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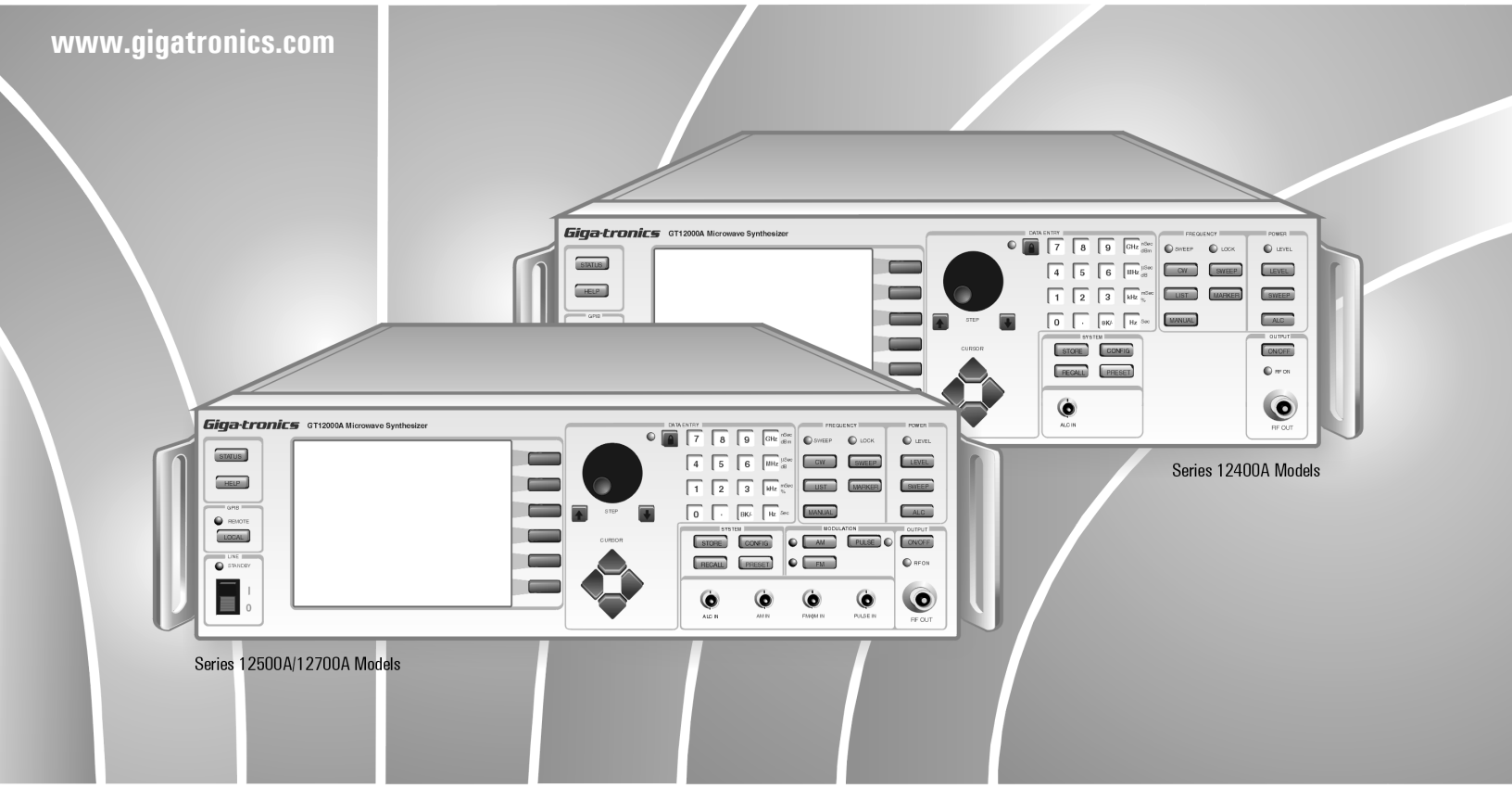

Series 12000A Microwave Synthesizers

Service Manual

Publication 31232, Rev. A7, October 2003

Registered 04 June 1996 ❖ Amended 10 September 2001
CE
Certified Product

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ISO 9001
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Registrar: BSI, Certification FM 34226

WARRANTY

Giga-tronics Series 12000A instruments are warranted against defective materials and workmanship for three years from date of shipment. Giga-tronics will at its option repair or replace products that are proven defective during the warranty period. This warranty DOES NOT cover damage resulting from improper use, nor workmanship other than Giga-tronics service. There is no implied warranty of fitness for a particular purpose, nor is Giga-tronics liable for any consequential damages. Specification and price change privileges are reserved by Giga-tronics.

MODEL NUMBERS

The Series 12000A has model numbers for each instrument with a specific frequency range as described in Chapter 1. All models are referred to in this manual by the general term 12000A, except where it is necessary to make a distinction between the models. In these cases, the specific model number(s) will be used.

Giga-tronics

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DECLARATION OF CONFORMITY

Application of Council Directive(s)

Standard(s) to which Conformity is Declared:

89/336/EEC and 73/23/EEC	EMC Directive and Low Voltage Directive
EN61010-1 (1993)	Electrical Safety
EN61326-1 (1997)	EMC – Emissions & Immunity

Manufacturer's Name:
Giga-tronics Incorporated

Manufacturer's Address:
4650 Norris Canyon Road
San Ramon, California 94583
U.S.A.

Type of Equipment:
Microwave Synthesizer

Model Series Number:
12000A

Model Number(s) in Series:
12408A, 12420A, 12422A, 12428A
12508A, 12520A, 12522A, 12528A
12708A, 12720A, 12722A, 12728A

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s).

Claudio Mariotta (Full Name) _____ (Signature) Acting Director of Quality Assurance (Position)

San Ramon, California (Place)

February 27, 2002 (Date)

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About this Publication

This publication contains the following to describe the service components of the Giga-tronics Series 12000A Microwave Synthesizers:

Preface:

In addition to a comprehensive Table of Contents and general information about the publication, the Preface also contains a record of changes made to the publication since its production.

Chapters:

1 – Specifications

Brief introduction to the instrument and its performance parameters for all three models. Section 1.4 begins data for native performance specifications for the Series 125XXA/127XXA models.

2 – Performance Verification

Defines procedures to verify the performance of the 12000A series. Section 2.3 begins modulation related performance verification issues that are native to the Series 125XXA/ 127XXA models.

3 – Calibration

Provides procedures for inspection, calibration and performance testing.

4 – Theory of Operation

Section provides the instrument's block diagram level descriptions and its circuits for maintenance and applications.

5 - Replaceable Parts

Lists replaceable parts for the Series 12000A Microwave Synthesizers.

6 - Troubleshooting

Section contains procedures for troubleshooting and lists a series of Error codes.

Index:

Series 12000A Microwave Synthesizer

A subject listing of contents for the Series 12000A data that is native to all three models (Series 124XXA, 125XXA and 127XXA.

Series 12500A/12700A Native Data Only

A subject listing of contents for the Series 125XXA/127XXA models only.

Changes that occur after production of this publication, and Special Configuration data will be inserted as loose pages in the publication binder. Please insert and/or replace the indicated pages as detailed in the Technical Publication Change Instructions included with new and/or replacement pages.

Conventions

The following conventions are used in this publication. Additional conventions not included here will be defined at the time of usage.

Warning

WARNING

The WARNING statement is encased in gray and centered in the page. This calls attention to a situation, or an operating or maintenance procedure, or practice, which if not strictly corrected or observed, could result in injury or death of personnel. An example is the proximity of high voltage.

Caution

CAUTION

The CAUTION statement is enclosed with single lines and centered in the page. This calls attention to a situation, or an operating or maintenance procedure, or practice, which if not strictly corrected or observed, could result in temporary or permanent damage to the equipment, or loss of effectiveness.

Notes

NOTE: *A NOTE Highlights or amplifies an essential operating or maintenance procedure, practice, condition or statement.*

Record of Publication Changes

This table is provided for your convenience to maintain a permanent record of publication change data. Replacement pages will be issued as a TPCI (Technical Publication Change Instructions), and will be inserted at the front of the binder. Remove the corresponding old pages, insert the new pages, and record the changes here. The TPCI Number and Date issued are found in the TPCI footer.

TPCI Number & Date		Date Entered	Comments

1

Specifications

1.1 Introduction

Specifications (Introduction)	Model	
	124XXA	125XXA/ 127XXA
1.1.1 - Environmental Standards	√	√

The Series 12000A are Microwave Synthesizers with Step, Ramp (Series 127XXA Only) and List Sweep capability; the instruments operate over a wide range of microwave frequencies, power levels and in a variety of modulation modes. The 12000A can generate output signals over a frequency range of 10 MHz to 20 GHz; the frequency range is dependent on the specific model number. Table 1-1 lists the models with their respective frequency range. The RF output can be Fixed (CW), Step, Ramp or List Sweep with External Frequency, Amplitude or Pulse Modulation. The Series 124XXA is a CW ONLY Microwave Synthesizer. Option 29 (Scan Modulation) and Option 24 (Internal Modulation Generator) are only available on Series 125XXA/127XXA models.

Table 1-1: Series 12000A Model Numbers

Series 12400A (CW Generator)	**Series 12500A** (Signal Generator)	**Series 12700A** (Swept Signal Generator)	**Frequency Range**
(Step Sweep, No Modulation)	(Step Sweep, Modulation)	(Step and Ramp Sweep Modulation)	
12408A	12508A	12708A	10 MHz to 8 GHz
12428A	12528A	12728A	2 GHz to 8 GHz
12420A	12520A	12720A	10 MHz to 20 GHz
12422A	12522A	12722A	2 GHz to 20 GHz

Observe the publication's legend header sections as a way to assist in the operability of the Series 12000A purchased. Operation from the instrument's front panel is detailed in Chapter 2 of the Operation Manual. Instructions on how to operate the instrument from a remote host computer over the GPIB (General Purpose Interface Bus) can be obtained from Chapter 3 of the Operation manual.

