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SG 503
LEVELED SINE-WAVE GENERATOR

INSTRUCTION MANUAL

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

070-1622-01
Product Group 75

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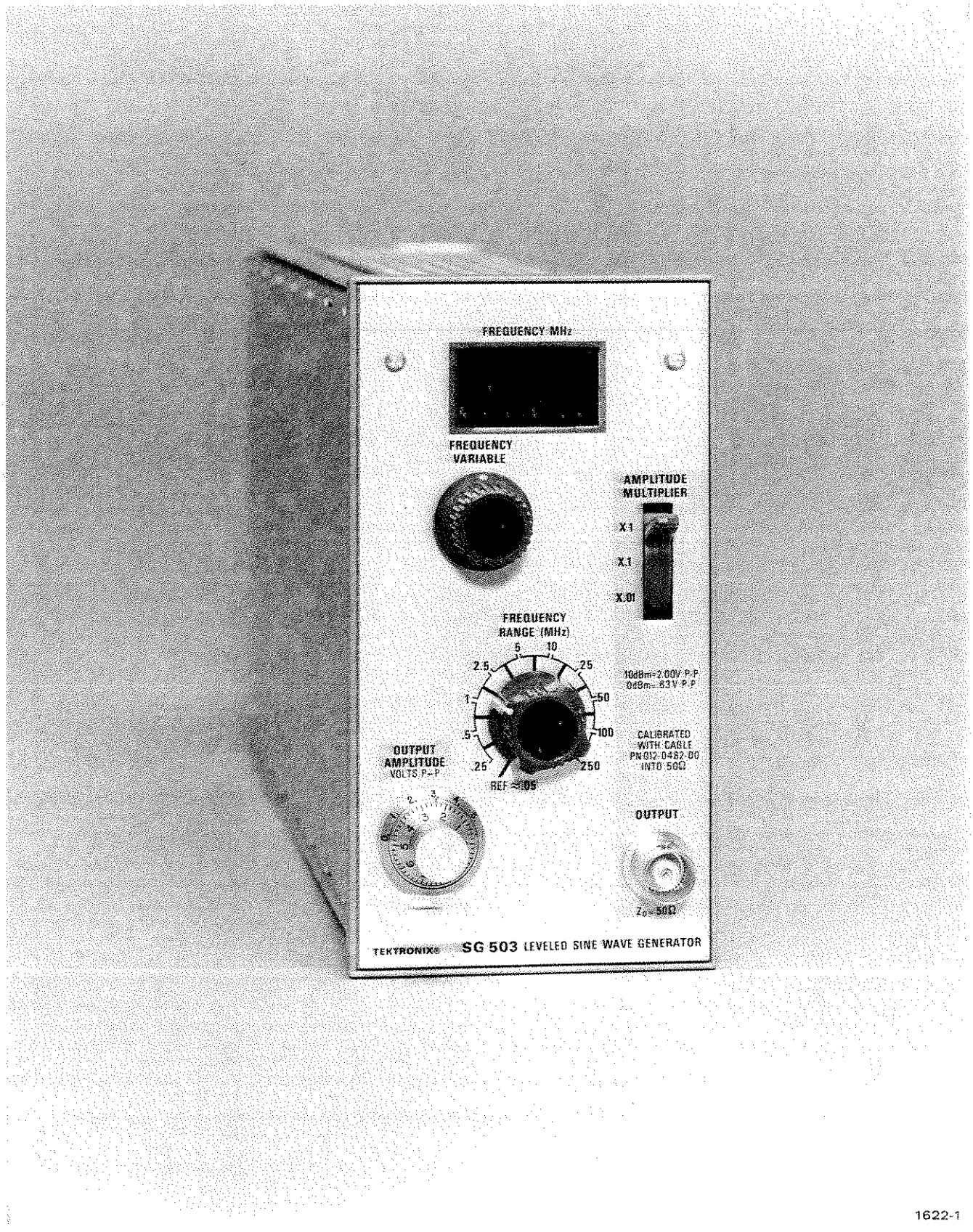
INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first number or letter designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B000000	Tektronix, Inc., Beaverton, Oregon, USA
100000	Tektronix Guernsey, Ltd., Channel Islands
200000	Tektronix United Kingdom, Ltd., London
300000	Sony/Tektronix, Japan
700000	Tektronix Holland, NV, Heerenveen, The Netherlands



1622-1

Fig. 1-1. SG 503 Leveled Sine Wave Generator plug-in module.

OPERATING INSTRUCTIONS

INTRODUCTION

Description

The SG 503 Leveled Sine-Wave Generator provides a regulated, constant-amplitude versus frequency output into a 50-ohm load. The SG 503 is primarily intended to be used as an oscilloscope calibration device for measuring bandwidths up to 250 megahertz. The SG 503 can also be used as a signal source for general electronics design and development.

Nine overlapping ranges cover the frequency band from 250 kilohertz to 250 megahertz, with an additional range reserved for a 50 kilohertz reference frequency.

A digital counter with automatic ranging and a front panel LED readout is used for frequency indication.

