TEKTRONIX®

PG 506 CALIBRATION GENERATOR

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

Serial Number ____________________

070-1740-00

First Printing OCT 1974

WARRANTY

All TEKTRONIX instruments are warranted against defective materials and workmanship for one year. Any questions with respect to the warranty should be taken up with your TEKTRONIX Field Engineer or representative.

All requests for repairs and replacement parts should be directed to the TEKTRONIX Field Office or representative in your area. This will assure you the fastest possible service. Please include the instrument Type Number or Part Number and Serial Number with all requests for parts or service.

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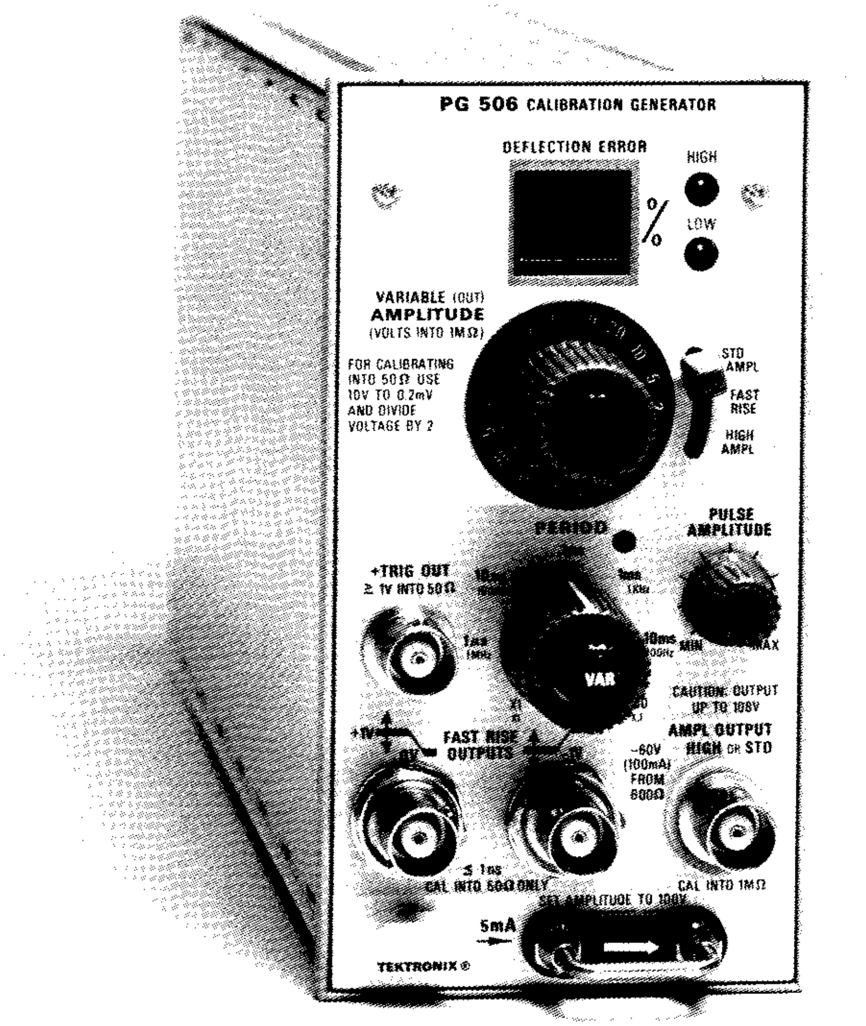
PG 506 CALIBRATION GENERATOR
DEFLECTION ERROR
HIGH
LOW
VARIABLE (OUT)
AMPLITUDE
(VOLTS INTO 1MΩ)
FOR CALIBRATING
INTO 50Ω USE
10V TO 0.2mV
AND DIVIDE
VOLTAGE BY 2
STD
AMPL
FAST
RISE
HIGH
AMPL
PERIOD
PULSE
AMPLITUDE
+TRIG OUT
≥ 1V INTO 50Ω
VAR
MIN
MAX
CAUTION: OUTPUT
UP TO 100V
FAST RISE
OUTPUTS
AMPL OUTPUT
HIGH OR STD
≤ 1ns
CAL INTO 50Ω ONLY
CAL INTO 1MΩ
SET AMPLITUDE TO 100V
5mA
TEKTRONIX®

OPERATING INSTRUCTIONS

INTRODUCTION

Description

The PG 506 Calibration Generator is designed to operate in a TM 500 Series Power Module. The instrument is a combination Amplitude Calibrator and Square Wave Pulse Generator intended for calibration and adjustments of oscilloscope amplifier systems with a 50-ohm or 1-megohm input resistance.

The Amplitude Calibrator function provides either a + dc voltage or a 1 kHz square-wave output, as selected by an internal switch. Peak-to-peak amplitudes from 0.2 millivolt to 100 volts across a 1-megohm load and amplitudes of 100 microvolts to 5 volts across a 50-ohm load are available. Output amplitudes are selected in a 1, 2, 5 sequence.

Because errors are often stated as a percentage, an internal digital differential voltmeter with front-panel light-emitting diode (LED) readout is used to provide a display equal to oscilloscope vertical or horizontal deflection errors. If the indicated deflection on an oscilloscope graticule does not agree with the proper reference line, the output amplitude from the PG 506 Amplitude Calibrator can be varied until the proper alignment is obtained. In this operating mode, the front-panel readout is a direct display of the oscilloscope deflection error.

A 5 mA Current Loop is provided, which supplies current (dc or 1 kHz) for calibration of current probes.

The Pulse Generator provides three square-wave outputs: variable High Amplitude pulses and simultaneous positive- and negative-going Fast Rise, variable-amplitude pulses. In the Pulse Generator mode, the Period is selectable from one microsecond to 10 milliseconds in decade steps. A variable control extends the maximum period to at least 100 milliseconds (for each decade step, the period is variable over a 10:1 range). A positive going pretrigger output is also provided for triggering external equipment.

Installation and Removal

WARNING

Dangerous voltage may be present on the front-panel BNC connector labeled AMPL OUTPUT (HIGH or STD). Before installation, turn the control labeled AMPLITUDE (VOLTS INTO 1 MΩ) fully counter-clockwise (ccw), and the control labeled PULSE AMPLITUDE to MIN.

CAUTION

Turn the Power Module off before inserting the plug-in; otherwise, damage may occur to the plug-in circuitry.

The PG 506 is calibrated and ready to use as received.

Referring to Fig. 1-1, install the PG 506.

To remove the PG 506 from the Power Module, pull the release latch to disengage the plug-in and pull straight out.

Refer to the foldout pages for a description of front-panel controls, connectors, and rear connector pin assignments.

Preliminary Checks

Make all desired connections to equipment under test before applying power to the PG 506. The power switch is on the Power Module. Power application to the PG 506 is indicated by the PERIOD light turning on, or the light behind the knob skirt of the AMPLITUDE control switch being lighted.

The front-panel LED's can be tested (888 display) by setting the three-position Mode switch to STD AMPL position, then pushing and holding the VARIABLE knob concentric with the AMPLITUDE switch.

To test the digital voltmeter system, release the VARIABLE knob to the out position and rotate the control in both directions.

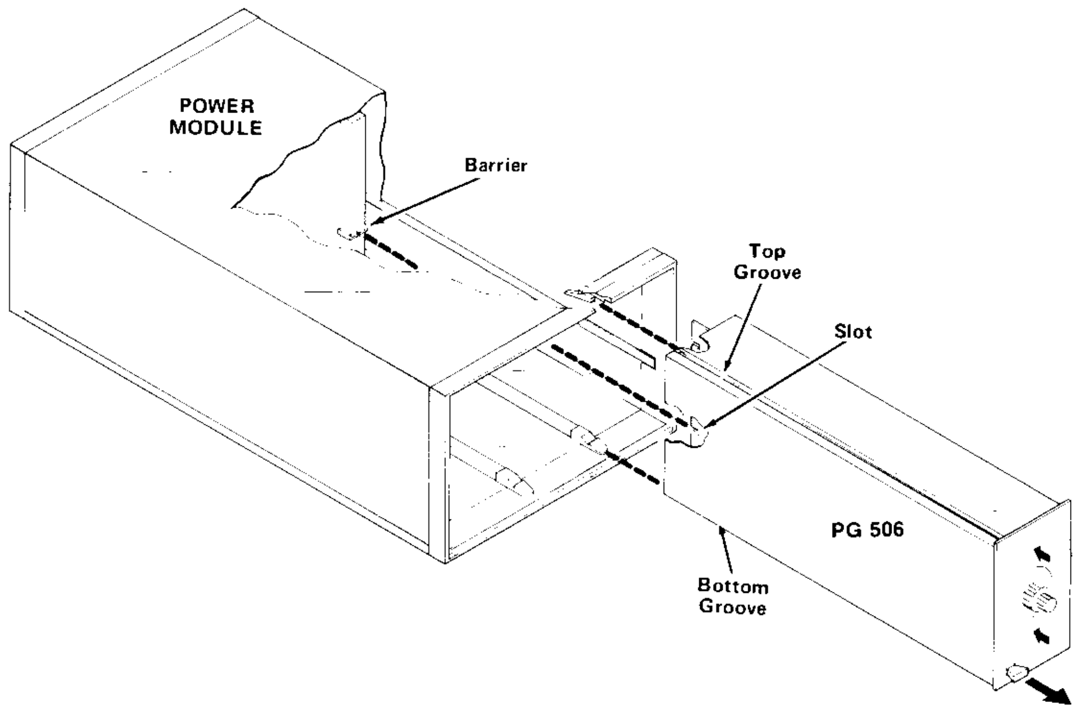

Fig. 1-1. PG 506 Installation and Removal.

Allow 15 to 20 minutes warmup time for all equipment before using the PG 506.

AMPLITUDE CALIBRATOR MODE

Connections and Terminations

To use the PG 506 Amplitude Calibrator system, set the mode switch to the STD AMPL position. Connect the 1 kHz calibrated amplitude signal at the AMPL OUTPUT connector to the input of an oscilloscope through a coaxial cable that has a 50-ohm characteristic impedance (RG-58/U) with a maximum length of 42 inches (shorter cables can be used).

With a cable termination of 1 MΩ and the DEFLECTION ERROR display off, the 1 kHz signal peak-to-peak output amplitude will be equal to the indicated reading on the AMPLITUDE switch. If the cable is terminated into a 50-ohm load, use an output amplitude in the 10-volt to 0.2-millivolt range: the output amplitude will then be one-half the indicated reading on the AMPLITUDE switch.

Oscilloscope Controls

The deflection factor (either vertical or horizontal) for oscilloscopes is the ratio of the amplitude of the input signal to the amount of beam deflection produced on the cathode-ray tube (crt), usually stated as volts per division of deflection (Volts/Div). Calibration procedures for some oscilloscopes require that the gain be set and the deflection accuracy be checked with a probe (properly compensated) connected between the PG 506 and the oscilloscope input connector.

For oscilloscope gain adjustments and checking of deflection accuracies, it is always best to set all oscilloscope controls exactly as called out in the calibration and performance sections of the oscilloscope instruction manual. However, it may be found desirable to set the oscilloscope sweep controls to a 0.1 millisecond/division (or faster) sweep rate and free-run the sweep when performing vertical deflection (amplitude) checks and adjustments. This procedure produces two horizontal traces that are separated vertically by an amount proportional to the peak-to-peak amplitude of the 1 kHz square-wave from the PG 506. At faster sweep rates, the display becomes more readable.

Deflection Error Readout

When performing gain adjustments on oscilloscope or amplifier systems, it is mandatory that the DEFLECTION ERROR readout be turned off in order to obtain calibrated output amplitudes. The PG 506 DEFLECTION ERROR readout feature finds its greatest use in its ability to allow an operator to verify the oscilloscope deflection accuracy associated with amplifier gain and input attenuators.

Gain adjustments for oscilloscope amplifiers are usually made at low levels, for example; at a 10 mV/div deflection factor and a 50 mV signal from the PG 506. This ratio corresponds to five major graticule divisions of beam deflection. If the gain of the oscilloscope amplifier system is low, the indicated deflection will be less than five major graticule divisions, for example; 4.8 major divisions. The VARIABLE AMPLITUDE (OUT) control on the PG 506 can then be used to increase the output amplitude until the total deflection is exactly five major divisions. At this point, the DEFLECTION ERROR readout will read 4.0% LOW. Conversely, if the oscilloscope amplifier system gain is too high, the indicated deflection on the crt will be above the proper reference line, for example; 5.2 major divisions. Using the VARIABLE AMPLITUDE control on the PG 506 to reduce the output amplitude for exactly five major divisions of deflection will produce a DEFLECTION ERROR readout of 4.0% HIGH.

