system. Counting in all modules stops at system preset or at print command. The start-data-transfer signal is supplied by the printer control into module 1 (Fig. 3.1), by module 1 into module 2, by module 2 into module 3, etc. As each module finishes transfer of its data, it sends a signal to the next counter in the loop; the signal that is accepted to start transfer is called previous module finished (PMF) and the signal that is furnished to indicate completion is called this module finished (TMF) in the 776 schematic.

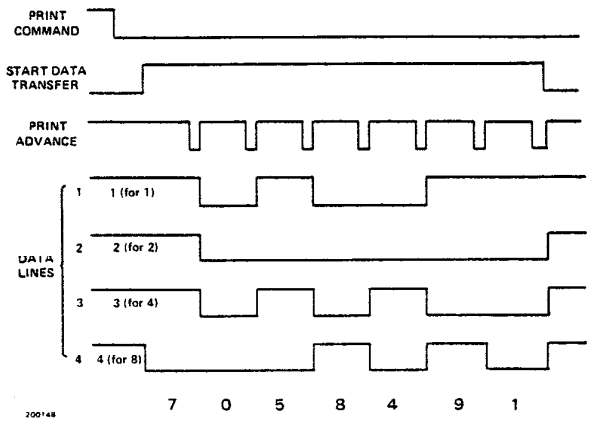

Fig. 4.1. Signal Sequence for Transferring Data for 7058491 from a Printing Scaler to the Printout Control.

The following sequence of events helps to explain how a multiple-scaler printing system operates:

1. A print command is generated manually, by preset, or is triggered.

2. All counters* and timers stop accumulating and remain static for 1 or 2 s.

3. All indicators go off except the most significant digit in counter 1, which is printed by the output device.

4. Each of the remaining digits in counter 1 is printed in succession and, as each digit is printed, the indicator for that digit is illuminated.

5. A space is formed in the printed format after the digits representing the first scaler module.

6. The digits of scaler 2 are printed in succession.

7. A space is formed as in step 5.

8. This sequence repeats until the last scaler module has finished printing. The this-module-finished signal to the Printout Control indicates completion of the printout cycle.

9. After the last scaler module has been printed, one of two basic modes can be selected:

a. The system will remain in a static or noncounting mode until a new cycle is started. The scaler module indicators will be on.

b. A system reset will be generated and data accumulation will restart.

*The word Counters is used here to indicate any one of the 400 and 700 series ORTEC digital printing modules.

5. CIRCUIT DESCRIPTION

5.1. GENERAL

A block diagram and a schematic diagram are included at the back of the manual and should be used for reference in this section.

The 776 consists of two complete 7-decade counters, A and B, that share a common display and set of control circuits. Counter A accepts either positive or negative pulses that are subjected to synchronization and gating before they are counted. Synchronization prevents ambiguity of pulse recognition at both the start and the stop of a counting interval, and the synchronization circuits include both local and system gate controls and both local and system preset. Reset of the counting registers can originate locally or from the system reset line.

Counter B can accept pulses from either an internal oscillator and countdown circuit or from the Ext B input connector on the rear panel. The input circuit selection is made with a slide switch on the printed circuit board, accessible through the left side panel of the module. When the switch is set at 0.1 Sec or at Min, counter B operates as a timer and counts time increments that are provided from the internal crystal-controlled 1-MHz oscillator and its countdown circuit. When the switch is set at Ext, counter B accepts and counts positive input pulses that are furnished through the rear panel connector. The external input circuit includes synchronization circuits that function the same as those described for counter A. Counter B is normally used as a preset stop control that affects both counting sections in the 776 and also generates a system preset signal for system use.

The 28 data lines, for seven 4-bit words from each counting register, are gated, one digit at a time in sequence, into a multiplexer. The multiplexer selects the available digit from counter A or from counter B according to the setting of the Display switch on the front panel. An internal scanner sequences the gating for all seven digits from each counter, selecting the most significant digit followed by each successively less significant digit and then recycling the scan for the digital display at the top of the front panel. The same scanner, operating at a much slower rate, selects the digits for gating into a printing loop, and the printing program also includes an automatic selection of counter A followed by counter B.

During nonprinting intervals the scanner is driven by an internal 1-kHz oscillator. It continually recycles the scan to display the seven digits in the register (A or B) that is selected by the front panel switch. During printing intervals the internal oscillator is turned off and the scan is advanced at the rate of the printing accessory to print all seven digits for counter A first. The printer controller generates a space or carriage return to the printing accessory and then selects the digits from counter B with the scan program.