1.1.1 Environmental Standards

All Series 12000A models are environmentally tested for compliance with MIL-PRF-28800F, Class 3.

1.2 Specifications
(Signal Parameters & Operational Modes)

Specifications	Model	
	124XXA	125XXA/ 127XXA
1.2.1 - CW Operation	√	√
1.2.2 - RF Output	√	√
1.2.3 - Spectral Purity	√	√
1.2.4 - Step Frequency Sweep	√	√
1.2.5 - Step Power Sweep	√	√

The following are specifications for the Series 12000A Microwave Synthesizers.

1.2.1 CW Operation

Ranges

	Model		
10 MHz to 8 GHz	12408A	12508A	12708A
2 GHz to 8 GHz	12428A	12528A	12728A
10 MHz to 20 GHz	12420A	12520A	12720A
2 GHz to 20 GHz	12422A	12522A	12722A

Resolution

0.1 Hz (Standard)
1 kHz (Optional)

Accuracy & Stability (Identical to Timebase Oscillator)

Timebase (Internal)	10 MHz
Aging Rate	$< 5 \times 10^{-10}$/day after 72 hours continuous oven operation
Temperature Stability	$< \pm 2 \times 10^{-10}$/ °C (0 to +55°C)
Timebase (External)	5 or 10 MHz (± 1 x 10^{-6} or better) (Software selected) 0.5 to 5 V_{P-P} into 100 Ω (Nominal)

Switching Time, List Mode

< 500 µs to within 1 kHz of set frequency (Typical)

Switching Time, CW Mode

35 ms to within 1 kHz of set frequency (Includes IEEE overhead) (Typical)

Residual FM During Switching
Refer to FM Table, Wide Mode Residual Column, Section 1.5.3

Phase Offset Mode	
Range	-180 to +180 degrees
Resolution	.01 degrees, maximum
Step Size	.01 to 180 degrees
Accuracy	Not specified. This is relative mode of operation and is designed to be used interactively

1.2.2 RF Output

Maximum Leveled Output (0 to 35°C)

Frequency Range (GHz)	**Output Power** (dBm)	**Option 26** (dBm)
0.01 to 2	+15 dBm	+14 dBm
> 2 to < 8	+15 dBm	+15 dBm
8 to 15	+15 dBm	+13 dBm
> 15 to 20	+15 dBm	+12 dBm

Incremental Level Range

-20 (Typical) to +25 dBm; -120 to +25 dBm (Option 26)

Resolution

-0.01 dB, entry and display

Minimum Calibrated Output Level

-120 dBm with attenuator Option 26
-10 dBm without attenuator Option 26
RF Off: Attenuates the output to < -140 dBm at the output connector

Flatness

±0.5 dB (-10 dBm to maximum specified power) at 25 ±10°C (Internally Leveled, CW or Frequency Step or Ramp Mode)

Add ±0.1dB/10 dB with attenuator option (±2.5 dB with Option 20*)

At 35 to 55°C, maximum output power is +13 dBm, flatness +/- 1 dB, Typical temperature coefficient is -0.025 dB per degree C

(*See Section 1.3.3 for Option 20 limitations involving use with the 124XXA)

Resolution

-Add 0.2 dB to Flatness (Internally Leveled, CW, Frequency Step or Ramp)

Maximum Slope of Level Variation

< 0.5 dB/MHz

Output Switching Time

< 500 μs; 20 ms with attenuator change

Output Impedance

50 Ω, nominal

Output SWR
< 2.0:1 (Typical)

Level Drift
< 0.05 dB/hour. Max 0.1 dB/24 hours

1.2.3 Spectral Purity

Harmonics

Frequency (GHz)	**Harmonic** (dBc)	**Power** (dBm)
0.01 to 0.10	-30	+6
0.10 to 2	-50	+6
> 2 to 20	-55	+6

Subharmonics

None, 0.01 - 2 GHz

0.01 - 2 GHz
55 dBc > 2 GHz

A subharmonic is defined as any ¼, ½, or ¾ multiple of the fundamental RF Output

Nonharmonics

< -60 dBc from 0.01 to 16 GHz (offsets > 300 Hz)
< -55 dBc from > 16 to 20 GHz (offsets > 300 Hz)

Single-Sideband Phase Noise (dBc/Hz, CW mode, all power levels)

Freq. (GHz)	**Offset from Carrier**				
	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz
0.25	-101	-101	-109	-122	-129
0.5	-95	-95	-103	-122	-124
2	-87	-92	-94	-120	-125
4	-81	-86	-88	-110	-130
6	-81	-83	-83	-110	-130
8	-75	-80	-80	-105	-130
10	-75	-80	-80	-105	-125
18	-68	-73	-73	-97	-120
20	-68	-73	-73	-97	-120

Residual FM (Hz, rms, CW Mode)

Frequency Range (GHz)	**Post Detection Bandwidth** (Hz)	
	300 to 3000	50 to 15000
< 2 GHz	Decreases by ½ per oct	Decreases by ½ per oct
2 to < 4	< 6	< 45
4 to < 8	< 12	< 70
8 to < 16	< 24	< 160
16 to 20	< 32	< 280

AM Noise

< -130 dB/Hz from 0.01 to 2 GHz
< -145 dBm/Hz at > 2 GHz

1.2.4 Step Frequency Sweep

Range

FA (minimum frequency of instrument) to FB (maximum frequency of instrument)

Step Size

Any increment within the frequency resolution

Dwell Time

May be set in 1 μs increments from approximately 1μs to 200 sec

Setup Time

200 μs (Typical)

Accuracy & Stability

Same as in CW when locked at each step during dwell time

Modes

Start/Stop	$FA \leq [F1 \neq F2] \leq FB$ Sweeps up or down from a preset start frequency (F1) to a preset stop frequency (F2)
Start/Δ	$FA \leq [F1 \pm \Delta F] \leq FB$ Sweeps up or down from a preset start frequency (F1) through a preset sweep width (ΔF)
CTR/Δ	$FA \leq [CF \pm (\Delta F/2)] \leq FB$ Sweeps up or down through a preset sweep width (ΔF) centered symmetrically about a preset center frequency (CF)
Start/Steps	$FA \leq [F1 \pm (\text{Step Size} \times \text{Number of Steps})] \leq FB$ Sweeps up or down from a preset start frequency (F1) through a preset number of frequency steps

Functions

Auto	Continuous cycle of the preset sweep
Single	A single cycle of the preset sweep or (with stop activated) a single preset step, initiated by the manual operation of the front panel push-button or reception of the corresponding GPIB command
EXT	A single cycle of the preset sweep initiated by each trigger from an external source
EXT Step	A single step of a preset step sweep initiated by each trigger input from an external source

1.2.5 Step Power Sweep

Range

LA (minimum level of instrument) to LB (maximum level of instrument)

Step Size

Any increment within the instrument's resolution

Dwell Time

May be set in 1 μs increments from approximately 1 μs to 200 sec

Setup Time

100 μs (Typical)

Accuracy & Stability

Same as in CW when locked at each step during dwell time

Modes

Start/Stop	$LA \leq [L1 \neq L2] \leq LB$ Sweeps up or down from a preset start level (L1) to a preset stop level (L2)
Start/Δ	$LA \leq [L1 \pm \Delta L] \leq LB$ Sweeps up or down from a preset start level (L1) through a preset sweep width (ΔL)
CTR/Δ	$LA \leq [CL \pm (\Delta L/2)] \leq LB$ Sweeps up or down through a preset sweep width (ΔL) centered symmetrically about a preset center level (LF)
Start/Steps	$LA \leq [L1 \pm (\text{Step Size} \times \text{Number of Steps})] \leq LB$ Sweeps up or down from a preset start level (L1) through a preset number of level steps

Functions

Auto	Continuous cycle of the preset sweep
Single	A single cycle of the preset sweep or (with stop activated) a single preset step, initiated by the manual operation of the front panel push-button or reception of the corresponding GPIB command
EXT	A single cycle of the preset sweep initiated by each trigger from an external source
EXT Step	A single step of a preset step sweep initiated by each trigger input from an external source

1.3 Supplemental Specifications

Supplemental Specifications	Model	
	124XXA	125XXA/ 127XXA
1.3.1 - General Specifications	√	√
1.3.2 - Weight & Dimensions	√	√
1.3.3 - Option 20 Specifications	√	√

1.3.1 General Specifications

Remote Interfaces	GPIB	IEEE STD 488.2 (GPIB), all parameters except AC power on/off
	Serial	EIA RS-232, Serial Interface, DB9 Connector
Operating Temperature	0 to 55°C	
Environmental	Complies with MIL-PRF-28800F, Class 3	
Approvals	CE marked	
Power	90-253 VAC, 47-64 Hz (400 Hz optional),150 Watts (Nominal)	
Fuse Rating	2 A, SB	

1.3.2 Weight & Dimensions

Item	Benchtop Model	Packed for Air Shipment
Width	16.75 in. (42.5 cm.)	24 in. (60.9 cm.)
Depth	21 in.	21 in.
Height	5.25 in. (13.3 cm.)	11.25 in. (28.6 cm.)
Volume	1850 cuin	1850 cuin
Weight	30 lbs.	40 lbs.

