TEKTRONIX®

550 MHz COUNTER

DC 502

INSTRUCTION MANUAL

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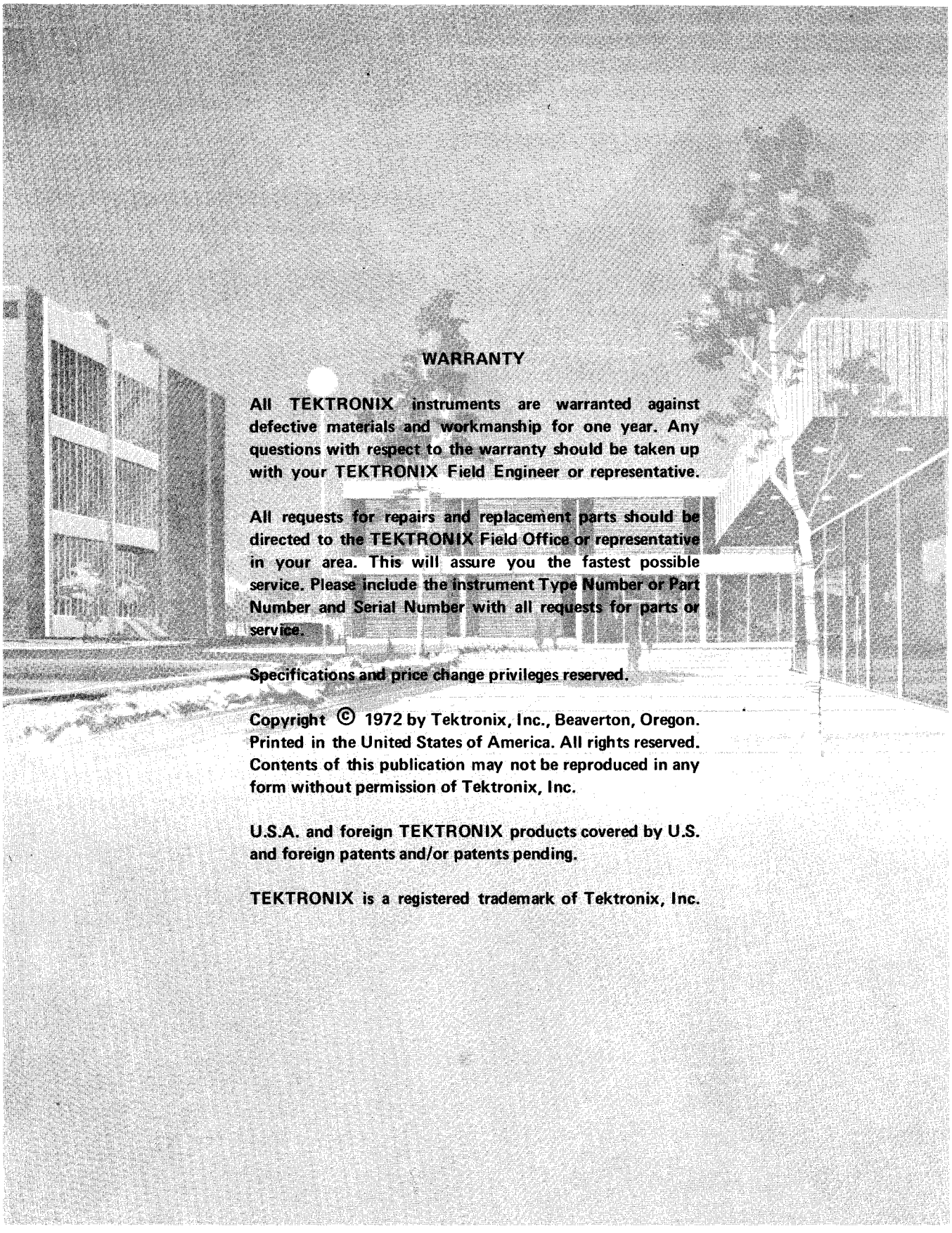

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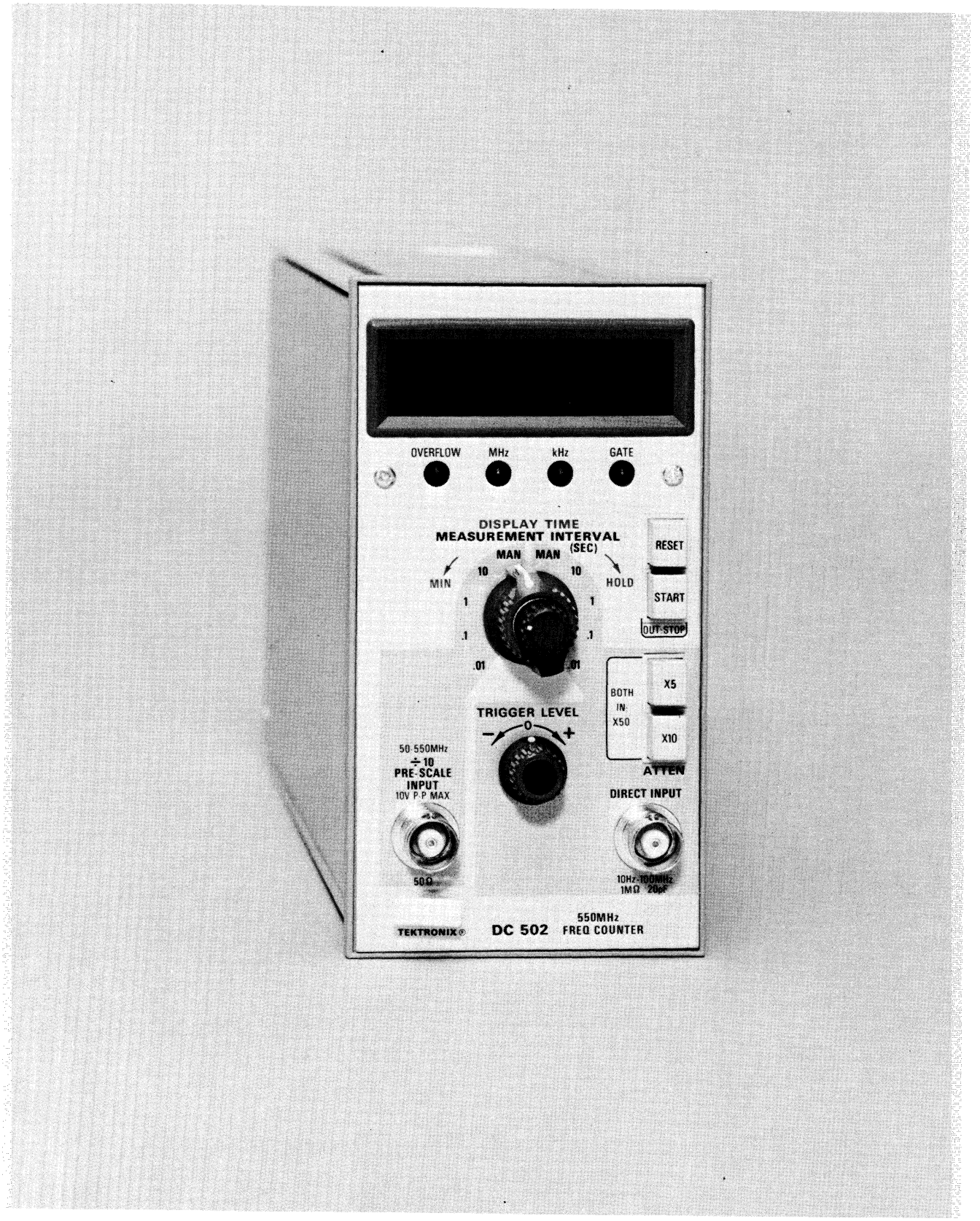

OVERFLOW
MHz
kHz
GATE
DISPLAY TIME
MEASUREMENT INTERVAL
(SEC)
MAN
MAN
MIN
HOLD
10
1
.1
.01
RESET
START
OUT STOP
BOTH IN
X50
X5
X10
ATTEN
TRIGGER LEVEL
0
50-550MHz
÷10
PRE-SCALE
INPUT
10V P-P MAX
50Ω
DIRECT INPUT
10Hz-100MHz
1MΩ 20pF
TEKTRONIX®
DC 502
550MHz
FREQ COUNTER

SECTION 1 OPERATING INSTRUCTIONS

INTRODUCTION

Description

The DC 502 550 MHz Frequency Counter measures frequencies from 10 Hz to 550 MHz or totalizes events to 10^7 at a maximum rate of 550 MHz. The DC 502 operates in a TEKTRONIX TM 500 Power Module only.

Frequency measurements are accomplished using one of two BNC inputs on the front panel. The DIRECT INPUT has a frequency range of 10 Hz to 110 MHz with a 300 mV peak-to-peak sensitivity, selectable attenuators, and an adjustable trigger level range. The ÷10 PRE-SCALE INPUT has a frequency range of 50 MHz to 550 MHz with a 500 mV peak-to-peak sensitivity and a 50 Ω input impedance. The same four measurement interval times are selectable for each input.

Front panel controls reset the Counter and provide Start/Stop commands for the manual totalizing mode of each input.

Measurement display is accomplished with seven-segment LED's in a 7-digit readout. The decimal point is automatically positioned by the MEASUREMENT INTERVAL selected, and leading zeros (to the left of the most significant digit or the decimal point) are blanked. LED's indicate when the GATE is open, when the kHz or MHz units are displayed, and when OVERFLOW occurs.

Installation

The DC 502 is calibrated and ready to use as received. Referring to Fig. 1-1, install the DC 502 into the Power Module and turn on the power.

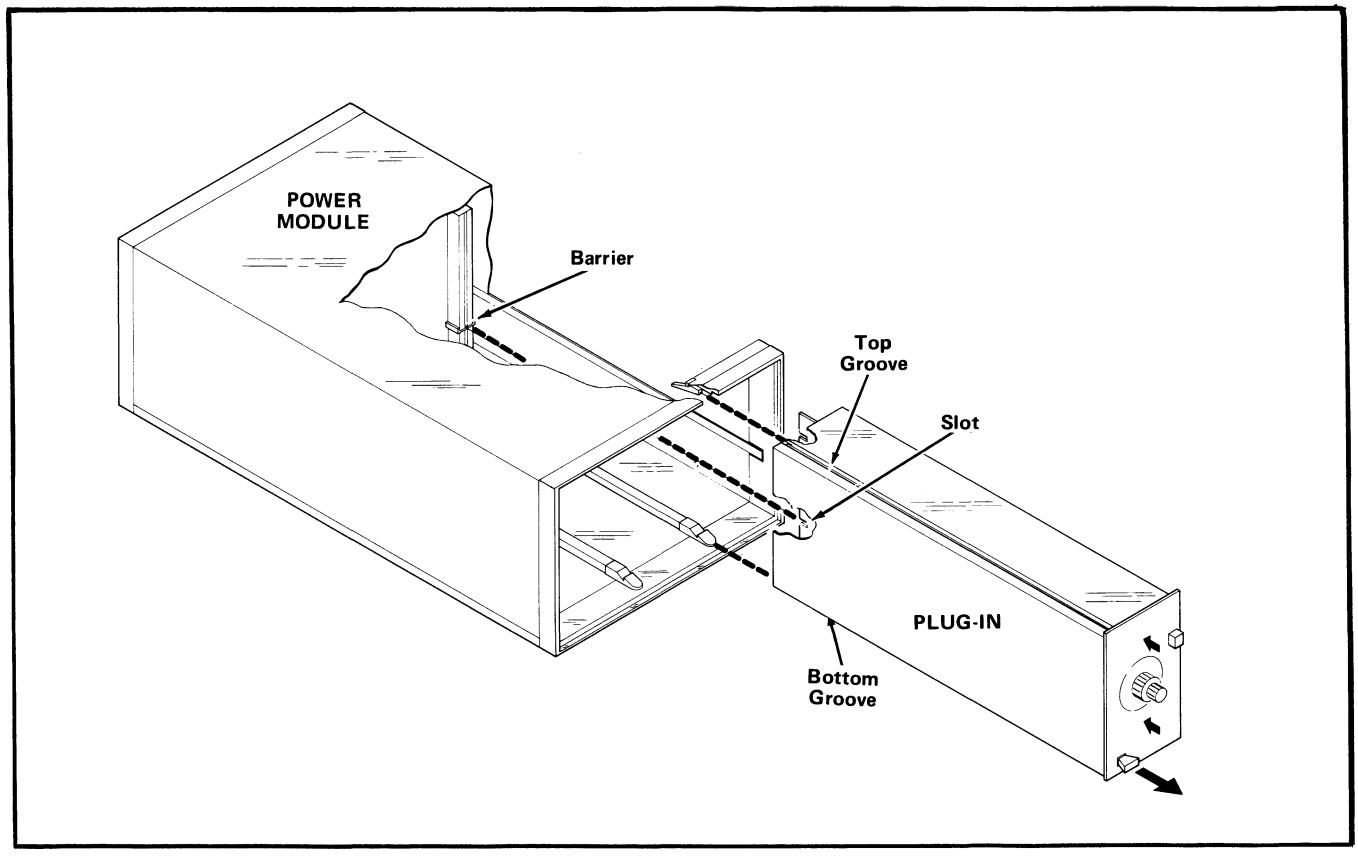


Fig. 1-1. Plug-in module installation/removal.

OPERATIONAL CHECK

Display Check

Press the RESET button to check the 7 character segments of each digit; the numerical display should be a row of eights. To check the decimal point position and the units indicators, set the MEASUREMENT INTERVAL switch as follows:

Switch Position		Numerical Display	Units
.01 SEC	DIRECT INPUT	.0000	MHz
.1 SEC		.00000	MHz
1 SEC		.000	kHz
10 SEC		.0000	kHz
MANUAL		000	
MANUAL	÷10 PRE-SCALE INPUT	000	
10 SEC		.000	kHz
1 SEC		.00000	MHz
.1 SEC		.0000	MHz
.01 SEC		.000	MHz

In the MANUAL position, no decimal point will be displayed. Press the START button and check that the GATE indicator lights, then release the button (STOP) and check that the GATE light goes out. To check the OVERFLOW indicator, set the MEASUREMENT INTERVAL switch to 10 s and apply 15- or 20-MHz to the INPUT connector. The length of time a display can be held is determined by the DISPLAY TIME control, and will be discussed in the next few paragraphs.

Frequency Measurements

Direct Input. The DC 502 provides direct measurement of the average frequency of signals from about 10 Hz to 110 MHz. The input sensitivity is 300 mV peak-to-peak, so select the proper attenuation (X1, X5, X10, or X50) for the given signal.

CAUTION

The input signal must not exceed 500 volts.

Apply a signal to the INPUT connector. Set the MEASUREMENT INTERVAL switch to the .01 SEC position and the DISPLAY TIME control fully CCW. Observe the numerical readout display. Adjust the TRIGGER LEVEL control for a stable reading. The zeroes leading the most significant digit in the display should be blanked. Then turn the MEASUREMENT INTERVAL switch to the position that gives the desired reading. Generally, use the shorter measurement intervals for high-frequency, low-resolution measurements and the longer intervals for measurements requiring a high resolution.