Installation and Removal

CAUTION

Turn the power module off before inserting the plug-in; otherwise, damage may occur to the plug-in circuitry. Because of the high current drawn by the SG 503, it is also recommended that the power module be turned off before removing the SG 503. Refer to Fig. 1-2. Check to see that the plastic barriers on the interconnecting jack of the selected power module compartment match the cut-outs in the SG 503 circuit board edge connector.

Align the SG 503 chassis with the upper and lower guides of the selected compartment. Push the module in and press firmly to seat the circuit board in the interconnecting jack.

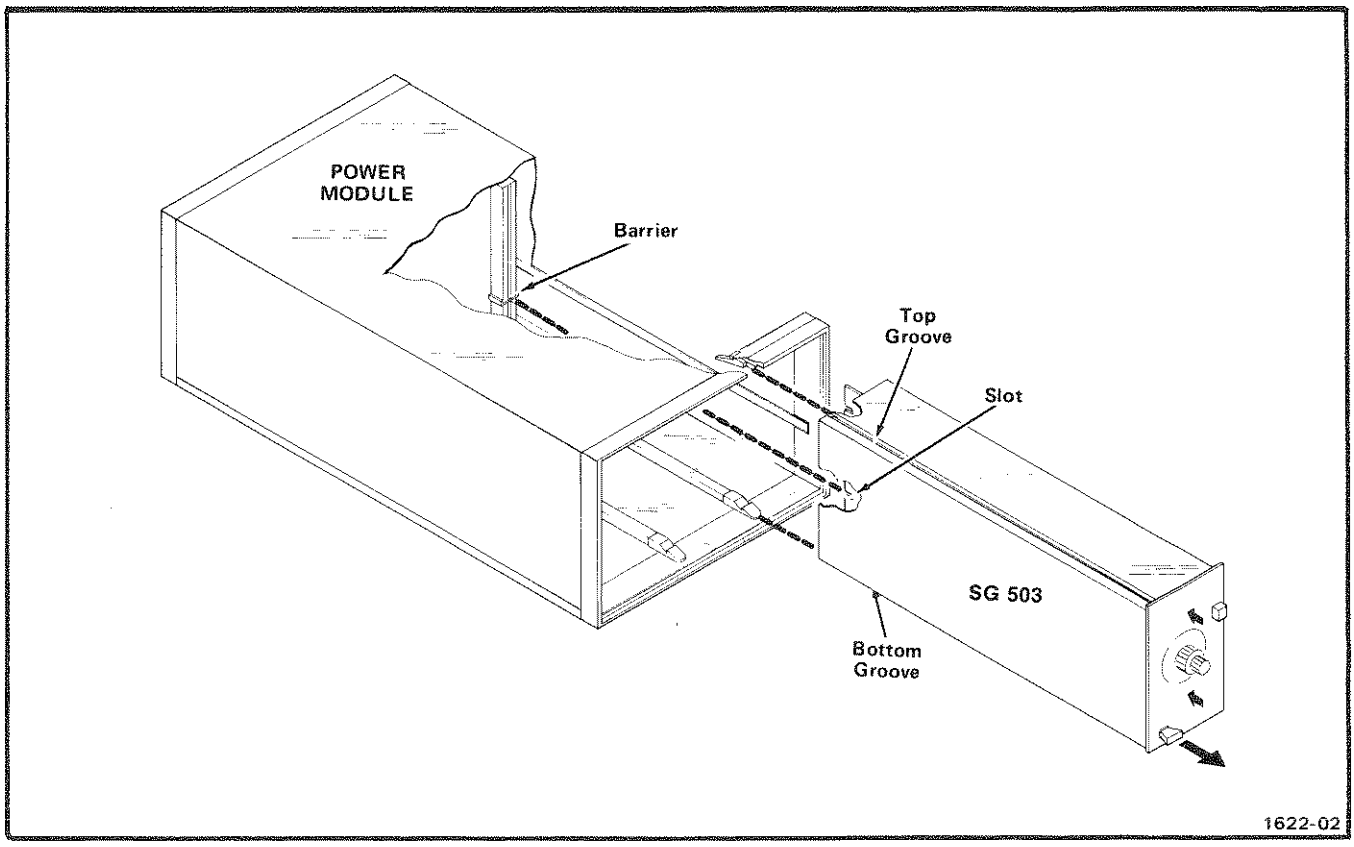
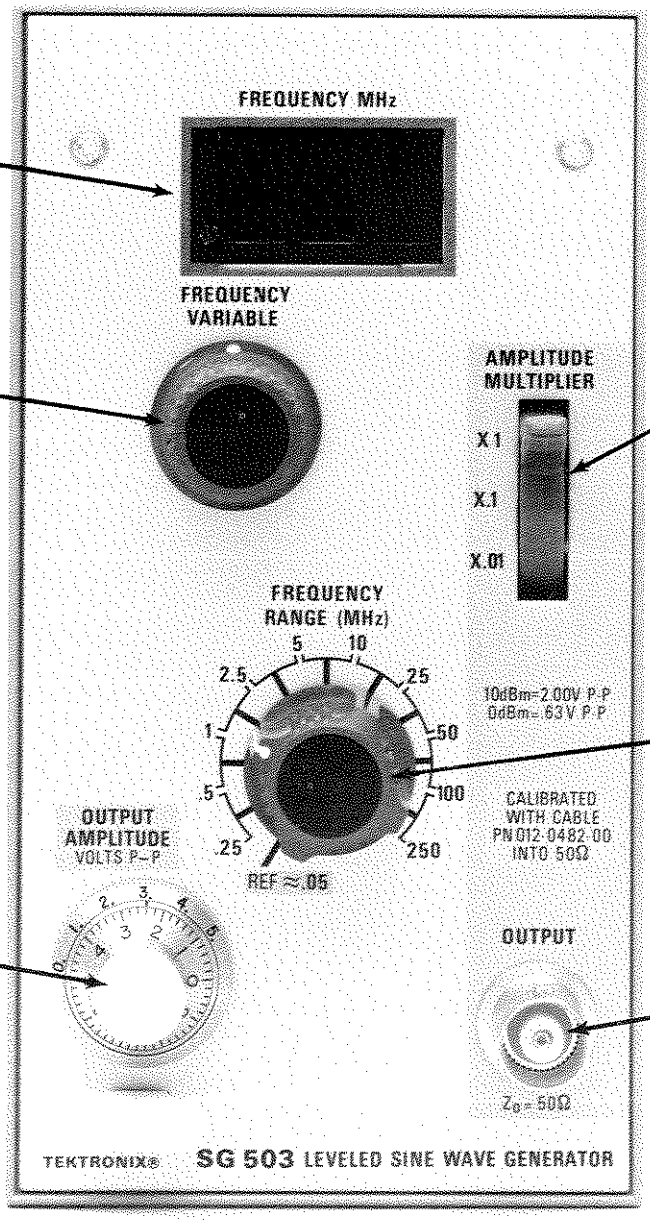