1.3.3 Option 20 (High Power) Specifications

(Apply from 0° to 35°C)

Output Power

+20 dBm

Flatness

+/- 2.5 dB

Harmonics

< -5 dBc from 0.01 to 0.1 GHz
< -20 dBc for 0.1 to 20.0 GHz @ +20 dBm Output Power

Pulse On/Off (PULSE ON/OFF ONLY ON SERIES 12500A/12700A)

60 dBc

AM (AM ONLY ON SERIES 12500A/12700A)

Functional, but not specified above 0 dBm

Option Activity

When the option is not active the output power is reduced by 2.0 dB
When active, the High Power Option switches in at +11 dBm

1.4 Specifications (Series 12500A/12700A)

(Signal Parameters & Operational Modes)

Specifications (Series 12500A/12700A)	Model	
	124XXA	125XXA/ 127XXA
1.4.1 - Ramp Frequency Sweep	N/A	√ (127XXA Only)
1.4.2 - Ramp Power Sweep	N/A	√ (127XXA Only)

Refer to Section 1.2 for specifications that apply to all models. Use this section for native specifications to the Series 125XXA/127XXA models.

1.4.1 Ramp Frequency Sweep

A continuous sweep is generated within the instrument. The continuous sweep may be operated simultaneously with digital power sweep.

	Description
Sweep Type	Smooth frequency ramp progression sweep
Sweep Type	Either up or down in frequency
Sweep Direction	Either up or down in frequency
Sweep Ramp Shape	Linear frequency ramp with respect to time
Sweep Range	Linear frequency ramp with respect to time
Start Frequency Accuracy	Phase locked to timebase (via YIG tune coil)
Stop Frequency Accuracy	Phase locked to timebase (via YIG tune coil)
Halted Frequency Accuracy	Phase locked to timebase (via YIG tune coil)
Start & Stop Freq. Resolution	0.1 Hz Standard (1 kHz, Option 36)
Minimum Sweep Width	100 Hz Standard (1 MHz, Option 36)
Maximum Step Width	From the minimum frequency to the maximum. Frequency of the Series 12000A as configured
Sweep Width Resolution	0.1 Hz standard (1 kHz, Option 36)
Sweep Time	1 ms to 200 sec
Sweep Time Resolution	10 μs
Minimum Sweep Rate	100 kHz/sec
Maximum Sweep Rate	8 ms/octave
Sweep Linearity	Better than 0.03% of sweep width relative to the 0 V to 10 V Ramp Output BNC voltage (Swept time < 100 sec) (Typical)
Sweep Modulation Formats	AM or Pulse Modulation

0 to 10 V Ramp Output

Vout = (10 V) |(fout - fstart)| / |(fstop - fstart)| (Frequency Ramp sweep mode)
Vout = (10 V) |(Pout - Pstart)| / |(Pstop - Pstart)| (Power Ramp sweep mode)
Vout = 0 to 10 V ramp @ current set sweep rate (Ramp during CW mode)

0.5 / GHz Output

Vout = (0.5 V) (Fout in GHz)

Sweep Modes

Start/Stop	FA ≤ [F1 ≠ F2] ≤ FB Sweeps up or down from a preset start frequency (F1) to a preset stop frequency (F2)
Start/Δ	FA ≤ [F1 ± ΔF] ≤ FB Sweeps up or down from a preset start frequency (F1) through a preset sweep width (ΔF)
CTR/Δ	FA ≤ [CF ± (ΔF/2)] ≤ FB Sweeps up or down through a preset sweep width (ΔF) centered symmetrically about a preset center frequency (CF)
Δ MKR	FA ≤ [Mx ≠ My] ≤ FB Sweeps up or down from a preset start frequency (Mx) through a preset marker (My)

Sweep Functions

Auto	Continuous recycle of the preset sweep
Single	A single cycle of the preset sweep initiated by manual operation of the front panel push-button or reception of the corresponding GPIB command
EXT	A single cycle of reset sweep initiated by a trigger from an external source

Frequency Markers

(Twelve intensity, video and/or amplitude markers, individually selected from either the front panel or via the GPIB)

Resolution	Sweep width/4000
Accuracy	Same as Sweep linearity except the marker may vary ±25 mV relative to the linear 0 to +10 V RAMP OUT
Amplitude Markers	A -10 to +10 dB change in RF output during analog frequency sweep
Video Markers	TTL level output or ±5 V
Intensity Markers	Provides a timed dwell of frequency sweep

1.4.2 Ramp Power Sweep

Continuous sweep, self generated within the instrument. Can be operated simultaneously with digital frequency sweep.

Range

- 10 dBm to maximum power, up or down (-120 dBm is maximum power with Option 26)

Sweep Time (Any Sweep Mode)

2 ms to 200 sec in five ranges. Minimum sweep time is determined by the sweep width and the maximum sweep speed

Range	Resolution
2 ms to 20 ms	10 μs
20 ms to 200 ms	100 μs
200 ms to 2 sec	1 ms
2 sec to 20 sec	10 ms
20 sec to 200 sec	100 ms

Minimum Sweep Width

.01 dB

Maximum Sweep Speed

1 dB/ms

Sweep Level Resolution (Any Sweep Mode)

0.01 dB

Start Level Accuracy (Any Sweep Mode)

0.2 dB to Flatness

Sweep Level Linearity (Any Sweep Mode)

±0.25 dB

Sweep Modes

Auto	Continuous recycle of preset sweep
Single	A single cycle of the preset sweep, initiated by manual operation of the front panel push-button or reception of the corresponding GPIB command
EXT	A single cycle of the preset sweep, initiated by a trigger input from an external source

1.5 Modulation Parameters & Operational Modes

Modulation Parameters & Operational Modes	Model	
	124XXA	125XXA/ 127XXA
1.5.1 - Amplitude Modulation (AM)	N/A	√
1.5.2 - Scan Modulation	N/A	√
1.5.3 - Frequency Modulation (FM)	N/A	√
1.5.4 - Phase Modulation (ϕM)	N/A	√
1.5.5 - Pulse/Square Wave Modulation (PM)	N/A	√

AM, FM, Pulse and Option 29 (Scan Modulation) driven by external waveforms is standard only on the 125XXA/127XXA models. Option 24 (Internal Modulation Generator) provides two function generators for internally generated amplitude and frequency modulation envelope waveforms. A pulse generator is also provided.

1.5.1 Amplitude Modulation (AM)

AM may be operated simultaneously with FM. AM Specifications apply with FM turned off.

1.5.1.1 AM Envelope Parameters

Modulation Depth
0 to 90% @ 0 dBm output power (Settable to 95.0%)

Modulation Resolution
1%

Modulation Bandwidth
DC to 150 kHz, ±3 dB @ 0 dBm output

Modulation Accuracy
±10% of depth setting (e.g. A setting of 50% may be within a 40% to 60% reading)

1.5.1.2 Externally Supplied AM Envelope

Waveform
Any waveform compatible with bandwidth considerations

Scaling
0%/V to 95%/V

Input Voltage
Minimum: -1 V, Maximum: +1 V_{P-P} for 50% depth ±10% depth @ 1 kHz modulation rate

Input Impedance
600 Ω (Nominal)

1.5.1.3 Internally Generated AM Envelope

See Option 24 specifications in Section 1.6.1

1.5.2 Scan Modulation

See Option 29 specifications in Section 1.6.2.

1.5.3 Frequency Modulation (FM)

Specifications apply with Scan/AM and PM off. FM may be operated simultaneously with Linear AM and or PM (PM & Linear AM not allowed simultaneously).

1.5.3.1 Wide Mode Envelope Parameters

Maximum Deviation
See table contained in Section 1.5.3.2

Minimum Deviation
10 kHz at 4 - 8 GHz (Other ranges proportionally)

Modulation Resolution
1 kHz (Deviation < 1 MHz); 10 kHz (Deviation < 1 MHz) (at 4 - 8 GHz, other range proportionally)

Flatness
±2 dB for rates from 100 Hz to 1 MHz; ±3 dB to 8 MHz

Residual FM
See table contained in Section 1.5.3.2

Modulation Accuracy
±5% at max deviation, 190 kHz modulation rate

Distortion
< 5% (±1 MHz Deviation)

Incidental AM
< ±0.2%/MHz of Deviation

1.5.3.2 Narrow Mode Envelope Parameters

Maximum Deviation

See table below

Modulation Resolution

10 Hz (Deviation < 10 kHz)
1 kHz (Deviation > 10 kHz) (at 4 - 8 GHz, other ranges proportional)

Flatness

±2 dB for rates from DC to 1 MHz (Measured at 1 V_{P-P} input, i.e., 500 KHz Deviation)
±3 dB for 1 MHz to 8 MHz

Residual FM

Same as CW

Modulation Accuracy

±5% at max Deviation, 190 kHz modulation rate

Distortion

< ±0.2%/MHz of Deviation

Incidental AM

< 5% (±1 MHz deviation)
< 1% @ 10 KHz (4 - 8 range)

Frequency (GHz)	**Max Wide Deviation** (Pk)	**Max Narrow Deviation** (Pk)	**Wide Mode Residual FM**
.010 to .016	40 kHz	2 kHz	< 200 Hz
> .016 to .032	80 kHz	4 kHz	< 200 Hz
> .032 to .064	160 kHz	8 kHz	< 200 Hz
> .064 to .125	320 kHz	16 kHz	< 200 Hz
> .125 to .25	640 kHz	32 kHz	< 200 Hz
> .25 to .5	1.25 MHz	64 kHz	< 200 Hz
> .5 - 1	2.5 MHz	125 kHz	< 375 Hz
> 1 - 2	5 MHz	250 kHz	< 750 Hz
> 2 - 4	10 MHz	.5 MHz	< 1.5 kHz
> 4 - 8	20 MHz	1 MHz	< 3 kHz
> 8 - 16	40 MHz	2 MHz	< 6 kHz
> 16 - 20	80 MHz	4 MHz	< 12 kHz

1.5.3.3 Internally Generated FM Envelope

See Option 24 specifications in Section 1.6.1

1.5.3.4 Externally Supplied FM Envelope

Waveform
Any waveform compatible with bandwidth considerations

Rate
DC to 8 MHz

Input Sensitivity, Settable
1 V_{P-P} for maximum Peak deviation (FM deviation control set to maximum)

Input Impedance
50 Ω (Nominal)

1.5.4 Phase Modulation (ϕM)

Specifications apply with SCAN/AM and PM off. ϕM may be operated simultaneously with Linear AM and or PM (PM & Linear AM not allowed simultaneously).

