

fication. If this prefix differs from that listed on the title page of this manual, there are differences between this manual and your instrument.

### 1-3. Configuration

There are two configurations available for the Model 776:

- Model 776 - Two-channel 225 MHz programmable counter/timer.
- Model 776/2.4G - Same as above with 2.4 GHz Channel C and TCXO time base.
- Model 776/2.4G/R - Same as above with rear panel inputs.

### 1-4. Warranty Information


Warranty information is located on the inside front cover of this instructions manual. Should your Model 776 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the instrument for repair, be sure to fill out and include the service form at the back of this manual to provide the repair facility with the necessary information.

### 1-5. Manual Addenda

Any improvements or changes concerning the instrument or manual will be explained in an addendum included with the manual. Be sure to note these changes and incorporate them into this manual.

### 1-6. Safety Symbols And Terms

The following symbols and terms may be found on an instrument or used in this manual.

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The **WARNING** heading used in this manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

### 1-7. Inspection

The Model 776 was carefully inspected, both electrically and mechanically before shipment. After unpacking all items from the shipping carton, check for any obvious signs of physical damage that may have occurred during transit. (Note: There may be a protective film over the display lens, which can be removed.) Report any damage to the shipping agent immediately. Save the original packing carton for possible future re-shipment. The following items are included with every Model 776 order:

**Table 1-1.** Model 776 Specifications

<b>INPUT CHARACTERISTICS</b> (Channel A & B)	
<b>RANGE</b>	
DC coupled	: 0 to 225 MHz.
AC coupled 1 M $\Omega$	: 30 Hz to 225 MHz.
50 $\Omega$	: 1 MHz to 225 MHz.
<b>SENSITIVITY (X1)</b>	
0 to 200 MHz	: 50 mV rms sine wave.
200 MHz to 225 MHz	: 75 mV rms sine wave.
5 ns Minimum Pulse Width	: 75 mVp-p.
<b>SIGNAL OPERATING RANGE</b>	
(X1)	: -5.00 Vdc to +5.00 Vdc.
(X10)	: -50.0 Vdc to +50.0 Vdc.
<b>DYNAMIC RANGE (x1)</b>	
0 to 100 MHz	: 75 mV to 5 Vp-p.
100 MHz to 225 MHz	: 150 mV to 2.5 Vp-p.

Table 1-1. Model 776 Specifications (continued)

IMPEDANCE	: 1 M $\Omega$ or 50 $\Omega$ nominal shunted by less than 45 pF. switchable.
LOW PASS FILTER	: -3 dB NOMINAL at 100 KHz. switchable.
COUPLING	: AC or DC. switchable.
DAMAGE LEVEL (AC or DC)	
(X1)	: DC to 2 KHz - 200 V (DC + pk AC); 2 KHz to 100 KHz - $4 \times 10^5$ V rms Hz/Freq; Above 100 KHz - 5 V rms.
(X10)	: DC to 20 KHz - 200 V (DC + pk AC); 20 KHz to 100 KHz - $4 \times 10^6$ V rms Hz/Freq; above 100 KHz - 50 V rms.
50 $\Omega$	: 5 V rms
<b>TRIGGER LEVEL CHARACTERISTICS</b> (Channel A and B)	
<b>MANUAL TRIGGER (auto trigger off)</b>	
(X1)	: -5.00 Vdc to +5.00 Vdc;
(X10)	: -50.0 Vdc to +50.0 Vdc.
Setting Accuracy	: X1, $\pm$ (35 mV +2% of reading); X10, $\pm$ (350 mV +2% of reading).
Resolution (X1)	: 10 mV; (X10): 100 mV.
Preset (X1)	: 0.00 Vdc; (X10) 00.0 Vdc.
Trigger Slope	: Independent selection of positive or negative slope. switchable.
<b>AUTO TRIGGER</b>	
Frequency Range	
DC Coupled	: 100 Hz to 150 MHz.
AC Coupled 1 M $\Omega$	: 100 Hz to 150 MHz.
50 $\Omega$	: 1 MHz to 150 MHz.
Auto Trigger Level Range	: $\pm 50$ Vp-p.
Minimum Amplitude	: 100 mV rms sine wave, 280 mVp-p.
<b>ATTENUATOR</b>	
Manual	: X1 or X10 NOMINAL. selectable.
Auto	: Attenuator is automatically enabled when in Auto Trigger Mode.
Auto Attenuator Sensitivity	: Attenuator is switched when peak input signal exceeds 5.1 Vp-p.
<b>NOTES:</b>	
1. Auto trigger is disabled in the following functions: Totalize B and Frequency C.	
2. Auto trigger function requires that a repetitive signal be present at the input connector.	
<b>FREQUENCY A &amp; FREQUENCY B</b>	
Measurement Technique	: Reciprocal, below 120 MHz and in User Gate, and in Hold operating modes; Conventional, above 120 MHz. Measurement technique is automatically selected by the instrument.
Range	: 0.01 Hz to 225 MHz.