Fig. 1-2. Plug-in installation and removal.



LED Display

Three-digit readout indicates output frequency

FREQUENCY VARIABLE

Selects output frequency within the desired frequency range

OUTPUT AMPLITUDE VOLTS P-P

Determines the peak-to-peak amplitude into the attenuator (AMPLITUDE MULTIPLIER)

AMPLITUDE MULTIPLIER

Three-position lever switch to allow choice of unattenuated or attenuated output amplitude. Output amplitude is OUTPUT AMPLITUDE VOLTS P-P control setting times the factor indicated by the AMPLITUDE MULTIPLIER switch position

FREQUENCY RANGE (MHz)

Selects the desired frequency range as indicated

OUTPUT

BNC connector output terminal. Use proper coaxial cable as indicated on front panel

1622-03

Fig. 1-3. SG 503 controls and connectors.

To remove the SG 503, pull on the release latch located in the lower left corner, until the interconnecting jack disengages and the SG 503 will slide out.

Power application to the SG 503 is indicated by the three-digit LED (Light-Emitting Diode) display being lighted. Turn the FREQUENCY RANGE (MHz) control between the detent positions to test the LED's (888 display). Reset the FREQUENCY RANGE (MHz) control to the desired range. Allow 15 to 20 minutes warmup time for all equipment before using the SG 503.

Overheating

The SG 503 is designed to operate at an ambient temperature from 0°C to +50°C. However, when operating several power supplies in a multi-plug-in power module, especially at low output voltages, or when operating close to other heat-producing equipment, internal temperature may exceed safe limits and actuate a thermal cutout in the power module. Refer to the power module instruction manual for more complete information.

Controls and Connectors

Refer to Fig. 1-3. Even though the SG 503 is fully calibrated and ready to use, the functions and actions of the controls and connectors should be reviewed before attempting to use it.

CAUTION

If the instrument is operated at the extreme limit of, or beyond a band range, the front-panel display may flash a blinking indication, alerting the user to an unleveled output amplitude condition.

OPERATING CONSIDERATIONS

Introduction

The SG 503 has been designed and calibrated with a high quality coaxial cable (Part Number 012-0482-00) to operate as a closely matched system when terminated into a 50-ohm load. See Fig. 1-4A. The absolute amplitude across the load is directly related to its impedance. Part Number 012-0482-00 should be connected directly to the equipment under test if the input impedance of the equipment is 50 ohms. For equipment with an input impedance much greater than 50 ohms, an accurate 50-ohm termination should be connected between the coaxial cable and the equipment. Tee connectors or wire of any type between the 50-ohm termination and the equipment being tested will produce some variation in the calibrated output amplitude at higher frequencies.

Coaxial cables of lesser quality or cables that are longer or shorter than Part Number 012-0482-00 can be used, but the output amplitude flatness specifications are no longer applicable. Cables that are 2 feet longer or 2 feet shorter than Part Number 012-0482-00 can cause amplitude variations that are as much as 4% low or 2% high (respectively) when compared to the calibrated amplitudes at 250 megahertz.

Optimum performance is obtained when the setting of the OUTPUT AMPLITUDE control is in the 1.0 to 5.0 range. For example; when an output amplitude of 0.5 volt peak-to-peak is desired, set OUTPUT AMPLITUDE control to 5.0 and AMPLITUDE MULTIPLIER switch to X.1 instead of 0.5 and X1.

The sine-wave output from the SG 503 may be applied to an external dc level that does not exceed ±1 volt. At higher dc offset levels, couple the output through a dc blocking capacitor. When operating the SG 503 always consider the total load impedance and its effect on the output amplitude.

Open-Circuit Operation

When the SG 503 is operating into an impedance much greater than 50 ohms, up to twice the maximum terminated output amplitude can be obtained. Under open-circuit conditions, the actual output amplitude will be two times the amplitude indicated by the front panel controls.

Open-circuit amplitude flatness is not specified, but is adequate for many applications in the lower frequency bands because the steady state 50-ohm output impedance of the SG 503 reverse-terminates the characteristic impedance of a 50-ohm coaxial cable. The reverse termination keeps the output amplitude constant at the unterminated end of the cable even though standing waves may exist in the coaxial cable.

Capacitive Loads

The input capacitance of the equipment under test will affect the bandwidth. The equivalent circuits shown in Fig. 1-4B and Fig. 1-4C are useful in estimating the amplitude changes caused by reactive loads. Note that as system input capacitance increases, bandwidth decreases. The bandwidth of an oscilloscope with a high input impedance is usually specified using an equivalent 25-ohm source.

When operating the SG 503 on the higher frequency bands with no output attenuation, the front-panel display may flash, indicating an unleveled output amplitude. Switch the AMPLITUDE MULTIPLIER control to the X.1 position and if the display flashing ceases, the problem may be related to an extreme mismatch between the SG 503 and the load. If the SG 503 is operating into a high SWR, a 3-decibel attenuator inserted between the output and the load may improve the operation at full output amplitude (X1 position of the AMPLITUDE MULTIPLIER switch).

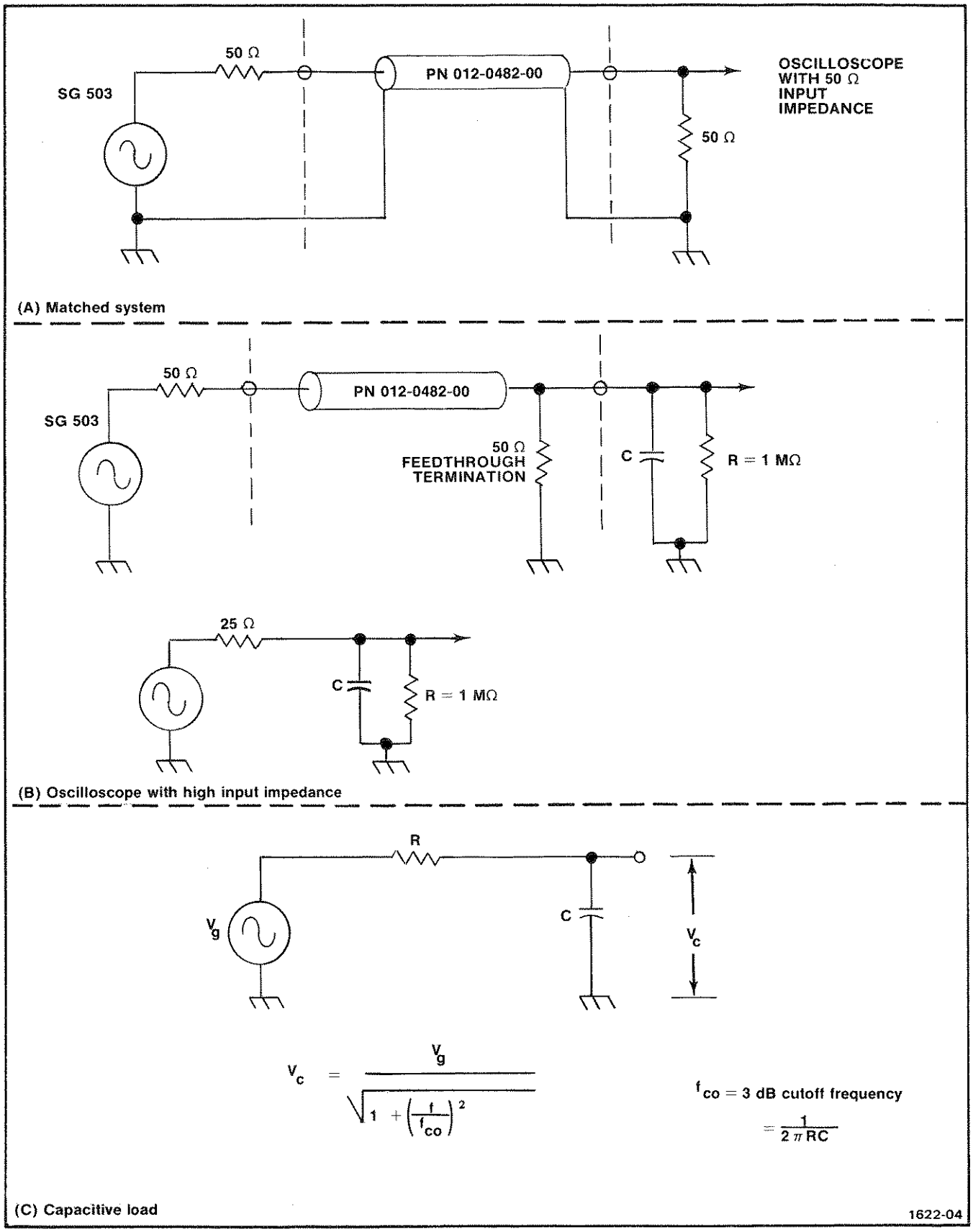


Fig. 1-4. Equivalent circuits for SG 503, 50 ohm coaxial cable and various terminations.