The preset circuit includes one decade counter that counts the overflow pulses at a selected decade level in the counter B register. When the preset decade reaches the selected preset digit, m, the control logic generates both local and system preset to stop counting in all registers. The decade overflow level in the counter B register is selected by the n switch on the front panel. The preset function is turned off when the m switch is set at 0.

The nomenclature used to identify the IC packages referred to in this manual is defined below for the example

IC2(4)

where

IC = integrated circuit,
2 = component number,
(4) = pin number.

Any portion of an IC package can be designated by its output pin designation.

5.2. COUNTER A

Positive Input Circuit Positive input pulses can be accepted through either the front or rear panel BNC, CN1 or CN2, and are dc-coupled into IC39, a differential comparator. A dc bias level is applied to the negative input of IC39 from the front panel Discriminator control, R36. When the input pulse amplitude exceeds the bias level, synchronization flip-flop IC41(11) and (8) can be triggered through IC42(8) unless triggering is inhibited by a gating condition. When the flip-flop is triggered, it sends a pulse through IC43(3) to IC1(14) to add one count in the counting register.

Negative Input Circuit Negative input pulses can be accepted through the rear panel BNC, CN3. An input that exceeds the −250-mV bias for a minimum of 4 ns will trigger a 20-ns one-shot, Q15 through Q18. If the gating condition permits it, this pulse then passes through IC46(11), IC46(8), and IC46(3) to be counted in the counting register.

Gating and Synchronization Gating can be controlled by a variety of signals. The manual Count switch enables the gate and the Stop switch disables the gate. A signal through the Gate connector, CN5 on the rear panel, disables the gate. Internal preset from counter B disables the gate. A system preset signal through the printer loop from another module also disables the gate. The gating function is common to both counter A and counter B.

The manual switches, Count and Stop on the front panel, control flip-flop IC8(8) and IC10(3) directly. When the Count switch is pressed, IC8(8) goes positive and IC8(12) goes low unless a gate or preset signal is present. When

IC8(12) goes low, the gate indicator, LED1, is turned on through IC14(8) and IC10(8). If counter B is being used as a timer, the LG line goes high at the next clock pulse after IC4(2) goes high; the circuit is through IC2(8), IC3(10), IC3(13), and IC4(10). If counter B is being used as a counter, the LG line goes high through IC8(12), IC3(1), IC3(13), and IC4(10).

When the Stop switch is pressed, the LG line goes low immediately but, if a pulse is present at the positive input of counter A or at the Ext Input of counter B, the pulse will be counted. The Stop switch sets IC8(8) low, IC8(12) high, IC14(8) low, and IC10(8) high and turns off LED1. The LG line is forced low through either IC3(10) or IC3(1), depending on whether counter B is being used as a timer or a counter. If the Gate input goes low or a local or system preset signal occurs, IC8(12) goes high to provide the LG line low condition.

Counting Register A This consists of IC1 through IC7, connected to form a ripple counter for all seven digits of the 9,999,999 count capacity. IC1 is the least significant digit and IC7 is the most significant digit. The BCD identification of each digit in each decade is carried through four BCD lines to a set of gates that will pass each group of four bits selectively by gating from the scanner.

Overflow Circuit The overflow from IC7 is coupled through C6 to generate an output pulse through CN7 unless the 8-bit of IC7 goes low because of a reset rather than because of an accumulated count level. The first overflow after a reset will also set flip-flop IC26(11) and (8) to light LED2, the Overflow indicator on the front panel. The LED2 remains lighted until the next reset.

5.3. COUNTER B

Input Counter B may be used as either a timer or a counter. The counting mode is selected by a switch accessible through the left side panel of the module, S3. The switch selects Ext for external input pulses and operation as a counter, or 0.1 Sec or Min for internally supplied crystal-controlled time increment pulses and operation as a timer.

Timing Oscillator and Countdown The timing oscillator is the circuit of Q1 and Y1 and operates at 1 MHz. Capacitor C4 is a factory-adjusted trimmer in the oscillator. The output is furnished to the countdown input at pin 3 of IC1 on the 776-0301 printed circuit board.

IC1 will count input pulses only when the signal at its pin 5 is at +5 V, and the signal is furnished from the Q output of IC2, synchronized by an oscillator pulse that follows the release of a gating control interval. If pin 11 of IC1 is held low, there is an output through pin 1 for the accumulated count of 10^5 input pulses. If pin 11 is high, the count in IC1 must reach 6×10^7 to generate an output and reset.