**Table 1-1. Model 776 Specifications (continued)**

LSD <sup>(1)</sup> Displayed Reciprocal	: $\frac{4 \text{ ns} \times \text{frequency}}{\text{gate time.}}$ e.g min 9 digits in one second of gate time.
Conventional	: $\frac{4}{\text{gate time.}}$
Resolution	: $\pm \text{LSD} \pm \frac{(1.4 \times \text{Trig error}^{(2)} \times \text{Frequency})}{\text{gate time}}$
Accuracy	: $\pm \text{resolution} \pm \text{Time Base error}^{(3)} \times \text{Frequency}$
<b>FREQUENCY C</b> (available with Model 776/2.4G)	
Range	: 50 MHz to 2.4 GHz.
Input Impedance	: 50 $\Omega$ . AC coupled.
Sensitivity	: 15 mV to 2.4 GHz.
Dynamic Range	: 15 mV rms to 4 V rms.
VSWR	: <2:1 (typically 1.5:1).
Damage Level	: AC. 5 V rms; DC. $\pm 40$ V.
LSD <sup>(1)</sup> Displayed	: Same as for Frequency A & B.
Resolution	: Same as for Frequency A & B.
Accuracy	: Same as for Frequency A & B.
<b><u>TIME MEASUREMENT - SINGLE SHOT</u></b>	
<b>PERIOD A, PULSE A, TIME INTERVAL A to B</b>	
Range:	
Period A, Pulse A	: 5 ns to 2000 s.
Time Interval A to B	: 0 ns to 2000 s.
LSD <sup>(1)</sup> Displayed	
Below 20 s	: 1 ns;
Above 20 s	: $5 \times \text{Time} \times 10^{-10} \text{ s.}$
Resolution	
Below 20 s	: $\pm 2 \text{ LSD} \pm \text{start trigger error}^{(2)} \pm \text{stop trigger error}^{(2)}$ ;
Above 20 s	: 1 LSD.
Accuracy	: $\pm (\text{Time Base error}^{(3)} \times \text{Time}) \pm \text{Trig level timing error}^{(4)}$ $\pm 1 \text{ ns} \pm \text{resolution.}$
Time Delay	: Active only with Time Measurements - single. First input transition opens the gate. Delay inhibits the consequent transitions.
Internal	: 500 internal pre-programmed delay intervals can be inserted between START and STOP of Time Interval A to B. Inputs during delay are ignored.
Internal Range	: 100 $\mu\text{s}$ to 100 s.
Preset Position	: 1 s.
External	: User selectable delay intervals can be applied through rear panel BNC connector.
External Range	: 100 $\mu\text{s}$ to 2000 s.