NOTE

The OVERFLOW indicator can be lit for high-resolution measurements, allowing the frequency to be indicated to 0.1 Hz. Refer to the Specifications at the end of this section for resolution and accuracy at each position of the MEASUREMENT INTERVAL switch.

The display is updated at a rate determined by the DISPLAY TIME control. Each time a sample of the input signal is taken, the GATE light will flash and the new reading will be displayed. To change the display time, which is continuously variable from about 0.1 second to 10 seconds, or to hold a display indefinitely, turn the DISPLAY TIME control.

÷10 Pre-Scale Input. The DC 502 also provides a pre-scaled, AC-coupled input to measure the average frequency of signals from 50 MHz to 550 MHz. This input has a sensitivity of 500 mV, peak-to-peak, and a maximum input voltage limit of 10 V, peak-to-peak. Signals greater than 10 V may damage the diodes of the input circuit. The ATTEN controls do not apply to this input.

Apply a 50 MHz to 550 MHz signal of at least 500 mV amplitude to the ÷10 PRE-SCALE INPUT. Set the MEASUREMENT INTERVAL switch to .01 SEC and observe the readout. Leading zeros should be blanked. Select a MEASUREMENT INTERVAL which gives the best accuracy and resolution. As with the DIRECT INPUT, shorter measurement intervals give higher frequency, lower resolution measurements; longer intervals offer greater resolution, especially when overflow is employed.

Totalizing

DIRECT INPUT. The DC 502 will count and display the accumulated number of signals (events) applied to the DIRECT INPUT connector up to the register capacity of 9,999,999 during the time interval between START/STOP commands from the front-panel pushbutton. Input signal rate should not exceed 110 MHz.

Set the MEASUREMENT INTERVAL switch to MANUAL, apply the signal, and push the START button. The GATE indicator will light and the progressing count will be displayed. Adjust the ATTEN and TRIGGER LEVEL controls as necessary for a steady count. To stop the counting, release the START button. The GATE light will go out and the displayed count will be held. The displayed count can continue when the START button is depressed again. The counter can be cleared to zero at any time by pressing the RESET button or by moving the MEASUREMENT INTERVAL switch to another position.

÷10 PRE-SCALE INPUT. In the MANUAL mode related to this input, the displayed count advances one count for every ten incoming events. The incoming events must have transition times and periods suitable for the 50 Ω pre-scale input triggering requirements.

USING THE COUNTER

DIRECT INPUT Attenuation and Trigger Level Adjustment

Signals to be counted in the DIRECT INPUT channel may have a wide variety of shapes and amplitudes, many of which are unsuitable to drive the counting circuits. Because of this, the signal is first passed through an attenuator, then applied to a signal-shaping circuit which converts it to rectangular pulses of uniform amplitude. This circuit includes a reference level adjustable between + and − 2 volts to which the incoming signal is compared, allowing the 300-millivolt sensitivity window of the signal-shaping circuit to be adjusted to a convenient amplitude on the incoming waveform (see Fig. 1-2). Obtaining a steady, reliable reading is dependent upon the proper selection of input attenuation and proper adjustment of the TRIGGER LEVEL control.

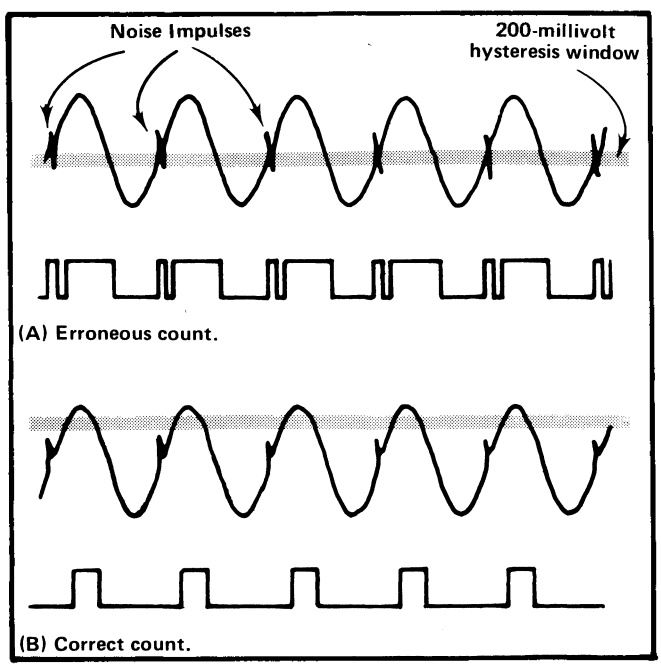


Fig. 1-2. Two examples of triggering circuit output showing how proper adjustment of TRIGGER LEVEL control can avoid an erroneous count.

Generally, the best point on a waveform for triggering the counter is where the slope is steep and therefore usually free of noise. On a sine-wave signal, for example, the steepest slope occurs at the zero-crossing point. Noise pulses or other signal components of sufficient amplitude to produce unwanted trigger pulses will cause an erratic or incorrect count. Fig. 1-2 shows the TRIGGER LEVEL control adjusted to avoid error. In critical measurement applications, monitor the incoming signal with a test oscilloscope.

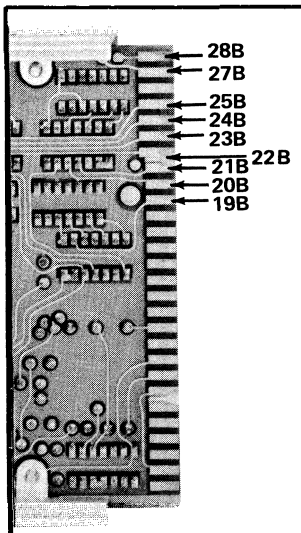
Signal Connection

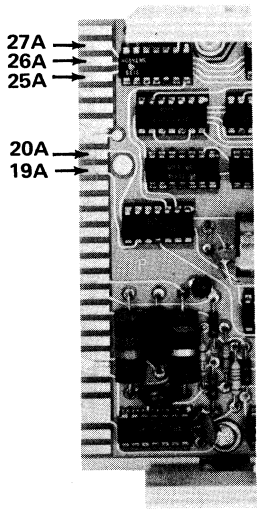
Coaxial cables and probes offer very convenient means of connecting the signals to the front-panel input BNC connectors. These devices are shielded to prevent pickup of electrostatic interference which can cause erroneous triggering and a faulty count. For the DIRECT INPUT, a X10 probe not only reduces the size of the signal, but also presents a high input impedance to allow the circuit under test to perform very close to normal operating conditions. For the ÷10 PRE-SCALE INPUT, the 50 Ω input requires careful impedance matching. If the signal must be attenuated to avoid exceeding the maximum input limit of 10 V, use 50 Ω attenuator pads terminated by the 50 Ω input impedance of the DC 502.

Measurement Interval and Display Time Controls

The MEASUREMENT INTERVAL switch selects the time interval (also called gate time) during which the DC 502 counts. The internal time-base circuit derives gate times from an accurate 1-MHz reference signal to make frequency measurements. These gate times are 0.01 s, 0.1 s, 1 s, or 10 s. The measurement interval selected determines the measurement range and resolution. Also, the displayed decimal point is positioned correctly and the correct measurement units (MHz or kHz) are indicated for the corresponding switch position.

The DISPLAY TIME control sets the length of time a measurement can be held in the counter and displayed. The HOLD detent position allows a measurement to be held indefinitely, or until the counter is reset to zero by the front-panel RESET button.





Contact	Assignment
28B	Second decimal point (D2) output.
27A	Internal scan clock disable input.
27B	MHz light output.
26A	Reset input/output.
25A	TSØ (Time Slot Zero) output.
25B	External scan clock input.
24B	Internal scan clock (2 kHz) output.
23B	Overflow output.
22B	MSD (Most Significant Digit) output.
20B	8
20A	4
21B	2
19A	1
	BCD output, serial by digit.
19B	Data good output.

Fig. 1-3. Input/Output pin assignments at rear connector.

Rear Connector I/O Assignments

Input and output data access to the DC 502 is available at the rear of the main circuit board. Fig. 1-3 identifies the contacts and their respective I/O assignments. A Power Module mainframe option is available which provides a rear-panel, multi-pin connector to which these data can be hard-wired for external access. Also possible are intra-compartment connections with other plug-in modules when using a multi-compartment Power Module.

Option 1—Precision Time Base

The DC 502 can be ordered with a temperature-compensated 5-MHz crystal oscillator to provide a highly stable (5 parts in 10^7) and precise internal time base. This option includes a divide-by-five IC counter to produce the 1-MHz clock.

SPECIFICATIONS

Measurement Ranges, Resolution, and Accuracy

Frequency, 10 Hz to 550 MHz; **Gate times**, 0.01 s, 0.1 s, 1 s, and 10 s; **Display time**, about 0.1 s to 10 s to HOLD; **Totalizing capacity**, 0 to 10^7; **Resolution (DIRECT INPUT)**, 100 Hz at 0.01 s gate time, 10 Hz at 0.1 s, 1 Hz at 1 s, and 0.1 Hz at 10 s; **Resolution (÷10 PRE-SCALE INPUT)**, 1000 Hz at 0.01 s, 100 Hz at 0.1 s, 10 Hz at 1 s, and 1 Hz at 10 s; **Accuracy**, ±1 count ± time base accuracy.

Direct Input

Frequency, 10 Hz to 110 MHz; **Sensitivity**, 300 mV peak-to-peak; **Trigger level range**, ±2 V; **Attenuators**, X1, X5, X10, and X50; **Coupling**, AC; **Input impedance**, approximately 1 MΩ paralleled by about 20 pF; **Maximum input volts**, 500 V (DC + peak AC, or peak-to-peak AC).

÷10 Pre-Scale Input

Frequency, 50 MHz to 550 MHz; **Sensitivity**, 500 mV peak to peak; **Coupling**, AC; **Input impedance**, approximately 50 Ω; **Maximum input volts**, 10 V peak-to-peak.

Data Inputs and Outputs

Available via plug-in connector to multi-pin connector at rear of Power Module. Input lines are available for internal and external scan clock control. Output lines are available for BCD output (serial-by-digit), and to indicate status of timing, data good, reset, scale, decimal point and overflow.

Internal Time Base

	Standard	Option 1
Crystal Frequency	1 MHz	5 MHz
Stability (0°C to +50°C), after 1/2 hour warm-up	Within 1 part in 10^5	Within 5 parts in 10^7
Long-term Drift	1 part or less in 10^5 per month	1 part in 10^7 per month
Accuracy	Adjustable to within 1 part in 10^7	Adjustable to within 5 parts in 10^9

Other

Temperature Range, Operating: 0°C to +50°C; Non-operating: −40°C to +75°C.

Altitude Range, Operating: to 15,000 feet; Non-operating: 50,000 feet.

SECTION 2 THEORY OF OPERATION

INPUT CIRCUITS

Direct Input

Attenuators. Signals to be counted are applied via front-panel DIRECT INPUT connector J100 to the attenuators. The attenuators are frequency-compensated voltage dividers consisting of resistors R102-R107 and capacitors C102-C107. Switches S100A and S100B allow front-panel selection of X1, X5, X10, or X50 attenuation of the input signal. C110 provides AC coupling.

FET source follower Q115 and emitter follower Q122 present a high impedance to the input signal. The diodes in the base circuit of E. F. Q128 form a series-limiter and clamping network, which reduces the input signal to limits suitable for driving the shaping circuits. The clamping diodes limit the voltage at the emitter of Q128 to a dynamic range of about 1.2 volts.

Signal-Shaping. U150B, an OR gate integrated circuit with push-pull outputs, is connected as a Schmitt trigger. It shapes the input signal into a square wave. Its "hysteresis window" is a width of about 200 mV. The output changes states when the signal voltage passes through the upper threshold, then reverts to its original state when the signal voltage passes through the lower threshold. For this reason, an input signal smaller in amplitude than the width of the hysteresis window cannot activate the counting circuits.

The quiescent level at the input of U150B can be adjusted to overcome some of the triggering difficulties arising from various input-signal shapes and frequencies. Integrated-circuit operational amplifier U135 and its associated discrete components are connected as a voltage follower. TRIGGER LEVEL potentiometer R135 selects a voltage between ground and about −2 volts and applies it to pin 3 of U135. This level is then established at pin 2, and hence, the input of U150B, through the action of the operational amplifier.

The output of U150B is applied to U150A, whose push-pull outputs drive Q160 and Q162, which are connected as a differential pair. This circuit provides a level shift to TTL level, and further shapes the signal to be counted. A waveform with fast rising and falling edges is produced at the collector of Q160. CR165 limits the amplitude of the count signal to 5 volts, clamping the negative-going portion of the signal to ground. The signal is then passed through emitter follower Q170 to U160B, where it receives a final phase inversion (to correspond with the input signal) and becomes the decade input.

÷10 Pre-Scale Input Circuit

50 MHz to 550 MHz signals applied to J180 are AC-coupled into a 50Ω environment. A quiescent 10 mA current, set by R185 and R187, keeps CR185, 186, 187 and 188 in the diode clamping bridge turned on until the input signal amplitude reaches about ±0.4 V. While the bridge is turned on, the signal source sees about 20Ω equivalent resistance of the bridge in series with R189, 24Ω, and the emitter resistance of Q190, about 5Ω. As the signal amplitude exceeds ±0.4 V, one pair of diodes (CR185, CR188) begins to turn off during positive-going excursions, while the other pair (CR186, CR187) turns off during negative-going excursions. As these diode pairs alternately turn off with signal amplitude changes, a matched pair of diodes (CR181A, CR181B) on the input side of the coupling capacitor, C182, alternately turn on to maintain the 50Ω input impedance. C181 prevents CR181A & CR181B from being biased on or off by DC levels which may be part of the input signal.

The clamping action of the bridge diodes limits the changing DC level at the bridge output to a maximum 0.8 V peak-to-peak. This signal is then coupled by C188 to Q190 via the high-frequency peaking network, C189-R189. C192 couples the amplified signal to pin 10, the high impedance input of the ÷10 counter, U190. C192 is mounted on the circuit board with special lead dress to aid high frequency response at minimum signal amplitudes. Bead L192 is mounted on one lead of C192 to suppress high frequency oscillations. R191 establishes a bias at pin 10 of U190. C191, 193, and 194 decouple pins 14, 13, and 12, respectively, right at the terminal connections to the circuit board. L199 and C199 suppress power supply noise and decouple the Vcc input, pin 14.

Pin 4 of U190 produces one output cycle, a level change of about 0.5 V, for every ten input events to pin 10. The base of Q195 swings approximately between 3.4 V and 3.9 V. The emitter-follower action of Q195 provides a healthy current drive to the base of Q198, which would saturate in no-signal conditions except for CR196. The collector of Q198 can, therefore, respond immediately to signal changes, producing a TTL-compatible output to drive pin 9 of U160B in the gating logic to the Decade Counting Units.

TIME BASE AND CONTROL CIRCUIT

1 MHz Clock

A precise one megahertz clock provides the reference for operation of the gate-generating circuits. The output of crystal oscillator Y200 is adjustable by C201 to exactly one megahertz. The four parts of U200 form a shaper-buffer stage to produce square-wave clock pulses and to isolate the oscillator from the 1-MHz output line.