The pulse at IC1(1) passes through the gating of IC44(6), (11), and (3) to reach the counting register. IC44(6) is enabled when S3 is set at either 0.1 Sec or Min. IC44(11) is enabled by the same control source. IC44(3) is enabled unless the counter has reached a preset condition. IC45(12) is an inverter and provides no gating conditions.

When S3 is set at Ext, IC1 generates output pulses at 1-min intervals but these will not reach the counting register. The entire countdown circuit is reset to zero by a local reset (LR) when this signal is furnished from IC9(8).

External B Input Circuit When switch S3 is set at Ext, the counter B register will count only the positive input pulses that are furnished through the Ext B Input connector, CN4 on the rear panel. This input circuit can accept pulses for counting at rates of up to 20 MHz. The low signal from S3 is inverted through IC4(12) to enable IC44(8) to pass the input pulses when they are furnished to IC44(9).

The external input is coupled through Q19 to trigger the synchronizing flip-flop IC43(8) and (11) through IC42(6), unless triggering is inhibited by a gating condition. The output of the flip-flop is passed to the counting register through IC44(8), IC44(11), IC44(3), and IC45(12), subject to gating conditions of S3 and whether or not the counter has reached a preset condition.

Counting Register B This consists of IC28 through IC34 connected as a ripple counter for seven decades. IC28 is the least significant decade and IC34 is the most significant decade. The BCD identification of each digit is carried through four BCD lines to a set of gates that will pass each group of four bits selectively by gating from the scanner.

Preset and Dwell Time Circuits The preset circuit includes switches S1 and S2 on the front panel. Each is a thumbwheel digit selector. S1, marked m, selects any digit, 0 through 9. S2, marked n, selects any decade level from 0 through 6. The resulting preset count level in counter B is equal to $m \times 10^n$. Setting m at 0 or n at a number greater than 6 disables the preset circuit.

The m decade uses IC48 and IC47 to count input pulses selected by n switch S2. The counted level in IC48 and IC47 provides a high output at its corresponding digit level. The m switch selects which digit to monitor for the high output to generate a preset condition. After the effective pulse has been counted in the main register, IC46(6) goes high and allows IC42(12) to generate the internal preset signal.

Preset inhibits IC44(3) and provides a gate-off signal to both counting register inputs through IC10(6), IC14(12), IC8(12), IC14(8), IC10(8), IC4(2), IC3(1), IC3(13), and IC4(10). If the Dwell Time control, R59, is at Off and the 776 is not in a printing loop, the counting function is inhibited until manual reset or an external reset is furnished. If the Dwell Time control is on, this triggers

monostable IC13(6), and the monostable period is selected by the resistance set with R59. At the end of the delay period monostable IC13(10) is triggered to generate a recycle reset signal, which then generates a local reset (LR) through IC8(6) subject to gating conditions that may be imposed by the printing control line, IC14(4), IC11(2), and IC9(8). When dwell time is being used, counting in both registers stops at preset, the accumulated count level is displayed through the dwell interval, both registers are reset to zero, and a new counting interval starts.

5.4. SCANNING AND DATA MULTIPLEXING

The scanner generates Z1 through Z7 output signals in sequence. When it generates Z1, the most significant decade in both counters is gated into the multiplexer. Then it gates each less significant decade in order through Z7. For example, at Z1 the gates in IC14 furnish the four bits in IC7 to the A inputs of IC27, and the gates in IC23 furnish the four bits in IC34 to the B inputs of IC27. The signal at IC27(1) chooses between the two sets of data to furnish the output signals at pins 4, 7, 9, and 12.

When no print signal is furnished from a printer loop, an internal oscillator advances the scanner. When a print signal is present, the scanner counts the print advance signals between a previous-module-finished (PMF) signal and a this-module-finished (TMF) signal. The PMF signal is furnished from the printing control or from the previous module in the printing loop, the 776 scans through the seven digits for counter A, changes the control signal, scans through the seven digits for counter B, and then delivers the TMF signal out to the printing loop. Each digit is printed by the printing accessory while it is being presented from the 776, and advance is returned from the printer after the digit has been accommodated. Spaces and line advance in the printer are also a standard part of the program.