Table 1-1. Model 776 Specifications (continued)

**TIME MEASUREMENTS AVERAGED****PERIOD A AVERAGED**

Range	: 8 ns to 10 s.
LSD <sup>(1)</sup> Displayed	: $\frac{4 \text{ ns} \times \text{Period}}{\text{gate time}}$ e.g min 9 digits in 1 second of gate time.
Resolution	: $\pm \text{LSD} \pm \frac{(1.4 \times \text{Trig error}^{(2)} \times \text{Period})}{\text{gate time}}$
Accuracy	: $\pm \text{resolution} \pm (\text{Time Base error}^{(3)} \times \text{Period})$ .
Number of Periods Averaged	: $N = \frac{\text{gate time}}{\text{Period}}$

**PULSE A, TIME INTERVAL A to B AVERAGED**

Range	
Pulse A	: 5 ns to 10 s
Time Interval A to B	: -3 ns to 10 s (A and B signals must have the same repetition rate).
LSD <sup>(1)</sup> Displayed	: $4 \text{ ns} / \sqrt{N}$ .
Resolution	: $\pm (1 \text{ LSD} + 10 \text{ ps})$ .
Accuracy	: $\pm (\text{Time Base Error}^{(3)} \times \text{Time}) \pm 1 \text{ ns} \pm \text{resolution}$ $\pm \text{Trigger Level Timing Error}^{(4)} \pm (\text{Trigger error}) / \sqrt{N}$
Dead Time Stop to Start	: 20 ns minimum.
Number of Samples Averaged	: $N = \text{gate time} \times \text{Frequency}$ .

**PHASE A to B AVERAGED**

Range	: 0 to 360° x (1 - 20 ns x Frequency A).
example	: 0 to 359.99° at 1 KHz; 0 to 180.0° at 25 MHz.
Frequency Range	: 0.1 Hz to 25 MHz. A and B signals must have the same frequency.
LSD <sup>(1)</sup> Displayed	: $\frac{4 \text{ ns} \times 360^\circ \times (1 + \sqrt{N})}{\text{gate time}}$ or 0.01°, whichever is greater.
Resolution	: $\pm 1 \text{ LSD}$ .
Accuracy	: $\pm \text{resolution} \pm (1 \text{ ns} \times \text{Frequency A} \times 360^\circ) \pm$ $\pm \text{Trigger Level Timing Error}^{(4)} \times \text{Frequency A} \times 360^\circ) \pm$ $\pm \frac{(\text{Trigger error}^{(2)} \times \text{Frequency A} \times 360^\circ)}{\sqrt{N}}$
Number of Cycles Averaged	: $N = \text{gate time} \times \text{Frequency A}$ .
Minimum Amplitude	: 100 mV rms sine wave.

**TOTALIZE B**

Frequency Range	: 0 to 120 MHz.
Totalizing Range	: 0 to 10 <sup>16</sup> - 1.
Gate Modes	
Infinite	: Totalizing on B indefinitely.
Gated by A	: Totalizing on B between a pair of two consecutive transitions of the opposite direction on A.
Gated by AA	: Totalizing on B between a pair of two consecutive transitions of the same direction on A.
Gating Transition	: Positive or Negative transitions, selectable.
Dead Time Stop to Start <sup>(7)</sup>	: 20 ns min from stop transition to the next start transition.

Table 1-1. Model 776 Specifications (continued)