1.5.4.1 Wide Mode Envelope Parameter

Maximum Deviation

See table contained in Section 1.5.4.2

Maximum Resolution

10 kHz at 4 - 8 GHz (other ranges proportional)

Modulation Resolution

.01 radians (at 4 - 8 GHz, other ranges proportional)

Flatness

±2 dB for rates from 100 Hz to 100 kHz

Modulation Accuracy

±5% (relative to FM) at max. deviation, 100 kHz modulation rate

Distortion

< 5% (±1 MHz deviation)

Incidental AM

< ±0.2%/MHz of deviation

1.5.4.2 Narrow Mode Envelope Parameters

Maximum Deviation

See table is on next page

Modulation Resolution

.01 radians (at 4 - 8 GHz, other ranges proportional)

Flatness

±2 dB for rates from 100 Hz to 100 KHz (Measured at 1 V_{p-p} input, i.e., 500 KHz Deviation)

Modulation Accuracy

±5% (relative to FM) at max deviation, 100 kHz modulation rate

Distortion

< 5% (±1 MHz deviation)

Incidental AM

< ±0.2%/MHz of deviation

Frequency (GHz)	**Max Wide Deviation**	**Max Narrow Deviation**
.010 to .016	.40 radians	.02 radians
> .016 to .032	.80 radians	.04 radians
> .032 to .064	1.6 radians	.08 radians
> .064 to .125	3.2 radians	.16 radians
> .125 to .25	6.4 radians	.32 radians
> .25 to .5	12.5 radians	.64 radians
> .5 to 1	25 radians	1.25 radians
> 1 to 2	50 radians	2.5 radians
> 2 to 4	100 radians	5 radians
> 4 to 8	200 radians	10 radians
> 8 to 16	400 radians	20 radians
> 16 to 20	800 radians	40 radians

1.5.4.3 Internally Generated PM Envelope

See Option 24 specifications in Section 1.6.1

1.5.4.4 External Supplied FM Envelope

Waveform

Any waveform compatible with bandwidth considerations

Rate

10 Hz to 100 kHz

Input Sensitivity, Settable

1 V_{P-P} for maximum peak deviation (FM deviation control set to Maximum)

Input Impedance

50 Ω (Nominal)

1.5.5 Pulse/Square Wave Modulation (PM)

Specifications apply with Scan/AM and FM off. PM may be operated with FM.

1.5.5.1 PM Basic Operation

On/Off Ratio

> 80 MHz

Rise Fall/Times:

Rise Time	Frequency Range
< 10 ns	> 500 MHz
< 50 ns	64 to 500 MHz
< 350 ns	25 to 64 MHz
< 500 ns	< 25 MHz

Overshoot, Undershoot & Ringing

< 10%, > 500 MHz

Settling Time (to within 1 dB)

< 75 ns (for pulse width > 75 ns)

Level Pulsed Output Accuracy (Reference to CW Output Power) at 25 ± 10° C

±0.5 dB, ≥100 ns pulse width (±1 dB pulse width, between 100 ns and 75 ns, Typical). (Requires a typical setup time of 100 ms after initial setting)

Typical Settling Time for a Series of Leveled Pulses

100 µs

Demand Pulse Polarity	RF will be on with TTL level demand pulse at Pulse Modulation Input BNC either at high or low logic level, selectable

Time Between Start of Demand Pulse (Video In) **& Start of RF Pulse**

< 50 ns

Minimum Required RF OFF Time between Pulses

100 ns

Delivered Minimum Pulse Widths

Minimum Width	Frequency Range
20 ns	> 500 MHz
100 ns	64 to 500 MHz
1 μs	< 64 MHz

1.5.5.2 Internally Generated PM Envelope

See Option 24 specifications in Section 1.6.1

1.5.5.3 Externally Generated PM Envelope

(One Envelope produced by each pulse)

Repetition Rate

5 Hz to 5 MHz, leveled
DC to 10 MHz, unleveled

Pulse Offset Delay (Output Envelope Leading Edge referenced to Input Pulse Leading Edge)

50 ns, typical

Input Pulse Required

Positive or negative-going TTL voltage Level trigger pulse, ≥ 75 ns wide (leveled output)
≥ 20 ns wide (unleveled output). Pulse must be able to drive a 50 ohm load

Pulse Width

Defined by external pulse width

1.6 Supplemental Specifications (Series 12500A/12700A)

Supplemental Specifications (Series 12500A/12700A)	Model	
	124XXA	125XXA/ 127XXA
1.6.1 - Option 24 Specifications	N/A	√
1.6.2 - Option 29 Specifications	N/A	√

1.6.1 Option 24 (Internal Modulation Generator) Specifications

1.6.1.1 Amplitude Modulation Source

Waveform

Sine, square, triangle, ramp (+ or –), Gaussian Noise

Rate

0.01 Hz to 1 MHz, all waveforms

Resolution

0.01 Hz

Accuracy

±0.01 Hz ± Timebase Accuracy

THD

1 % (Typical)

AM Output

2 V_{P-P}, into 1 M Ω

1.6.1.2 Frequency Modulation Source

Waveform
Sine, square, triangle, ramp (+ or −)

Rate
0.01 Hz to 1 MHz, all waveforms

Resolution
0.01 Hz

Accuracy
±0.01 Hz ± Timebase Accuracy

THD
1 % (Typical)

FM Output
2 V_{P-P}, into 1 M Ω

1.6.1.3 Pulse Modulation Source

Rate		
1 Hz to 3 MHz		
Rate Resolution	Range	Resolution
	1 Hz to 1 kHz	1 Hz
	1 kHz to 10 kHz	10 Hz
	10 kHz to 100 kHz	100 Hz
	100 kHz to 1 MHz	1 kHz
	1 MHz to 3 MHz	10 kHz
	Accuracy	±2.5% of range maximum value; f_m < 100 KHz
		±4% of range maximum value; f_m 100 KHz to < 1 MHz
		±10% of range maximum value; f_m > 1 MHz
	Jitter	Same as instrument timebase

1.6.1.4 Pulse Start Variable Delay

(Referenced to Sync Output)

Range
0 to 1.67 seconds

Resolution
10 ns

Accuracy
±2.5% of setting or ±20 ns, whichever is greater

Jitter
±0.01% of setting or ±100 ps, whichever is greater

1.6.1.5 Pulse Width

Range
0 to 1.67 seconds

Resolution
10 ns

Accuracy
±2.5% of setting or ±20 ns, whichever is greater

Jitter
±0.01% of setting or ±100 ps, whichever is greater

1.6.1.6 Pulse Modes

(Triggered, Gated, Delayed, Singlet, Doublet, Triplet, or Quadlet and Free Running)

Interval	
Range	100 ns to 1.67 seconds
Resolution	10 ns
Accuracy	±2.5% of setting or 20 ns, whichever is greater
Jitter	0.01% of setting or 100 ps, whichever is greater

☛ ***NOTE:*** *The interval between pulse one and pulse two, and the interval between triplets and quadlets are the same. The start delay for pulse one is independent.*

1.6.1.7 Externally Triggered PM Envelope

(One PM envelope produced by each trigger)

Repetition Rate
5 Hz to 5 MHz

Pulse Delay
Set by internal delay control

Pulse Width
Set by internal width control

Input Trigger Required
Positive or negative-going TTL Level trigger pulse, >20 ns wide, unleveled or >75 ns wide, leveled

1.6.1.8 PM Sync Output

TTL levels into a 50 Ω load, 50 ns pulse coincident with start delay

1.6.1.9 PM Video Output

TTL levels into a 50 Ω load

1.6.2 Option 29 (Scan Modulation) Specifications

Specifications apply with FM and PM turned off.

1.6.2.1 Envelope Parameters

Frequency of Operation
0.01 to 20 GHz

1.6.2.2 Scan Mode

Range
0 to 60 dB, ≥ +10 dBm (Settable to 65 dB)

Resolution
0.1 dB

Scaling
0 dB/V to 65 dB/V

Input Voltage
Minimum: 0 V, Maximum: +6 V

Step Response
< 1 microsecond for 50 dB change; < 10 ms, < 1 GHz

Frequency Response
DC to 150 kHz, sine wave

Input Impedance
600 Ω (Nominal)

Accuracy (at cal points)	±0.25 dB plus +/- 5% of depth in dB (For .01 to 2 GHz, specification applies only up to 30 dB) and frequencies above 2 GHz is 50 dB.	
	Linearity	±0.6 dB (0 - 20 dB), ± 1 dB (20 - 50 dB)

1.6.2.3 Internally Generated Scan/AM Envelope

See Specifications for Option 24 in section 1.6.1

1.6.2.4 Power

2 dB reduction in power, .01-20 GHz

2

Performance Verification

2.1 Introduction

Introduction (Performance Verification)	Model	
	124XXA	125XXA/ 127XXA
2.1.1 - Recommended Equipment	√	√

- This chapter provides step-by-step procedures to verify performance of the Series 12000A Microwave Synthesizers for all three models (Modulation related items are in Section 2.3 for the Series 125XXA/127XXA models)
- Sectional header page references are only provided for items pertaining directly to performance verification testing
- The required warm-up time before testing is 72 hours. The warm-up period can be reduced to 30 minutes if timebase accuracy is not to be tested for all three models
- In these procedures, the instrument being tested may be referred to as the 12000A or UUT (Unit Under Test) for all three models

2.1.1 Recommended Equipment

The following equipment is recommended before starting the performance test routines (the recommended equipment can be substituted provided the specifications are sufficiently compatible):

Table 2-1: Series 12000A Recommended Equipment

Equipment	Example
Frequency Standard	10 MHz Stanford Research FS 725
Oscilloscope	Tektronix TDS3052B or Equivalent
Microwave Frequency Counter	XL Microwave 3260 or Equivalent
Power Meter and Sensor	Giga-tronics 8541C/Series 8650A w/ 80313A Sensor or Equivalent
Spectrum Analyzer	HP 8566B or Equivalent
Detector	Herotek Model DZ262-44 or Equivalent
Function (Audio) Generator	Stanford Research DS-345 or Equivalent
Measuring Receiver	HP 8902A or Equivalent
Distortion Analyzer	HP 339A or Equivalent
L.O. Generator	Giga-tronics Microwave Synthesizer 12720A or Equivalent
Universal Counter	Racal Dana 2201 or Equivalent
Mixer IF Amplifier w/ Divide-by-40 Output	Giga-tronics Mixer/Divider (P/N 002CA04900)
Mixer (For Attenuator Test)	Marki M40020MJ
Filter 21.4 MHz	Mini-Circuits SVP 21.4
Fixed Attenuator 3 dB	Midwest ATT-0263-03-SMA-02
Fixed Attenuator 10 dB	Midwest ATT-0263-10-SMA-02

2.2 Performance Tests

2.2.1 Introduction

The procedures in this section verify the electrical performance of the 12000A using the specifications in Chapter 1. Use Section 2.1 for features that are applicable to all three models. Use Section 2.3 for native specification data for the Series 125XXA/127XXA models.

Each of the performance tests includes a list of recommended test equipment. There is a consolidated list at the beginning of this chapter. Equivalent test equipment can be substituted provided that the accuracies and specifications are sufficiently compatible.

A test data sheet is included for entering the various readings taken. The specification and tolerance range is listed for ease of verification. It is suggested that copies be made of the manual sheets. When automated tests are run, a printed data sheet is produced.

Performance verification is recommended at least every two years, or more often when required to ensure proper operation of the instrument.

Each procedure specifies a required warm-up time if the procedure is to be done individually. Only one warm-up period is required for a sequence of tests. Test equipment must be warmed up according to specifications.

2.2.2 Frequency Range, Resolution & Accuracy

2.2.2.1 Description

Connect the 12000A RF output to the input of a frequency counter. The internal timebase of the counter is a reference for the 12000A to eliminate timebase errors from the measurements. This procedure does not check for timebase accuracy, and therefore the frequency in the 12000A display should agree with the counter, within the resolution of each instrument. It is possible for a fault in the 12000A to cause a frequency error even though the lock indicators show normal operation. For this reason a number of specific frequencies are tested. Test frequencies have been selected so that any defective circuits will be easily isolated.

2.2.2.2 Equipment Required

UUT • Frequency Counter • Coaxial Cable

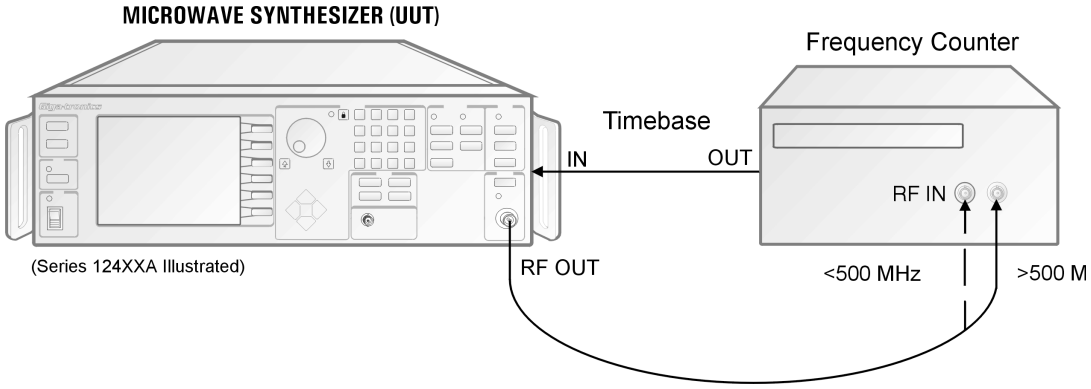


Figure 2-1: Frequency Range, Resolution & Accuracy

2.2.2.3 Procedure

1. Connect the equipment as shown in Figure 2-1. Connect the 12000A RF Output to the 10 to 500 MHz counter input using the coaxial cable and the SMA to BNC adapter. Allow the equipment to warm up for at least 30 minutes. Because the 12000A and the counter use the same timebase, timebase errors are eliminated. The 12000A will automatically switch to the external reference when it is connected.

2. Set the 12000A to 10 MHz. Press **[LEVEL]** in the POWER field and enter **[-] [1] [0] [DBM]**. Press **[RF ON]** in the RF OUTPUT field to turn on the RF output.

3. Set the 12000A to each frequency listed on the data sheet and verify that the counter reads the set frequency plus or minus the counter resolution. This tests each divider stage.

4. Connect the 12000A RF Output to the 500 MHz to 26.5 GHz input on the counter and continue with the divider tests.

5. To check that the multipliers are functioning properly, refer to the test data sheet and program each of the listed frequencies into the 12000A by entering (for example) **[CW] [2] [0] [0] [1] [MHZ]**. For each listed frequency the counter should read the entered frequency ±1 Hz, plus or minus the counter resolution. Ignore all frequencies outside the range of the instrument under test.

2.2.3 Spurious Signals Tests

2.2.3.1 Description

The output of the 12000A is connected to a spectrum analyzer. Various frequencies are selected and the analyzer tuned to determine the presence of either harmonically or non-harmonically spurious signals.

2.2.3.2 Equipment Required

UUT • Spectrum Analyzer • Coaxial Cable

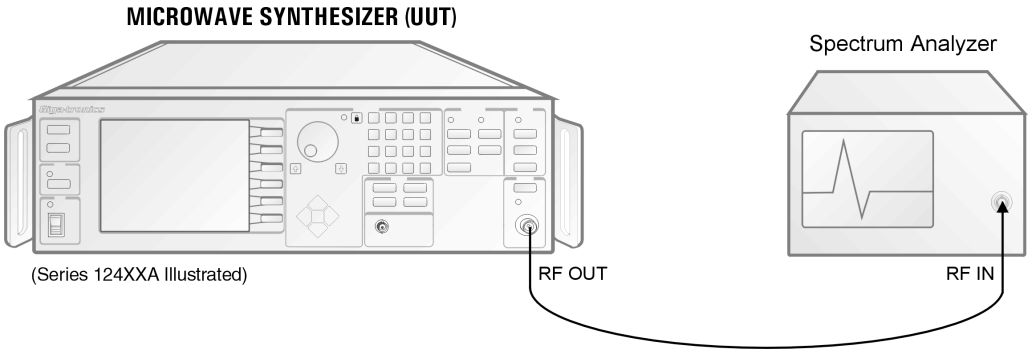


Figure 2-2: Spurious Signals Tests

2.2.3.3 Procedure

1. Connect the equipment as shown in Figure 2-2. Allow the equipment to warm up for at least 30 minutes. Press **[CW]** in the FREQUENCY field on the 12000A and enter the first test data sheet frequency within the range of the 12000A. The RF amplitude should be at +6 dBm. Press **[RF ON]** to turn on the RF output. Be certain that all modulation is OFF.

2. Set the spectrum analyzer to view the 12000A output signal. Adjust the analyzer reference level so that the peak of the displayed signal is at the top graticule line.

3. Set the spectrum analyzer to maximum span with the signal centered on the screen. Gradually narrow the span, keeping the signal centered, to observe any spurious signals. Use appropriate resolution and video bandwidths to allow sufficient dynamic range.

4. Repeat steps 2 and 3 for the other frequencies on the test data sheet which are within the operating range of the instrument.

Many spectrum analyzers have a tuned preselector when the frequency is above about 2 GHz. This reduces the likelihood of analyzer generated spurious signals, but does not eliminate the possibility. If in doubt, increase the RF attenuation of the analyzer by 10 dB. The signal in question should be reduced by exactly 10 dB. If not, it is analyzer generated. It is also important for frequencies below the range of the preselector that sufficient analyzer RF Attenuation be used (typically 30 dB) to avoid the analyzer generating harmonics of the input signal. The above attenuator shift technique will also allow verification of harmonic levels.

If a spurious signal appears to be out of specification, first check that the fundamental signal level is at +6 dBm. Next verify the analyzer accuracy by connecting a known amplitude signal (from the 12000A, for example) at the spurious frequency.

The adjusting knob on the 12000A may generate some noise spikes when it is rotated. The acquisition of the various phase lock loops in the instrument can also cause transients (within the specified settling time). Both of these effects will disappear when a steady state condition has been reached.

It is important to identify the particular class of spurious signal as the specifications may be different for each. If the spurious signal is an exact multiple of the 12000A RF output then the harmonic specification applies. Any other spurious signals must meet the non-harmonically related specification.

For frequencies above the fundamental range of the spectrum analyzer, either a mixer supplied with the spectrum analyzer or an external mixer and local oscillator may be used to downconvert the signal. Care must be taken to identify spurious signals which are inherently generated by the mixing process.

2.2.4 Single Sideband Phase Noise

2.2.4.1 Description

The test in this procedure is limited by the measuring system and verifies only the majority of the phase noise specification. To completely test the phase noise specification requires a far more sophisticated measurement system. This test uses the spectrum analyzer to make all measurements from 100 Hz to 1 MHz offsets. The 100 Hz and 1 MHz offsets are particularly susceptible to measurement system limitations.

2.2.4.2 Equipment Required

UUT • Spectrum Analyzer • Coaxial Cable

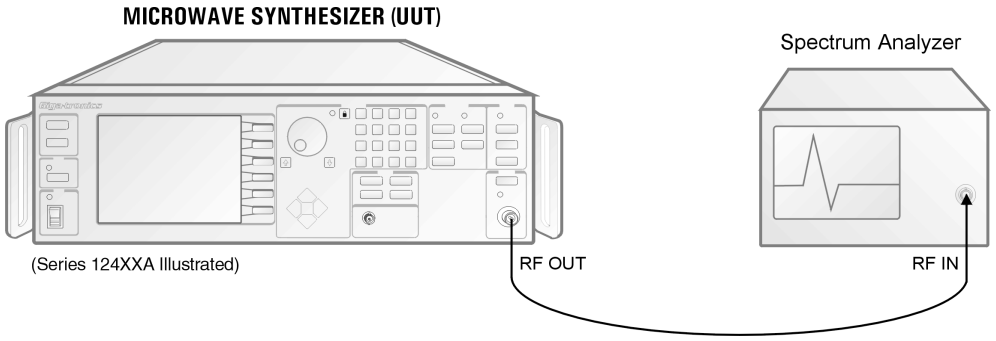


Figure 2-3: Single Sideband Phase Noise

2.2.4.3 Procedure

1. Connect the 12000A RF output to the spectrum analyzer input. Place the 12000A on a foam pad to isolate it from any external mechanical vibrations, which could affect the phase noise measurement.

2. Turn off all modulation on the 12000A.

3. For the first frequency on the test data sheet within the range of the instrument, press **[CW]** and enter the frequency. Tune the spectrum analyzer to the generator frequency and adjust the 12000A RF level to obtain a reference of 0 dBm on the analyzer. This allows direct measurement of the phase noise by the analyzer.

4. Set the analyzer span such that the desired offset is at ±2 divisions, select an appropriate bandwidth, activate the phase noise measurement and place the marker two divisions to the right of the carrier. Read the phase noise in dBc/Hz. Repeat for all offsets.

5. Repeat steps 3 and 4 for the other test data sheet frequencies which are within range of the 12000A.

2.2.5 RF Output Power Tests

2.2.5.1 Description

Although it is possible to make the following measurements manually, it is extremely tedious. It is recommended that an automated system be set up to take and record the data. Three tests are run. The first measures the maximum available output with the level control loop disabled. The second verifies the accuracy and flatness across the operating frequency range at a fixed output (0 dBm). The remaining test checks the step attenuator accuracy at a number of frequencies. This section outlines the general procedure followed by the automated system, a similar measurement could be done manually.

2.2.5.2 Equipment Required

UUT • Local Oscillator • Measuring Receiver & Sensor • Downconverter • Plotter • Computer & Programs

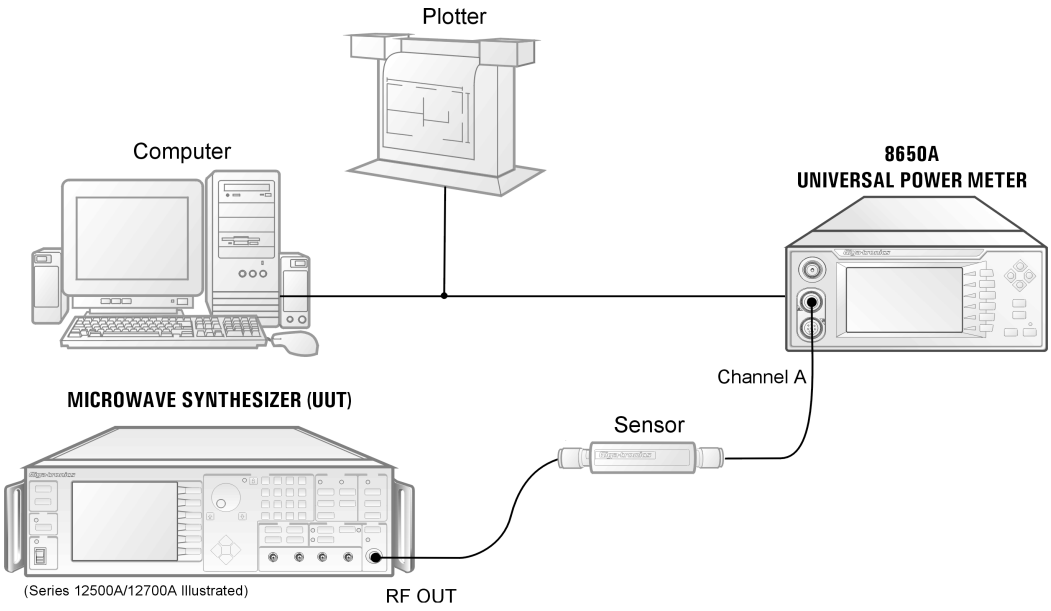


Figure 2-4: RF Output Power Test

2.2.5.3 Procedure (Output Power)

1. Connect the power sensor to the 12000A. Disable the leveling system of the 12000A. Step the frequency across the particular instrument operating range in 50 MHz increments. At each point measure the power, apply the appropriate sensor correction factor, and plot the result.
2. Using the above setup, set the 12000A to 0 dBm with the leveling enabled. Again, step the frequency across the operating range; measure, correct, and plot the power.
3. Repeat this procedure for the remaining test frequencies.

☛ ***NOTE:*** *When measuring the flatness and accuracy of the model 12000A, consideration must be given to the various measurement uncertainties in the test system. These include, but are not limited to, VSWR, Cal Factor uncertainty and calibration.*

2.2.5.4 **Procedure** (Attenuator Test: Option 26)

1. Connect the 12000A to the measuring receiver via the downconverter. With the 12000A at 0 dBm and set to the first test frequency; set LO 21.4 MHz above UUT set frequency. Establish a reference on the receiver in a tuned RF level mode. Reduce the 12000A output in 10 dB steps, observing and recording the receiver reading. As needed, perform the recalibration requested by the receiver.

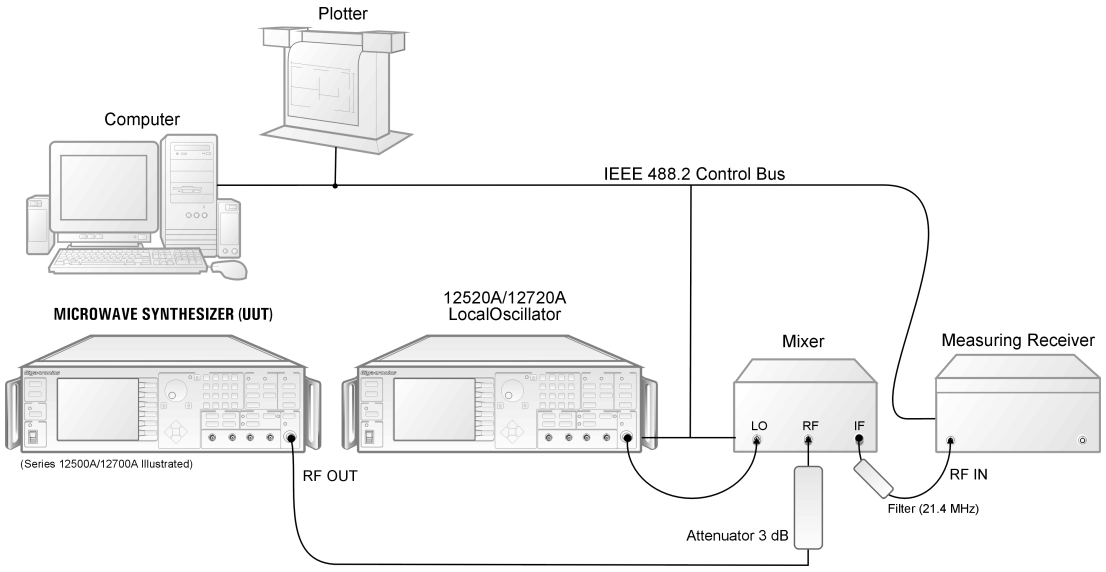


Figure 2-5: RF Output Power Attenuator Test

2. Repeat this procedure for the remaining test frequencies.

☛ ***NOTE:*** *When measuring the flatness and accuracy of the model 12000A, consideration must be given to the various measurement uncertainties in the test system. These include, but are not limited to, VSWR, Cal Factor uncertainty and calibration.*

2.3 Performance Tests (Series 12500A/12700A)

Performance Tests (Series 12500A/12700A)	Model		Page
	124XXA	125XXA/ 127XXA	
2.3.1 - Amplitude Modulation Test	**N/A**	√	2-10
2.3.2 - Frequency Modulation Test	**N/A**	√	2-12
2.3.3 - Pulse Modulation On/Off Ratio Test	**N/A**	√	2-15
2.3.4 - Pulse Modulation Rise & Fall Time Test	**N/A**	√	2-16
2.3.5 - Pulse Modulation Overshoot & Settling Time	**N/A**	√	2-17
2.3.6 - Pulse Modulation Accuracy Test	**N/A**	√	2-18

Use the Performance Verification Test Data Sheet provided at the end to record your data. The data sheet is compatible with all three models.

☛ ***NOTE:*** *Units that have Option 24 will have these tests repeated using the internal generators.*

2.3.1 Amplitude Modulation Test

2.3.1.1 Description

The output from the 12000A is connected to a discriminator. The discriminator output is monitored on an oscilloscope to determine deviation and bandwidth.

2.3.1.2 Equipment Required

UUT • Mixer/Divider • Oscillator • Measuring Receiver

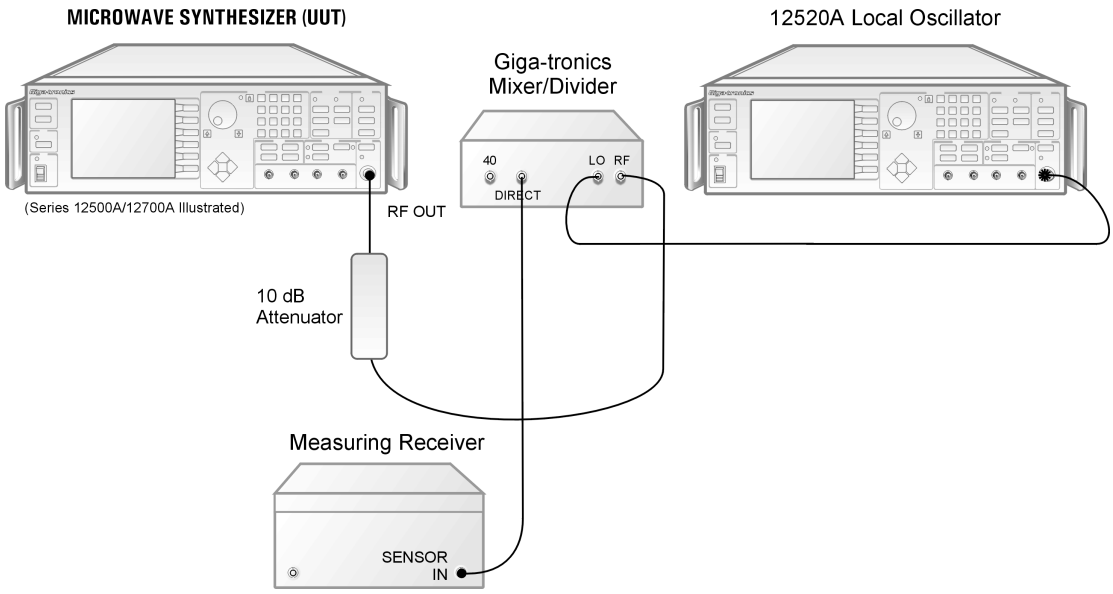


Figure 2-6: Amplitude Modulation Test

2.3.1.3 Procedure (AM Depth)

1. Set UUT to 1.5 GHz with level set at 0 dBm. Connect UUT output to the Mixer Box RF input connector with a 10 dB pad.

2. Connect LO (Source) output to the Mixer Box LO input connector. Set LO frequency to 130 MHz higher than UUT and set source leveled output to 10 dBm.

3. Connect Direct output of Mixer Box to the HP 8902 Measuring Receiver RF input.

4. Connect Modulation Output/Audio Input to channel 2 of Oscilloscope.

    a. Set to 500 mV per Division.

5. On Measuring Receiver press **[FREQUENCY]** and verify 130 MHz on receiver.

6. Select AM, set measuring receiver filters to 50 Hz and 15 KHz. Press **[(PEAK-PEAK)/2 MODE]**.

7. On UUT turn AM on. Set depth to 50%. Connect the DS-345 Function Generator at 1 KHz modulation to the AM input. Set scope to 50 Ohm termination and sinewave amplitude for a

2 V_{P-P} signal. Press **[AM]** button on Measuring Receiver. Verify a reading of 40.0 to 60.0% on the measuring receiver.

8. Set external function to SQR. Turn off all filters on the measuring receiver. Verify a receiver reading of 40.0 to 60.0% (Typical).

9. Set external function to TRI and verify that the measuring receiver reads 40.0 to 60.0%

10. Set UUT to 10 GHz. Repeat Steps 2 to 8.

11. At 1.5 and 10 GHz, check AM Depth at 30, 90% modulation. Verify accuracy of +/- 10% of reading at each step.

12. Enter data in the **AM Modulation Test - AM Depth** area of the Series 12000A Microwave Synthesizers Performance Verification Data Sheet, Section 2.3.1.3.

2.3.1.4 Procedure (AM Bandwidth)

1. Set UUT to 1.5 GHz with level set at 0 dBm. Set AM Depth to 50% @ 1 KHz rate (Sinewave).

2. Verify a 50% reading on HP 8902 with filters turned off. On receiver, press **[RATIO]**, then the **[LOG/LIN]** button, display indicates 0.00 dB.

3. Vary the frequency of the external DS-345 Function Generator from DC to 150 KHz. Verify that the amount of change is within the +/- 3 dB window.

4. Repeat steps 1 to 3 for 10 GHz.

5. Complete the **AM Modulation Test - AM Bandwidth** area of the Series 12000A Microwave Synthesizers Performance Verification Data Sheet, Section 2.3.1.4.

2.3.2 Frequency Modulation Test

2.3.2.1 Description

The output from the 12000A is connected to a discriminator. The discriminator output is monitored on an oscilloscope to determine deviation and bandwidth.

2.3.2.2 Equipment Required

UUT • Function Generator • Oscilloscope • Digital Voltmeter • FM Test Fixture

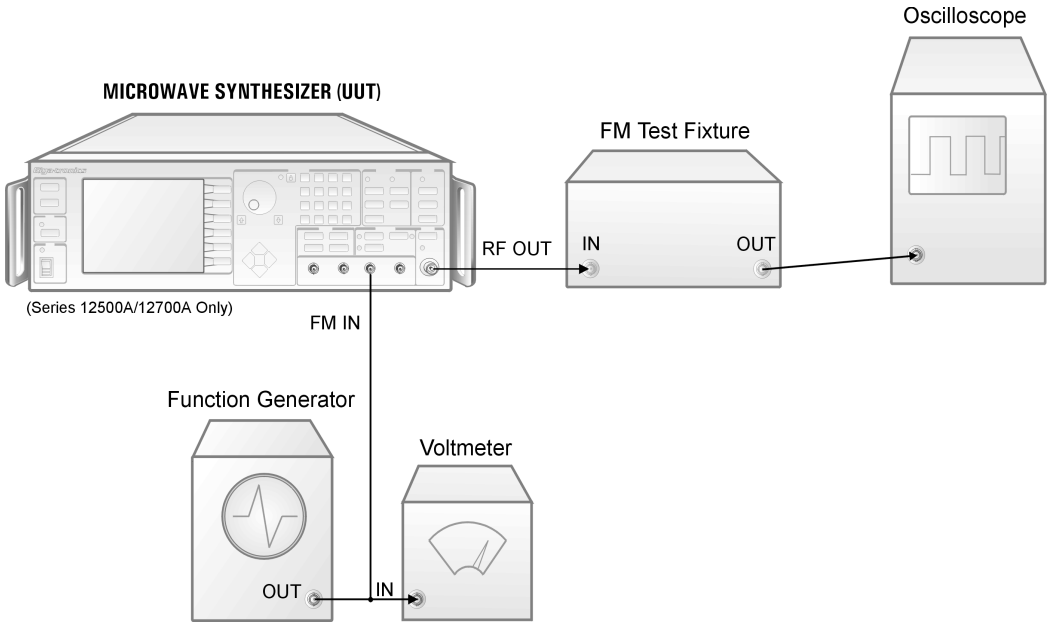


Figure 2-7: Frequency Modulation Test

2.3.2.3 Delay Discriminator Description

In order to calibrate and test the frequency modulation circuits, a special test fixture must be assembled. The recommended FM test fixture includes an RF splitter, two lines of unequal length, and an RF mixer. The RF output of the 12000A is divided by the splitter into two signals, unequally delayed.

Different length cables determine the number of frequency nulls or 0 volt outputs found in the frequency band of interest. For the Frequency Modulation performance test, the frequency band of interest is 4 to 8 GHz.

The procedure does not identify a specific mixer for the discriminator circuit. There are two factors to consider when selecting a mixer.

1. The mixer RF and LO frequency range must be greater than 4 to 8 GHz.
2. A low conversion loss mixer will provide a higher output.

Maximizing Delay Discriminator Output

Obtaining a six division change on a 5 mV scale may be difficult to obtain for a 1 MHz change in frequency. Increasing output power will improve the output of the discriminator. The output of the UUT can be adjusted to levels as high as +13 dBm or higher for the 4 to 8 GHz frequency band. The output performance of discriminator is improved with a very high cable length ratio. Cable length ratios of 16 to 1 (48 inches to 3 inches) will produce a large number of frequency nulls within the 4 to 8 GHz frequency band.

☛ ***NOTE:*** *Increasing the number of frequency nulls increases the rate of change of the output voltage per unit frequency as the output transitions through the frequency null.*

Optimal Test Performance Null Selection

The maximum deviation of the Frequency Modulation test is ±10 MHz. The rate of change for the output voltage per unit frequency (ΔV/ΔF) must remain constant (linear) for the ±10 MHz deviation range. Rate changes within this deviation range will result in a non-symmetrical waveform and will produce invalid test results.