SPECIFICATION AND PERFORMANCE CHECK

SPECIFICATION

Performance Conditions

The electrical characteristics are valid only if the SG 503 has been calibrated at an ambient temperature between +20° C and +30° C and is operating at an ambient temperature between 0° C and +50° C unless otherwise noted.

The SG 503 is calibrated for use with a furnished coaxial cable accessory (See Standard Accessories in Replaceable Mechanical Parts list section) terminated into a 50-ohm load.

Items listed in the Performance Requirements column of the Electrical Characteristics are verified by completing the Performance Check in this manual. Items listed in the Supplemental Information column are not verified in this manual; they are either explanatory notes or performance characteristics for which no limits are specified.

Table 2-1

ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
Frequency Range	250 kHz to 250 MHz, plus 50 kHz reference frequency.	
Output Accuracy	Within ±0.7 of the least significant displayed digit.	
Amplitude Range	5 mV to 5.5 V peak-to-peak over three decade ranges and terminated into a 50-Ω load.	
Accuracy	At 50 kHz reference frequency; within 3% of indicated amplitude on X1 range, 4% on X.1 range, and 5% on X.01 range.	Accuracy must be set to within 0.3% on X1 range and checked to be within 2.0% on X.1 and X.01 ranges.

NOTE

Flatness (Peak-to-Peak) valid only when precision coaxial cable is used. Flatness referenced to NBS corrections of Tektronix standards. NBS uncertainties not included.

Table 2-1 (cont)

ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
Flatness (Peak-to-Peak) Amplitude Multiplier Setting: X1, X.1, X.01	From 250 kHz to 50 MHz output amplitude will not vary more than 1% of the value at 50 kHz. From 100 MHz to 250 MHz amplitude variation is within 3% of the value at 50 kHz.	
Amplitude Multiplier Setting: X1	50 MHz to 100 MHz range; output amplitude will not vary more than 1% of the value at 50 kHz.	
Amplitude Multiplier Setting: X.1 and X.01	50 MHz to 100 MHz range; output amplitude will not vary more than +1.5% and −1.0% of the value at 50 kHz.	
Harmonic Content	Harmonic suppression relative to fundamental: Second harmonic at least 35 dB down. Third and all higher harmonics at least 40 dB down.	

Table 2-2

ENVIRONMENTAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
Temperature Operating	0° C to +50° C.	
Storage	−40° C to +75° C.	
Altitude Operating	To 15,000 feet maximum operating temperature decreased by 1°C/1000 feet from 5000 to 15000 feet.	
Storage	To 50,000 feet.	
Vibration Operating and Non-operating	With the instrument complete and operating, vibration frequency swept from 10 to 55 to 10 Hz at 1 minute per sweep. Vibrate 15 minutes in each of the three major axes at 0.015 inch total displacement. Hold 10 minutes at any major resonance, or in none, at 55 Hz. Total time, 75 minutes.	
Shock Operating and Non-operating	30 g's 1/2 sine, 11 ms duration, 3 shocks in each direction along 3 major axes, for a total of 18 shocks.	

Table 2-3

PHYSICAL CHARACTERISTICS

Characteristics	Information
Overall Dimensions (measured at maximum points) Height	5.0 inches 12.7 centimeter
Width	2.6 inches 6.6 centimeter
Length	12.2 inches 31.0 centimeter
Net Weight (Instrument Only)	2.25 lbs. 1.02 kilograms

PERFORMANCE CHECK

Introduction

This procedure checks the electrical characteristics of the SG 503 that appear in the Specification section of this manual. If the instrument fails to meet the requirements given in this performance check, the calibration procedure should be performed. This procedure can also be used by an incoming inspection facility to determine acceptability of performance.

The electrical characteristics in Section 2 are valid only if the SG 503 is calibrated at an ambient temperature of +20° C to +30° C and operated at an ambient temperature of 0° C to +50° C. Forced air circulation is required for ambient temperature above +40° C.

Tolerances that are specified in this performance check procedure apply to the instrument under test and do not include test equipment error.

Test Equipment Required

The test equipment listed in Table 2-4, or equivalent, is required to perform the performance check. Test equipment characteristics listed are the minimum required to verify the performance of the equipment under test. Substitute equipment must meet or exceed the stated requirements. All test equipment is assumed to be operating within tolerance.