For some oscilloscopes the deflection factor may not be constant throughout the full vertical dimension of the graticule, due to compression or expansion nonlinearities. To check for this type of nonlinearity; center a two-division display, then position the display to the top of the graticule. Measure any deflection errors with the PG 506 VARIABLE AMPLITUDE control. Next, position the two-division display to the bottom of the graticule and measure the deflection errors. These nonlinearities should be taken into account when making measurements with full graticule deflection, or with the crt trace positioned towards the top or bottom graticule limits and using small deflection factors.

Current Loop

One end of the Current Loop is grounded and terminates a precision voltage divider. The direction of the arrow is oriented for conventional current. To obtain a calibrated 5 mA from the Current Loop, set the mode switch to STD AMPL position and the AMPLITUDE control switch to the 100 V position. The DEFLECTION ERROR readout should be off, or adjusted to read 0.0%. The current signal can be either dc or 1 kHz square-wave current, as selected by an internal switch.

PULSE GENERATOR MODE

General

In order to ensure waveform fidelity when using the Pulse Generator function of the PG 506, the following precautions should be observed.

1. Use high quality 50-ohm coaxial cable, connectors, and terminations (where applicable). Make all connections as tight and short as possible.

2. Reduce capacitive and inductive loads to a minimum. Risetime degradation occurs with long cable lengths.

3. Minimum risetime and pulse aberrations are obtained with 50-ohm loads and loads must be capable of dissipating the power available at any output connector in any operating mode.

4. The external equipment is assumed to have no dc voltage across the load to which the PG 506 is connected. If a dc voltage exists, the output amplitude from the PG 506 will be in error by the amount of the dc offset. To prevent dc-offset errors, couple the PG 506 outputs through a dc blocking capacitor to the load. The time constant of the coupling capacitor and the total resistance in series must be long enough to maintain pulse flatness.

High Amplitude Output

To use the PG 506 Pulse Generator system to produce high amplitude square-waves, set the mode switch to HIGH AMPL position and connect external equipment to the AMPL OUTPUT HIGH connector. Set the Period controls for the period or frequency desired. The output amplitude of this signal can be adjusted with the PULSE AMPLITUDE control.

This signal can be used to adjust oscilloscope amplifier input capacitance, attenuator compensation networks, and other internal frequency compensation networks. The AMPL OUTPUT HIGH signal is negative with respect to ground, with its risetime related to the rising portion (from a negative potential) of the waveform. Refer to Fig. 1-2. The absolute peak-to-peak value of the square-wave is determined by the load resistance and the setting of the PULSE AMPLITUDE control. Table 1-1 lists the *typical amplitudes* available when the PG 506 is terminated into three different load resistances.

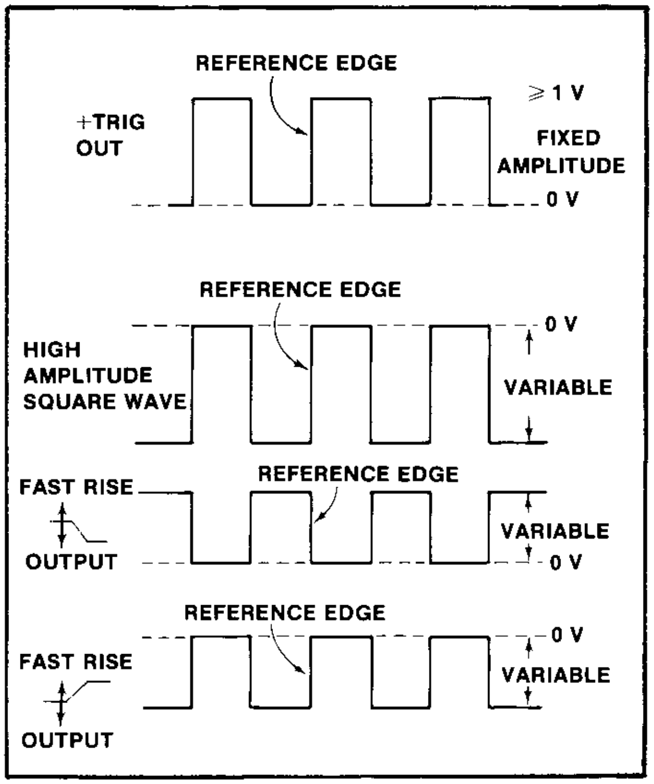

Fig. 1-2. Output signals from PG 506 Square Wave Generator system. Dashed line is zero volt level for each waveform. -TRIG OUT signal leads HIGH AMPL pulse by about 18 nanoseconds and leads FAST RISE pulse by about 8 nanoseconds.

TABLE 1-1

HIGH AMPL OUTPUT Termination	PULSE AMPLITUDE Control[1] MIN	MAX
50 Ω Load	0.3 V p-p	5.2 V p-p
600 Ω Load	1.9 V p-p	32.5 V p-p
1 MΩ Load	3.8 V p-p	≥60.0 V p-p

[1]**Approximate amplitudes.**

Fast Rise Outputs

To use the PG 506 Pulse Generator system to produce low amplitude, fast-rise square-waves, set the mode switch to FAST RISE position and connect external equipment to the FAST RISE OUTPUTS connector(s). Set the PERIOD controls for the period or frequency desired. The output amplitude can be adjusted by the PULSE AMPLITUDE control. Coaxial cable, PN 012-0482-00 should be used when operating the PG 506 in a FAST RISE mode.

These signals are usually used to adjust high-frequency compensation networks in oscilloscope amplifier circuits. The adjustments are made for optimum response (minimum aberrations). The risetime and amplitude specifications for the FAST RISE outputs apply only when they are terminated into a 50-ohm load. Larger amplitudes (greater than 1 volt peak-to-peak) can be obtained from these output connectors under unterminated conditions, but the risetime specification is no longer applicable.

GENERAL INFORMATION

Risetime Considerations

The PG 506 can be used in conjunction with an oscilloscope to determine the risetime of a device under test (dut). Risetime is normally measured (unless otherwise specified) between the 10% and 90% amplitude levels on the leading edge of a waveform. The risetime of a displayed waveform is illustrated in Fig. 1-3.

Before measuring the risetime of a device under test, the combined risetime of the PG 506 output signal and the oscilloscope vertical amplifier system must be known. Refer to Fig. 1-3 for the percentage error to be expected when the two devices are cascaded. Sweep timing accuracy should be verified before any risetime measurements are made. Inaccuracies in the sweep timing and display reading errors must be added algebraically to the percentage error obtained from computations related to Fig. 1-3.

The graph for Fig. 1-3 can be used as a guideline for the following general conclusions.

1. Oscilloscopes should have a vertical system risetime about one-seventh of the fastest signal applied to keep system errors to a minimum.

2. Conversely, if the signal risetime is at least seven times faster than the risetime of the oscilloscope vertical system, the displayed (observed) waveform will have a risetime that is very close to the risetime of the vertical system.

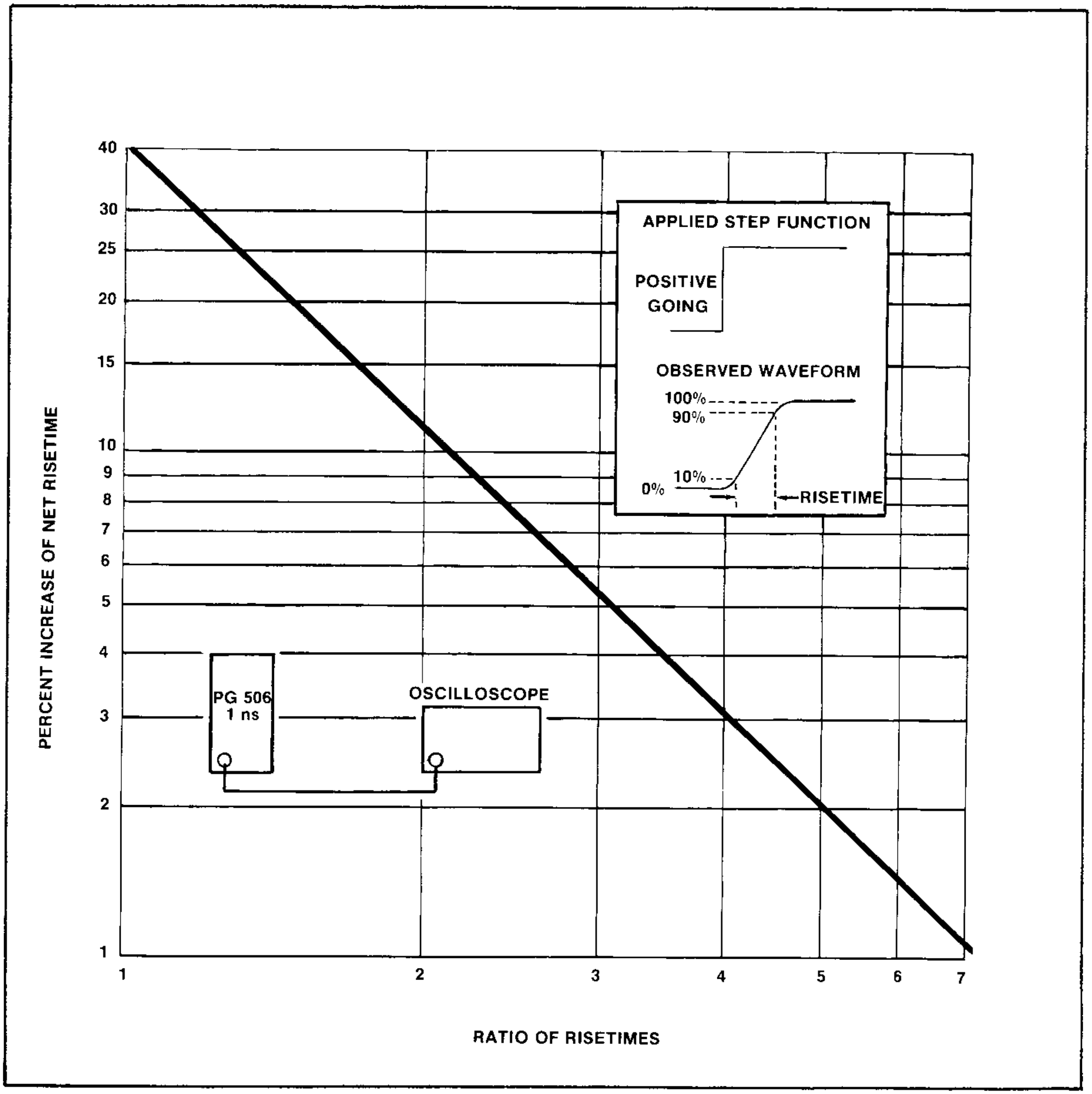

Fig. 1-3. Percentage increase of net risetime vs ratio of risetimes for two cascaded devices. For example, a 2-ns oscilloscope monitoring a 10-ns signal (5:1 ratio) would permit an observation with an error of 2%. Note that if the risetimes are equal the error is 41.4%. Sweep timing and display-reading errors not included.

3. The displayed risetime as observed on any oscilloscope can never be faster than the risetime of the slowest device in the system.

Risetime of a displayed waveform is related to total system bandwidth. A system with limited high-frequency response will produce a displayed risetime that is slower than expected. If a fast-step signal produces a crt display with little or no overshoot or ringing, the product of oscilloscope risetime and oscilloscope bandwidth should result in a factor whose value lies between 0.329 and 0.350.

The following steps describe the procedure to follow in determining the risetime of a device under test.

1. Connect the appropriate output signal from the PG 506 to the oscilloscope vertical input with a short 50-ohm coaxial cable terminated into a 50-ohm load.

2. Set the oscilloscope controls to display the leading edge of the waveform. Risetime measurements should be made over the largest part of the graticule area possible. When the fastest sweep rate is relatively slow compared with the vertical system risetime (or the scale is small), measurements become confined to small sections of the graticule, and the probability of display reading errors becomes greater.

3. Measure the time duration between the 10% and 90% amplitude levels. This is the combined risetime of the PG 506 and the oscilloscope (T_{rc}).

4. Disconnect the coaxial cable and 50-ohm termination from the oscilloscope.

5. Connect the coaxial cable from the PG 506 to the input of the device under test and connect the output of the device under test to the oscilloscope vertical input. Terminate the dut in its characteristic impedance for optimum performance.

6. Set the oscilloscope controls to display the leading edge of the displayed waveform and measure the time duration between the 10% and 90% amplitude levels (over the same graticule area, if possible). This is the total system risetime (T_{rs}).

7. Calculate the risetime of the device under test using the following formula:

$$T_r\,(\text{dut}) = \left[(T_{rs})^2 - (T_{rc})^2\right]^{1/2}$$

Checking Amplifier Response

The square-wave output signals from the PG 506 can be used to check the response of active or passive systems. Because the characteristics of a pulse from the PG 506 is known (see ELECTRICAL CHARACTERISTICS), distortion of the waveform beyond these limits is due to the device under test.