Optional Clock

An optional 1 MHz clock is available, using a very stable 5 MHz crystal oscillator and a divide-by-five counter. This combination is shown on the schematic as Y201 and U201.

Decade Divider Units (DDU's)

The DDU's consist of seven cascaded divided-by-ten counters, U209 through U215. They produce four gate times, 0.01 sec, 0.1 sec, 1 sec and 10 sec, which are made available via the MEASUREMENT INTERVAL switch to the gate generator to establish the precise time interval the GATE is open. The 1-MHz clock signal is applied to pin 14 of U209, whose output is connected to the input of the subsequent decade. Each decade is clocked with a negative-going transition. The DDU's are reset by a CLEAR pulse, which places a 0 count in U209 and a 9 count in each subsequent decade.

Gate Generator

The gate generator produces the GATE control signal and initiates the CLEAR, $\overline{\text{CLEAR}}$, and LATCH pulses. The generating portion consists of U220A, U222A, U220B, and U222B. The display time control portion consists of Q230, Q238, and Q240. The circuit will be described first in the normal gate mode (MEASUREMENT INTERVAL switch in one of the four gate time positions).

Assume that the T_0 conditions are as given in Fig. 2-1. The Q outputs of U220A, U222A, U220B, and U222B are all LO. Q230 is off and the emitter of Q238 rises as C235 charges. At T_1, Q238 reaches its firing potential and discharges the capacitor. This results in a short-duration LO pulse on the direct-set input (pin 2) of U220A, forcing its Q output HI and its $\overline{Q}$ output LO. With two HI inputs on NAND gate U230A, its output goes LO and the output of

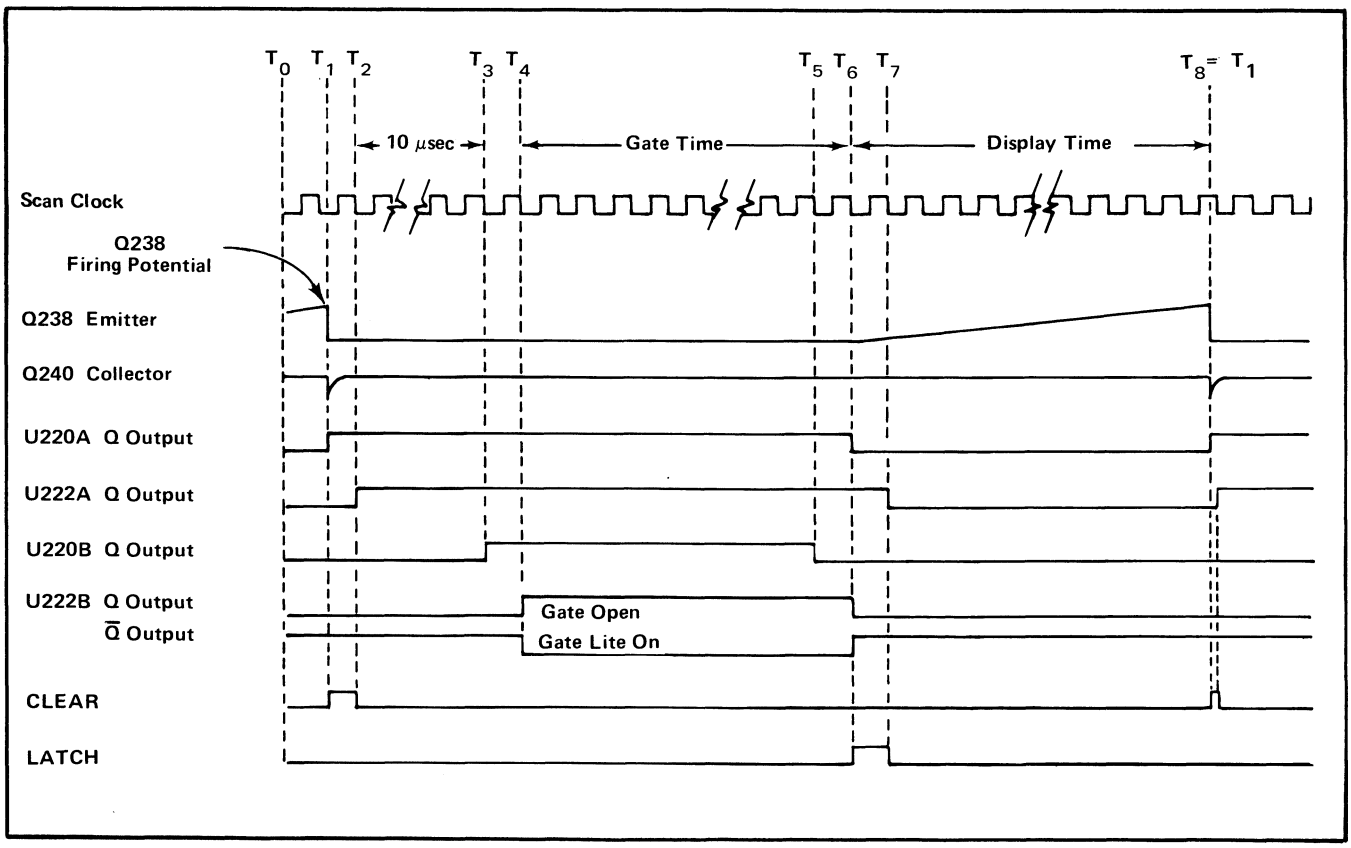


Fig. 2-1. Time Base generator normal gating mode ladder diagram.

NOR gate U230C goes HI, producing the CLEAR and $\overline{\text{CLEAR}}$ control signals. The next HI-to-LO transition from the 1-MHz clock (T_2) toggles U222A, causing its Q output to go HI and its $\overline{Q}$ to go LO. With a LO applied to one of its inputs, U230A reverts to its original condition, terminating the CLEAR and $\overline{\text{CLEAR}}$ pulses. The DDU's then start counting from their 0999999 reset condition.

At the end of a 10-microsecond delay (time for the DDU's to count the first digit, plus a propagation delay), a negative transition from the DDU's via the MEASUREMENT INTERVAL switch toggles U220B. This corresponds to T_3 in Fig. 2-1. U220B's Q output goes HI and its $\overline{Q}$ output goes LO. The next negative transition from the 1-MHz clock (T_4) toggles U222B, causing its Q output to go HI (GATE open) and its $\overline{Q}$ output to go LO (supplying current to the front-panel GATE indicator LED, DS225). The GATE signal is also applied to the base of Q230, saturating the transistor and preventing C235 from charging.

The GATE remains open (HI) for the time duration selected by the MEASUREMENT INTERVAL switch. At the end of this time, which corresponds to T_5 in Fig. 2-1, another negative transition from the DDU's toggles U220B. U220B's Q output goes LO and its $\overline{Q}$ output goes HI. The next negative transition from the 1-MHz clock (T_6) toggles U222B, causing its Q output to go LO, closing the GATE. Simultaneously, the $\overline{Q}$ output goes HI, removing current from the GATE indicator LED.

When the GATE output goes LO, the negative transition toggles U220A, switching Q LO and $\overline{Q}$ HI. Now NAND gate U230D has two HI inputs, placing a LO at the input of OR gate U230B and activating the LATCH control signal (HI state). One microsecond later (T_7), a negative edge from the 1-MHz clock toggles U222A, switching its outputs and placing a LO on the input of NAND gate U230D. U230D reverts to its original condition, terminating the LATCH signal.

The display time begins when the GATE signal ends (T_6). When Q230 turns off, C235 begins to charge through R232-R235 toward the Vcc supply. R235, DISPLAY TIME, provides an adjustable time constant to vary the display time from about 0.1 second to about 10 seconds. When the DISPLAY TIME control is fully clockwise (HOLD detent position), S235 opens, and C235 stops charging. When S235 is closed and C235 charges sufficiently to bring Q238 to its firing potential (T_1), the display time ends and the next GATE-opening sequence begins.

Manual Gate

The manual mode of operation is selected by placing the MEASUREMENT INTERVAL switch in the MANUAL position. The switch closure to ground (cam 5 of the switch) places a LO on the set inputs of U220B and U222A, and a LO on the clear input of U220A. This forces the Q outputs of U222A and U220B HI, and the Q output of U220A LO. With both inputs of U230D held HI, the LATCH output is held HI, allowing the counter to update the display continuously. The GATE is opened when the front-panel START button is pushed in, opening S210 and applying a HI to the clear input of U222B. As before, the GATE-open condition is HI at the Q output of U222B. The GATE is then closed when S210 is set to STOP (button out). To reset the counters in the manual mode, the RESET button must be pushed to activate to CLEAR, $\overline{\text{CLEAR}}$ and $\overline{\text{RESET}}$ control signals.

COUNTER CIRCUITS

Decade Counter Units (DCU's)

The 10^0 through 10^6 DCU's are seven cascaded divide-by-ten counters. The first decade counter is made up of four individual J-K flip-flops to accept the high-speed decade input (up to 100 MHz), and each subsequent DCU is a single IC. U165A, U165B, U167, and U169 comprise the first (10^0) decade counter, and U235 through U240 make up the remaining six DCU's.

When the J and K inputs of U165B are HI (GATE open), the counter is enabled. The input signal is applied to the toggle input of U165B. On every tenth clock input counted by the first decade counter, the output of U169 goes LO, providing a carry signal which becomes the clock input for the second decade counter. Each subsequent decade divides by ten in a similar manner. Four BCD output lines are connected from each DCU to its associated storage-register latch. When the CLEAR (HI) and $\overline{\text{CLEAR}}$ (LO) signals are activated, all of the decade counters are reset to the zero-count state.

Storage Register

The seven IC latches (U250 through U256) comprise a storage register which stores the corresponding decade counter BCD output. The BCD output is applied to the data inputs at pins 1, 5, 7, and 3 (2^0, 2^1, 2^2, and 2^3 bits respectively). The LATCH pulse is applied to the data-strobe input at pin 2 of each latch immediately upon closure of the GATE or when the MEASUREMENT INTERVAL switch is placed in the MANUAL position, as

described in the time base and control circuit. When the LATCH input goes HI, the logic levels at the data inputs are transferred to the associated BCD bit output to be scanned by the multiplexing circuit.

Overflow Register

When the decade counters have counted to 9,999,999, the counters are full. At the next count, the 2^3 output of U240 goes LO, providing a toggle input to U241B. When this occurs, a LO is transferred from pin 10 to pin 8 of U241B, then when the LATCH pulse ends (goes LO), U241A is toggled and the LO is transferred to pin 13. When pin 13 of U241A goes LO, CR241 and DS242 conduct. DS242 is an LED, and in its conduction state gives a front-panel OVERFLOW indication.

In the Manual counting mode, OVERFLOW indication is achieved via Q242 and CR244. The emitter of Q242 is grounded by a switch closure, then when pin 9 of U241B goes HI on the first overflow count, Q242, CR244, and DS242 turn on.

U241 is reset by the $\overline{\text{CLEAR}}$ pulse. To prevent leading-zero suppression during the overflow condition, the display-controlling circuits are notified via U245A that the count is in excess of that displayed by the LED readout.

DECODE AND DISPLAY MULTIPLEX

Scan Clock

The scan rate of the multiplexing circuit is determined by the scan clock. The scan clock is composed of U260B and U260D, which operate as a free-running multivibrator at an approximate 2-kilohertz rate. The scan-clock output is passed through NOR gate U260A, which can also accept an externally applied scan-clock signal. Other input/output lines provide internal scan-clock disable and internal scan-clock output. The scan clock drives an eight-state counter and a storage register for zero suppression.

÷8 Counter and Time-Slot Decoder

The divide-by-eight counter is made up of U262B, U263A, and U262A, which are three halves of SN7474 type D flip-flops. The output of this counter drives U265, an SN74145 BCD-to-decimal decoder. U265 provides eight output lines (designated TS_0 through TS_7 in the schematics and in Fig. 2-2) to simultaneously enable the output of each counter latch and its corresponding display LED sequentially. For example, when the TS_1 line goes LO, Q280 is turned on to supply anode voltage to DS280 at the same time inverter U267C applies a HI to pin 6 of latch U256, enabling its output. Operation in a time sequence allows the latches to share a common set of output lines.

Seven-Segment Decoder and Display LED's

U270 is a BCD-to-seven decoder. It accepts the BCD output of the latches, then supplies current to the appropriate cathodes of the enabled LED to display the correct number. The display LED's are DS280 through DS286. When looking at the front panel of the DC 502, DS280 controls the numerical digit displayed at the far left (10^6), DS281 controls the second (10^5), etc. Each LED has seven segments, arranged so that a combination of lighted segments forms a number. When all of the segments are lighted, an "8" is formed.

Leading Zero Suppression

Decoder driver U270 also has a zero-blanking feature which allows suppression of the zeroes leading the most significant digit (MSD) in the display. At TS_0, a LO is applied to the direct-clear input of U263B, the zero-suppression storage register. This sets U263B to the zero-suppress state (HI at pin 8), allowing the Ripple-Blanking Input (RBI, pin 5) of U270 to be LO. When the output of U265 advances to the next time slot (TS_1), the RBI of U270 remains LO for a few nanoseconds due to propagation delays, which allows the first digit to arrive from the latches while RBI is LO. If this first digit being decoded is a zero, the output to the display LED will be inhibited and the Ripple Blanking Output (pin 4) will be LO. If the digit is not a zero, the outputs are enabled and RBO goes HI. The RBO is applied to the D input (pin 12) of U263B and is transferred to the output when the next scan-clock HI-to-LO transition occurs. Thus, if the first digit is a zero, pin 5 of U270 is held LO, inhibiting the output until the first non-zero digit comes through the decoder. When the first non-zero digit arrives, the outputs of U270 are enabled and the digit is displayed. Also, the RBO output at pin 4 is set HI, removing the RBI from pin 5 and allowing all succeeding digits to be displayed through the TS_7 sequence.