LSD displayed	: 1 count of channel B input signal.
Resolution	: 1 LSD.
Accuracy	
Infinite	: Same as LSD.
Gated by A, Gated by AA	: $\pm \frac{\text{pulse repetition rate B} \times \text{Trigger error}^{(2)} \text{ A}}{\text{total counts B}}$
<b>RATIO A/B</b>	
Frequency Range	
A	: 0.01 Hz to 225 MHz;
B	: 0.01 Hz to 125 MHz.
LSD <sup>(1)</sup> displayed	: $\frac{4 \times \text{Ratio}}{\text{Frequency A} \times \text{gate time}}$
Resolution	: $\pm \text{LSD} \pm \frac{\text{Trigger error B}^{(2)} \times \text{Ratio}}{\text{gate time}}$
Accuracy	: Same as resolution.
<b>RATIO C/B</b>	
Frequency Range	
C	: 50 MHz to 2.4 GHz;
B	: 10 Hz to 225 MHz.
LSD <sup>(1)</sup> displayed	: $\frac{4 \times \text{Ratio}}{\text{Frequency B} \times \text{gate time}}$
Resolution and Accuracy	: $\pm \text{LSD}$ .
<b>V PEAK A</b>	
Function	: Displays simultaneously, with 3 digits each, the maximum and minimum peaks of Channel A input signal. Decimal points and polarity are automatically displayed.
Frequency range	
Slow Rate	: 40 Hz to 10 MHz;
Fast Rate	: 100 Hz to 10 MHz.
Dynamic Range	: 280 mV p-p to 51 V p-p.
Resolution x1	: 10 mV; x10: 100 mV. Attenuator is activated automatically if either the positive or the negative peaks of the input signal exceeds $\pm 5.1$ V or when the peak to peak voltage exceeds 5.1 V.
Accuracy	: $\pm \text{resolution} \pm 0.1(V_{\text{pos pk}} - V_{\text{neg pk}}) \pm 35 \text{ mV}$ .
<b>GATE TIME</b>	
Internal Gate Time	: 500 pre-programmed gate time intervals.
Internal Range	: 100 $\mu\text{s}$ to 10 s or one period of the input, which ever is longer.
Preset Position	: 1 s.
External Gate Time	: User selectable gate time intervals, ranging from 100 $\mu\text{s}$ to 1000 s.
External Range	: 100 $\mu\text{s}$ to 2000 s. External gate not available with Time measurements - single shot. Totalize B and Phase A to B.
External Input	: Rear panel BNC connector; accepts TTL level signals.
External Gate Delay <sup>(6)</sup>	: <10 $\mu\text{s}$ .

Table 1-1. Model 776 Specifications (continued)

<b>EXTERNAL ARMING (TRIGGER)</b>	
Function	: Arms the instrument when set to HOLD mode.
Input	: Via Rear panel BNC.
Impedance	: 1 K $\Omega$ nominal.
Level	: TTL.
Logic	: Positive true.
Minimum Pulse Width	: 10 $\mu$ s.
Trigger Delay <sup>(5)</sup>	: <50 $\mu$ s.
<b>STANDARD TIME BASE</b>	
Frequency	: 10 MHz.
Aging Rate	: <1 x 10 <sup>-7</sup> /month.
Temperature Stability	: <5 x 10 <sup>-6</sup> , 0 to 50 °C.
Line Voltage	: <1 X 10 <sup>-7</sup> for 10% change (short term).
Clock IN/OUT	: Selected with an internal switch.
External Time Base Input	: Rear Panel BNC accepts 10 MHz TTL.
Time Base Out	: 10 MHz approx 2 V from a 51 $\Omega$ source.
<b>TCXO TIME BASE</b>	
(available with Model 776/2.4G)	
Frequency	: 10 MHz.
Aging Rate	: <1 x 10 <sup>-7</sup> /month; <1 x 10 <sup>-6</sup> /year.
Temperature Stability	: <1 x 10 <sup>-6</sup> , 0 to 50 °C.
Line Voltage	: <1 x 10 <sup>-7</sup> for 10% change (short term).
Clock IN/OUT	: Selected with an internal switch.
External Time Base Input	: Rear Panel BNC accepts 5 or 10 MHz TTL. Selected via an internal switch.
Time Base Out	: 10 MHz approx 2 V from a 51 $\Omega$ source.
<b>GPIO INTERFACE</b>	
Programmable Controls	: All front panel controls except POWER switch.
Multiline Commands	: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD.
Uniline Commands	: IFC, REN, EOI, SRQ, ATN.
Interface Functions	: SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.
Data Output Format Reading	: With prefix 18 ASCII characters plus terminator; Without prefix - 14 ASCII characters plus terminator.
Gate/Delay Time and Trigger Level	: With prefix - 9 ASCII characters plus terminator; Without prefix - 5 ASCII characters plus terminator.
Data Output	
Single Shot	: One reading processed after trigger.
Normal Mode	: Approximately four readings/second, formatted.
Fast Mode	: Up to 100 reading/second, formatted.
Address Selection	: Front panel programming. Address is stored in a non-volatile memory.
<b>GENERAL</b>	
Display Rate	
Normal	: Approximately four measurements per second;
Hold	: Single shot measurement, taken with each press of RESET;
Fast	: Up to 100 measurements per second.