The compensation of an ac-voltage divider, such as used in the input attenuator of an oscilloscope or a passive attenuator probe, can be checked by observing its response when a square-wave signal is applied. Correct response is shown by optimum square corner on the displayed waveform. If the waveform has overshoot, rolloff, or front-corner rounding, the system is not correctly compensated. Fig. 1-4 shows typical waveforms illustrating correct and incorrect compensation adjustments. When performing these compensation checks, the repetition rate of the applied square-wave signal should be at least 3 to 4 decades above the low-frequency cutoff point (frequency where the equivalent sine-wave amplitude is 30% down).

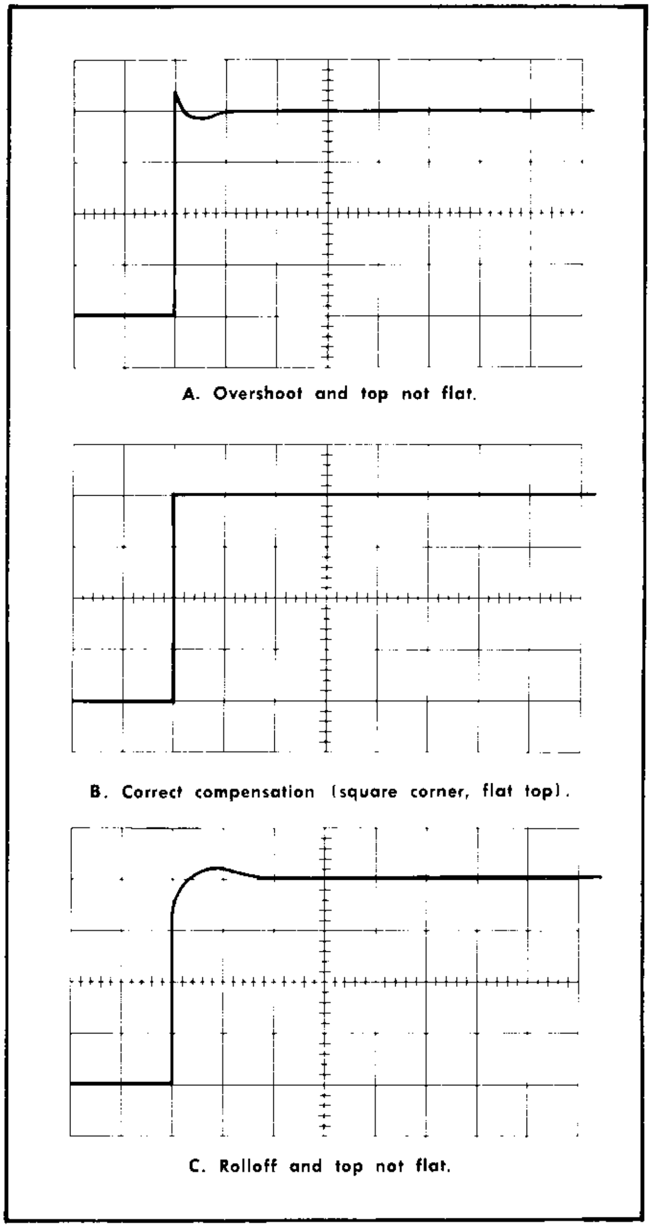

Fig. 1-4. Typical waveforms showing correct and incorrect compensation adjustments.

The low end cut-off frequency (due to RC coupling) for an amplifier can be approximated very closely by using the following procedure.

1. Apply a square-wave at a repetition rate that is not affected by the low-frequency limit.

2. Slowly reduce the square-wave frequency and adjust the oscilloscope (amplifier) controls to display a signal similar to Fig. 1-5.

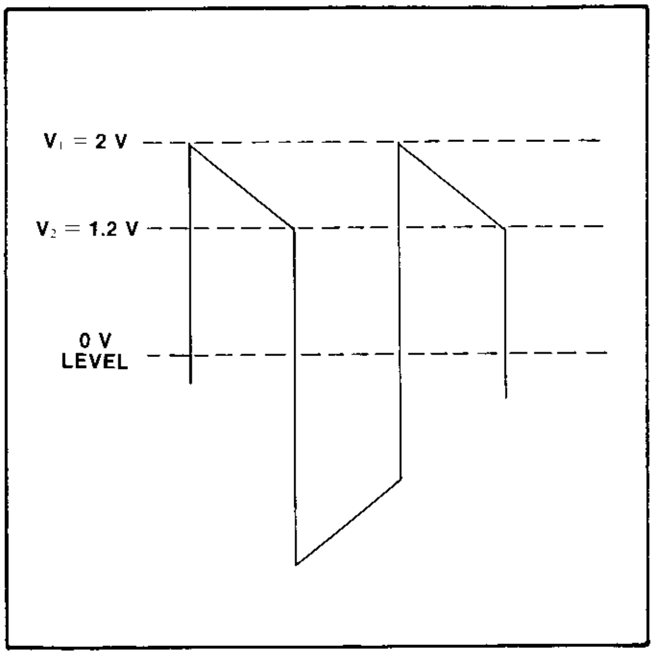

Fig. 1-5. Limited low frequency response due to RC coupling. Ratio V_1/V_2 can be used to determine the low end cut-off frequency (see text). Waveform is due to phase lead and low amplitude for low frequencies.

3. Determine the ratio between the amplitude levels, V_1 and V_2. Note that V_1 and V_2 are peak values above the zero-volt reference level.

4. The equivalent RC product can be determined by using the following formula; where F_a is the applied frequency for a given ratio of V_1/V_2 (greater than unity).

$$\frac{1}{2\,F_a \ln V_1/V_2} = \text{RC (for square-waves only)}$$

5. Using the RC product obtained in step 4, calculate the low-end cut-off frequency.

$$F_L\ (3\ \text{dB}) \cong \frac{159 \times 10^{-3}}{RC}$$

For example; if the applied frequency, F_a, is 10 Hz and the amplitude values shown in Fig. 1-5 are used, the lower cut-off frequency is calculated to be about 1.6 Hz.

Fig. 1-6 illustrates other waveform distortion effects that may be observed if amplifier circuits are not properly compensated for low frequencies.

Fig. 1-7 illustrates waveform distortion due to incorrect high-frequency compensations. Ringing indicates incorrect peaking adjustments or undesired inductive effects, while excessive overshoot and rolloff indicates incorrect capacitive adjustments. Limited high-frequency response is also indicated by risetime measurements that are much slower than expected (see Risetime Considerations). Impedance mismatching will usually show up as excessive aberrations somewhere along the flat portion of the waveform.

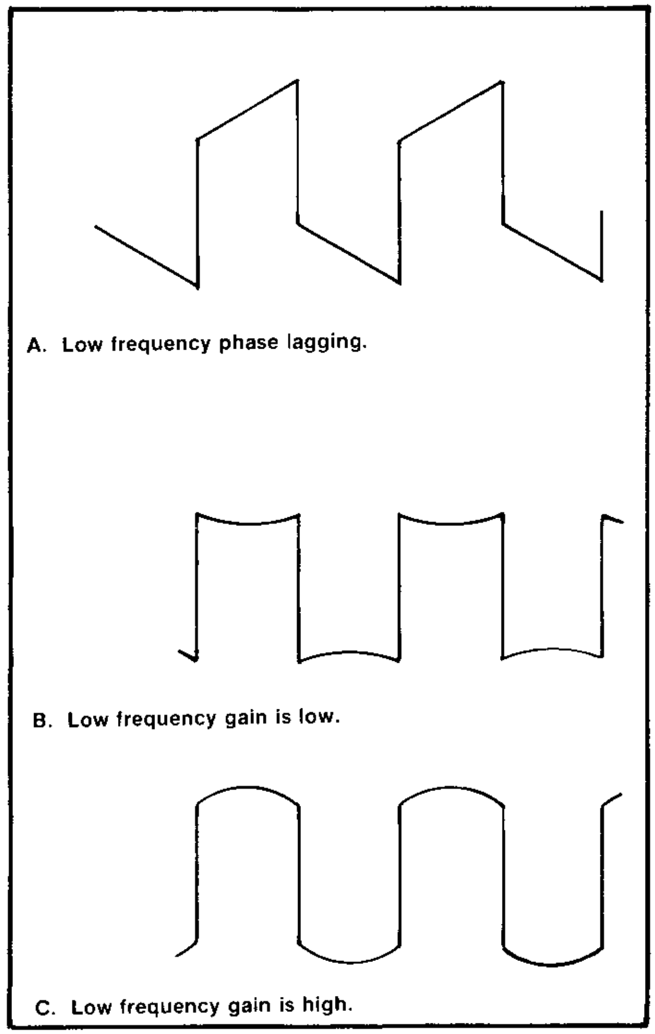

Fig. 1-6. Distortion of square waves caused by low frequency effects.

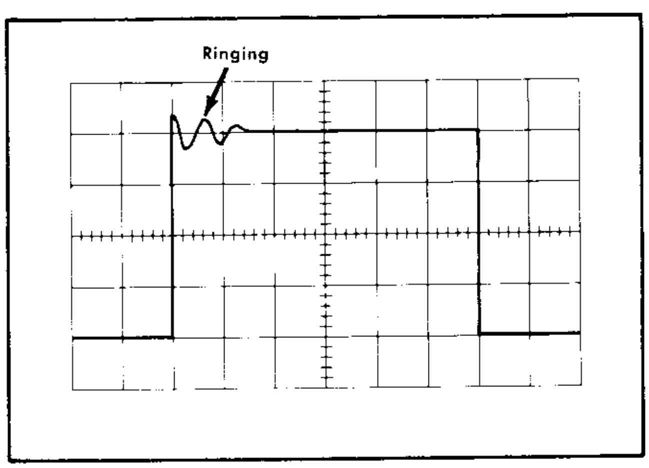

Fig. 1-7. Typical waveform showing ringing at front corner.

INTERFACE NOTES

Amplitude Output

To obtain the AMPL OUTPUT signal at the rear interface connectors, pull the coaxial cable from the coaxial socket on the main board (located in the lower left hand corner of the B side). Replace this cable with a miniature 50—Ω coaxial cable (Tektronix Part No. 175-1827-00). Remove the coaxial connector from the output end, and connect as follows:

Solder the shield to 27A (3rd hole down from top on the B side)

Solder the center conductor to 28A (4th hole down on the B side)

See the Rear Connector Pin Assignments pullout for pictorial interface connection detail.

NOTE

Connecting front panel signals to the rear interface will degrade their performance slightly.

Trigger Output

To connect TRIG OUT to the rear interface, disconnect the coaxial 50-Ω lead to the front panel at the DVM Board end (located in the upper right hand corner of the right hand side as viewed from the rear). Replace this cable with a miniature 50-Ω coaxial cable (Tektronix Part No. 175-1826-00). Remove the coaxial connector from the output end, and connect as follows:

Solder the shield to 28B (2nd hole down from top on the A side)

Solder the center conductor to 27B (5th hole down on the A side)

NOTE

Ground connections to 26B and 22A are the only rear interface signal connections that are factory wired.

MSE & LSD Outputs

To obtain readout information at the interface, use flat ribbon-wire to connect this digital information to the through plated holes as shown in the following listing:

MSD A to 24B MSD B to 23B MSD C to 22B MSD D to 21B LSD A to 20B LSD B to 19B	6 lead flat ribbon-wire
LSD C to 18B LSD D to 17B Hi-Lo to 16B	3 lead flat ribbon-wire

NOTE

Each of the MSD LSD outputs is capable of driving only one TTL load. The active level of each output is high.

For the Hi-Lo Output, output is low when the HIGH display light on the front panel is on.

CAUTION

When a Power Module compartment has been selected for a PG 506 and wired for a specialized interface system, a plastic barrier (Tektronix Part Number 214-1593-02) should be installed in the key slot between contacts 23 and 24 on the Power Module.

Do not insert any TM 500 Series plug-in in a live Power Module and do not use excessive force when inserting the plug-in.

ELECTRICAL CHARACTERISTICS

The ELECTRICAL CHARACTERISTICS are valid for the following environmental conditions.

Temperature

Operating:	0°C to +50°C. Forced air circulation is required for ambient temperatures above +40°C.
Storage:	−40°C to +75°C.

Altitude

Operating:	To 15,000 feet.
Storage:	To 50,000 feet.

STANDARD AMPLITUDE OUTPUT

Amplitude (Peak-to-Peak)

1 MΩ Load:	200 microvolts to 100 volts in a 1,2,5 sequence.
50 Ω Load:	100 microvolts to 5 volts in a 1, 2.5, 5 sequence.
Accuracy:	Within 0.25%, ±1 μV.
Period:	Approximately one millisecond (1 kHz square-wave, chopped dc).

Amplitude (dc)	Selected by internal switch.
Accuracy:	Same as stated for peak-to-peak values, except that accuracy is not specified for dc amplitudes below 200 mV.
Deflection Error Readout	
Range:	±7.5%.
Resolution:	Within 0.1%.

HIGH AMPLITUDE OUTPUT

Amplitude (Peak-to-Peak)	
Unterminated:	6 volts or less to at least 60 volts.
50-Ω Load:	0.5 volts or less to at least 5 volts.
Polarity:	Positive. Measured from a negative potential to ground.
Output Resistance:	600 Ω, within 5%.
Output Period:	1 μs to 10 ms in decade steps.
Accuracy:	Within 5%.
Variable:	Extends output period to at least 100 ms. X1 to greater than X10 range for each decade step.
Duty Cycle:	Approximately 50%.
Risetime	
Unterminated:	100 nanoseconds or less at output connector.
50-Ω Load:	10 nanoseconds or less.
Leading Edge Aberrations:	During first 50 nanoseconds. Within 2% of signal peak-to-peak amplitude or 50 millivolts, whichever is greater.

FAST RISE OUTPUTS

Amplitude (Peak-to-Peak)	
50-Ω Load:	100 millivolts or less to at least 1 volt.
Polarity:	Simultaneous positive and negative. Positive is measured from a negative potential to ground. Negative is measured from a positive potential to ground.
Output Resistance:	50 Ω, within 3% at either output connector.
Risetime	
50-Ω Load:	One nanosecond or less.
Leading Edge Aberrations:	During first 10 nanoseconds. Within 2% of signal peak-to-peak amplitude or 10 millivolts, whichever is greater.
Flatness:	Within 0.5% after first 10 nanoseconds.
Output Period:	1 μs to 10 ms in decade steps.
Accuracy:	Within 5%.
Variable:	Extends output period to at least 100 ms. X1 to greater than X10 range for each decade step.
Duty Cycle:	Approximately 50%.

REPACKAGING FOR SHIPMENT

If the Tektronix instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing: owner (with address) and the name of an individual at your firm that can be contacted. Include complete instrument serial number and a description of the service required.

Save and re-use the package in which your instrument was shipped. If the original packaging is unfit for use or not available, repackage the instrument as follows:

> Surround the instrument with polyethylene sheeting to protect the finish of the instrument. Obtain a carton of corrugated cardboard of the correct carton strength and having inside dimensions of no less than six inches more than the instrument dimensions. Cushion the instrument by tightly packing three inches of dunnage or urethane foam between carton and instrument, on all sides. Seal carton with shipping tape or industrial stapler.

The carton test strength for your instrument is 200 pounds.

THEORY OF OPERATION

Primary Power ⟨1⟩

The 120-volt dc supply is the main power source for the Standard Amplitude system.

The ±16.5-volt dc supply is the main power source for the Digital Voltmeter circuitry, the Fast Rise stages, and two operational amplifier circuits in the Standard Amplitude system.

The −72-volt, variable dc supply is the main power source for the High Amplitude section. This supply can vary from about −10 volts to about −72 volts, dependent upon operating conditions.

All of the above dc supplies are produced by conventional, full-wave bridge rectifier circuits that are driven by an inverter system that changes a dc voltage to 25 kHz power in the primary and secondaries of T130. Each supply is switched on or off, dependent upon the operating modes.

The 5.2-volt dc supply is derived from a 11.5-volt dc source in the Power Module and is distributed mainly to the Period Generator, Counter circuits, and certain logic gates. This supply is also used as a return for the High Amplitude circuits.

CR10 and CR11, together with C10, convert 25 volts ac (rms) from two transformer secondaries in the Power Module to about 35 volts dc. VR10 sets and regulates the base voltage of emitter-follower Q15 to about 15 volts, establishing a fixed 14 volt supply for the 25-kHz free-running multivibrator (Q90-Q100).

The output at the collectors of the free-running multivibrator circuit has a peak-to-peak amplitude of about 5 volts, and the positive swing is limited to about +5.8 volts by CR86 and CR105. This signal drives the bases of Q85 and Q120 for the inverter system. The feedback connections from the collectors of Q80 and Q125, through CR80 and CR125, ensures that both transistors are never on at the same time.

The maximum voltage swing at the collectors of Q80 and Q125 is about twice the dc level established at the junction of L35 and C36 in any operating mode. For the High Amplitude mode, this dc level is dependent on the setting of the PULSE AMPLITUDE control and the external load that terminates the PG 506. With a 1-megohm (unterminated) load, the dc level will be about 3.5 volts for the MIN position and about 20 volts for the MAX position.

Remote voltage sensing to regulate the −72-volt variable supply originates in the High Amplitude circuit and is applied through CR27 to pin 4 of voltage regulator U20.

When the PG 506 is in a Standard Amplitude or Fast Rise mode, the junction of L35 and C36 is about 20 volts dc, with the −72-volt variable supply disconnected from the High Amplitude circuitry.

Voltage regulation for the Standard Amplitude and Fast Rise modes is dependent upon the peak voltage (about 10 volts) developed across C75 by the half-wave rectifier action of CR78, which obtains its ac voltage from a sense winding of T130. The peak level across C75 is applied to a voltage divider composed of R31, R30, and R29. The quiescent level set on pin 4 of U20 by the adjustment of R30 determines the quiescent current through the NPN series-pass transistor. Pin 4 of U20 is the inverting input terminal for an internal comparator, and any voltage change on pin 4 causes a voltage change in the opposite direction on pin 10. R30 is adjusted to produce a potential difference of exactly 33.00 volts across the ±16.5-volt supplies.

Current limiting for the 35-volt dc input is controlled by the voltage drop across R22. If pin 2 of U20 goes about 0.6 volt more positive than pin 3, pin 10 goes negative to limit current through the NPN series-pass transistor and the load. CR22 protects a transistor internal to U20. C22 frequency compensates the voltage regulator. VR30 is not normally on; it protects the supply from over-voltage conditions if the potential difference across it exceeds 12 volts.

U20 sets its own reference voltage of about 7 volts on pin 6, with pin 5 being the non-inverting input to an internal comparator. The reference voltage on pin 6 is divided down by R40 and R42 to set a reference level of 5.2 volts on pin 2 of error amplifier U50.

Voltage regulation of the 5.2-volt supply is accomplished by comparing the voltage level on pin 3 of U50 with the voltage reference on pin 2. If the voltage on pin 3 is higher than the reference level, the output of U50 goes positive. This voltage increase is applied through emitter-follower Q60 to the base of the PNP series-pass transistor. This action decreases current in the PNP series-pass transistor and the load, returning the 5.2-volt supply to its original level.

VR55 and CR55 operate as current limiting control devices. The normal operating potential at the base of Q60 is about 9.2 volts, with VR55 and CR55 not conducting. If the load current increases (due to lower load resistance), pin 3 of U50 goes negative. This drives the base of Q60 negative to about 8.3 volts. The action is sufficient to cause VR55 and CR55 to conduct, clamping the emitter of Q60 and the base of the PNP series-pass transistor to about 9 volts. R65 limits the load current to about 1.5 amperes.

An over-voltage condition of about one volt on the 5.2-volt supply causes VR45 to conduct, developing a SCR firing pulse across R45. If Q45 turns on, the output level is clamped to about 0.2 volt.

The collector of Q70 serves as a 5-volt source for the Digital Voltmeter and Display circuits when the PG 506 is in a Standard Amplitude mode.

Standard Amplitude 2

The Standard Amplitude system consists of two sections, a high-voltage section and a 50-ohm source section. Output amplitudes of 100 V, 50 V, and 20 V originate directly from a precision voltage divider composed of R278, R277, R276, R275, and the 5 mA Current Loop. For these three output amplitudes, the input to the 50-ohm source section is disconnected and pin 2 of U375 is grounded through R380. With pin 2 of U375 grounded, its output locks the base of Q365 to +16 volts, disabling the current drive for the 50-ohm source section.

120 V from the Primary Power system is applied to the emitter of Q280, a 10 mA current source. This 10 mA is split between two branches containing matched diodes; 5 mA through CR280A and the precision divider, 2 and 5 mA through CR280B from the 100-volt bus. In the dc mode, Q255 and Q270 are cut off (due to saturation of U255) and the quiescent level at the anodes of the matched diodes is about 100.7 volts.

With S225 closed, (VARIABLE AMPLITUDE control pushed in, and DEFLECTION ERROR readout off), a 100-volt bus is established across a voltage divider composed of R237 and R234. The reference source for the 100-volt bus originates with Zener diode VR210, which produces an exact 9-volt drop when drawing exactly 7.5 mA through R210. The 9-volt level across R210 also serves as a reference voltage for the Digital Voltmeter circuit.

When R205 has been adjusted to produce exactly 100.000 volts across an external 1-megohm load, pins 2 and 3 of U200 will be essentially at the same potential (9 V) and pin 6 of U200 is at a quiescent level of about 4 volts. The emitter of Q190 will be at 18 volts and this point serves as a regulated voltage source to power operational amplifiers in the 50-ohm source section. Because Q190 is included in the feedback loop around U200, the current through VR210 and R210 remains constant.

One milliampere through R237 and R234 sets a 9-volt level on pin 2 of U240. Pin 3 of U240 is returned to the 9-volt Zener reference through R225A and R215. With almost equal potentials on each side of R225A, the current through this network is in the low microampere range. R225A tracks with R225B and serves only as a variable Thévenin input impedance for the non-inverting input terminal of U240, which aids in stabilizing the offset bias current.

U240 and the circuitry associated with Q245 and Q290 operate as a voltage regulating circuit for the 100-volt bus. Any voltage change on the 100-volt bus is sensed across R237 (or through C237) and applied to pin 2 of U240. Q245 operates as a level shifter and signal inversion through Q290 returns the 100-volt bus to its calibrated level. CR290 and CR291 operate to limit turn-on surge current through Q290.

When the VARIABLE AMPLITUDE control is released to the out position, R237 is disconnected from ground and R227 is inserted in series with R225B. The 100-volt bus now becomes a variable level. R225B can adjust the 100-volt bus over a range of approximately 92—108 volts (±8.0%), and the regulating circuit will hold the selected level. The difference in potential between the adjustable level on the 100-volt bus and the 9-volt Zener reference is applied to the Digital Voltmeter circuitry for DEFLECTION ERROR readout (100 volts equals 0.0%).

When the 1 kHz (calibrated amplitude) mode is selected, a 1 kHz square-wave is applied to the base of Q270 through U255 and emitter follower, Q255. The positive step on the base of Q270 saturates this transistor, pulling its collector below 0.4 volt. This action disconnects CR280A and CR280B, allowing the voltage swing across the precision divider to start from ground and rise to the level selected on the variable bus when Q270 is cut off by the negative step of the 1 kHz signal.

The 50-ohm source section must drive either a 1-megohm or 50-ohm external load resistance. This requirement is met by using a constant-current supply; which, by definition, will alter its output voltage by just the proper amount to maintain its total output current at a constant value when the load resistance changes. The 50-ohm source section operates only when amplitude settings of 10 volts or lower are selected.

A nominal 14-volt input to the 50-ohm source section is derived from the precision divider at the junction of R275 and R276 and applied to pin 2 of U375 (R380 is disconnected from ground). This input voltage will always be a dc level proportional to the dc level established on the 100-volt bus. U375 and Q365 operate as a tracking voltage source. If the input to U375 changes by 5%, the collector voltage of Q365 changes by 5%.

The constant-current supply is programmed by current-setting resistors in series with the emitter of Q325 and the collector of Q365 to produce three selected output current levels through CR320. Selected calibrated currents of 200 mA, 100 mA, or 40 mA split between three branches consisting of R316, the symmetrical pi (ladder) attenuator network, and the external load. With R340 properly adjusted, three voltage levels (10 V, 5 V, or 2 V) can be selected to appear across R316 for an external termination of one megohm. With an external termination of 50 ohms, the three selected levels across R316 will drop to 5 V, 2.5 V, or 1 V. Each section of the ladder attenuator divides by 10 and if the level across R316 is considered to be a 0 dB reference, the total attenuation is 80 dB (20 dB per section). The attenuator presents an output impedance of 50 ohms at any voltage take-off point.

Regulation for the constant-current supply is provided by the operational amplifier feedback connections from the low level end of the current-setting resistors through U330 to the base of Q326. Q320 is cut off for the dc mode and operates as a saturating switch for the 1 kHz mode.