When the scan gets past the decimal point in the display, or if the display overflows, any zeroes arriving at the decoder should be displayed. This is achieved as follows: TS_5 is inverted by U267E and applied through OR gate U245B as a LO at the direct-set input of U263B. This holds pin 5 of U270 HI, preventing zero-blanking during the TS_5, TS_6, and TS_7 time slots. The location of the decimal point in the display is determined by the MEASUREMENT INTERVAL switch. The proper information is applied via the closed contacts of the switch to either NAND gate U246A or U246B. Then either TS_3 or TS_4 is enabled to the

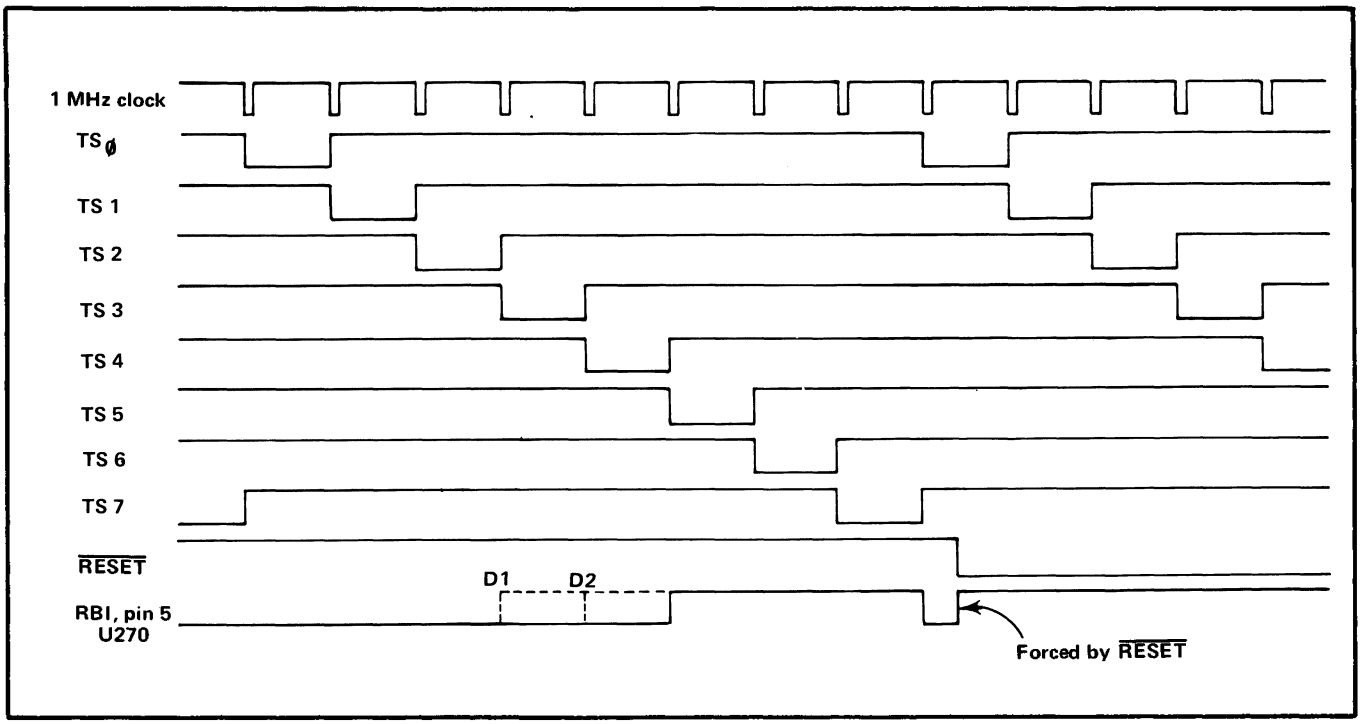


Fig. 2-2. Multiplexing circuit ladder diagram showing timing with an all-zero display.

input of OR gate U245B via these NAND gates, setting U263B to the non-blank state at the appropriate time. In the case where the counter overflows, the HI output from U245A is applied to U245B, setting U263B to the non-blank state.

When the front-panel RESET button is pushed, $\overline{\text{RESET}}$ goes LO, overriding the output of U263B, applying the non-blank and lamp-test functions to the decoder. This causes all seven segments in the display LED to be turned on.

POWER SUPPLIES AND INPUT/OUTPUT LINES

Regulated Power Supplies

The DC 502 operating power is obtained from the power module mainframe and then electronically regulated to provide stable supplies of +15 volts, +5 volts, −5.2 volts, and −10 volts. The +15-volt supply, whose active device is U300, provides the reference for the remaining supplies. Its output is set to +15 V by adjustment of R305.

Integrated circuit U320 regulates the +5-volt supply, and transistors Q330 and Q340 regulate the −5.2-volt and −10-volt supplies respectively. The series-pass transistors for these supplies are located in the mainframe, where they can provide the proper heat dissipation.

Input/Output Lines

The following inputs and outputs are available via the plug-in connector to external equipment. See Fig. 1-3, also.

INT SCAN DISABLE: A LO applied to this line disables the internal scan clock.

EXT SCAN: Provides input for an external scan clock.

INT SCAN CLOCK OUT: Provides output for the internal scan clock.

TS_0: A LO is present on this output line in the TS_0 state.

DATA GOOD: A HI is present on this output line when a new reading is being transferred into the storage-register latches.

OVERFLOW: This output is HI when the count overflows.

$\overline{\text{RESET}}$: This is a dual-function input/output line. It provides a LO output during reset, or can be used as an external reset input.

Data Lines: $\overline{1}$, $\overline{2}$, $\overline{4}$, $\overline{8}$ provide BCD output, serial by digit, from the currently enabled storage-register latch. Other data lines include a LO when the MHz light is on, a LO when the second decimal point is lit, and a HI when the left-side digit (MSD) is enabled.

DC 502 SERVICE INFORMATION

DIAGRAMS, PARTS LISTS, AND ILLUSTRATIONS

Symbols and Reference Designators

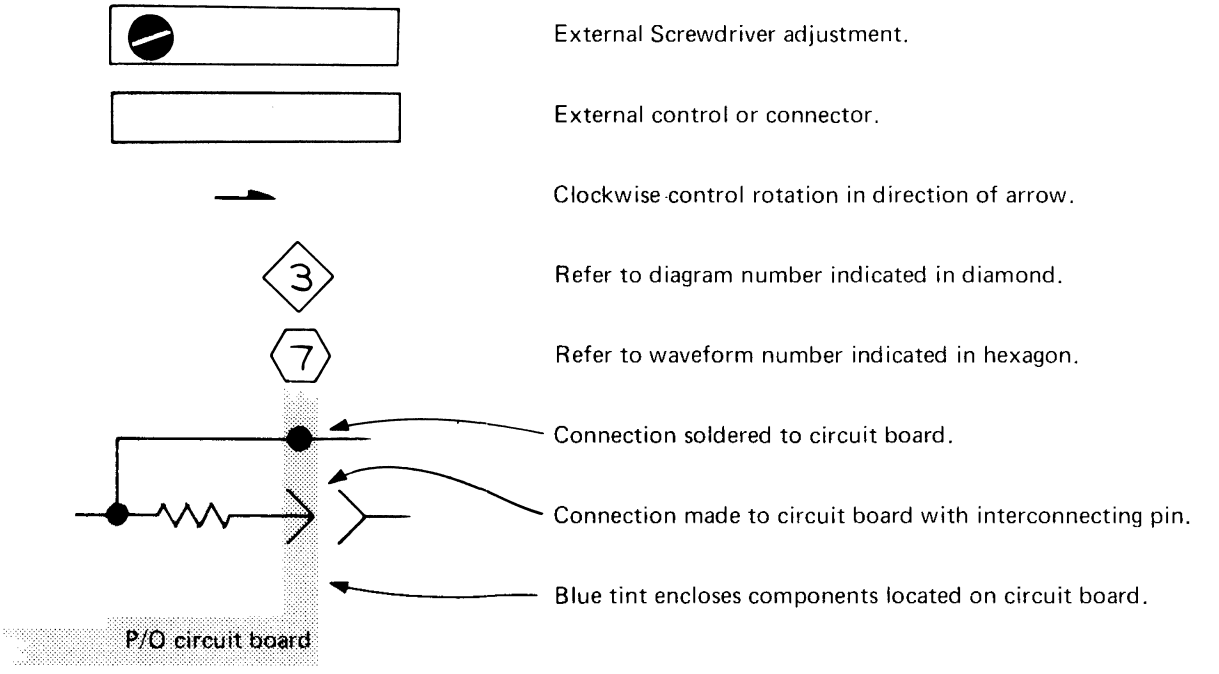
Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors =	Values one or greater are in picofarads (pF). Values less than one are in microfarads (μF).
Resistors =	Ohms (Ω)

Symbols used on the diagrams are based on ANSI Y32.2 – 1970.

Logic symbology is based on MIL-STD-806B in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The following special symbols are used on the diagrams:



External Screwdriver adjustment.

External control or connector.

Clockwise control rotation in direction of arrow.

Refer to diagram number indicated in diamond.

Refer to waveform number indicated in hexagon.

Connection soldered to circuit board.

Connection made to circuit board with interconnecting pin.

Blue tint encloses components located on circuit board.

ELECTRICAL PARTS LIST

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

ABBREVIATIONS AND REFERENCE DESIGNATORS

A	Assembly, separable or repairable	FL	Filter	PTM	paper or plastic, tubular molded
AT	Attenuator, fixed or variable	H	Heat dissipating device (heat sink, etc.)	R	Resistor, fixed or variable
B	Motor	HR	Heater	RT	Thermistor
BT	Battery	J	Connector, stationary portion	S	Switch
C	Capacitor, fixed or variable	K	Relay	T	Transformer
Cer	Ceramic	L	Inductor, fixed or variable	TP	Test point
CR	Diode, signal or rectifier	LR	Inductor/resistor combination	U	Assembly, inseparable or non-repairable
CRT	cathode-ray tube	M	Meter	V	Electron tube
DL	Delay line	Q	Transistor or silicon-controlled rectifier	Var	Variable
DS	Indicating device (lamp)	P	Connector, movable portion	VR	Voltage regulator (zener diode, etc.)
Elect.	Electrolytic	PMC	Paper, metal cased	WW	wire-wound
EMC	electrolytic, metal cased	PT	paper, tubular	Y	Crystal
EMT	electrolytic, metal tubular				
F	Fuse				

Ckt. No.		Tektronix Part No.	Serial/Model No. Eff	Disc	Description
ASSEMBLIES					
A1[1]		670-2102-00	B010100	B039999	MAIN Circuit Board Assembly
A1[1]		670-3409-00	B040000		MAIN Circuit Board Assembly
A1[2]		670-3410-00			MAIN Circuit Board Assembly
A2		670-2103-00			DISPLAY Circuit Board Assembly
A3		670-2438-00			÷ 10 PRE-SCALER Circuit Board Assembly
A4		670-2708-00			PROTECTION Circuit Board Assembly
A5		670-3300-00	XB040000		÷ 5 Circuit Board Assembly
CAPACITORS					
C102	M5	281-0510-00			22 pF, Cer, 500 V, 20%
C103	M4	281-0605-00			200 pF, Cer, 500 V
C106	L4	281-0509-00			15 pF, Cer, 500 V, 10%
C107	L5	281-0540-00			51 pF, Cer, 500 V, 5%
C110[1]	L5	283-0068-00	B010100	B050499	0.01 µF, Cer, 500 V, +100%-0%
C110[1]	L5	283-0267-00	B050500		0.01 µF, Cer, 500 V, 20%
C110[2]	L5	283-0068-00	B010100	B040502	0.01 µF, Cer, 500 V, +100%-0%
C110[2]	L5	283-0267-00	B040503		0.01 µF, Cer, 500 V, 20%
C112	L5	281-0571-00			82 pF, Cer, 500 V, 20%
C113	L6	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C122	K5	283-0000-00			0.001 µF, Cer, 500 V, +100%-0%
C127	K5	283-0000-00			0.001 µF, Cer, 500 V, +100%-0%
C139	M5	283-0003-00			0.01 µF, Cer, 150 V, +80%-20%
C140	L5	283-0177-00			1 µF, Cer, 25 V, +80%-20%
C141	M5	283-0000-00			0.001 µF, Cer, 500 V, +100%-0%
C152	J5	281-0589-00			170 pF, Cer, 500 V, 5%
C181	R2	283-0219-00			1500 pF, Cer, 50 V, 20%
C182	R3	283-0219-00			1500 pF, Cer, 50 V, 20%
C184	R2	283-0219-00			1500 pF, Cer, 50 V, 20%
C187	R3	283-0219-00			1500 pF, Cer, 50 V, 20%
C188	Q3	283-0219-00			1500 pF, Cer, 50 V, 20%
C189	Q3	283-0154-00			22 pF, Cer, 50 V, 5%
C191	Q2	283-0204-00			0.01 µF, Cer, 50 V, 20%

[1]Standard only.
[2]Option 1 only.

ELECTRICAL PARTS LIST (cont)

Ckt No.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)					
C192	Q3	283-0067-00			0.001 µF, Cer, 200 V, 10%
C193	Q3	283-0204-00			0.01 µF, Cer, 50 V, 20%
C194	Q2	283-0204-00			0.01 µF, Cer, 50 V, 20%
C196	Q3	283-0167-00			0.001 µF, Cer, 200 V, 10%
C199	R2	290-0532-00			150 µF, Elect., 6 V, 20%
C200	G5	281-0504-00			10 pF, Cer, 500 V, 10%
C201	G4	281-0166-00			1.9-15.7 pF, Var, Air
C202	G5	281-0739-00			18 pF, Cer, 500 V
C235	L4	290-0526-00			10 µF, Elect., 25 V, 20%
C252		281-0523-00	XB080000		100 pF, Cer, 350 V, 20%
C254		281-0523-00	XB080000		100 pF, Cer, 350 V, 20%
C256		281-0523-00	XB080000		100 pF, Cer, 350 V, 20%
C258		281-0523-00	XB080000		100 pF, Cer, 350 V, 20%
C260	L1	283-0111-00			0.1 µF, Cer, 50V
C265	L1	283-0111-00			0.1 µF, Cer, 50 V
C267		283-0000-00	XB010129		0.001 µF, Cer, 500 V, +100%-0%
C302	D6	290-0529-00			47 µF, Elect., 20 V, 20%
C305	D6	283-0060-00			100 pF, Cer, 200 V, 5%
C322	B5	290-0531-00			100 µF, Elect., 10 V, 20%
C325	B6	283-0150-00			650 pF, Cer, 200 V, 5%
C334	H6	283-0000-00			0.001 µF, Cer, 500 V, +100%-0%
C335	H6	283-0177-00			1 µF, Cer, 25 V, +80%-20%
C340	D6	290-0529-00			57 µF, Elect., 20 V, 20%
DIODES					
CR115	K5	152-0141-02			Silicon, replaceable by 1N4152
CR122	K4	152-0141-02			Silicon, replaceable by 1N4152
CR124	J5	152-0141-02			Silicon, replaceable by 1N4152
CR125	J5	152-0141-02			Silicon, replaceable by 1N4152
CR127	J5	152-0141-02			Silicon, replaceable by 1N4152
CR128	J5	152-0141-02			Silicon, replaceable by 1N4152
CR165	H5	152-0141-02			Silicon, replaceable by 1N4152
CR181A,B	P1	152-0442-01			Schottky barrier, matched pair
CR185	Q1	152-0322-00			Silicon, replaceable by A1108
CR186	P1	152-0322-00			Silicon, replaceable by A1108
CR187	Q1	152-0322-00			Silicon, replaceable by A1108
CR188	Q1	152-0322-00			Silicon, replaceable by A1108
CR196	Q3	152-0322-00			Silicon, replaceable by A1108
CR240	K3	152-0141-02			Silicon, replaceable by 1N4152
CR241	I1	152-0141-02			Silicon, replaceable by 1N4152
CR244	I1	152-0141-02			Silicon, replaceable by 1N4152
VR230	Q5	152-0166-00			Zener, selected from 1N753A, 0.4 W, 6.2 V, 5%
INDICATORS					
DS225	O6	150-1001-01			Lamp, light emitting diode, 2 V, 70 mA
DS242	P6	160-1001-01			Lamp, light emitting diode, 2 V, 70 mA
DS280	N5	150-1002-00			Numeric display, seven-segment, red
DS281	Q5	150-1002-00			Numeric display, seven-segment, red
DS282	Q5	150-1002-00			Numeric display, seven-segment, red
DS283	Q5	150-1002-00			Numeric display, seven-segment, red
DS284	P5	150-1002-00			Numeric display, seven-segment, red
DS285	P5	150-1002-00			Numeric display, seven-segment, red
DS286	P5	150-1002-00			Numeric display, seven-segment, red
DS290		150-1001-01			Lamp, light emitting diode, 2 V, 70 mA
DS292		150-1001-01			Lamp, light emitting diode, 2 V, 70 mA
FUSE					
F320	R5	159-0021-00			Cartridge, 2A, 3AG, fast-blo