The internal oscillator uses IC45(2) and (4) to generate an output signal at an approximate rate of 1 kHz. The output feeds through IC38(11) and (8) unless a print signal is present at the clock input of IC37. The BCD outputs from IC37 are fed to the 10-line decoder, IC36. IC37 is preset to 9 and this is decoded by IC36 as a $\overline{Z1}$ at IC36(11) and inverted for Z1 at IC24(2). The next oscillator output pulse advances IC37 to zero and this is decoded as $\overline{Z2}$ at IC36(1) and as Z2 at IC35(12). A sequential signal generation cycles through Z3 to Z7. When the counter advances out of the Z7 condition, IC37 is preset to 9 through IC38(3) and IC38(6) to start a new scan cycle.

5.5. DECODER AND DISPLAY

The four BCD bits that are present on the common lines out of the multiplexer at any time represent one of the digits in the counter section that is selected for display. This combination is decoded in IC15 to furnish the correct configuration of blanking and illumination for the seven LED segments at the anodes of all seven digits in the display. The scanner signal will have selected which of the digits is to be gated from the counting register to the four common lines, and the same signal, Z1 through Z7, completes the cathode path for the correct digit in the display. For example, when Z7 is present, the cathode for the least significant digit in the display is selected through Q2 and the configuration of the digit is identified through IC8 or IC17, depending on which counter is selected for display. IC25(6), IC25(3), IC26(6), IC25(8), and IC25(11) provide control for automatic blanking of insignificant zeros in the display. At Z1 time, for the most significant digit, IC15 receives a signal from IC25(8) to blank all segments if all inputs to IC15 are low. Internal logic in IC15 resets the blanking circuit through IC25(11) when it identifies any digit other than zero from the four common lines. Until there is a digit that is not zero, no digits will be shown in the display.

When switch S8 is at Counts (A) and the scan reaches Z7, the signal at IC25(3) removes the blanking through IC26(6) and IC25(8) if it had not been removed prior to this time in the scan cycle; so the least significant digit is always displayed. When switch S8 is at Time (B) and switch S3 is set at Min (for 1-min increments), the blanking is the same as for S8 in the Counts (A) position. When S8 selects Time (B) and S3 selects 0.1-Sec increments, blanking is turned off when the scan reaches Z6 through IC25(6) and IC26(6), and the last two digits are included in the display. Also when S3 selects 0.1-Sec increments, a decimal point is included in the display by the circuit through IC5(11), IC4(4), and Q27.

5.6. PRINTING CIRCUIT

A printing loop is formed by cabling the printing modules with either an ORTEC 777 Line Printer or a 432A Printout Control in a circuit as shown in Fig. 3.1. In normal operation the counters and timers can count until a system preset signal occurs, and then all modules will stop counting and the accumulated data will be transferred to the printer from each module in the loop. At system preset all modules stop counting and the 777 or 432A generates a print output signal.

System preset is generated in the 776 through IC42(12), IC14(2), and Q4 or it is accepted from the system common line through Q3, IC10(6), and IC14(12). At preset the 776 turns off the input gate through IC8(12) to prevent any advance of either counting register.

The print signal is accepted through pin 5 of the In/Out connector on the rear panel, which is connected into the printing loop. The signal is coupled through Q24 to inhibit oscillator gate IC38(11), to reset the scan to Z1 through IC3(4), IC4(8), and IC38(6), and to clamp all four gates of IC16 to provide a "code 15" input to IC15 that blanks the display. The module then waits for its turn in the printing loop to transfer its data to the printer.

A PMF signal from the printer loop starts the scan cycle in the module. If the 776 is the first module in the loop, PMF originates in the 777 or 432A. If the 776 is in any other location in the loop, PMF is the TMF output from the previous module to be served in the loop as described in Section 3. The PMF releases the reset latch at IC38(6) through Q9, Q10, IC5(3), IC5(8), IC3(4), and IC4(8); it releases the blanking clamp to IC15; it enables gates IC40 to transfer data from the four common lines in the 776 to the system common lines; and it passes a signal from IC5(3) through IC14(6) and IC11(3) to hold IC27(1) low to select the data from counter A for presentation to the common lines. The most significant digit from counter A is gated from IC7 through IC14 by Z1, through IC27 to IC40, and out to the system common lines. When the digit has been accepted by the printer, print advance is returned through Q23 and IC38(8) to advance IC37 and select Z2. Each subsequent print advance selects the next digit until Z7. Flip-flop IC2(5) and (6) is triggered at the end of Z7; IC5(6) goes low and IC5(3) goes high and selects counter B data through IC14(6), IC11(3), and IC27(1). It also generates a high signal on the TMP line through IC5(8) and IC24(8) to the printing control. When IC2(5) goes high, it triggers monostable IC7(9) for the period that is set by R48 and C11. At the end of this period IC6(6) is clocked high to again pull the TMP line low through IC5(6), IC5(8), and IC24(8). The scan has been reset to Z1 and the data from IC34 are gated to the common lines through IC23; print advance again advances the scan through counter B and at the end of Z7 monostable IC7(6) and (7) is triggered for the period set by R60 and C21. During this period flip-flop IC6(8) is clocked low and IC6(9) high. When IC6(8) is low, it forces TMP high through IC5(6), IC5(8), and IC24(8). At the end of this period a TMF signal is generated through IC10(11), IC12(6), and Q8. IC5(8) goes low to gate off IC40 and restore the off-line condition of the 776.