Digital Voltmeter ③

The Digital Voltmeter circuitry is an analog-to-digital converter, which operates on the principle of a modified dual-slope integrating system. A change in input current to integrator U460 causes a ramp voltage to appear at pin 6. At a given time during the ramp, C462 is discharged by a reference current of opposite polarity. At the time the discharge current is applied, a counter is at a count of 200 (00). When the integrated waveform on pin 3 of differential comparator U470 (zero crossing detector) reaches zero, a number in the counter is stored. The accumulated counts are displayed as being proportional to the value of the input voltage applied; a higher input voltage means a longer time to zero crossing, thus a higher count. It takes a few cycles of dual-slope integration for the analog-to-digital converter system to settle down for a stable readout.

A non-linear reciprocal relationship exists between the Standard Amplitude output from the PG 506 and the actual deflection error of an oscilloscope amplifier system. Consequently, to indicate a deflection error that is 6.8% LOW, the output from the PG 506 must be adjusted to be 7.3% high (variable 100-volt bus set to 107.3 volts). For an indicated deflection error of 7.3% HIGH, the variable 100-volt bus must be adjusted for 93.2 volts. It is the voltage changes on the variable 100-volt bus that result in a DEFLECTION ERROR readout.

Assume that the Latch Pulse for the counter has just occurred. The nominal calibrated level (0.0%) on pin 3 of U460 is 9 volts. A decrease in voltage on the 100-volt bus pulls pin 3 of U470 negative below zero and C462 begins to charge through R460, producing the first ramp after the Latch Pulse. During this charge time the output of U470 is high and the counter is counting up to a count of 200 (00). Q475 is turned on and light-coupled through U480 to the base of Q480. The collector of Q480 is high, turning on CR480 and HIGH indicator light DS480.

The system contains two reference current sources; a $+I_r$ source from the collector of Q415, and a $-I_r$ source from the collector of Q440. Only one of these current sources is switched on at a given time, dependent on the polarity of the voltage change on the 100-volt bus. For a ramp that is negative, pin 5 of U400B is set to a high and pin 1 of U400A is set to a low. Pins 2 and 4 of these NAND gates connect to a common control line, and while the counter is counting up to a count of 200 (00), pin 8 of U400C is at a low level. During the first ramp period, the output levels of U400A and U400B are high and both reference current sources are cut off. See Fig. 2-1.

When the counter has reached a count of 200 (00), a negative-going Full Pulse appears on pin 9 of U400C. This Full Pulse switches the common control line (pin 8) to a high level. Pin 3 of U400A remains high while pin 6 of U400B goes low, turning off Q410. Q415 is switched on for the $+I_r$ discharge current to C462. The ramp on pin 3 of U470 switches polarity (runs toward zero). The counter begins to accumulate the necessary counts for display. Q535 has been turned on by the Full Pulse and light-coupled through U535 to the emitter of Q540, cutting this transistor off.

When the ramp crosses the zero-volt level, a negative-going Latch Pulse occurring on pin 7 of U470 is transmitted through C506 and CR502 to pin 13 of U400D. This Latch Pulse switches pin 8 (common control line) of U400C to a low, locking out both reference current sources and turning off Q535. A positive-going Latch Pulse appears at the collector of Q565 to store the count in the counters for display. After the Latch Pulse has been produced at zero crossing, C462 again starts to charge through R460 (ramp increases in a negative direction) and the cycle repeats.

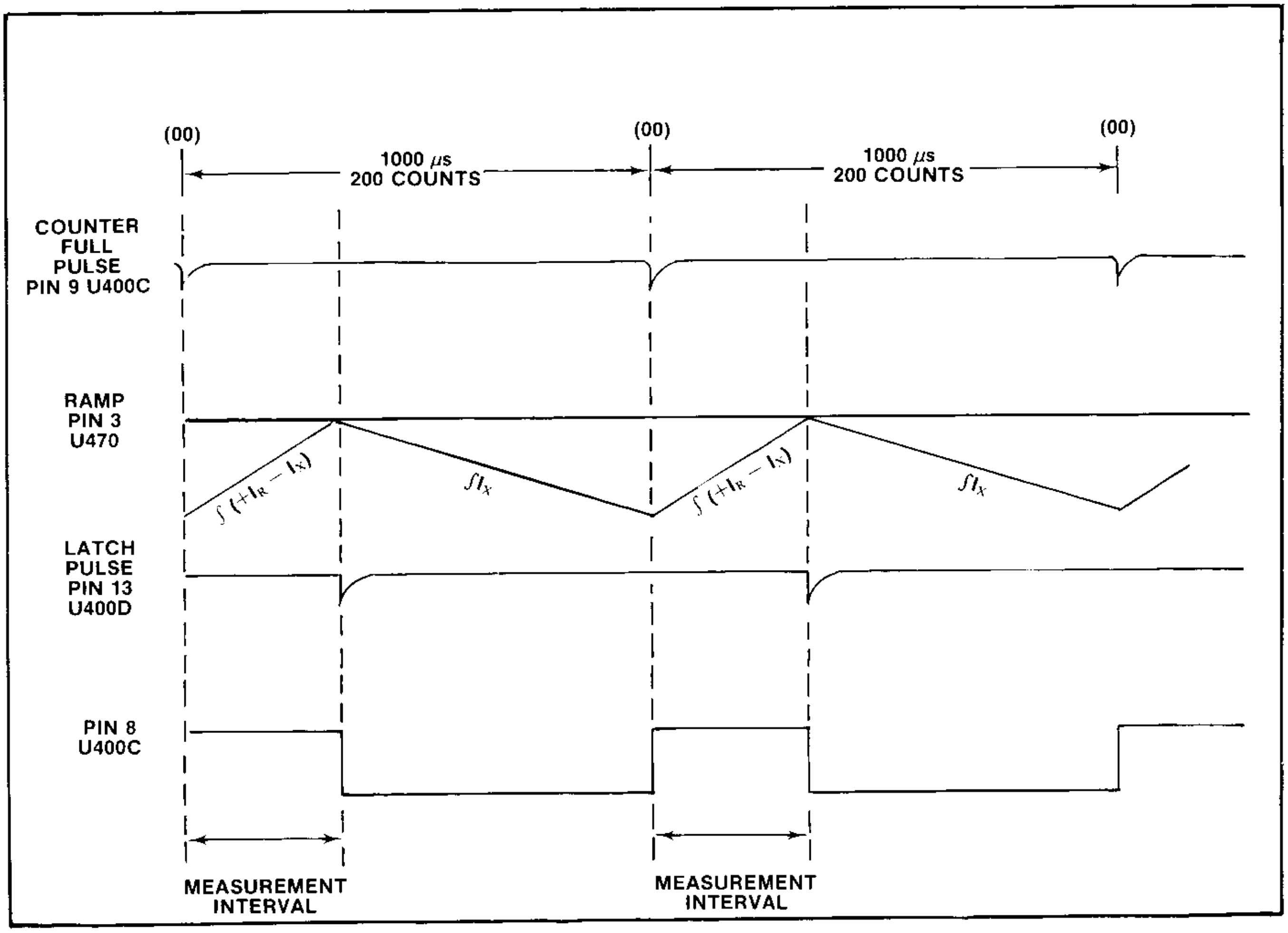

Fig. 2-1. DVM timing diagram for a negative input to the integrator U460.

For input voltages above 100 volts, the circuit action is similar to the action just discussed; except that the dual ramps on pin 3 of U470 are positive, DS482 is turned on for a LOW indication of DEFLECTION ERROR, and the $-I_r$ reference current source is used to discharge C462. For positive ramps, the Latch Pulse occurring at zero crossing is transmitted through C500 and CR500 to pin 13 of U400D.

Reference currents from both reference sources track with changes on the 100-volt bus and in the same direction, allowing the instrument to be calibrated directly for oscilloscope deflection error rather than output amplitude from the PG 506. The adjustment of R415 calibrates the HIGH indication, while the adjustment of R425 calibrates the LOW indication.

CR395 and CR397 protect components in the DVM circuitry if the ±16.5-volt input connections are accidentally reversed.

Period Generator and Display ⟨4⟩

The Period Generator circuit consists of six transistors (Q575, Q580, Q585, Q595, Q605 and Q610) and timing capacitor C580 in series with main timing resistors R587, R590, and R593. These components set a basic 0.5 microsecond period (2 MHz square-wave signal) for the entire instrument.

The timing capacitor and resistor(s) have a common connection at the base of Q580. The signal on the base of Q580 is basically a linear ramp (with switching transients) that causes the output level at the collector of Q605 to go high and low when the ramp crosses the hysteresis limits of the circuit.

Assume that when power is applied, Q575 turns on and Q580 turns off. This action also turns off Q595, setting one end of the timing resistors to the saturated level at the collector of Q595. The base of Q580 now begins a ramp rundown toward the lower limit of the hysteresis window. C580 is charging toward a 5-volt supply through R582 and the timing resistors. When the ramp at the base of Q580 crosses the lower limit of the hysteresis window, Q580 turns on and Q575 turns off. This action turns Q585 on and Q595 off. R593 is now disconnected from essentially a ground potential and connected to a 5-volt supply through Q610. The effective voltage across the timing resistors has now changed polarity and C580 begins to discharge because the emitter of Q585 is essentially at zero. The base of Q580 begins a ramp runup toward the upper limit of the hysteresis window. When the ramp crosses the upper limit, Q580 is again turned off and Q575 turned on, reconnecting the timing resistors to the collector level of Q595. The voltage swings across R600 (caused by Q580 turning on and off) are inverted by Q605 and applied as TTL levels to pin 14 of U665.

U665, U666, U667, and U668 operate as divide-by-ten frequency dividers (multiplies input period by ten) with a 0.2 kHz (5 millisecond) square-wave on pin 11 of U668 and a 5 microsecond (200 kHz) square-wave on pin 11 of U665. Input data for the counter latch circuits originates on pins 1, 12, 9, 8 and 11 of U666 and U667, respectively. BCD data from the counter latches (U670-U671) is decoded by U673 and U675 to drive the seven-segment LED displays (DS700-DS702).

U610A and U610B are each one-half of a Dual J-K Master-Slave Flip-Flop. The input to pin 1 of U610A is always a 2-kHz signal, obtained from pin 11 of U667. Pin 12 of U610 is a Q terminal and the 1-kHz output signal is used to drive the diode section of U255 in the Standard Amplitude circuitry. To remove the 1 kHz drive to the Standard Amplitude circuitry when it is not needed, pin 2 of U610A is held low, which sets pin 12 to a logical zero. The Standard Amplitude circuitry is in a dc mode when pin 2 is grounded by the closure of S660. For the High Amplitude mode, pin 2 is grounded through CR661; for the Fast Rise mode, through CR660. CR656 and CR657 provide ground connections for the PERIOD light when the instrument is used as a Pulse Generator.

The input signals to U610B (as selected by the PERIOD control) are obtained from pin 11 of the frequency dividers or directly from the 2 MHz Period Generator. The period of the output signals on pins 8 and 9 of U610B are twice the selected input period. These signals are applied to NAND gates U615B and U615C to drive the High Amplitude or Fast Rise circuits. The drive signals on one input terminal of a NAND logic device are gated through with inverted polarity if the other input terminal is held high. The · TRIG OUT signals are supplied by inverter connections of U615A and U615D. To remove (lockout) drive signals through both NAND gates when they are not needed (Standard Amplitude mode), pin 6 of U610B is held low by the closure of S180A-5B. This action sets pin 9 of U610B to a logical zero (low) and pin 8 to a logical one (high).

The closure of S180A-7B locks out drive signals to the High Amplitude circuitry when the instrument is in a Fast Rise mode; for the High Amplitude mode, the closure of S180A-6B locks out signals to the Fast Rise circuitry.

To disable the High Amplitude power supply when operating in a Standard Amplitude mode, CR616 is grounded through S180A-5B. When operating in a Fast Rise mode, CR615 is grounded through S180A-7B.

High Amplitude ⟨5⟩

The negative-going output, with Q745 and Q755 supplying the current, is developed across 600-ohm resistor R805 and the external load. CR755 and CR756 operate as disconnect diodes at the zero volt output levels. The specified reference is the positive-going edge of the output waveform, requiring that Q745 and Q755 be switched off for the output to swing from a negative potential to ground. Q760 serves as a 2 mA current shunt through disconnect diodes CR766 and CR767. This circuit absorbs the leakage currents from Q745 and Q755 during transitions and adds a slight amount of reverse bias to the output disconnect diodes, improving the risetime and ensuring very sharp corners for the output voltage swing.

The bases of Q745 and Q755 are connected in parallel and the voltage transitions at this point determine the output current swing. A negative transition at the bases of Q745 and Q755 requires a negative-going transition at the base of Q715 to saturate Q730 and cut off the output current. The RC networks associated with Q725 and in the base circuit of Q755 are wave-shaping components.

The High Amplitude circuitry is floating on a variable power supply with limits of about −10 volts to a maximum of about −72 volts. The collectors of Q725, Q740, and Q790 translate the dc (and signal) levels from ground to a negative supply for the output stages and amplitude control circuitry. Q790 is a 4 mA current source that floats the amplitude control circuitry at about 6 volts more positive than the variable supply voltage level.