Table 1-1. Model 776 Specifications (continued)

Arming	: Each channel is armed by it's own signal
Reset	: Clears display and re-cycles measurement.
Trigger Level Outputs	: DC Outputs via rear panel terminals. not adjusted for attenuators.
Accuracy	: DC (X1) $\pm 35 \text{ mV} \pm 2\%$ of trigger level reading.
Output Impedance	: 1 K $\Omega$ , 1%.
Display	: 10 digits seven segments LED, 0.56" high. 2 digits for exponent.
Displayable Digits	: Selectable from 3 to 10 most significant digits.
Gate	: LED indicator lights when gate is open.
Stored Set-ups	: Ten measurement set-ups. including trig levels, gate/delay time, input conditioning and measurement rate may be stored in memory and subsequently recalled. When AC mains power is removed, a non-volatile memory preserves the stored set-ups for a typical period of 3 years.
Operating Temperature	: 0 to 50 °C ambient, 0 to 80% relative humidity.
Storage Temperature	: -25 to 65 °C.
Power Requirements	: 115/230 V rms $\pm 10\%$ (rear panel switch select) 48-60 Hz. 30 W maximum.
Warm-Up	: 1 hour to rated accuracy and stability.
Dimensions	: 3.5" x 8.3" x 15.4" (H x W x D) 89 x 211 x 391 m"m.
Rack Mount Dimensions	: 3.5" x 19" (H x W) 89 x 483 m"m.
Weight:	approximately 8 lb (3.5 kg).
Accessories Furnished:	Power Cord, Operating Manual.
<b>DEFINITION OF TERMS</b>	
(1) LSD	: Unit value of least significant digit. Calculation should be rounded as follows 1 to <5 Hz becomes 1 Hz, 5 ns to <10 ns becomes 10 ns etc.
(2) Trigger Error	: $\frac{\sqrt{(e_i^2 + e_n^2)}}{\text{Input slew rate at trigger point}}$ Where: $e_i$ is the rms noise voltage of the counter's input channel (250 $\mu\text{V}$ typ.) $e_n$ is the rms noise of the input signal for 225 MHz band-width.
(3) Time Base Error	: Maximum fractional frequency change in time base frequency due to all errors: e.g aging, temperature, line voltage etc.
(4) Trigger Level Timing Error (x1)	: $\frac{18\text{mV}}{\text{Input slew rate at start trigger point}} \pm \frac{18\text{mV}}{\text{Input slew rate at stop trigger point}}$
5) External arming (trigger) delay	: Delay from the positive going slope of the arming signal to the internal gate open signal.
(6) External gate delay	: Delay from the positive going slope of the gating signal to the internal gate open signal.
(7) Dead Time	: Minimum time between measurement which the counter is busy in performing the measurement. The counter will not at this time respond to any input transition.

- Model 776 Programmable Counter/Timer with line cord.
- Model 776 Instructions Manual.

If an additional manual is required, order:

- Keithley part number 776-901-00.

## **1-8. Specifications**

Instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument is tested.

### **NOTE**

All specifications in the following table apply after a warm-up period of 1 hour and at ambient temperature of  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ .