Model 976
Quad 250-MHz Counter/Timer
Operating Manual

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Advanced Measurement Technology, Inc.

a/k/a/ ORTEC®, a subsidiary of AMETEK®, Inc.

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Before being approved for shipment, each ORTEC instrument must pass a stringent set of quality control tests designed to expose any flaws in materials or workmanship. Permanent records of these tests are maintained for use in warranty repair and as a source of statistical information for design improvements.

Repair Service

If it becomes necessary to return this instrument for repair, it is essential that Customer Services be contacted in advance of its return so that a Return Authorization Number can be assigned to the unit. Also, ORTEC must be informed, either in writing, by telephone [(865) 482-4411] or by facsimile transmission [(865) 483-2133], of the nature of the fault of the instrument being returned and of the model, serial, and revision ("Rev" on rear panel) numbers. Failure to do so may cause unnecessary delays in getting the unit repaired. The ORTEC standard procedure requires that instruments returned for repair pass the same quality control tests that are used for new-production instruments. Instruments that are returned should be packed so that they will withstand normal transit handling and must be shipped PREPAID via Air Parcel Post or United Parcel Service to the designated ORTEC repair center. The address label and the package should include the Return Authorization Number assigned. Instruments being returned that are damaged in transit due to inadequate packing will be repaired at the sender's expense, and it will be the sender's responsibility to make claim with the shipper. Instruments not in warranty should follow the same procedure and ORTEC will provide a quotation.

Damage in Transit

Shipments should be examined immediately upon receipt for evidence of external or concealed damage. The carrier making delivery should be notified immediately of any such damage, since the carrier is normally liable for damage in shipment. Packing materials, waybills, and other such documentation should be preserved in order to establish claims. After such notification to the carrier, please notify ORTEC of the circumstances so that assistance can be provided in making damage claims and in providing replacement equipment, if necessary.

CONTENTS

SAFETY INSTRUCTIONS AND SYMBOLS

This manual contains up to three levels of safety instructions that must be observed in order to avoid personal injury and/or damage to equipment or other property. These are:

DANGER Indicates a hazard that could result in death or serious bodily harm if the safety instruction is not observed.

WARNING Indicates a hazard that could result in bodily harm if the safety instruction is not observed.

CAUTION Indicates a hazard that could result in property damage if the safety instruction is not observed.

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product.

In addition, the following symbol may appear on the product:

ATTENTION – Refer to Manual

DANGER – High Voltage

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product.

SAFETY WARNINGS AND CLEANING INSTRUCTIONS

DANGER	Opening the cover of this instrument is likely to expose dangerous voltages. Disconnect the instrument from all voltage sources while it is being opened.

WARNING	Using this instrument in a manner not specified by the manufacturer may impair the protection provided by the instrument.

Cleaning Instructions

To clean the instrument exterior:

- Unplug the instrument from the ac power supply.
- Remove loose dust on the outside of the instrument with a lint-free cloth.
- Remove remaining dirt with a lint-free cloth dampened in a general-purpose detergent and water solution. Do not use abrasive cleaners.

CAUTION	To prevent moisture inside of the instrument during external cleaning, use only enough liquid to dampen the cloth or applicator.

- Allow the instrument to dry completely before reconnecting it to the power source.


ORTEC®
976
QUAD COUNTER/TIMER
IN
GATE
NORMAL
GATE
GT+CLR
CH1
IN
GATE
CARRY
NORMAL
GATE
GT+CLR
CH2
IN
GATE
NORMAL
GATE
GT+CLR
CH3
IN
GATE
CARRY
NORMAL
GATE
GT+CLR
CH4
RST
CH1
CH2
CH3
CH4
IN
OUT
END MARKER
SGL
REP
COUNTER
1uS
LOAD
TIMER
1mS
2 2 1 4 0 7 5
Ser. n.

ORTEC MODEL 976 QUAD COUNTER/TIMER

1. DESCRIPTION

The ORTEC Model 976 Quad Counter/Timer is a double-width NIM module that includes four independent 8-digit up-counters, plus a fifth 7-digit down-counter, making the module a flexible and powerful tool for several applications involving time, frequency, and ratio measurements.

Each of the 8-digit counters has its own display and can accept up to 250 MHz input rates. These counters can be cascaded to increase the word length to 16 digits for two counters, and 24 digits for three counters.

Counters 1 and 3 have a set of bridged gate connectors to allow a single gate to be used on multiple counters. Counters 2 and 4 have a “carry” or overflow output to allow the cascading of the counters.