R736 in the emitter of Q736, along with R746 and R749 in the emitters of Q745 and Q755 are chosen so that the current into these nodes is a function of the actual supply voltage. The actual current that enters Q745 and Q755 is controlled by their base voltages and the voltage drops across R745 and R748. The emitter of Q736 is a low-impedance driving point that controls the limits of the output current. Q736 also temperature-compensates the base junctions of Q745 and Q755. The base of Q736 (and the collector of Q782) is considered to be a zero temperature coefficient voltage point.

The PULSE AMPLITUDE control is R785A, located in the base circuit of Q784. This control obtains its reference voltage from across VR790. Q780 and Q784 form a differential circuit with Q780 connected as a diode for temperature compensation. Q736 is driven by Q782, which adds additional gain to set the base of Q780 equal to the base of Q784. R784 sets the minimum output current limit, and R790 is adjusted to set a 5.2-volt output amplitude across a 50-ohm load. CR734, connected between the variable supply and the most negative level of the amplitude control circuitry, allows an additional 0.7 voltage drop across Q780 and Q782, thereby improving the amplitude linearity.

The sensing point to regulate any one level of the variable supply is at the collector of Q790. A drift in the supply voltage is level shifted through VR790 and applied to pin 2 of U840. CR27 is turned on to control the level at pin 4 of U20, the voltage regulator in the Primary Power supply.

The actual voltage of the variable supply is made a function of the negative peak levels of the output signal. The negative peaks are sampled through CR800 and emitter-follower Q800 to store a charge on memory capacitor C800. If the output signal amplitude is increased (larger negative peaks), pin 3 of U840 goes negative. A negative charge on pin 4 of U840 results in a larger dc supply for the inverter system in the Primary Power circuit and the variable supply to the High Amplitude circuit goes more negative. The net result is that the voltage drop across the output transistors remains relatively constant. The variable supply tracks with the selected output amplitude and in the same direction. The emitters of Q745 and Q755 are connected through VR790 to pin 2 of U840, and the collectors are connected through Q800 to U840 pin 3. Because an operational amplifier (U840) always attempts to reduce the voltage difference between its input terminals to zero, the constant voltage drop across the output transistor network is essentially equal to the drop across VR790 plus about two to seven volts across other components in the feedback loop.

K810 and K812 are energized to connect a noise filter network in series with output terminal J820 only when the 50-ohm source section of the Standard Amplitude circuitry is being used.

Fast Rise ⟨6⟩

The Fast Rise circuit produces two output signals that occur simultaneously. Q935 and Q995 operate as non-saturated current-mode switching sources for the output signals. CR944 and CR1004 are disconnect diodes that have very low leakage current characteristics at zero-bias levels. These levels occur when Q935 and Q995 are cut off.

In order to produce 1 volt across a 25-ohm load (50-ohm termination in parallel with either R950 or R1010) it requires 40 mA. This current is available through resistors in series with the emitters of Q935 and Q995. A negative transition occurs at J950 when Q935 is turned off and a positive transition occurs at J1010 when Q995 is turned off. Both transistors turn off simultaneously with R935 and R995 providing return paths for leakage currents. C940 and C1000 are provided to reduce excessive overshoot and ringing.

Simultaneous amplitude control of the output signals is accomplished by diverting current from the emitters of Q935 and Q995 through the series path of Q1036 and Q1045. The voltage drop across R1040 is controlled by the adjustable voltage level at the emitter of Q1030, a low impedance source for the base of Q1036. Q1020 operates as a current switch to set the collector of Q1030 to about 5 volts when the Fast Rise mode is selected. R1025 sets the minimum amplitude available at the output and R785B controls the minimum and maximum amplitudes.

When the Fast Rise mode is switched off, the ±16.5-volt supply is switched off. The collectors of Q1020 and Q1030 drop to about zero, driving the base of Q1036 negative. This action completely cuts off the leakage currents that might have existed in the collectors of Q935, Q1036, Q995, and Q1045 if the collector of Q1030 had been tied to a fixed 5-volt source. This arrangement ensures that the output connectors rest at a zero-volt level when the instrument is not in a Fast Rise mode.

Q860 and Q862 operate as a Schmitt trigger for the Fast Rise circuit, with VR866 providing positive feedback and Q850 serving as a constant-current source. A positive-going pulse at the base of Q860 results in a negative-going pulse at the collector of Q880 and a positive-going pulse at the collector of Q890, where the transitions are speeded up and translated to ground levels by R882 and R892. At this point, the signal currents are split into two paths through differential amplifiers (Q900-Q910 and Q960-Q970). For a positive-going input to the base of Q860, the emitter of Q935 is driven negative by the saturation of Q920 and the emitter of Q995 is driven positive by the saturation of Q980.

CR1062 and CR1067 protect the Fast Rise circuit components if the wiring plug to the circuit board is accidentally reversed. The diodes in the base circuits of Q1030 and Q1045 are for temperature compensation.

SERVICING INFORMATION

CALIBRATION PROCEDURE

Calibration Interval

To ensure instrument accuracy, check the calibration of the PG 506 every 500 hours of operation, or every three months, if used infrequently. Before calibration, thoroughly clean and inspect this instrument as outlined in the service section of the Power Module instruction manual.

Services Available

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

System Maintenance

System maintenance procedures are provided in the Power Module manual; i.e., preventive maintenance, trouble-shooting aids, parts removal and replacement procedures, parts ordering information, etc.

Test Equipment and Accessories Required

The following test equipment and accessories, or their equivalents, is required for complete calibration of the PG 506. Specifications given for the test equipment are the minimum necessary for accurate calibration or measurement. All test equipment is assumed to be correctly calibrated and operating within specifications.

If other test equipment is substituted, control settings or calibration setups may need to be altered to meet the requirements of the equipment used. Detailed operating instructions for the test equipment used are not given in the adjustment or calibration procedures. Refer to instruction manual for the test equipment if more information is desired.

1. TM 500 Series Power Module.

2. TM 500 Series Plug-in Extender. Tektronix Part Number 067-0645-02.

3. Variable autotransformer, such as a General Radio W10MT3A for 115-volt nominal line or a General Radio W20HMT3A for 230-volt nominal line operation.

4. Precision Dc Voltmeter. This should be a 5 1/2-digit DVM, accurate to within 0.025% or better on any range from 100 V down to and including 100 mV. A John Fluke Model 8375A or equivalent is suggested.

5. Resistor. 1 MΩ, 1/2 W, 0.1%.

6. Resistor. 50 Ω precision, 0.05%, 2 W minimum.

7. Stable 20 mA current source. Output current variable over a 0.5% range (±0.1 mA).

8. Real-time oscilloscope. Minimum bandwidth 50 MHz with a Dual-Trace Vertical Amplifier. 1 MΩ input resistance. A Tektronix 7603 Mainframe, 7A26 Dual-Trace Amplifier, and 7B53A Time Base was used for this procedure.

9. Sampling oscilloscope. A Tektronix 7603 Mainframe, 7M11 50 Ω Delay Line, 7S11 Sampling Unit with S-1 Sampling Head, and 7T11 Sampling Sweep Unit was used for this procedure.

10. Calibration Fixture (Tunnel Diode Pulser). Tektronix Part Number 067-0681-01.

11. Coaxial Cable, 50 Ω, 18 inches. Tektronix Part Number 012-0076-00.

12. Coaxial Cable. 50 Ω, 42 inches. Tektronix Part Number 012-0057-01.

13. Coaxial Cable. 50 Ω Precision, 36 inches. Tektronix Part Number 012-0482-00. Supplied with PG 506 (substitution may cause fast rise calibration to be difficult).

14. Coaxial Cable, GR Connectors, 50 Ω, 2 ns RG58A/U. Tektronix Part Number 017-0505-00.

15. Adapter, BNC Female to GR. Tektronix Part Number 017-0063-00.

16. Adapter, SMA Male to BNC Female. Tektronix Part Number 015-1018-00.

17. Adapter, BNC Female to BNC Female. Tektronix Part Number 103-0028-00.

18. Two 50 Ω Feed-Through Terminations. Tektronix Part Number 011-0049-01.

19. One 2.5X 50 Ω Attenuator. Tektronix Part Number 011-0076-02.

20. One 5X 50 Ω Attenuator. Tektronix Part Number 011-0060-02.

21. Adjustment Tool. Tektronix Part Number 003-0675-00 or equivalent.

22. Marking Pencil; for example, Dixon Phano (for glazed surfaces).

Preparation

WARNING

Dangerous potentials exist at several points throughout this instrument. When the instrument is operated with the covers removed, do not touch exposed connections or components. Disconnect power before cleaning or replacing parts.

1. Check that the correct nominal line selector block has been installed on the line selector pins on the Power Module interface and that the regulating range selected includes the input line voltage. See the installation section of the Power Module manual.

2. Remove the PG 506 side covers and connect the PG 506 to the Power Module using the Plug-in Extender. Connect the Power Module to the variable autotransformer and autotransformer to the input line. Adjust the autotransformer for nominal line voltage output.

NOTE

Refer to the foldout page labeled ADJUSTMENT LOCATIONS before proceeding with the next step.

3. Set the PG 506 AMPLITUDE switch to the 10 V position and the mode switch to STD AMPL position. Apply power to the PG 506 and allow at least 20 minutes warmup time for all equipment. Make adjustments at an ambient temperature between +20° C (+68° F) and +30° C (+86° F).

NOTE

The numerical quantities listed in this procedure are adjustment aids only and are not be be interpreted as a specification that contradicts the items as listed under ELECTRICAL CHARACTERISTICS.

Adjustments

1. Primary Power Adjustment (R30)

Change the PG 506 mode switch to the FAST RISE position. Set internal switch S660 to the dc position (up). The front-panel LED display must be off. Using the precision dc voltmeter, measure the potential difference between the + and −16.5 V test points. Adjust R30, 16 V Set, for a voltmeter indication of 33.00 volts. Check the +5.2-volt supply; the voltage must be between 4.9 and 5.5 volts.

2. 100 V Regulator Adjustment (R205)

a. Connect the precision coaxial cable (Tektronix Part Number 012-0482-00) from the PG 506 AMPL OUTPUT connector to the input of the precision dc voltmeter. If necessary, shunt the input terminals of the dc voltmeter with a precision resistor that ensures that the total load resistance on the AMPL OUTPUT connector is 1 MΩ (within 0.1%).

b. Set the voltmeter to the 100 V range and change the PG 506 AMPLITUDE switch to the 100 V position. Change the PG 506 mode switch to STD AMPL position. Adjust R205 (100 V Set) for a voltmeter indication of 100.000 volts (as close as possible). After R205 has been adjusted, use the variable autotransformer to check that the voltmeter indications change less than 4 mV from high-line to low-line voltage. Reset the autotransformer for the nominal line voltage output and recheck the adjustment of R205. Switch the PG 506 AMPLITUDE control to the 50 V and 20 V positions and verify that the accuracy of the 50 V and 20 V outputs are within 0.15%.

NOTE

Refer to Table 3-1 for voltage limits associated with a 0.15% tolerance and the PG 506 AMPLITUDE control settings.

TABLE 3-1
Voltage Limits (1 MΩ Load)

PG 506 Amplitude Switch Setting	±0.15% Tolerance	Voltage Limits High	Voltage Limits Low
100 V	±150 mV	Set for 100.000 (as close as possible)	
50 V	±75 mV	50.075	49.925
20 V	±30 mV	20.030	19.970
10 V	±15 mV	Set for 10.000 (as close as possible)	
5 V	±7.5 mV	5.0075	4.9925
2 V	±3.0 mV	2.0030	1.9970
1 V	±1.5 mV	1.0015	0.9985
0.5 V	±0.75 mV	0.50075	0.49925
0.2 V	±0.30 mV	0.20030	0.19970
0.1 V	±0.15 mV	0.10015	0.09985

3. 10 V Regulator Adjustment (R340)

a. Change the PG 506 AMPLITUDE switch to the 10 V position. Adjust R340, 10 V Set, for a dc voltmeter indication of 10.0000 volts (as close as possible). Switch the PG 506 AMPLITUDE control and the dc voltmeter controls down range to verify the output amplitudes down to and including 0.1 V (100 mV). Accuracy of each selected amplitude setting must be within 0.15%.

b. Note and record the actual 6-digit voltage readout on the precision dc voltmeter for the 0.1 V position. This actual voltage value is needed for the next step.