ELECTRICAL PARTS LIST (cont)

Ckt No.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
INTEGRATED CIRCUITS (cont)					
U241	G2	156-0039-00			Dual 15 MHz J-K master-slave flip-flop replaceable by SN7473N
U245	J2	156-0165-00			Dual 4-input positive nor gates, replaceable, by SN7425N
CONNECTORS					
J100		131-0955-00			Receptacle, electrical, BNC, female
J180		131-0955-00			Receptacle, electrical, BNC, female
INDUCTORS					
L192	Q3	276-0569-00			Core, toroid ferrite
L199	Q2	120-0382-00			Toroid, 14 turns single
TRANSISTORS					
Q115	K5	151-1022-00			Silicon, FET, selected from 2N4392
Q122	K4	151-0325-00			Silicon, PNP, replaceable by 2N4258
Q128	J6	151-0259-00			Silicon, NPN, selected from 2N3563
Q160	I6	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q162	I6	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q170	H6	151-0325-00			Silicon, PNP, replaceable by 2N4258
Q190	Q3	151-0362-00			Silicon, PNP, replaceable by SMT1105
Q195	O3	151-0190-00			Silicon, NPN, replaceable by 2N3904 or TE3904
Q198	N3	151-0259-00			Silicon, NPN, selected from 2N3563
Q230	M4	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q238	L4	151-0504-00			Silicon, unijunction, replaceable by 2N4851
Q240	L4	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q242	J1	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q280	F2	151-0301-00			Silicon, PNP, replaceable by 2N3907
Q281	F1	151-0301-00			Silicon, PNP, replaceable by 2N3907
Q282	G2	151-0301-00			Silicon, PNP, replaceable by 2N3907
Q283	G1	151-0301-00			Silicon, PNP, replaceable by 2N3907
Q284	G1	151-0301-00			Silicon, PNP, replaceable by 2N3907
Q285	G1	151-0301-00			Silicon, PNP, replaceable by 2N3907
Q286	G2	151-0301-00			Silicon, PNP, replaceable by 2N3907
Q320	S5	151-0515-01			Thyristor, 50 V, 8A, replaceable by 2N4441
Q330	D6	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q340	B4	151-0342-00			Silicon, PNP, replaceable by 2N4249
RESISTORS					
R102	M4	323-0611-00			900 kΩ, 1/2 W, 1%
R103	M4	321-0617-00			111 kΩ, 1/8 W, 1%
R106	L4	323-0620-00			800 kΩ, 1/2 W, 1%
R107	L5	321-0423-00			249 kΩ, 1/8 W, 1%
R112	L5	321-0356-00			49.9 kΩ, 1/8 W, 1%
R113	L6	315-0103-00			10 kΩ, 1/4 W, 5%
R115	K6	315-0470-00			47 Ω, 1/4 W, 5%
R117	I5	315-0101-00			100 Ω, 1/4 W, 5%
R118	K5	315-0182-00			1.8 kΩ, 1/4 W, 5%
R120	K5	315-0101-00			100 Ω, 1/4 W, 5%
R121	K5	315-0561-00			560 Ω, 1/4 W, 5%
R122	J4	315-0332-00			3.3 kΩ, 1/4 W, 5%
R123	K5	315-0223-00			22 kΩ, 1/4 W, 5%
R126	J5	315-0470-00			47 Ω, 1/4 W, 5%
R127	J5	315-0202-00			2 kΩ, 1/4 W, 5%
R130	J6	315-0102-00			1 kΩ, 1/4 W, 5%
R132	J6	315-0103-00			10 kΩ, 1/4 W, 5%
R135		311-1220-00			20 kΩ, Var
R137	M6	315-0513-00	B010100	B029999	51 kΩ, 1/4 W, 5%
R137	M6	315-0513-00	B030000		51 kΩ, (nominal value), selected
R139	M6	315-0103-00			10 kΩ, 1/4 W, 5%
R140	L5	323-0612-00			950 kΩ, 1/2 W, 1%

ELECTRICAL PARTS LIST (cont)

Ckt. No.		Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS	(cont)				
R152	J5	315-0101-00			100 Ω, 1/4 W, 5%
R153	J5	315-0101-00			100 Ω, 1/4 W, 5%
R155	I5	315-0331-00			330 Ω, 1/4 W, 5%
R158	H5	315-0102-00			1 kΩ, 1/4 W, 5%
R159	I5	315-0102-00			1 kΩ, 1/4 W, 5%
R162	I5	315-0102-00			1 kΩ, 1/4 W, 5%
R163	I5	315-0102-00			1 kΩ, 1/4 W, 5%
R165	I5	315-0561-00			560 Ω, 1/4 W, 5%
R167	I5	315-0621-00			620 Ω, 1/4 W, 5%
R169	I5	315-0561-00			560 Ω, 1/4 W, 5%
R172	H5	315-0152-00			1.5 kΩ, 1/4 W, 5%
R173	H6	315-0470-00			47 Ω, 1/4 W, 5%
R175	H5	315-0562-00			5.6 kΩ, 1/4 W, 5%
R177	K6	315-0562-00			5.6 kΩ, 1/4 W, 5%
R181	R2	317-0240-00			24 Ω, 1/8 W, 5%
R184	R3	315-0101-00			100 Ω, 1/4 W, 5%
R185	R2	315-0152-00			1.5 kΩ, /4 W, 5%
R187	R3	315-0102-00			1 kΩ, 1/4 W, 5%
R188	R3	315-0101-00			100 Ω, 1/4 W, 5%
R189	Q3	317-0240-00			24 Ω, 1/8 W, 5%
R190	Q3	315-0102-00			1 kΩ, 1/4 W, 5%
R191	Q2	315-0203-00			20 kΩ, 1/4 W, 5%
R192	Q3	315-0221-00	B010100	B059999	220 Ω, 1/4 W, 5%
R192	Q3	315-0561-00	B060000		560 Ω, 1/4 W, 5%
R192[1]	Q3	315-0221-00	B010100	B049999	220 Ω, 1/4 W, 5%
R192[1]	Q3	315-0561-00	B050000		560 Ω, 1/4 W, 5%
R193	P3	315-0101-00			100 Ω, 1/4 W, 5%
R194	P3	315-0332-00			3.3 kΩ, 1/4 W, 5%
R196	O3	315-0303-00			30 kΩ, 1/4 W, 5%
R198	N2	315-0122-00			1.2 kΩ, 1/4 W, 5%
R200	G5	315-0181-00			180 Ω, 1/4 W, 5%
R203	G5	315-0242-00			2.4 kΩ, 1/4 W, 5%
R205	G6	315-0271-00			270 Ω, 1/4 W, 5%
R209	G5	315-0301-00			300 Ω, 1/4 W, 5%
R220	L3	315-0562-00			5.6 kΩ, 1/4 W, 5%
R222	L2	315-0562-00			5.6 kΩ, 1/4 W, 5%
R224	L2	315-0562-00			5.6 kΩ, 1/4 W, 5%
R226	L3	315-0301-00			300 Ω, 1/4 W, 5%
R230	L3	315-0562-00			5.6 kΩ, 1/4 W, 5%
R232	L3	315-0202-00			2 kΩ, 1/4 W, 5%
R235[2]	C3	311-1342-00			500 kΩ, Var
R238	L3	315-0100-00			10 Ω, 1/4 W, 5%
R240	L3	315-0102-00			1 kΩ, 1/4 W, 5%
R242	I1	315-0562-00			5.6 kΩ, 1/4 W, 5%
R244	I1	315-0301-00			300 Ω, 1/4 W, 5%
R260	M3	315-0562-00			5.6 kΩ, 1/4 W, 5%
R261	M2	315-0242-00			2.4 kΩ, 1/4 W, 5%
R264	M2	315-0562-00			5.6 kΩ, 1/4 W, 5%
R265	M2	315-0242-00			2.4 kΩ, 1/4 W, 5%
R267	M2	315-0102-00			1 kΩ, 1/4 W, 5%
R271	H1	315-0750-00			75 Ω, 1/4 W, 5%

[1]Option 1 only.
[2]Furnished as a unit with S235.

ELECTRICAL PARTS LIST (cont)

Ckt No.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)					
R272	H2	315-0750-00			75 Ω, 1/4 W, 5%
R273	H2	315-0750-00			75 Ω, 1/4 W, 5%
R274	H2	315-0750-00			75 Ω, 1/4 W, 5%
R275	H2	315-0750-00			75 Ω, 1/4 W, 5%
R276	H2	315-0750-00			75 Ω, 1/4 W, 5%
R277	H2	315-0750-00			75 Ω, 1/4 W, 5%
R280A	F1	307-0357-00			300 Ω Thick film, 7 section divider
R280B					1 kΩ
R280C					300 Ω
R280D					1 kΩ
R280E					300 Ω
R280F					1 kΩ
R280G					300 Ω
R280H					1 kΩ
R280J					300 Ω
R280K					1 kΩ
R280L					300 Ω
R280M					1 kΩ
R280N					300 Ω
R280P					1 kΩ
R282	I2	315-0151-00			150 Ω, 1/4 W, 5%
R283	I2	315-0151-00			150 Ω, 1/4 W, 5%
R284	I2	315-0151-00			150 Ω, 1/4 W, 5%
R290	M2	315-0301-00			300 Ω, 1/4 W, 5%
R292	M2	315-0301-00			300 Ω, 1/4 W, 5%
R302	C5	307-0107-00			5.6 Ω, 1/4 W, 5%
R304	C5	315-0332-00			3.3 kΩ, 1/4 W, 5%
R305	D5	311-1408-00			1 kΩ, Var
R306	D5	315-0302-00			3 kΩ, 1/4 W, 5%
R307 [1]		305-0621-00	XB050000		620 Ω, 2 W, 5%
R307 [2]		305-0621-00	XB040000		620 Ω, 2 W, 5%
R308	C5	315-0152-00			1.5 kΩ, 1/4 W, 5%
R310 [1]	B5	306-0560-00	B010100	B049999	56 Ω, 2 W, 10%
R310 [1]	B5	306-0121-00	B050000		120 Ω, 2 W, 10%
R310 [2]	B5	306-0560-00	B010100	B039999	56 Ω, 2 W, 10%
R310 [2]	B5	306-0121-00	B040000		120 Ω, 2 W, 10%
R320	R5	316-0102-00			1 kΩ, 1/4 W, 10%
R322	B5	308-0463-00			0.3 Ω, 3 W, WW, 1%
R325	B5	315-0162-00			1.6 kΩ, 1/4 W, 5%
R327	B5	321-0260-00			4.99 kΩ, 1/8 W, 1%
R328	B5	321-0231-00			2.49 kΩ, 1/8 W, 1%
R330	C5	315-0161-00			160 Ω, 1/4 W, 5%
R334	D5	321-0256-00			4.53 kΩ, 1/8 W, 1%
R335	D5	321-0308-00			15.8 kΩ, 1/8 W, 1%
R340	B4	315-0202-00			2 kΩ, 1/4 W, 5%
R344	D5	321-0286-00			9.31 kΩ, 1/8 W, 1%
R345	C5	321-0308-00			15.8 kΩ, 1/8 W, 1%
R350 [1]	A5	305-0101-00	B010100	B049999	100 Ω, 2 W, 5%
R350 [1]	A5	306-0560-00	B050000		56 Ω, 2 W, 10%
R350 [2]	A5	305-0101-00	B010100	B039999	100 Ω, 2 W, 5%
R350 [2]	A5	306-0560-00	B040000		56 Ω, 2 W, 10%
SWITCHES					
S100A	M4				X10
S100B	M4	260-1353-01			Pushbutton, ATTENUATOR X5
S200	K3	105-0406-00			Actuator assembly, MEASUREMENT INTERVAL
S210	M3				
S220	M3	260-1425-00			Push, START / RESET
S235 [3]	C4				

[1] Standard only.
[2] Option 1 only.
[3] Furnished as a unit with R235.

ELECTRICAL PARTS LIST (cont)

Ckt No.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
INTEGRATED CIRCUITS					
U1[1]		156-0118-00	XB040000		Dual 100 MHz J-K master-slave flip-flop, replaceable by SN74S112N
U2[1]		156-0180-00	XB040000		Quad 2-input nand gate, replaceable by SN74S00N
U135	L6	156-0067-00			Operational amplifier, replaceable by UA741C
U150	I4	156-0182-00			Type 2-3-2 input gate, replaceable by MC10105
U160	H4	156-0180-00			Quad 2-input nand gate, replaceable by SN74S00N
U165	H4	156-0118-00			Dual 100 MHz J-K master-slave flip-flop, replaceable by SN74S112
U167[1]	G4	156-0100-00	B010100	B039999X	Single 40 MHz J-K edge-triggered flip-flop, replaceable by SN74H102
U167[2]		156-0100-00	B010100	B059999	Single 40 MHz J-K edge-triggered flip-flop, replaceable by SN74H102
U167[2]		156-0100-02	B060000		Single 40 MHz J-K edge-triggered flip-flop, replaceable by SN74H102
U169[1]	F4	156-0100-00	B010100	B039999X	Single 40 MHz J-K edge-triggered flip-flop, replaceable by SN74H102
U169[2]		156-0100-00	B010100	B059999	Single 40 MHz J-K edge-triggered flip-flop, replaceable by SN74H102
U169[2]		156-0100-02	B060000		Single 40 MHz J-K edge-triggered flip-flop, replaceable by SN74H102
U190	P3	156-0278-00			Divide by 10 ctr, replaceable by SP630B
U200	F5	156-0030-00			Quad 2-input positive nand gate, replaceable by SN7400N
U201[2]	E6	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U209	E5	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U210	D4	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U211	E4	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U212	E4	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U213	F3	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U214	G3	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U215	H3	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U220	K2	156-0042-00			Dual 15 MHz J-K master-slave flip-flop, replaceable by SN7476N
U222	L2	156-0174-00			Dual 20 MHz J-K master-slave flip-flop, replaceable by SN74111N
U230	J2	156-0150-00			Quad 2-input positive nand buffer, replaceable by SN7437N
U235	D3	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U236	C2	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U237	B2	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U238	B1	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U239	C1	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N
U240	D1	156-0079-00			Single 10 MHz divide-by-2-&-5 ripple counter, replaceable by SN7490N

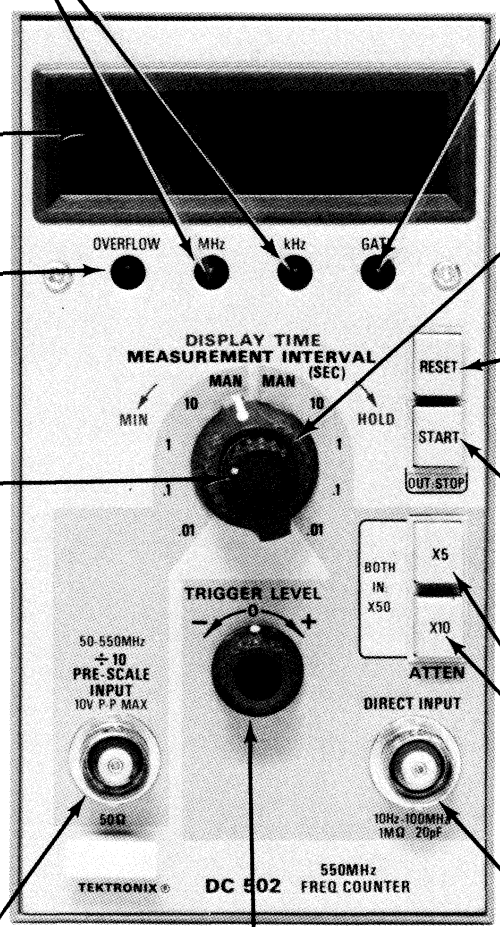
[1]Standard only.
[2]Option 1 only.