Counter 5 has its own display and can accept up to 80 MHz input. It can be used as a timer, counter, rate divider, or delay.

All counters can accept either TTL or NIM inputs. All control and output signals are standard NIM. All input and output connectors as well as all the control switches are located on the front panel. All input and output connectors are LEMO 00 type. Figure 1 (page 2) shows the front panel.

2. SPECIFICATIONS

2.1. PERFORMANCE

CLOCK 1 MHz crystal controlled internal clock +/-50 ppm. Temperature coefficient <2ppm/°C. Jitter <3 ppm at 1 μs clock period, <5ppm at 1 ms clock period.

TIME DELAY UNCERTAINTY Equal to one clock period.

2.2. INPUTS AND OUTPUTS

CH 1, 2, 3, 4 IN Accepts positive TTL or Fast negative NIM signals. Minimum pulse width is 2 ns. Pulse-pair resolution is 4 ns. Accepts up to 250 MHz. Z_{in} = 50 Ω. LEMO 00 connector. FWHM = 2 ns in NORMAL and GATE modes, 2.2 ns in GT+CLR mode.

SECTION 5 IN Accepts positive TTL or fast negative NIM signals up to 80 MHz. Z_{in} = 50 Ω. LEMO 00 connector. Pulse-pair resolution is 12.5 ns.

CH 1 and 3 GATE Accepts positive TTL or fast negative NIM levels. Z_{in} = 50 Ω. LEMO 00 connector.

CH 2 and 4 GATE Accepts positive TTL or fast negative NIM signals. Bridged input allows multiple connections. Z_{in} = 1 kΩ . LEMO 00 connector.

CH 2 and 4 CARRY Provides a fast NIM output when the counter rolls over to zero from the maximum value 99,999,99, allowing cascading of counter (see Section 4.2).

RESET Input clears all four counter inputs accepts positive TTL or fast negative NIM levels. Z_{in} = 50 Ω. LEMO 00 connector. FWHM = 3 ns.

LOAD Input accepts positive TTL or fast negative NIM signals. Z_{in} = 50 Ω. Lemo 00 connector. Loads the Section 5 counter with preset values from the thumb switches. Load input is disabled in REP mode and while the counter is counting in SGL mode. FWHM = 3 ns.

The LOAD input signal (by button push or sending LOAD input signal) resets the Section 5 counter if the counter has an error condition due to:

- Using an external clock greater than 80 MHz
- Using an external clock with pulse widths <3 ns
- Changing the external clock frequency
- Switching from internal to external clock

OUT Two separate outputs provide a negative NIM level output (-800 mV) as long as the counter contents are other than zero. The trailing edge of the first input pulse initiates the NIM level output and the trailing edge of the last input pulse switches the output to zero.

END MARKER Negative NIM level output (-800 mV). Pulse width adjustable from 50 ns to 1 μs.

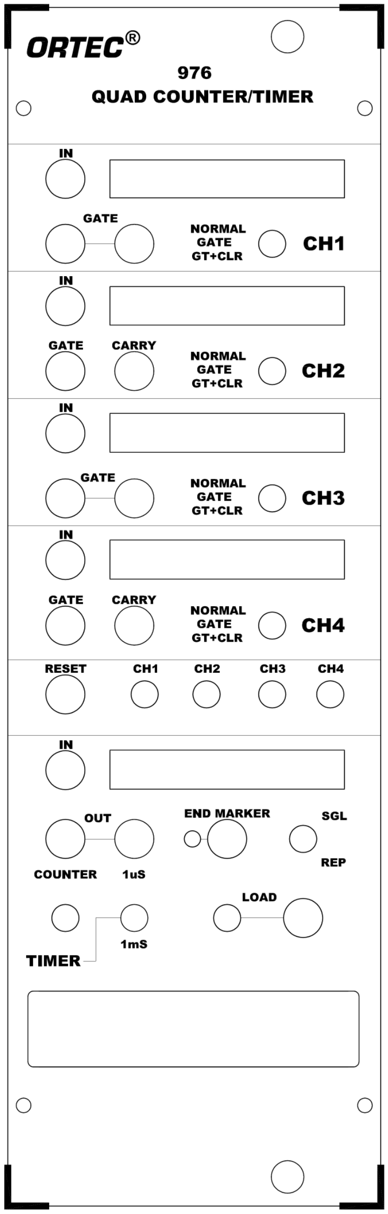

Figure 1. Front Panel.