4. Check Attenuator Accuracy Below 0.1 V

a. Remove the plug-in extender to disconnect power from the PG 506. Retain the 0.1 V position of the PG 506 AMPLITUDE switch and connections to the precision dc voltmeter. Apply a stable, adjustable 20 mA current source to R308. Connect the negative probe to common floating ground and the positive probe to the top of R308.

b. Adjust the current source so that the precision dc voltmeter indicates a 6-digit voltage readout that is exactly ten times the 6-digit voltage readout recorded for step 3b. Change the PG 506 AMPLITUDE control to the 10 mV position. The precision dc voltmeter should indicate 100 mV within 0.15%. Note and record this actual 6-digit voltage readout for the next step.

c. Retain the 10 mV position of the PG 506 AMPLITUDE switch. Move the positive probe to the top of R304. Adjust the current source so that the precision dc voltmeter indicates a 6-digit voltage readout that is exactly ten times the readout recorded for step 4b. Change the PG 506 AMPLITUDE control to the 1 mV position. The precision dc voltmeter should again indicate 100 mV within 0.15%.

d. Disconnect both current-source probes. Reset the PG 506 AMPLITUDE switch and dc voltmeter controls to the 100 V range. Reapply power to the PG 506. Allow 10 minutes for the temperature to stabilize. Retain connections to precision dc voltmeter.

5. DEFLECTION ERROR Readout Adjustments (R450-R425-R415)

a. Release the VARIABLE (OUT) control to turn on the front-panel LED display for the PG 506. Rotate the VARIABLE (OUT) control for a dc voltmeter indication of 100.000 volts. Adjust R450, Zero Set, for a 0.1% HIGH and 0.1% LOW with the final adjustment of R450 resulting in a 0.0% display with both the HIGH and LOW indicator lights slightly on.

b. Rotate the VARIABLE (OUT) control for a voltmeter indication of 107.3 volts. Adjust R425, −6.8% Set, for a display of 6.8% LOW. Adjust R425 to center on 6.8%.

c. Rotate the VARIABLE (OUT) control for a dc voltmeter indication of 93.2 volts. Adjust R415, +7.3% Set, for a display of 7.3% HIGH. Adjust R415 to center on 7.3%.

d. Recheck the 0.0%, 6.8% and 7.3% indications. If necessary, repeat steps 5a through 5c until no further adjustments are required. The final performance of the DEFLECTION ERROR readout can be verified over its complete range by referring to Table 3-2.

TABLE 3-2

Output Amplitude (100 V Range)	PG 506 Display
108.7	8.0% LOW
107.3	6.8% LOW
106.5	6.1% LOW
105.6	5.3% LOW
104.6	4.4% LOW
103.2	3.1% LOW
100.000	0.0%
96.9	3.2% HIGH
95.6	4.6% HIGH
94.7	5.6% HIGH
93.9	6.5% HIGH
93.2	7.3% HIGH
92.6	8.0% HIGH

6. Check DEFLECTION ERROR Tracking and Accuracy into a 50 Ω Load

a. Set the PG 506 AMPLITUDE switch to the 10 V position. Adjust the VARIABLE (OUT) control for a display of 0.0%. The voltmeter should indicate 10.000 volts (for a 1 MΩ load). Rotate the VARIABLE (OUT) control until the voltmeter indicates 10.73 volts. The PG 506 display should indicate 6.8% LOW. Rotate the VARIABLE (OUT) control until the voltmeter indicates 9.32 volts. The PG 506 display should indicate 7.3% HIGH. Return the VARIABLE (OUT) control on the PG 506 to 0.0% and turn off the LED display. Retain the 10 V output position in STD AMPL mode.

NOTE

The actual output voltage from the PG 506 (in the STD AMPL mode) when operating into a 50 Ω load is highly dependent on the TOTAL load resistance; including coaxial cable resistance, all contact resistances, and the accuracy of the 50 Ω termination. For the next step all connections must be made in a manner to eliminate (as much as possible) the inaccuracies caused by external factors. If desired, the 50 Ω precision resistor can be installed (soldered) in an accessory housing with the proper input and output BNC connectors. The total errors caused by external factors should not exceed 0.1%.

b. Remove the coaxial cable and 1 MΩ termination from the system. Connect the 50 Ω precision resistor as close as possible to the AMPL OUTPUT connector on the PG 506. If an accessory housing is being used, reconnect the coaxial cable to the input of the precision dc voltmeter. Check for 5 V, 2.5 V, and 1 V outputs on the 10 V, 5 V and 2 V positions of the PG 506 AMPLITUDE switch, respectively. Output amplitudes must be within specifications.

c. Reset the PG 506 AMPLITUDE switch to the 10 V position and release the VARIABLE (OUT) control. A DEFLECTION ERROR readout of 0.0% corresponds to a 5 V output. 5.365 V corresponds to 6.8% LOW and 4.66 V corresponds to 7.3% HIGH, respectively. Disconnect all terminations, cables and the dc voltmeter from the sytem.

7. Adjust Period in STD AMPL Mode (R587)

Connect the coaxial cable from the PG 506 AMPL OUTPUT terminal directly to the 1 MΩ input on the Dual-Trace Amplifier unit of the real-time oscilloscope. Change S660 (PG 506 internal switch) to the ⊓⊔ position. Adjust the oscilloscope controls to display a 1 kHz square-wave at a sweep rate of 200 μs/div. Adjust R587, Period, for exactly 1 complete period over the first 5 horizontal divisions. After R587 has been adjusted, change the PG 506 AMPLITUDE switch to the 20 V position and check for a 20 V peak-to-peak, 1 kHz output signal. Return to the 10 V position of the PG 506 AMPLITUDE switch and insert a 50 Ω feed-through termination between the coaxial cable and the oscilloscope input. Check for a 5 V peak-to-peak, 1 kHz output signal.

8. Adjust Max Ampl Set into 50 Ω (R790)

Retain connection and 50 Ω termination into one channel. Switch the PG 506 to HIGH AMPL mode and set the PERIOD control to 1 μs/1 MHz (X1) position. Set the PG 506 PULSE AMPLITUDE control to MAX (fully clockwise). Adjust the oscilloscope controls for a convenient amplitude and sweep rate display. Adjust R790 (Max Ampl Set) for exactly 5.2 V peak-to-peak of displayed signal. After R790 has been adjusted for a 50 Ω load, use the oscilloscope controls to check for output signals for every position of the PG 506 PERIOD control and check operation of the Period Variable control on at least one range (greater than X10). Also check for a + TRIG OUT signal from the PG 506.

9. Check High Amplitude Output (Unterminated)

Remove the 50 Ω feed-through termination and connect coaxial cable from the PG 506 AMPL OUTPUT terminal directly to the 1 MΩ input of the oscilloscope. Reset PG 506 controls for a 1 μs/1 MHz (X1) output period in a HIGH AMPL mode. Retain the PULSE AMPLITUDE controls at the MAX position. Use the oscilloscope controls to check for at least a 60 V peak-to-peak displayed signal. For oscilloscopes with a maximum calibrated vertical deflection factor of 5 V/div, the vertical system can be calibrated for a 10V/div deflection factor by using the PG 506 STD AMPL mode (1 kHz and 10 V output) and adjusting the oscilloscope vertical variable control for a one-division signal. After checking for a 60 V output signal, rotate the PG 506 PULSE AMPLITUDE control to the MIN position and check for a 6 V (or less) peak-to-peak output signal. Retain the MIN position of PG 506 PULSE AMPLITUDE control. Retain the position of the PERIOD controls.

NOTE

If risetime measurements are made for an unterminated condition of the PG 506, the displayed risetime on the real-time oscilloscope crt is dependent on the oscilloscope system used. Refer to the Operating Instructions. The risetime for an unterminated condition can be calculated by using the formula $T_r \approx 2.2RC$: where R is the 600-ohm output resistance of the PG 506 and C is the total load capacitance, including about 32 pF/ft for 50 Ω coaxial cable.

10. Adjust Fast Rise Min Ampl (R1025)

Use two 50 Ω coaxial cables to connect both FAST RISE OUTPUTS to the Dual-Trace Amplifier unit. Terminate both cables with 50 Ω feed-through terminations. Connect the positive-going signal to Channel 1 and the negative-going signal to Channel 2. Set the PG 506 to FAST RISE mode. Use the oscilloscope controls to display both signals in either a chopped or alternate mode at a 1 μs/div sweep rate. Adjust R1025 Min Ampl, located on the Fast Rise board until the larger signal at either of the FAST RISE OUTPUTS is 80 mV peak-to-peak. Rotate the PG 506 PULSE AMPLITUDE control to MAX and check for at least a 1 V signal from each FAST RISE OUTPUT. Disconnect all cables and terminations from the PG 506 and the real-time oscilloscope. Reset the PG 506 PULSE AMPLITUDE control to the MIN position.

11. Check and Adjust Fast Rise Aberrations (C1000-C940)

a. Connect an 18-inch, 50 Ω coaxial cable (Tektronix Part Number 012-0076-00) from the PG 506 AMPL OUTPUT connector to the input of the Tunnel Diode Pulser (Calibration Fixture No. 067-0681-01). Connect a BNC Female to BNC Female adapter to the output of the TD Pulser. Connect a precision coaxial cable (Tektronox Part Number 012-0482-00) between the TD Pulser and Input 2 on the 7M11 via a BNC Female to GR adapter. Connect a 2 ns GR to GR Cable from Output 2 on the 7M11 to the input of S-1 Sampling Head installed in the 7S11 Sampling Unit. Connect a 42-inch, 50 Ω coaxial cable (Tektronix Part Number 012-0057-01) from the Trigger Output on the 7M11 to the Trig Input connector on 7T11 via a 2.5X 50 Ω Attenuator and SMA Male to BNC Female adapter.

b. Set the following controls on the 7T11; Ext Trig (50 Ω, 2 V Max), + Slope Triggering, Sequential sampling, Scan (Rep), Time Pos Rng 50 ns, Time/Div 2 ns.

c. Set Trigger Selector on the 7M11 to 2. Set the following controls on 7S11; 50 mV/div (Cal In), + up, Delay (10 ns Range) centered, Smooth Dot Response, DC Offset for centered trace.

d. Set the TD Triggered Level on the TD Pulser fully counterclockwise. Set the PG 506 mode switch to HIGH AMPL and PERIOD controls for 10 μs/100 kHz. Set the PG 506 PULSE AMPLITUDE control to the MAX position.

e. Rotate TD Triggered Level control on the TD Pulser slowly clockwise just to the point of obtaining a stable triggered display on the crt. It may be necessary to readjust the Time Position and Triggering controls on the 7T11 to locate the leading edge of a positive-going pulse. When a stable, triggered display is obtained, do not readjust the Trig Level or Stability controls on the 7T11. The display should be a positive-going pulse approximately 2 divisions in amplitude.

f. Use the Variable deflection and DC Offset controls on the 7S11 to expand and display an exact 5-division (vertical) signal on the crt. Use the Time Position control on the 7T11 to align the 50% level of the positive-going pulse with the first-division reference line. If stable triggering is lost after this time position reference point has been established, repeat step 11e and 11f up to this point.

g. Without changing the Variable deflection control on the 7S11, switch to a 5 mV/div deflection factor setting. Use the DC Offset controls to return the top of the waveform to center screen. Set the SCAN control on the 7T11 for the slowest convenient scanning rate just above an eye-flicker rate (about 15 Hz); faster scanning rates tend to smooth out the front-corner aberrations. A display similar to Fig. 3-1 should be obtained. Each major vertical division now represents 2% of the original 5-division signal. This display is the total sampling system response to a signal from the TD Pulser and is used as a reference for comparison purposes.

h. Use a grease-marking pencil to carefully reproduce the displayed signal on the crt graticule. Not all sampling systems will display a signal exactly as illustrated in Fig. 3-1. Once this reference graph has been drawn on the crt, do not erase it until all aberration checks (adjustments) and risetime measurements have been completed. If stable triggering or the Trig Level (Stability) control on the 7T11 have been readjusted before the graph has been drawn, repeat steps 11e through 11g.

i. Remove the TD Pulser and an 18-inch coaxial cable from the system. Connect the coaxial cable (Tektronix Part Number 012-0482-00) from Input 2 on the 7M11 to the positive-going FAST RISE output on the PG 506. Switch the PG 506 to FAST RISE mode. Set the 7S11 for a calibrated 100 mV/div (Cal In). Reset the 7T11 Trigger controls if necessary, to obtain a stable display. Use the PG 506 PULSE AMPLITUDE control and DC Offset controls on the 7S11 to establish an exact 5-division (1 volt peak-to-peak) signal from the PG 506. Use the Time Position controls on the 7T11 to set the 50% level of the positive-going pulse on the first-division reference line. Switch the deflection factor of the 7S11 to a calibrated 10 mV/div (Cal In). Use the DC Offset controls to return the top of the waveform to center screen. Align the displayed signal vertically with the reference graph in the area of the last horizontal division. Do not use the Time Position or Triggering controls on the 7T11 in an attempt to align the leading edges of the displayed signal with the leading edge of the reference graph. The signal from the TD Pulser has a faster risetime than the PG 506.