ELECTRICAL PARTS LIST (cont)

Ckt. No.		Tektronix Part No.	Serial/Model No. Eff	Disc	Description
INTEGRATED CIRCUITS (cont)					
U246	F2	156-0043-00			Quad 2-input positive nor gate, replaceable by SN7402N
U250	E3	156-0198-00			Quad latch, replaceable by MC4035P
U251	D3	156-0198-00			Quad latch, replaceable by MC4035P
U252	C4	156-0198-00			Quad latch, replaceable by MC4035P
U253	B3	156-0198-00			Quad latch, replaceable by MC4035P
U254	B2	156-0198-00			Quad latch, replaceable by MC4035P
U255	C2	156-0198-00			Quad latch, replaceable by MC4035P
U256	D2	156-0198-00			Quad latch, replaceable by MC4035P
U260	M1	156-0030-00			Quad 2-input positive nand gate, replaceable by SN7400N
U262	K2	156-0041-00			Dual 15 MHz D-type pos-edge-trig flip-flop, replaceable by SN7474N
U263	L2	156-0041-00			Dual 15 MHz D-type pos-edge-trig flip-flop, replaceable by SN7474N
U265	E1	156-0111-00			Single BCD-to-decimal decoder/driver, replaceable by SN74145N
U267	E2	156-0058-00			Hex. inverter, replaceable by SN7404N
U270	H2	156-0128-00			Single BCD-to-seven-segment decoder/driver, replaceable by SN7447N
U300	C6	156-0071-00			Voltage regulator, replaceable by UA723C
U320	B6	156-0071-00			Voltage regulator, replaceable by UA723C
CRYSTALS					
Y200	F5	158-0079-00			Crystal, 1 MHz
Y201[1]	F6	119-0262-00			Oscillator, RF, 5 MHz

[1]Option 1 only.

CONTROLS AND CONNECTORS



MHZ and kHz Units Indicators

LED indicates that readout displayed number should be multiplied by 10^6 (MHz) or 10^3 (kHz).

Gate Indicator

Lights during the active gating interval.

Display Readout

LED readout, seven 7-segment digits with automatically placed decimal point. The leading zeroes are suppressed unless an overflow is indicated.

Overflow Indicator

LED indicates overflow of leading digits when readout attempts to display more than seven digits.

DISPLAY Time Control

Variable control concentric with MEASUREMENT INTERVAL switch sets the length of time the reading will be displayed after the count is made and before the next measurement is taken. Display time can be varied from 0.1 second (MIN) to about 10 seconds. HOLD position (clockwise) provides continuous display until reset by pressing the RESET button.

MEASUREMENT INTERVAL Switch

Selects one of four gate times from the internal time-base clock (10 s, 1 s, .1 s, .01 s), or selects MANual gate, for either the DIRECT INPUT or the ÷10 PRE-SCALE INPUT.

RESET Pushbutton

Manually resets the counter to zero, initiates a new count when not in manual-gate mode, and provides a segment check of the 7 readout digits.

Manual Gate Pushbutton

Operable when MANual is selected by the MEASUREMENT INTERVAL switch. Button in starts the measurement interval gate; button out terminates the gate.

ATTEN Pushbuttons

Two buttons select X1, X5, X10, or X50 attenuation of the input signal.

÷10 PRE-SCALE INPUT Connector

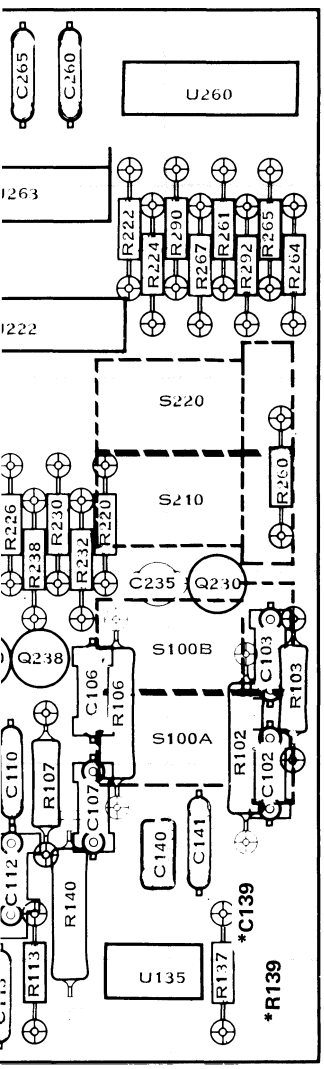
BNC connector for signal inputs to pre-scaling circuitry.

TRIGGER LEVEL Control

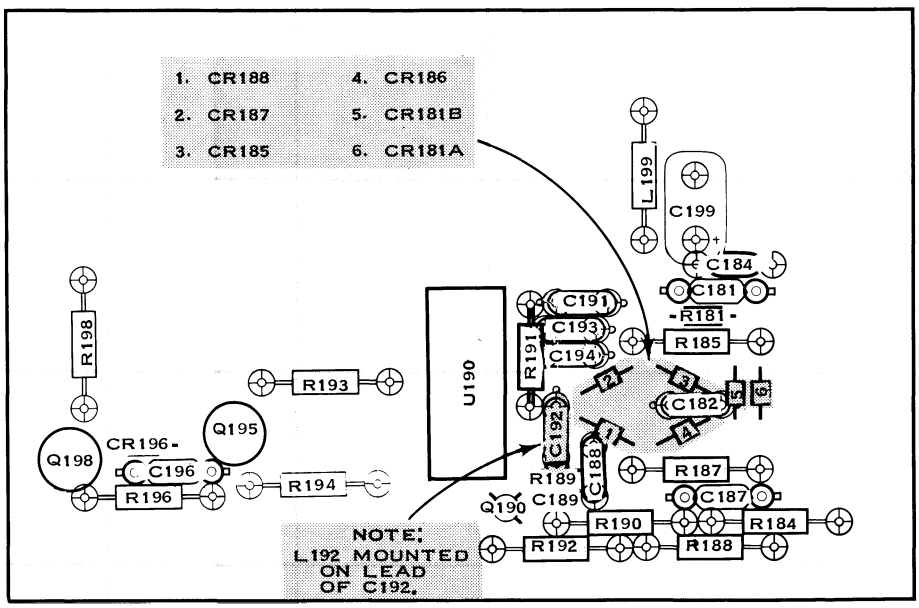
Selects the amplitude point on the DIRECT INPUT signal at which the triggering window is placed.

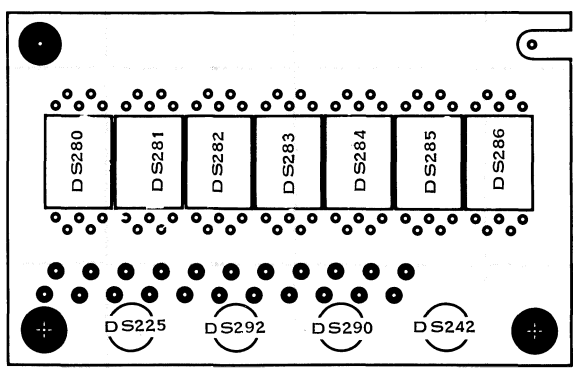
DIRECT INPUT Connector

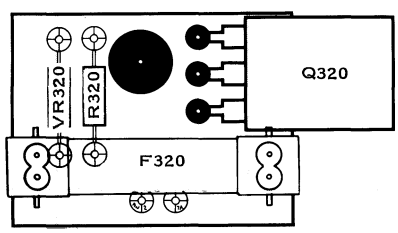
BNC connector for signal inputs to the attenuators and direct-counting circuitry.



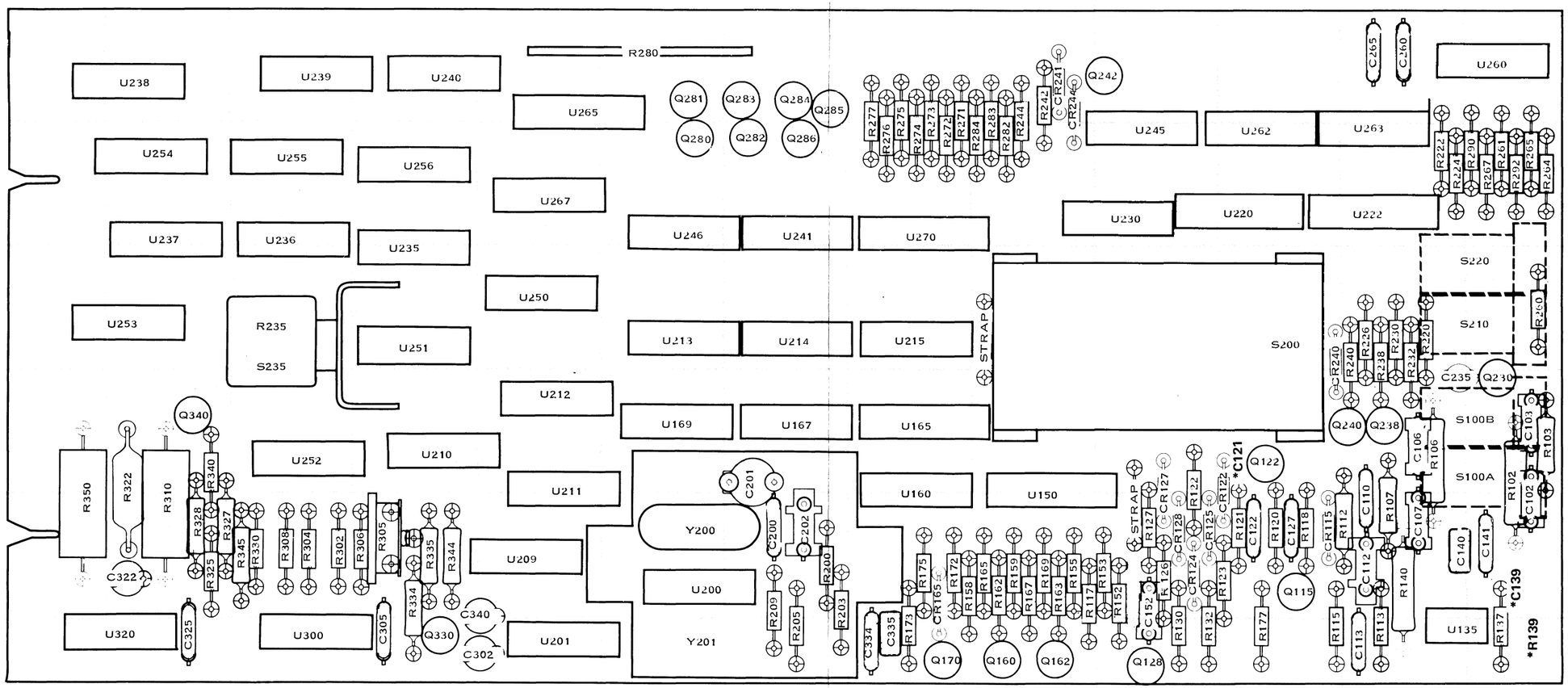
39 Relocated on back
39 of board SN B070000.







PARTS LOCATION GRID



*See Parts List for serial number ranges.

* R307 added to backside of board SN B050000-up.

C139 Relocated on back
R139 of board SN B070000.

COMPONENTS SHOWN WITH DASHED LINES ARE LOCATED ON BACK SIDE OF BOARD.

INTERNAL ADJUSTMENTS PROCEDURE

Services Available

Tektronix, Inc. provides complete instrument repair and adjustment at local Field Service Centers and at the Factory Service Center. Contact your local TEKTRONIX Field Office or representative for further information.

Test Equipment

For measurement of the power supply voltages, a 20,000 ohms/volt VOM will give satisfactory measurements. For example, Triplett 630 NA multimeter.

For 1-MHz frequency measurement, a secondary frequency standard or other frequency source having a stability of at least 5 parts on 10^7 (5 parts in 10^8 if measuring optional 5 MHz crystal output) is recommended for accuracy. Also recommended is a test oscilloscope with a bandwidth of at least 1 MHz and a stable triggering circuit for frequency-comparison measurement.

Procedure

NOTE

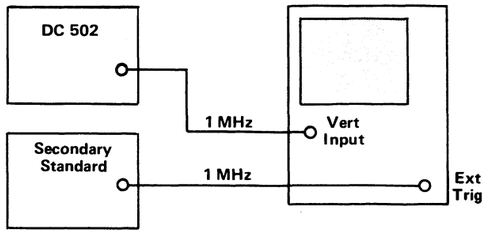
The performance of this instrument can be check at any temperature within the 0°C to +50°C range. Make any adjustment at a temperature between +20°C and +30°C (+68°F and +86°F).

The DC 502 can be operated either fully installed in a TM 500 Series Power Module or connected to a plug-in extender (TEKTRONIX Part No. 067-0645-01).

Power Supply Checks and Adjustment. Connect the voltmeter between the +15-volt test point and ground. Adjust R305 for a reading of +15 volts. Then check the +5-volt, –5.2-volt, and –10-volt supplies to be within 5%.