2.3. CONTROLS

CH1, 2, 3, & 4 NORMAL, GATE, GT+CLR Switches Switch counter modes:

- **NORMAL** — Counter free runs and is incremented by the input.
- **GATE** — Counter runs only with a gate present.
- **GT+CLR (Gate plus clear)** — Counter runs with gate present; the leading edge of the gate clears the counter.

A logic signal at the RESET input resets all four counters to zero, and individual channels can be manually reset by pushing the corresponding channel reset button.

RST CH1, CH2, CH3, CH4 Switches Pushbutton manually resets the corresponding channel to zero.

END MARKER (Trimpot) Screwdriver adjustment for setting the End Marker pulse width between 50 ns and 1 μs.

SGL/REP Switch Switches Section 5 operation mode. SGL or Single mode disables the LOAD input during an active count. The LOAD input can start a new count after a count is complete. Once started, the counter counts until zero is reached and then stops. The LOAD button can start a new count at any time, even during a count. Note the counter delays acceptance of a manual LOAD pulse (i.e., a push of the LOAD button) by 80 ns. REP or Repeat mode causes an automatic LOAD pulse to be generated 2 s after a cycle ends. Connection of the END MARKER output to the LOAD input removes this 2 s delay. The LOAD input is completely disabled in REP mode. Note that activating the LOAD pushbutton causes a restart at any time.

COUNTER/TIMER Switch Switches the function of Section 5 between COUNTER and TIMER mode.

1 μs/1 ms Switch In TIMER mode, switches the clock frequency to 1 MHz in the 1 μs position and 1 KHz in the 1 ms position.

LOAD Switch Pushbutton switch loads the thumbwheel settings for Section 5, for either the counter or timer mode.

Note that activating the LOAD pushbutton (e.g., sending the LOAD input signal) resets Section 5 if the Section 5 counter has an error condition due to:

- Using an external clock greater than 80 MHz
- Using an external clock with pulse widths <3 ns
- Changing the external clock frequency
- Switching from internal to external clock

Thumbwheel Switches 7 switches designate preset value to be loaded into Section 5; functions in both COUNTER and TIMER modes.

2.4. ELECTRICAL AND MECHANICAL

POWER REQUIRED +6 V, 0.7 A; -6V, 0.9 A

WEIGHT
- Net 1.02 kg (2.3 lb)
- Shipping 3.7 kg (8.2 lb)

DIMENSIONS NIM-standard double width module 6.90 cm X 22.13 cm (2.70 in. X 8.714 in.) front panel per DOE/ER-0457T.

3. PRINCIPLES OF OPERATION

3.1. SECTIONS 1–4

The 8-digit up-counters can operate in three distinct modes:

- **NORMAL** Free running. The counter is incremented by the input pulses.
- **GATE** The counter is incremented by input pulses only if the GATE input is true.
- **GATE+CLR** Same as GATE mode, but the leading edge of the GATE input clears the counter.

The modes are manually selectable, for each section, with the relevant front-panel switches (Section 2.3). The up-counters are reset to zero, either manually (individually for each section) by pressing the RESET pushbuttons, or electrically (common to all sections) by means of a NIM/TTL pulse on the RESET input.

Sections 1 and 3 have two NIM/TTL, high-impedance GATE bridged inputs which are internally connected. A NIM/TTL input must be terminated with a 50 Ω impedance at the other port.

Sections 2 and 4 have one 50 Ω GATE NIM/TTL input and one CARRY NIM output. The CARRY output generates a NIM pulse when the counter has fully cycled (e.g., when it rolls over to zero from the maximum counter value, 99,999,999). This can be used to extend the counters' range by cascading sections, as discussed in Section 4.2.

3.2. SECTION 5

The fifth counter is a 7-digit counter that can operate as a preset DOWN-COUNTER or as a TIMER. Choose the mode with the manual source-select switch, labeled COUNTER/TIMER. Figure 2 shows the Section 5 timing diagram.

In COUNTER mode the counter is decremented by the external (NIM or TTL) input pulses.

In TIMER mode the counter is decremented by an internal clock, regardless of the input pulses. Select the frequency, 1 KHz (1 ms) or 1 MHz (1 µs), with the TIMER switch.

In both modes, the counter must be preset to the desired value by setting the thumbwheel switches then loading the preset either by manually pushing the LOAD button or sending the LOAD NIM/TTL pulse.[1] At the trailing edge of the first input pulse, the OUT ports become true. The counter is then decremented by the input pulses until zero is reached. At the trailing edge of the last input pulse:

- The OUT outputs are reset to FALSE (0 V).
- The END MARKER output generates a NIM pulse whose length can be adjusted between 50 ns and 1 µs by setting the trimmer next to the END MARKER connector. This signal is retriggerable, thus it can be extended while active by another completed cycle. If the END MARKER is used for retriggering purposes (i.e., if it is sent to the LOAD connector), a delay longer than the END MARKER duration is required between these connectors.