When the last module in the loop furnishes TMF to the control module, the control module determines the next sequence. It can remove preset, generate reset, or do whatever is appropriate to the program that has been selected.

5.7. LOCAL RESET

Local reset (LR in the schematic) is generated at IC9(8) if any one or more of its inputs go low. The inputs originate with Reset switch S10, from Reset Input CN10 through IC11(2), from Q14 when power is first applied to the module, or from the system reset line through Q6. When LR goes high and $\overline{LR}$ goes low, all counting circuits are reset to zero. If in IC7 this causes the 8 bit to be reset, an overflow output is inhibited by LR through IC24(6).

5.8. POWER SUPPLY

The 776 includes an internal power supply that uses the 115-V ac power source from the bin and power supply in which the module is installed for operation. The internal power supply generates +5 V that is used for input power for all the integrated circuit packages in the module.

Transformer T1 furnishes the secondary voltage that is full-wave rectified and filtered and furnished to Q28 on the rear panel. Q28, Q25, and Q26 together form a regulator for the +5-V output. Fuse F1 protects the power supply from overload.

The 776H version of this instrument accepts +6 V from the bin and power supply and applies it directly to the collector of Q28 and it is equivalent to the rectified output from T1 in the basic 776 design. The transformer, rectifier, and capacitor C1 are not included in the 776H circuit, but all the other components are the same in both versions of the instrument.

6. MAINTENANCE

6.1. GENERAL

The basic performance of the 776 Counter and Timer can be tested by following the procedure outlined in Section 4.2. This will not check the unit to its published specifications.

If the unit fails to respond properly during testing, use the information in Section 5 to determine the fault. Block diagram 776-0101-B1 and schematic 776-0101-S1 at the back of this manual include all the circuits in the instrument.

6.2. FUSE REPLACEMENT

If the front panel and LED indicators cannot be lighted, remove the module from the bin and take off the left side panel for access to the inside of the rear panel. Inspect fuse F1, mounted in a fuseholder on the rear panel. This fuse protects the +5-V power source from overload, and the indicators cannot be lighted unless this power is present. Replace with a 1.5-A fast-acting type 3AG fuse only.

6.3. FACTORY REPAIR

The 776/776H may be returned to ORTEC for repair service at a nominal cost (see Warranty in front of manual). Our standard procedure requires that each repaired instrument receive the same extensive quality control tests that a new instrument receives. It is essential that our Customer Service Department be contacted [(615) 482-4411] for shipping instructions before the instrument is shipped.

BIN/MODULE CONNECTOR PIN ASSIGNMENTS FOR STANDARD NUCLEAR INSTRUMENT MODULES PER DOE/ER-0457T

Pin	Function	Pin	Function
1	+3 volts	23	Reserved
2	−3 volts	24	Reserved
3	Spare Bus	25	Reserved
4	Reserved Bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 volts
7	Coaxial	*29	−24 volts
8	200 volts dc	30	Spare Bus
9	Spare	31	Spare
*10	+6 volts	32	Spare
*11	−6 volts	*33	117 volts ac (Hot)
12	Reserved Bus	*34	Power Return Ground
13	Spare	35	Reset (Scaler)
14	Spare	36	Gate
15	Reserved	37	Reset (Auxiliary)
*16	+12 volts	38	Coaxial
*17	−12 volts	39	Coaxial
18	Spare Bus	40	Coaxial
19	Reserved Bus	*41	117 volts ac (Neut.)
20	Spare	*42	High Quality Ground
21	Spare	G	Ground Guide Pin
22	Reserved		

Pins marked (*) are installed and wired in EG&G ORTEC's 4001A and 4001C Modular System Bins.