Special test devices are used where necessary to facilitate the procedure. Most of these are available from Tektronix, Inc. and can be ordered through your local Tektronix Field Office or representative.

Table 2-4

LIST OF TEST EQUIPMENT REQUIREMENTS

Description	Performance Requirements	Application	Example
Oscilloscope	Bandwidth, dc to 100 MHz; minimum deflection factor, 1 mV/div with differential comparator; sweep rate, 10 ms/div to 1 μs/div; accuracy, within 3%.	Used throughout procedure to provide display.	TEKTRONIX 7603, 7A13, 7B70 Oscilloscope System.
Digital Voltmeter	Range, 0 to 50 V; accuracy, within 0.1%.	Output voltage flatness check.	TEKTRONIX DM 501 Digital Multimeter.[a]
Digital Counter	Range, 50 kHz to 250 MHz.	Output accuracy	TEKTRONIX DC508 Digital Counter.[a]
Power Module	Three compartments or more.	All tests.	TEKTRONIX TM 503 or TM 504.
Calibration Generator	Amplitude calibration, 5 mV to 5 V; accuracy, ±0.25% into 1 MΩ; output, square wave at approximately 1 kHz.	Amplitude Set check.	TEKTRONIX PG 506 Calibration Generator.[a]
Spectrum Analyzer	Range, 100 kHz to 300 MHz; calibrated levels in decade steps from −45 dB to −35 dB; impedance, 50 Ω; accuracy, linear display, within 10%.	Buffer Distortion, Harmon-Suppression check.	TEKTRONIX 7L12 Spectrum Analyzer.
Peak-to-Peak Detector	Frequency range, 50 Hz to 500 MHz; requires 1.2 V p-p input voltage.	Output voltage flatness check.	Tektronix 067-0625-00 Calibration Fixture.
Coaxial cable	Impedance, 50 Ω; length, 36 inches; connectors, bnc; (precision coaxial cable).	Provides signal interconnection.	Tektronix Part No. 012-0482-00 (supplied with SG 503).
Patch cord (2 required)	Bnc to banana plug-jack, 18 inch.	Provides signal interconnection.	Tektronix Part No. 012-0090-00 (black) 012-0091-00 (red)
Coaxial cable (2 required)	Impedance, 50 Ω; length, 42 inches; connectors, bnc.	Provides signal interconnection.	Tektronix Part No. 012-0057-01.
Attenuator, 2X (2 required).	Impedance, 50 Ω; connectors, bnc.	Output voltage flatness check.	Tektronix Part No. 011-0069-02.
Tee connector	Connectors, bnc.	Reference amplitude check.	Tektronix Part No. 103-0030-00.
Adapter	GR to bnc female.	Output voltage flatness check.	Tektronix Part No. 017-0063-00.
Termination	Impedance, 50 Ω; connectors, bnc.	Output termination for signal generator.	Tektronix Part No. 011-0049-01.
Resistor	Fixed, 2.4 M Ω, 1/2 W, 5%.	Output voltage flatness check.	Tektronix Part No. 301-0245-00.

[a]Requires TM 500-Series Power Module.

Preliminary Procedure

1. Ensure that all power switches are off.

2. Ensure that all test equipment and the SG 503 under test are suitably adapted to the line voltage to be applied.

3. Install the SG 503 into the power module, and if applicable, install all other TM 500-series test equipment into the power module.

4. Connect the equipment under test and the test equipment to a suitable line voltage source. Turn all equipment on and allow at least 20 minutes for the equipment to warm up and stabilize.

Initial Control Settings

Set the following controls during warm-up time:

SG 503

AMPLITUDE MULTIPLIER	X1
FREQUENCY VARIABLE	Midrange
FREQUENCY RANGE (MHz)	REF ≈ .05
OUTPUT AMPLITUDE	5.0

Oscilloscope

Intensity, Focus	Set for well-defined trace and normal brightness.

Differential Comparator

Volts/Div	.1 V
Variable	fully clockwise (cal)
+Input	ac
−Input	ac
Bandwidth Limit	5 MHz

Time Base Plug-In

Time/Div	.2 ms
Variable	(cal in)
Triggering	
+Slope	selected
Mode	P-P Auto
Coupling	ac hf rej
Source	Ext
Position	Set so trace starts at left side of graticule.
Magnifier	X1

PERFORMANCE CHECK PROCEDURE

NOTE

The SG 503 must be terminated into an accurate 50-ohm load for all checks. Measure the 50-ohm termination to determine percent of error. A 2% error in the termination (1 ohm) will cause amplitude errors of 1%. For example, a 51-ohm termination causes an amplitude error that is 1% high at 50 kilohertz.

1. Check Reference Amplitude Accuracy at 0.05 megahertz.

a. Connect a 1 kilohertz, 5 volt square-wave signal from the calibration generator, through a bnc tee connector, to the + input of the differential comparator, using a 42-inch cable. Connect a 42-inch cable from the tee connector to the time-base unit external trigger input.

b. Connect the precision 50-ohm cable (supplied with SG 503) to the SG 503 OUTPUT connector.

c. Connect a 50-ohm termination to the remaining end of the precision 50-ohm cable; connect the other end of the 50-ohm termination to the − input of the differential comparator.

d. Set the time-base triggering controls for a stable display; a crt display similar to Fig. 2-1 is obtained.

e. Check—that the corners of the idealized waveform are aligned as illustrated in Fig. 2-1, within 1.5 vertical divisions. Disregard waveform tilt.