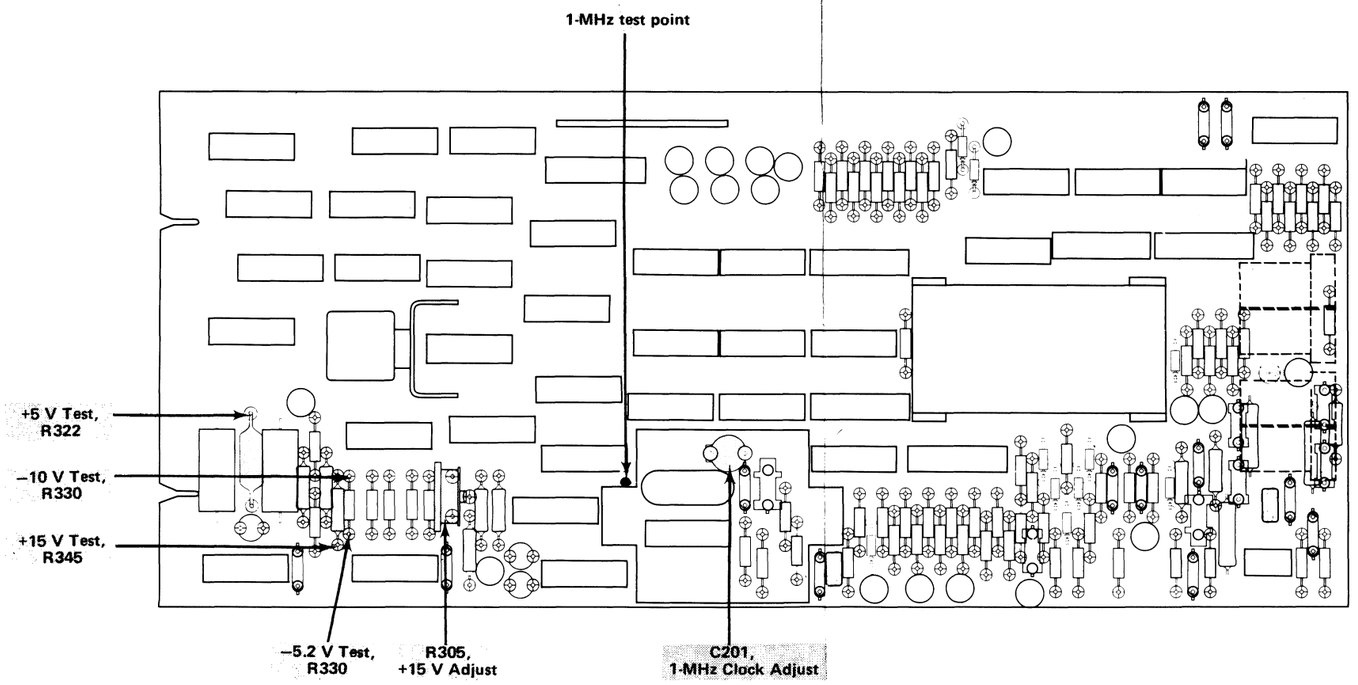
NOTE

If the instrument is operated on the plug-in extender, the +5-volt supply may not regulate.

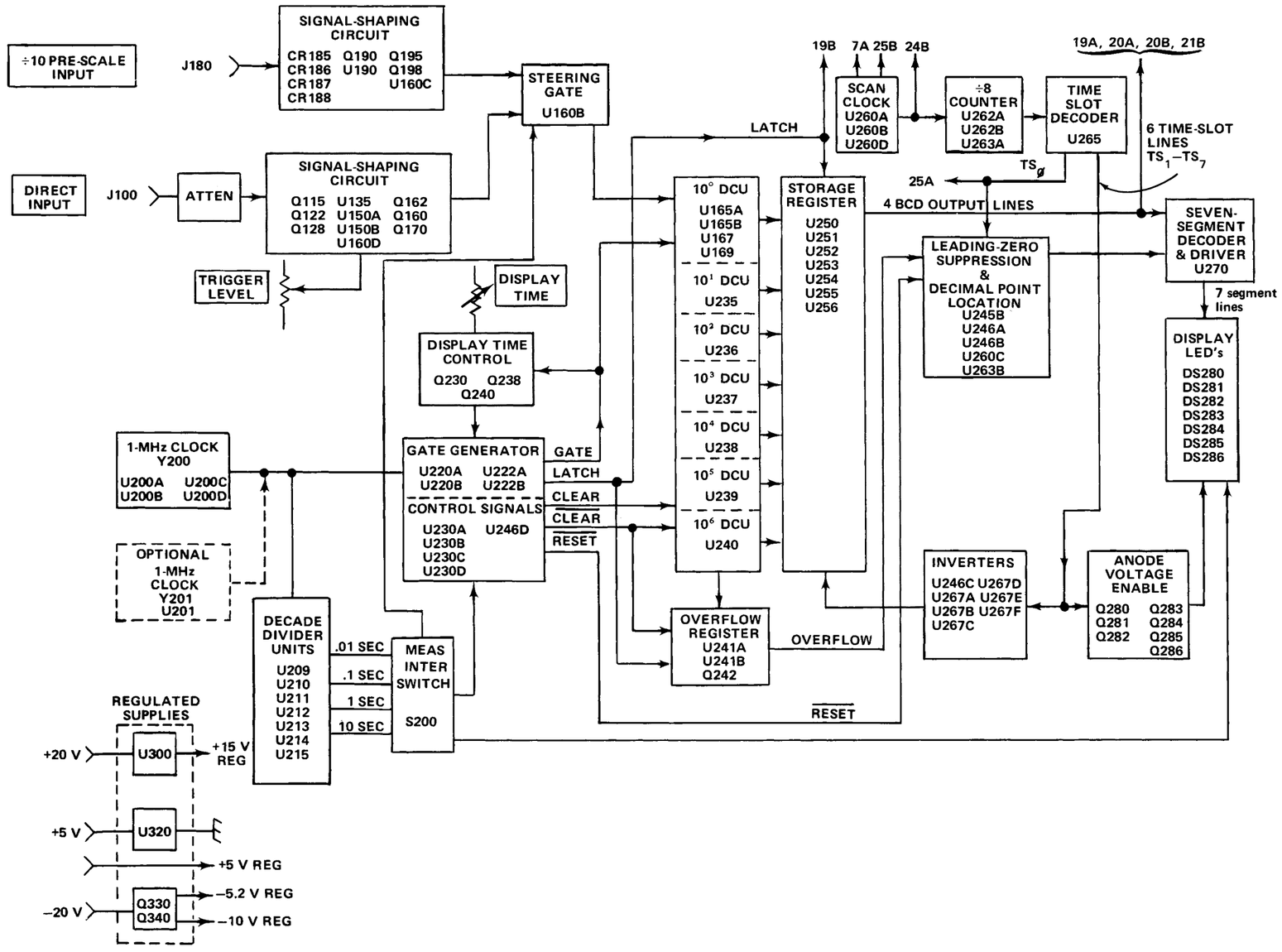


Time-Base Frequency Check and Adjustment. Connect the DC 502 1-MHz time base reference and the secondary standard to the oscilloscope as shown. Adjust the oscilloscope to display several complete cycles.

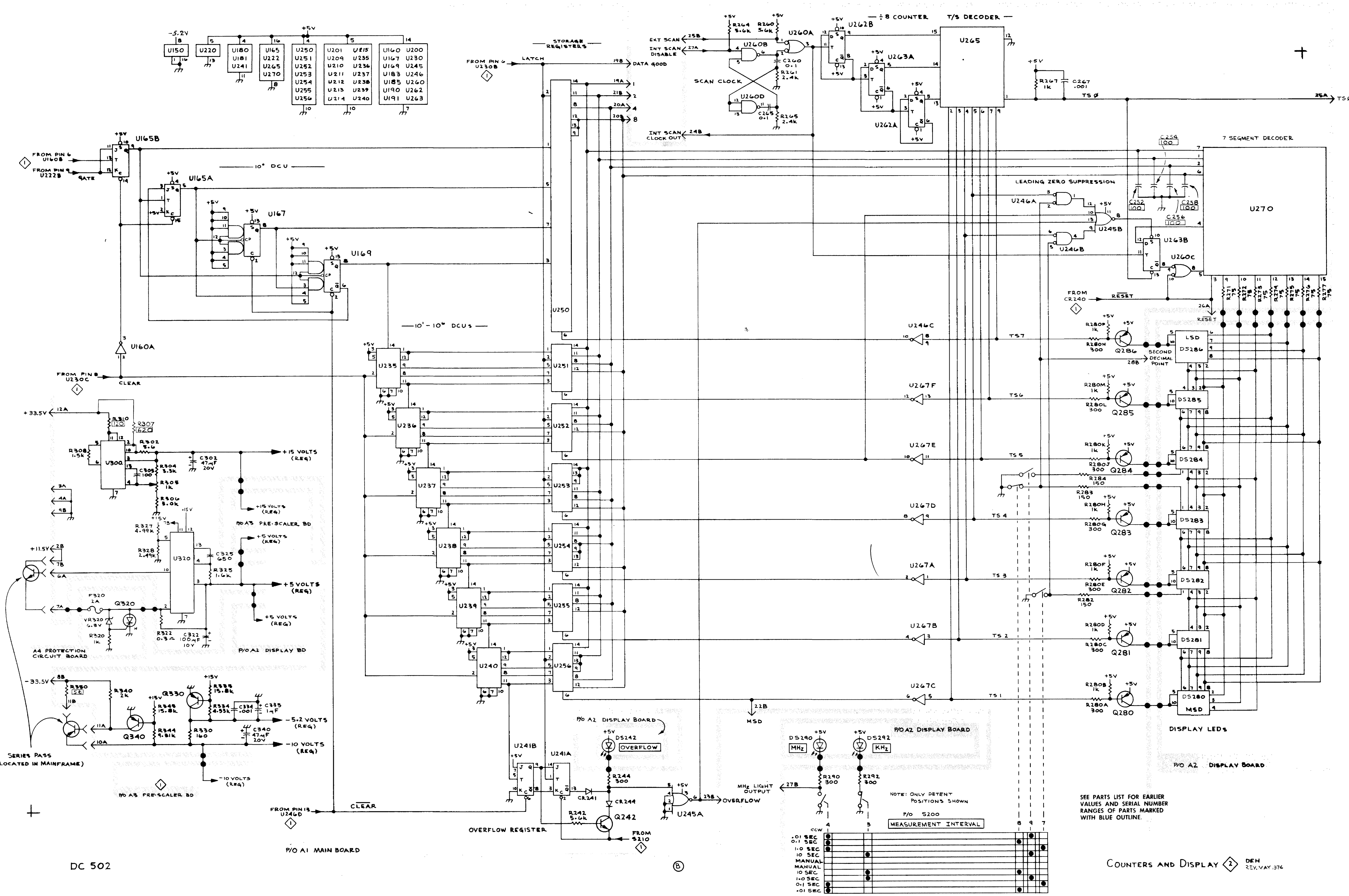
To determine oscillator error, observe the rate of horizontal drift of the displayed waveform. Waveform moving to the right indicates that the time-base frequency is <1 MHz; to the left, > 1 MHz. The period in seconds for the waveform to move the width of one cycle is equal to the frequency difference in parts in 10^6. For example, if the waveform drifts to the right at a rate of one cycle's width every 10 seconds, the time-base frequency is 0.1 part in 10^6 low. Maximum allowable frequency difference is 1 part in 10^5 (5 parts in 10^7 for the optional 5 MHz crystal). Adjust C201 for no drift.



DC 502 BLOCK DIAGRAM



ATTENUATORS
SIGNAL SHAPING
TIME BASE
GATING
DDU'S
PRE-SCALER
OPTIONAL OSCILLATOR
P/O A1 MAIN BOARD
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.
(BOTH x50)
ATTEN
X10
X5
S100A
S100B
DIRECT INPUT
J100
Q115
Q122
Q128
Q160
Q162
Q170
U135
TRIGGER LEVEL
U150A
U150B
U160B
U160C
U160D
TO PIN 13 U165B
Y200 1MHz
U200A
U200B
U200C
U200D
Y201 5 MHz OSC
U201
U209
U210
U211
U212
U213
U214
U215
CLEAR
TO PIN 2 U235
U230A
U230B
U230C
U230D
U246D
LATCH
TO PIN 1 U250
RESET
TO PIN 10 U260C
DISPLAY TIME
HOLD
S235 (GANGED W/R235)
Q230
Q238
Q240
CR240
U220A
U220B
U222A
U222B
S220
RESET
TO EMITTER Q242
GATE
TO PIN 12 U165B
D5225
P/O A2 DISPLAY BOARD
START
S210
(OUT) (STOP)
S200
MEASUREMENT INTERVAL
DIRECT INPUT
.01 SEC
0.1 SEC
1.0 SEC
10 SEC
MANUAL
MANUAL
10 SEC
1.0 SEC
0.1 SEC
.01 SEC
÷10 PRE-SCALE INPUT
CW
CCW
* SWITCH DETENT
J180 ÷10 PRE-SCALE INPUT
U190
Q190
Q195
Q198
CR181A
CR181B
+15 VOLTS
+5 VOLTS
-10 VOLTS
TO U160C-9
A3 PRE-SCALER BOARD
DC502
COUNTER TIME BASE AND CONTROL
DEM REV. MAY 1974
COUNTER TIME BASE & CONTROLS


STORAGE REGISTERS
LATCH
DATA GOOD
EXT SCAN
INT SCAN DISABLE
SCAN CLOCK
INT SCAN CLOCK OUT
÷ 8 COUNTER
T/S DECODER
U265
TSØ
7 SEGMENT DECODER
U270
LEADING ZERO SUPPRESSION
10° DCU
10¹ - 10⁶ DCUs
U250
U251
U252
U253
U254
U255
U256
U235
U236
U237
U238
U239
U240
U165B
U165A
U167
U169
U160A
CLEAR
FROM PIN 8 U230C
FROM PIN 13 U246D
FROM CR240
RESET
SECOND DECIMAL POINT
LSD
MSD
DS286
DS285
DS284
DS283
DS282
DS281
DS280
DISPLAY LEDS
P/O A2 DISPLAY BOARD
OVERFLOW
OVERFLOW REGISTER
MHz LIGHT OUTPUT
MHz
KHz
NOTE: ONLY DETENT POSITIONS SHOWN
P/O S200
MEASUREMENT INTERVAL
.01 SEC
0.1 SEC
1.0 SEC
10 SEC
MANUAL
MANUAL
10 SEC
1.0 SEC
0.1 SEC
.01 SEC
CCW
CW
+15 VOLTS (REG)
+5 VOLTS (REG)
-5.2 VOLTS (REG)
-10 VOLTS (REG)
P/O A3 PRE-SCALER BD
A4 PROTECTION CIRCUIT BOARD
SERIES PASS (LOCATED IN MAINFRAME)
P/O A1 MAIN BOARD
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.
DC 502
COUNTERS AND DISPLAY 2

MECHANICAL PARTS LIST

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

ABBREVIATIONS

BHB	binding head brass	h	height or high	OHB	oval head brass
BHS	binding head steel	hex.	hexagonal	OHS	oval head steel
CRT	cathode-ray tube	HHB	hex head brass	PHB	pan head brass
csk	countersunk	HHS	hex head steel	PHS	pan head steel
DE	double end	HSB	hex socket brass	RHS	round head steel
FHB	flat head brass	HSS	hex socket steel	SE	single end
FHS	flat head steel	ID	inside diameter	THB	truss head brass
Fil HB	fillister head brass	lg	length or long	THS	truss head steel
Fil HS	fillister head steel	OD	outside diameter	w	wide or width