This arrangement allows direct use of the OUT ports as GATE inputs to the counters of Sections 1–4.

CYCLING of Section 5 is controlled by the SINGLE/REPEAT switch, which is labeled SGL/REP.

[1]Any value can be loaded except zero, which is not recognized by the module.

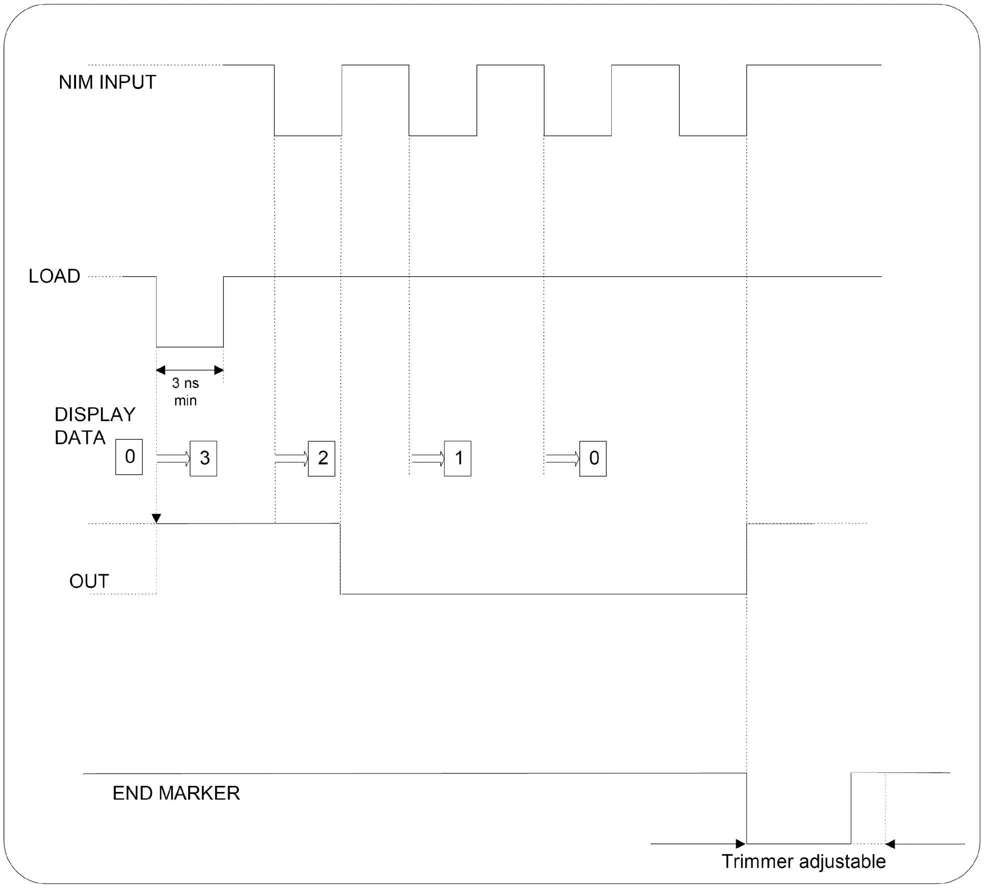

Figure 2. Section 5 Timing Diagram.

- In SINGLE mode, the selected function (PRESET COUNTER or TIMER) is performed only once, until zero is reached. In order to restart the counter, a new load operation is required. Actually, when using the LOAD button, the counter can be restarted even BEFORE zero is reached. The LOAD NIM/TTL signal is disabled during counting. After a LOAD via pushbutton, the unit requires 80 ns at least before accepting LOAD pulses, even if the counter is already zero and thus the cycle completed.

- In REPEAT mode, a few seconds after zero is reached the counter re-triggers itself automatically, by performing an automatic LOAD, and a new cycle is restarted. The automatic LOAD takes place every 2 seconds after every cycle end. This procedure is repeated indefinitely; anyway, the LOAD button allows to restart the counter at any time. The LOAD NIM/TTL is disabled in REPEAT mode.

To cycle the counter without the REPEAT mode time delay, connect the END MARKER output load to the LOAD input.

NOTE The following error conditions could cause Section 5 to operate incorrectly:

- The use of an external clock with frequency larger than 80 MHz
- The use of an external clock with pulse width shorter than 3 ns
- The variation during the counter operation of the external clock frequency
- The switching from internal clock to external or vice versa

To recover and return Section 5 to normal operation, issue the LOAD signal manually or electrically.