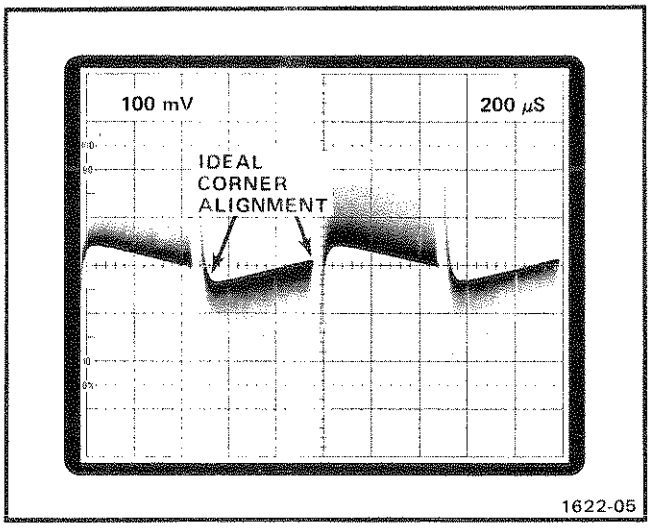


Fig. 2-1. Representation of complex waveform (idealized) with 5 volt reference amplitude at 0.05 MHz, properly set.

f. Set the SG 503 OUTPUT AMPLITUDE control to 0.5; set the calibration generator for a 0.5 volt, 1 kilohertz square-wave signal.

g. Set the differential-comparator deflection factor for 10 mV/div.

h. Check—that the waveform is similar as illustrated in Fig. 2-2, (within 1.5 vertical divisions).

i. Disconnect all cables.

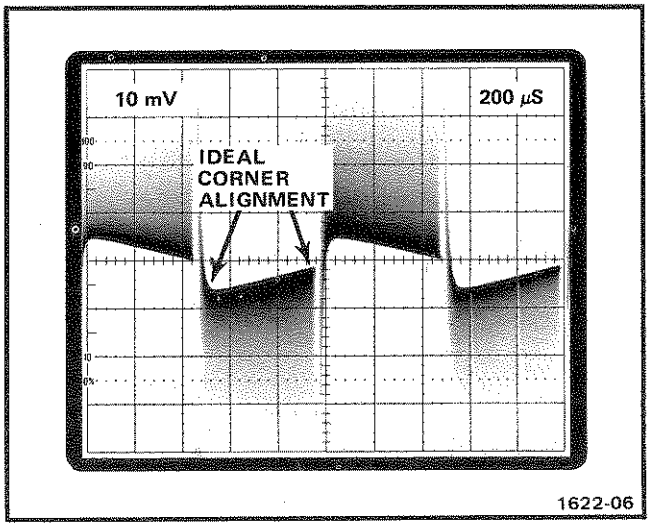


Fig. 2-2. Display of complex waveform (idealized) with 0.5 volt reference amplitude of 0.05 MHz, properly set.

2. Check Harmonic Suppression and Leveling

a. Connect the SG 503 output to the spectrum analyzer input, using the precision 50-ohm cable (supplied with SG 503).

b. Set the SG 503 OUTPUT AMPLITUDE control to 5.5 and the AMPLITUDE MULTIPLIER switch to the X1 position.

c. Set the SG 503 FREQUENCY RANGE (MHz) switch to the 100-250 range.

d. Position the fundamental display to the top graticule line with the spectrum analyzer position control. See Fig. 2-3 for reference.

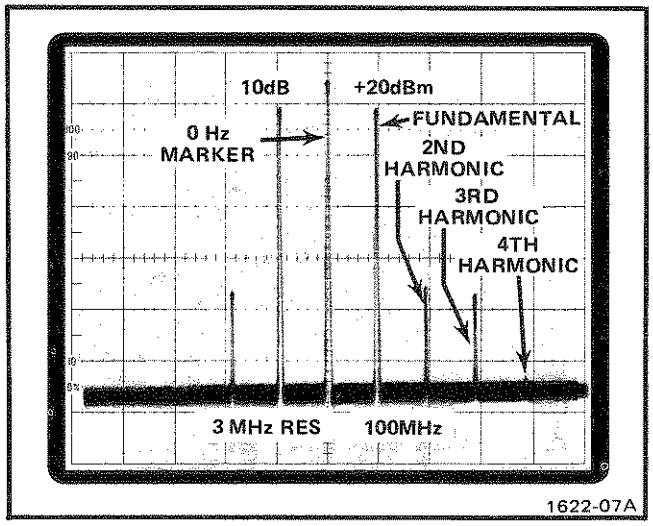


Fig. 2-3. Display of 100 MHz signal and harmonics.