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
1-1	366-0494-00			1		KNOB, gray--TRIGGER LEVEL
	- - - - - -			-		knob includes:
	213-0153-00			1		SETSCREW, 5-40 x 0.125 inch, HSS
-2	366-1031-00			1		KNOB, red--DISPLAY TIME
	- - - - - -			-		knob includes:
	213-0153-00			1		SETSCREW, 5-40 x 0.125 inch, HSS
-3	366-1165-00			1		KNOB, gray--MEASUREMENT INTERVAL
	- - - - - -			-		knob includes:
	213-0153-00			2		SETSCREW, 5-40 x 0.125 inch, HSS
-4	366-1422-00			1		KNOB, latch
-5	366-1257-30			1		PUSHBUTTON--RESET
	366-1402-01			1		PUSHBUTTON--START
-6	366-1402-00			1		PUSHBUTTON--X5
	366-1257-87			1		PUSHBUTTON--X10
-7	131-0955-00			2		CONNECTOR, receptacle, BNC, w/hardware (See J100 &
	- - - - - -			-		J180 electrical list)
	- - - - - -			-		mounting hardware for each: (not included w/connector)
-8	210-0255-00			1		TERMINAL, lug, 0.391 inch ID, SE
-9	- - - - - -			1		RESISTOR, variable (See R135 electrical list)
	- - - - - -			-		mounting hardware: (not included with resistor)
-10	210-0583-00			1		NUT, hex., 0.25-32 x 0.312 inch
-11	210-0940-00			1		WASHER, flat, 0.25 ID x 0.375 inch OD
-12	426-0681-00			4		FRAME, pushbutton
-13	426-0916-00			1		FRAME, readout window
-14	331-0314-00			1		WINDOW, readout
-15	337-1399-00			2		SHIELD, electrical, side
-16	333-1653-00			1		PANEL, front
	- - - - - -			-		mounting hardware: (not included with panel)
-17	211-0159-00			2		SCREW, 2-56 x 0.375 inch, PHS
-18	210-0405-00			2		NUT, hex., 2-56 x 0.188 inch

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
1-19	214-1513-00			1		LATCH, plug-in retaining
	- - - - - -			-		mounting hardware: (not included with latch)
-20	213-0254-00			1		SCREW, thread forming, 2-56 x 0.25 inch, 100° csk, FHS
-21	386-2292-00			1		SUBPANEL, front
	- - - - - -			-		mounting hardware: (not included w/subpanel)
-22	213-0229-00			4		SCREW, thread forming, 6-20 x 0.375 inch, 100° csk, FHS
-23	- - - - - -			1		CIRCUIT BOARD ASSEMBLY--DISPLAY (See A2 electrical list)
-24	337-1719-00			1		SHIELD, electrical, subpanel
-25	- - - - - -			1		CIRCUIT BOARD ASSEMBLY--PRESCALER (See A3 electrical list)
	- - - - - -			-		circuit board assembly includes:
-26	136-0269-02			1		SOCKET, integrated circuit, 14 pin
-27	136-0252-04			6		SOCKET, pin connector
	- - - - - -			-		mounting hardware: (not included w/circuit board assy)
-28	211-0001-00			2		SCREW, 2-56 x 0.25 inch, PHS
-29	- - - - - -			1		CIRCUIT BOARD ASSEMBLY--MAIN (See A1 electrical list)
	- - - - - -			-		circuit board assembly includes:
-30	131-0604-00			13		CONTACT, electrical (For repair, see maint. section)
-31	136-0252-04			16		SOCKET, pin connector
	136-0234-00			2		SOCKET, pin connector
	131-0566-00			2		LINK, terminal connecting
-32	376-0051-00			1		COUPLING, shaft
	- - - - - -			-		coupling includes:
	213-0022-00			4		SETSCREW, 4-40 x 0.188 inch, HSS
	354-0251-00			2		RING, coupling
	376-0049-00			1		COUPLING, plastic
-33	384-1146-00			1		SHAFT, extension
-34	260-1425-00			1		SWITCH, push--START-STOP (S235)
-35	361-0382-00			8		SPACER, switch, brown
-36	260-1353-01			1		SWITCH, push--ATTEN (S100A & S100B)
-37	- - - - - -			1		RESISTOR, variable (See R235 electrical list)
	- - - - - -			-		mounting hardware: (not included w/resistor)
-38	210-0583-00			1		NUT, hex., 0.25-32 x 0.312 inch
-39	210-0046-00			1		WASHER, lock, internal, 0.261 ID x 0.40 inch OD
-40	407-0803-00			1		BRACKET, component mounting
	- - - - - -			-		mounting hardware: (not included w/circuit board assy)
-41	213-0146-00			3		SCREW, thread forming, 6-20 x 0.312 inch, PHS

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
1-42	426-0724-00			1		FRAME SECTION, bottom
-43	426-0725-00			1		FRAME SECTION, top
-44	179-1767-00			1		WIRING HARNESS
	105-0406-00			1		ACTUATOR ASSEMBLY, cam switch (S200)
	- - - - - -			-		actuator assembly includes:
-45	200-1391-00			1		COVER
	- - - - - -			-		mounting hardware: (not included with cover)
	211-0022-00			2		SCREW, 2-56 x 0.188 inch, PHS (Discard & use ref #28)
-46	210-0001-00			2		WASHER, lock, internal, 0.092 ID x 0.18 inch OD
-47	354-0219-00			1		RING, retaining
-48	401-0057-00			1		BEARING, front
-49	214-1139-00[1]			-		SPRING, flat, gold
	214-1139-02[1]			-		SPRING, flat, green
	124-1139-03[1]			-		SPRING, flat, red
-50	214-1127-00			1		ROLLER, detent
-51	105-0405-00			1		DRUM ASSEMBLY
-52	401-0057-00			1		BEARING, rear
-53	210-0405-00			2		NUT, hex., 2-56 x 0.188 inch
-54	210-0406-00			4		NUT, hex., 4-40 x 0.188 inch
	- - - - - -			-		mounting hardware: (not included w/actuator assembly)
-55	211-0116-00			3		SCREW, sems, 4-40 x 0.312 inch, PHB
-56	- - - - - -			1		CIRCUIT BOARD ASSEMBLY--PROTECTION (See A4 elect. list)
	- - - - - -			-		circuit board assembly includes:
-57	344-0154-00			2		CLIP, electrical, fuse
	- - - - - -			-		mounting hardware: (not included w/circuit board assy)
-58	213-0206-00			1		SCREW, thread forming, 6-32 x 1.25 inches, PHS
-59	361-0516-00			1		SPACER, sleeve, 0.986 inch long

[1] Replace only with part bearing the same color code as the original part in your instrument.

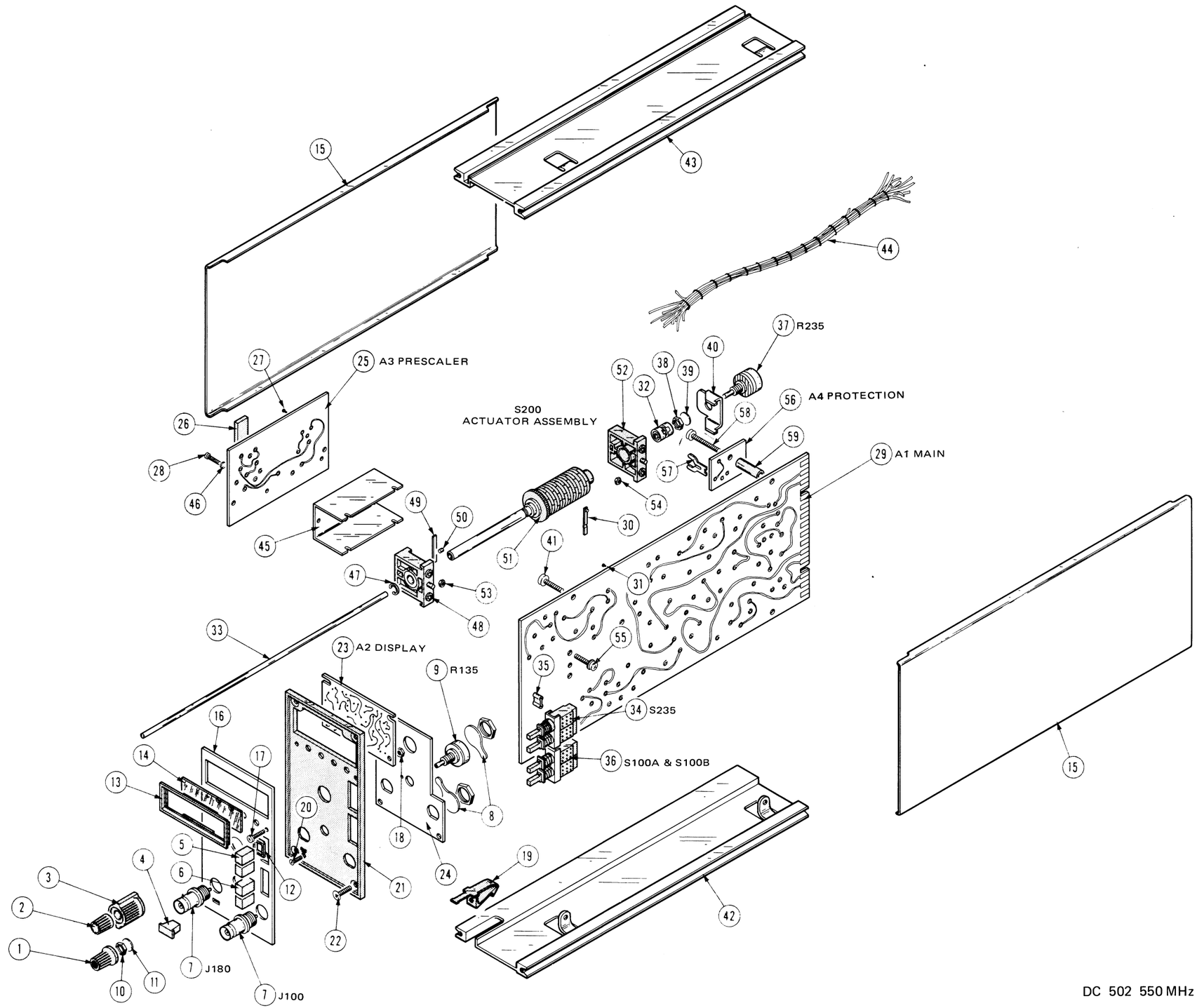


FIG. 1 EXPLODED

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

DC501, DC502

TEXT CORRECTION

The upper limit frequency response specifications has been changed to 110 MHz. Any reference to a 100 MHz should be changed to read: 110 MHz.

ELECTRICAL PARTS LIST AND SCHEMATIC CHANGES

REMOVE:

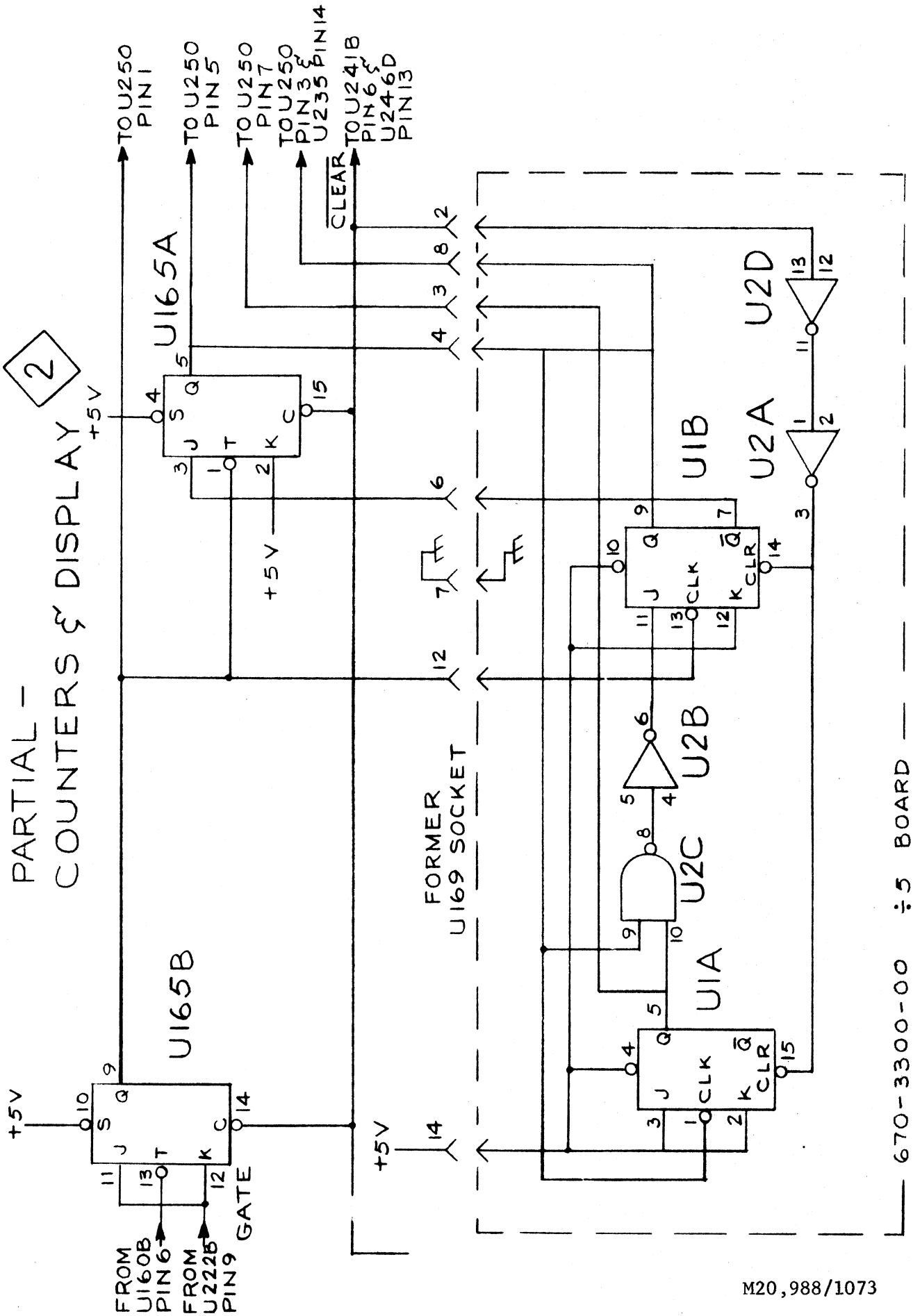
U167	156-0100-00	Single 40 MHz J-K edge-triggered flip-flop, replaceable by SN74H102
U169	156-0100-00	Single 40 MHz J-K edge-triggered flip-flop, replaceable by SN74H102

CHANGE TO:

A1	670-2102-01	MAIN Circuit Board Assembly

ADD:

	670-3300-00	DIVIDE BY 5, Circuit Board Assembly
U1	156-0118-00	Dual 100 MHz J-K master-slave flip-flop, replaceable by SN74S112
U2	156-0180-00	Quad 2-input nand gate, replaceable by SN74S00N


2
PARTIAL - COUNTERS & DISPLAY
670-3300-00 ÷5 BOARD
TO U250 PIN 1
TO U250 PIN 5
TO U250 PIN 7
TO U250 PIN 3 & U235 PIN 14
TO U241B PIN 6 & U246D PIN 13
CLEAR
U165A
U165B
U1A
U1B
U2A
U2B
U2C
U2D
+5V
FROM U160B PIN 6
FROM U222B PIN 9
GATE
FORMER U169 SOCKET

DC 501 EFF SN B060000-up

DC 502 EFF SN B070000-up

ELECTRICAL PARTS LIST AND SCHEMATIC CHANGE

CHANGE TO:

R137	311-1554-00	200 kΩ, Var

ADD:

C121	283-0111-00	0.1 μF, Cer, 50 V

(R137 and C121 are located on Diagram 1 COUNTER TIME BASE & CONTROL)