4. OPERATING MODES

4.1. GATED UP-COUNTING

In NORMAL MODE, the counters (Sections 1–4) do not require a GATE input. However, in GATE (or GATE+CLEAR) mode, a NIM/TTL signal must be supplied at the GATE input of each counter used.

> **NOTE** When using NIM input signals, this signal has to be terminated with a 50 Ω impedance at the other GATE bridged input, on Sections 1 or 3.

A single GATE signal can be sent, in parallel, to two channels via cables. If the last Section is either 2 or 4, this also provides the correct 50 Ω cable termination. For example, Sections 1 and 2 can share a GATE by feeding the external GATE signal to the GATE input of Section 1, then connecting a cable between the other GATE output of Section 1 to the GATE input of Section 2, which has a 50 Ω impedance. It is also possible to connect three sections (for instance #1 with #3, and then #3 with #2 or #4) via cables, in order to send them a single external GATE input.

The OUT signal of Section 5 can be used as the GATE input to the counters. The double OUT connector permits parallel GATE feeding of all four sections, as described above.

4.2. 16- OR 24-DIGIT UP-COUNTING

It is possible to increase the up-counting range to 16 or 24 digits by using the CARRY outputs of Sections 2 and 4.

For instance, 16-digit up-counting is obtained by connecting the CARRY output of Section 2 to the input of Section 1. When the counter of Section 2 has fully cycled (rolls over from 99,999,999 to zero) the CARRY output supplies a NIM input pulse to Section 1, and so on. Thus Section 1 will show the most significant digits of the counting operation and Section 2 the least significant digits.

Similarly, for 24-digit up-counting, the CARRY output of Section 2 can be connected to the input of Section 4; the CARRY output of Section 4 can then be fed to the input of Section 1 or 3.

4.3. FREQUENCY MEASUREMENTS

The Model 976 can make relative frequency measurements using Section 5 in TIMER mode.

To do this:

- Use the TIMER switch (τ = 1 µs or 1 ms) to select the clock rate: $f = 1/\tau$
- Select a value *N* (for instance, a power of 10) with the thumbwheel switches. The measurement time is then $T_i = N\tau$.
- Choose one of Sections 1–4 as the counter and use the OUT signal as the GATE input to the selected section, operating in GT+CLR mode.

The external input frequency is then given by:

$$f_i = M_c / N\tau$$

where M_c is the number of pulses received by the counter while GATE is active.

4.4. DIVIDER

Section 5 can also be used as a divider of an external input sequence. For that purpose:

- Connect the END MARKER output to the LOAD input.
- Select the input/output ratio *R* by setting the thumbwheel switches.
- Connect the external input at the Section 5 INPUT port and select the NIM output (a signal generated every *R* pulses at the input) from the OUT ports.

4.5. DELAY UNIT

Section 5 can also be used to generate a delayed pulse (at the END MARKER output) or transition (at the OUT ports).

An absolute delay can be obtained with Section 5 in TIMER Mode. The duration of the delay (actually the time interval between the LOAD signal leading edge and the leading edge of the END MARKER) is:

$$T_d = N\tau$$

where *N* is the preset value on the thumbwheel switch display, and τ is the internal clock period. The time delay, *d*, is the elapsed time between the time of the leading edge at the LOAD input and leading edge either at the END MARKER output. See the next section for accuracy. With the counter in COUNTER Mode, a relative delay (in terms of number of pulses) can be obtained between the NIM/TTL input and the END MARKER, after the preset number of input pulses have been counted.

4.6. MEASUREMENT ACCURACY

For the previous applications, it is important to remember that, for any measurement made with a counter on a periodic waveform, there is always an intrinsic uncertainty of one pulse. This is due to the fact that, depending on the position of the start of the measurement window with respect to the period of the waveform, one pulse may or may not be totally included and thus accounted for. This also applies to the uncertainty of the selection of the reference time window. The uncertainty of the measurement of an absolute time delay is therefore equal to the clock period.

For frequency measurements it is:

$$\Delta f_i = f_{max} - f_{min} = (M_c / N\tau) - ((M_c - 1)/N\tau) = 1/N\tau$$

where Δf_i is the absolute frequency uncertainty.

The relative frequency uncertainty is then:

$$\Delta f_i = 1 - M_c$$

and, since for a given (constant) frequency, M_c ($= N f \tau$) is proportional to N, the percent accuracy is increased by increasing N.