NOTE

It will be necessary to change the spectrum analyzer input attenuation (sensitivity) to maintain a reasonable display on screen, with harmonics above the baseline noise level and within the graticule area.

e. Slowly adjust the SG 503 FREQUENCY VARIABLE control over its entire range and check that the vertical distance (suppression) between the top of the fundamental and second harmonic display is at least 3.5 divisions; the tops of the remaining harmonics are separated at least 4.0 divisions. (Adjust the spectrum analyzer Frequency Span/Div control as necessary to maintain the harmonic display on screen.) See Fig. 2-3.

f. Set the SG 503 FREQUENCY RANGE (MHz) switch to the 50-100 range.

g. Repeat part e of this step for the remaining frequency ranges, using Table 2-5 as reference. (Suppression limit of 45 decibels down corresponds to 4.5 divisions on the display.)

NOTE

All coil adjustments have been adjusted for minimum harmonic amplitude at the high end of the associated range (worst case harmonic conditions). Check that the output remains leveled (display will blink if unleveled condition occurs) as the SG 503 FREQUENCY VARIABLE control is slowly rotated over its associated frequency range.

Table 2-5

SG 503 FREQUENCY (RANGE (MHz)	SG 503 FREQUENCY VARIABLE Typical Displayed Count (Frequency Range)*	Typical Harmonic Suppression (2nd and all higher harmonics, relative to fundamental)
100-250	97.5-260	≥40 dB down
50-100	41.0-109	≥40 dB down
25-50	23.7-52.5	≥40 dB down
10-25	9.09-27.3	≥45 dB down
5-10	4.70-11.1	≥45 dB down
2.5-5	2.30-5.50	≥45 dB down
1-2.5	.950-2.55	≥45 dB down
.5-1	.480-1.05	≥45 dB down
.25-.5	.240-.520	≥45 dB down
REF≈.05	.049-.051	≥45 dB down

*The minimum and maximum displayed count on each range will vary slightly between instruments.

h. Disconnect the cable from the spectrum analyzer.

3. Readout Accuracy

a. Connect the SG 503 output to the frequency counter using the 50 Ω coax. (Set the counter to 50 Ω.)

b. Set the SG 503 OUTPUT AMPLITUDE to a level that stabilizes the frequency counter display.

c. Slowly adjust the SG 503 FREQUENCY VARIABLE control over its entire range at each of the frequency range positions of the FREQUENCY RANGE (MHz) switch.

d. Check that the frequency counter display is within ±0.7 of the least significant displayed digit on the SG 503.

4. Check Flatness (Peak-to-Peak Amplitude Regulation)

a. Set the SG 503 controls as follows: FREQUENCY RANGE (MHz) switch to REF ≈ .05 position, and the AMPLITUDE MULTIPLIER switch to X1.

b. Connect a 2.4 megohm, 5% resistor across the digital voltmeter floating input terminals. Connect the SG 503 via the precision cable (012-0482-00) and the bnc female-to-GR adapter to the input of the peak-to-peak detector. Use two bnc to banana-plug-jack patch cords to connect the output of the peak-to-peak detector to the floating input terminals on the digital voltmeter; maintain correct polarity, HI to + and LO to −. Set the digital voltmeter to the 20 volts dc range.

c. Slowly adjust the SG 503 OUTPUT AMPLITUDE VOLTS P-P control until the digital voltmeter display indicates ±.000. Output amplitude from the SG 503 should be about 1.1 to 1.2 volts; this establishes a 0.0% reference setting at .050 megahertz.

d. Slowly adjust the SG 503 FREQUENCY VARIABLE control over its entire range at each of the frequency range positions of the FREQUENCY RANGE (MHz) switch.

e. Check—the flatness deviation from 0.25 megahertz to 50 megahertz, must be within 1% of the value at .050 megahertz. The total percentage deviation calculation must include the digital voltmeter reading and the calibration factor of the peak-to-peak detector. For example, a reading of +.008 volt on the digital voltmeter is equivalent to +0.8% deviation. Applying a correction factor of −0.3% results in a total percentage deviation of +0.5%.

f. Check—the flatness deviation from 50 megahertz to 100 megahertz, must be within 1% of the value at .050 megahertz. The same calculation must be considered for this deviation reading as described in part e of this step.

NOTE

A 1% total percentage deviation ensures flatness specification when the SG 503 is operating at the X.1 and X.01 AMPLITUDE MULTIPLIER switch positions.

g. Check—the flatness deviation from 100 megahertz to 250 megahertz, must be within 3% of the value at .050 megahertz. The same calculation must be considered for this deviation reading as described in part e and f of this step.

h. To check the flatness deviation at a higher voltage output from the SG 503, insert two 2X attenuators between the SG 503 cable and the peak-to-peak detector. Repeat part c of this step to obtain another 0.0% reference reading of about 4.7 volts output from the SG 503.

i. After obtaining the new 0.0% reference indication on the digital voltmeter, repeat parts e and f of this step to check flatness deviation for about 4.7 volts output from the SG 503. Tolerance limits are the same as in parts e and f of this step.

j. Disconnect all cables from the SG 503.

This completes the Performance Check procedure of the SG 503 Leveled Sine Wave Generator.