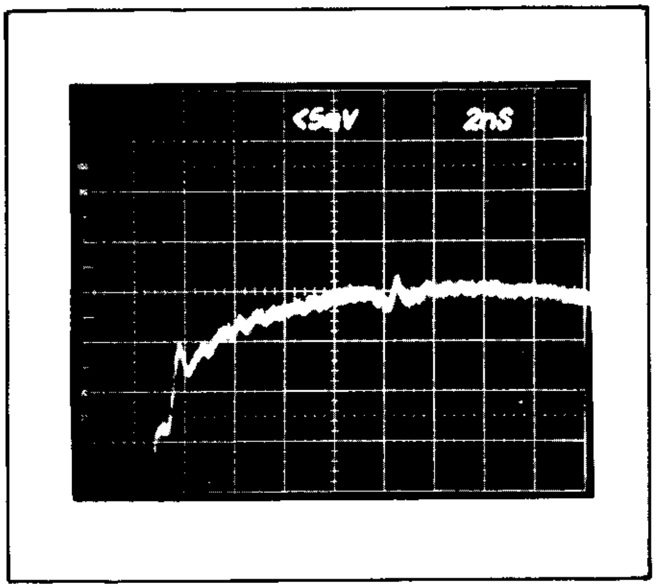

Fig. 3-1. Typical response curve of total sampling oscilloscope system when step 11g has been completed. The response curve is used as a graticule reference graph for all aberration checks and adjustments. See step 11h.

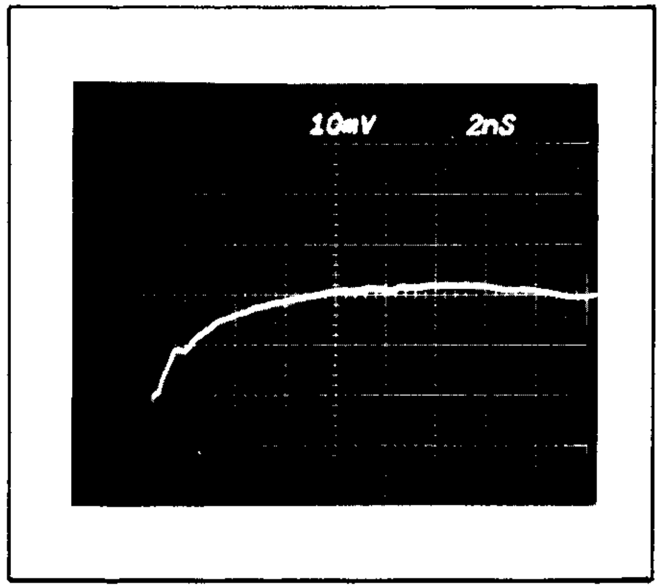

Fig. 3-2. Typical sampling oscilloscope system response curve obtained when C1000 has been properly adjusted (step 11j).

j. When the proper vertical alignment has been made, adjust C1000 so that the response curve for the positive-going FAST RISE output signal is aligned with the reference graph as close as possible. A very slight amount of front-corner overshoot relative to the graph is desirable. See Fig. 3-2. Do not expect to obtain the same aberration amplitudes as the reference graph. In no case should the displayed signal aberrations deviate from the reference graph by more than 1 vertical division.

k. Connect the coaxial cable to the negative-going FAST RISE Output from the PG 506. Reset the 7S11 for a calibrated, 100 mV/div deflection factor and push the INVERT button. Push the − Slope button on the 7T11 and adjust the Trig Level controls for a stable display. Use the PG 506 PULSE AMPLITUDE control and DC Offset controls on the 7S11 to establish an exact 5-division (1 volt peak-to-peak) signal on the crt. Use the Time Position controls on the 7T11 to position the 50% level of the pulse on the first-division reference line. Switch the deflection factor control on the 7S11 for a calibrated 10 mV/div. Use the DC Offset controls to return the top of the waveform to center screen and vertically align the displayed signal with the reference graph in the area of the last horizontal division. Do not readjust Triggering controls or Time Position controls on the 7T11.

l. When the proper vertical alignment has been made for the negative-going FAST RISE OUPUT signal, adjust C940 so that the response curve is aligned with the reference graph as close as possible. A slight amount of front-corner overshoot relative to the graph is desirable. See Fig. 3-3. Do not expect to obtain the same aberration amplitudes as the reference graph. In no case should the displayed signal aberrations deviate from the reference graph by more than 1 vertical division.

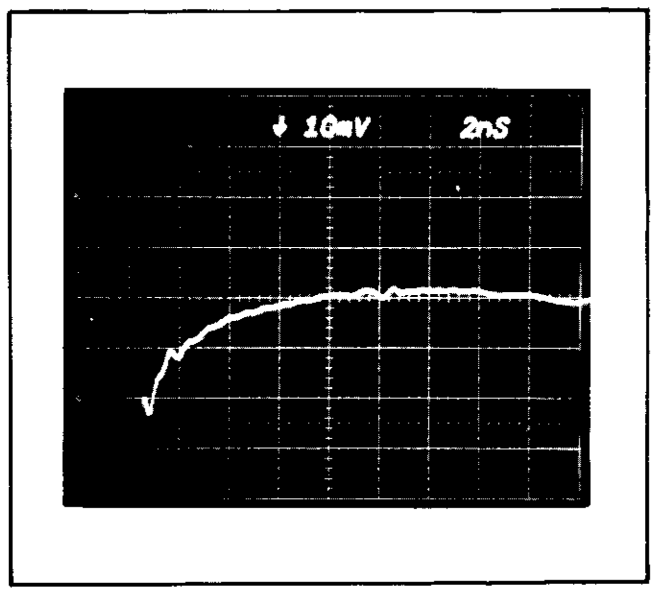

Fig. 3-3. Typical sampling oscilloscope system response curve obtained when C940 has been properly adjusted (step 11l).

12. Check Rise and Fall Times of Fast Rise Output Signals

Use the sampling system set-up to measure the risetime (between 10% and 90% levels) of a 1 volt peak-to-peak positive-going output signal from the PG 506 FAST RISE OUTPUT connector. Establish a 5-division signal at a calibrated 100 mV/div deflection factor. See Fig. 3-4. A risetime greater than 1 nanosecond can be caused by C1000 not being properly adjusted. Measure the fall time (between 90% and 10% levels) of a 1 volt peak-to-peak, negative-going output signal from the PG 506 FAST RISE OUT connector. Establish another 5-division displayed signal. See Fig. 3-5. A fall time greater than 1 nanosecond

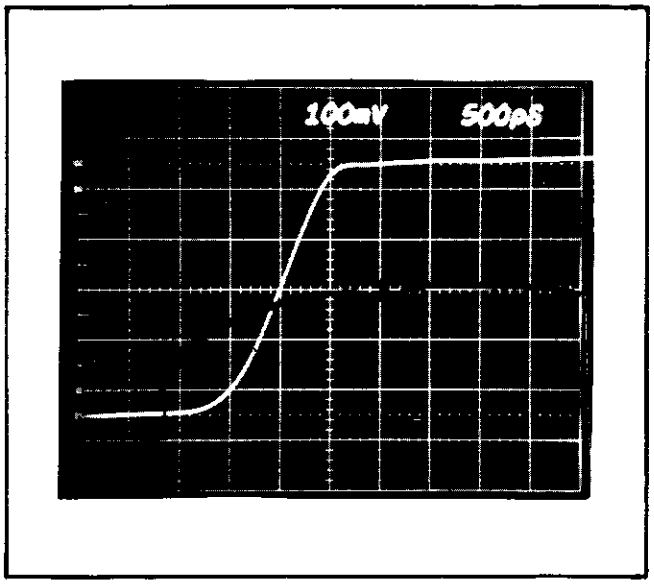

Fig. 3-4. Risetime measurement of a 1 volt peak-to-peak, positive-going Fast Rise Output signal from the PG 506. Signal has been attenuated 2X by sampling oscilloscope system. See step 12.

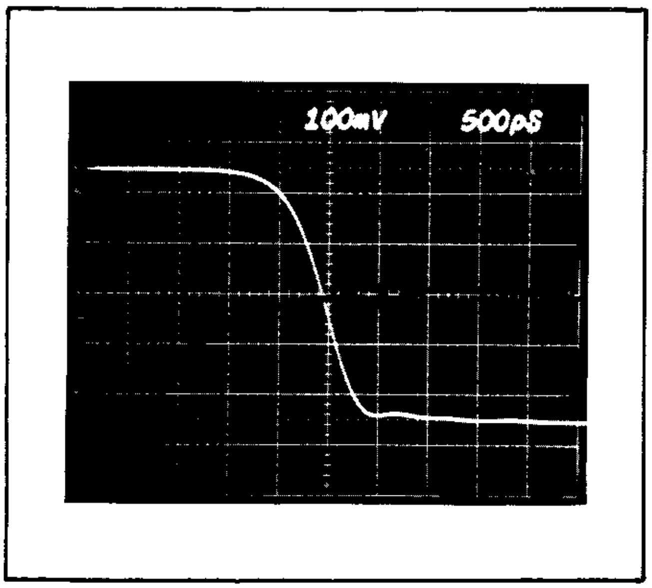

Fig. 3-5. Falltime measurement of a 1 volt peak-to-peak, negative-going Fast Rise Output signal from the PG 506. Signal has been attenuated 2X by sampling oscilloscope system. See step 12.

can be caused by C940 not being properly adjusted. If the rise or fall times are not within specifications, it may be necessary to repeat steps 11a through 11k and adjust C1000 or C940 for slightly more front-corner overshoot, but do not exceed the 2% aberration limits relative to the graph.

13. Check High Amplitude Risetime and Aberrations into 50 Ω

a. After the FAST RISE checks and adjustments have been made, the reference graph should still be on the crt graticule. Insert a 5X, 50 Ω Attenuator between the adapter on the 7M11 and the precision coaxial cable. Connect the coaxial cable (Tektronix Part Number 012-0482-00) to the PG 506 AMPL OUTPUT connector and switch the PG 506 to HIGH AMPL mode. Use + Slope Triggering and 2 ns/div sweep rate for the 7T11. Push + Up button on the 7S11 and use a calibrated 100 mV/div deflection factor (Cal In).

b. Use the PG 506 PULSE AMPLITUDE control and DC Offset controls on the 7S11 to establish a stable 5-division (vertical) signal on the crt. It may be necessary to rotate the Delay Range control on the 7S11 to the right in order to display the complete leading edge of a positive-going, 5 volt signal from the PG 506. Total attenuation is 10X.

c. After a stable display has been achieved at this point, measure the risetime. It must be 10 ns or less (between 10% and 90% levels).

d. Rotate the Time Position control on the 7T11 to align the 50% level of the positive-going pulse with the first-division reference line. Switch to a calibrated, 10 mV/div deflection factor for the 7S11 and use the DC Offset controls to align the top of the waveform with the last horizontal division of the reference graph. The 1 major vertical division aberration limit applies for the High Amplitude signal only during the last 5 horizontal divisions of the reference graph. See Fig. 3-6. Switch to a 5 ns/div sweep rate for the 7T11. While rotating the Time Position control on the 7T11 fully counterclockwise, note displayed signal aberrations in the area of the last 5 horizontal divisions. Aberrations should not exceed 1 major vertical division.

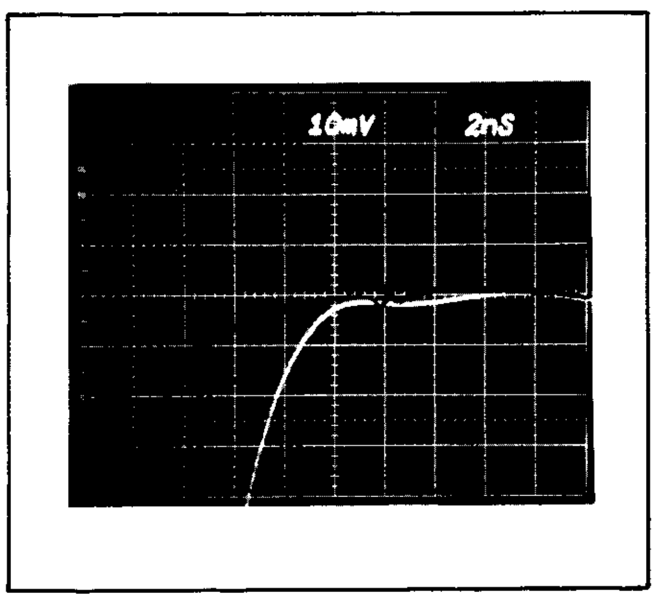

Fig. 3-6. Typical sampling oscilloscope system response curve obtained when performing High Amplitude aberration check (step 13d).

e. This completes the Calibration/Performance Check procedure for the PG 506.