Identifying an optimal frequency null is achieved by sweeping the frequency through the frequency range of the test and observing the Delay Discriminator waveform on an oscilloscope.

Recommended Test Equipment (FM)

- Delay Discriminator
- Digital Oscilloscope
- Pulse Generator with 1 shot Capability
- BNC Cables and Tee

Recommended Configuration

1. Connect the input of the delay discriminator to the RF output of the 12000A and the output to the digital scope.
2. Set the 12000A to Sweep Mode with the following settings:
   a. Start Frequency: 4 GHz
   b. Stop Frequency: 8 GHz
   c. Sweep Type: Ramp
   d. Sweep Time: 900 msec
   e. Repeat Mode: Single Sweep
   f. Trigger Type: Trigger in BNC
   g. Power: +10 dBm
3. Connect the output of the pulse generator to the External Trigger Input or second channel of the digital scope and the Trigger In of the 12000A.
4. Set the trigger selection of the digital scope to the port where the trigger signal will be detected (Use the BNC Tee at this port).

5. Adjust the time base of the digital scope to 1 second for the entire span of the X axis (100 mSec typical). Set the vertical scale to 100 mV per division.

6. Pulse the generator to initiate the RF sweep.

Repeat the sweep several times. The output of the Delay Discriminator should not vary from one sweep to another. Review the waveform and identify the nulls where the voltage transitions through the nulls are steeper and linear for a ±50 mV range above and below the null. Perform the FM modulation tests at these frequency nulls.

For certain frequencies, which may be identified by experiment, the mixer will produce a DC voltage near zero. The number of null frequencies can be increased by making the delay lines longer in absolute terms or by increasing the ratio between their lengths. If the output becomes frequency modulated, the mixer output voltage will change, and the voltage variation will be proportional to FM deviation.

The polarity of the voltage change may be either directly or inversely related to the direction of frequency deviation. When voltage levels have been established for different frequencies, the mixer output can be monitored on an oscilloscope to provide a continuous display of FM deviation.

2.3.2.4 Procedure

1. Connect the FM test fixture to the RF OUT connector of the 12000A as shown in Figure 2-7. Monitor the mixer output with the oscilloscope. Set the 12000A to any null frequency between 4.0 and 7.99 GHz (that is, at a frequency where the mixer output voltage is zero); +10 dBm out, no modulation.

2. Establish the voltage at 1 MHz above and 1 MHz below the null frequency. Adjust the oscilloscope gain and the 12000A output power level (near +5 dBm) to place the null point at the center of the screen and the 1 MHz deviation points at 3 divisions above and 3 divisions below the null point.

3. Set the 12000A to Narrow EXT FM with 1 MHz deviation. Connect the function generator, set to a 100 kHz rate SINE wave, 1 V_{P-P}. Verify that the waveform is 6 divisions peak-to-peak.

4. Adjust the 12000A FM deviation for exactly a six division peak-to-peak display. Vary the function generator from 10 Hz to 1 MHz and verify that the display remains between five and seven divisions peak-to-peak.

5. Vary the function generator from 1 MHz to 8 MHz and verify that the display remains between 4 and 8 divisions.

6. Establish the voltage at 10 MHz above and below the null frequency. Adjust the oscilloscope gain and the 12000A output power level (near +5 dBm) to place the null point at the center of the screen and the 10 MHz deviation points at 3 divisions above and 3 divisions below the null point (terminate the Mixer output in 50 Ω).

7. Set the 12000A to Wide EXT FM with 10 MHz deviation. Set the function generator to 100 kHz. Verify that the waveform is 6 divisions peak-to-peak.

8. Adjust the 12000A FM deviation for exactly a 6-division peak-to-peak display. Vary the function generator from 100 Hz to 1 MHz and verify that the display remains between 4.7 and 7.3 divisions.

9. Vary the function generator from 1 MHz to 8 MHz and verify that the display remains between 4 and 8 divisions.

2.3.3 Pulse Modulation On/Off Ratio Test

2.3.3.1 Description

The 12000A is set to a CW frequency at a power level of 0 dBm. A spectrum analyzer is used to view the signal. The pulse modulation is then enabled and the resulting waveform is measured.

2.3.3.2 Equipment Required

UUT • Spectrum Analyzer • Pulse Generator • Coaxial Cable

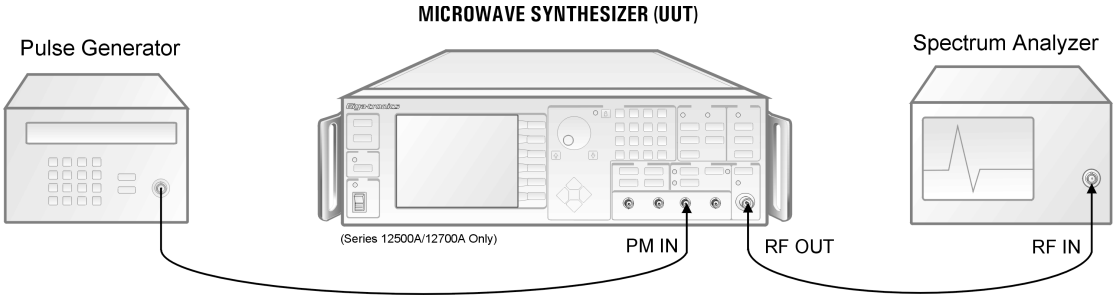


Figure 2-8: Pulse Modulation On/Off Ratio Test

2.3.3.3 Procedure

1. Connect the equipment as shown in Figure 2-8. Allow 30 minutes warm-up time.
2. Enter the first frequency on the test data sheet within the frequency range of the instrument. The RF power level should be at 0 dBm. Select external pulse modulation (PM) on the 12000A.
3. Tune the analyzer to the source frequency, select an analyzer span of 0 Hz and fine tune the analyzer to place the line at the top of the screen graticule (adjust analyzer reference level as needed).
4. Set the pulse generator for a 100 Hz square wave; press **[PULSE]** then use the softkey to turn on the pulse modulation.
5. Adjust the analyzer sweep time to display a few cycles of the waveform. Use internal triggering. Reduce resolution bandwidth and carefully retune the analyzer center frequency until the maximum resolution is achieved. Read and record the peak-to-peak value (use marker delta).
6. Repeat steps 3, 4 and 5 for all other test data sheet frequencies which are within the range of the instrument. Note that the dynamic range of the analyzer may limit its measurement capability.

2.3.4 Pulse Modulation Rise & Fall Time Test

2.3.4.1 Description

A crystal detector is connected to the 12000A, terminated in 50 Ω, and monitored with an oscilloscope.

> ***NOTE:*** *It is very important to use either the specified detector or one with similar rise time characteristics. Even when terminated in 50 Ω with a short cable, the detector parameters can markedly influence the measurement.*

2.3.4.2 Equipment Required

UUT • Oscillator • Pulse Generator • Crystal Detector • Coaxial Cable

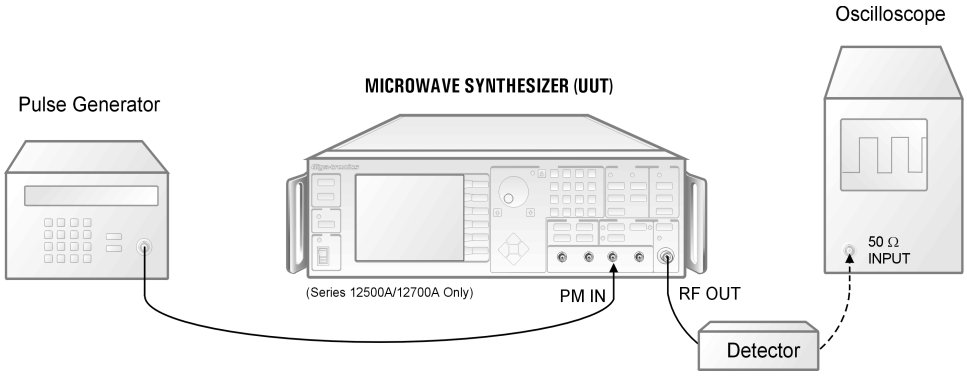


Figure 2-9: Pulse Modulation Rise/Fall Time Test

2.3.4.3 Procedure

1. Connect the equipment as shown in Figure 2-9. The cable from the detector to the oscilloscope should be kept as short as possible.
2. Press **[PRESET]** on the 12000A and set the frequency to the first test data sheet frequency within the operating range of the instrument.
3. Enable external pulse modulation (at a 1 MHz rate and 0.5 μs width) on the 12000A. Press **[PULSE]** and use the softkey to turn on pulse modulation.
4. Set the oscilloscope to 5 mV/div and using the RF Level control of the 12000A, adjust the peak to peak oscilloscope display to fall on the dotted lines on the screen (100% and 0%). Adjust the oscilloscope sweep time to 5 ns/div. Measure and record the rise and fall times between the 10% and 90% points.
5. Repeat Step 4 for each of the test data sheet frequencies within the operating range of the instrument.

2.3.5 Pulse Modulation Overshoot & Settling Time

2.3.5.1 Description

A crystal detector is connected to the 12000A, terminated in 50 Ω and monitored with an oscilloscope.

☛ ***NOTE:*** *It is very important to use either the specified detector or one with similar rise time characteristics. Even when terminated in 50 Ω with a short cable, the detector parameters can markedly influence the measurement.*

2.3.5.2 Equipment Required

UUT • Oscillator • Pulse Generator • Crystal Detector • Coaxial Cable

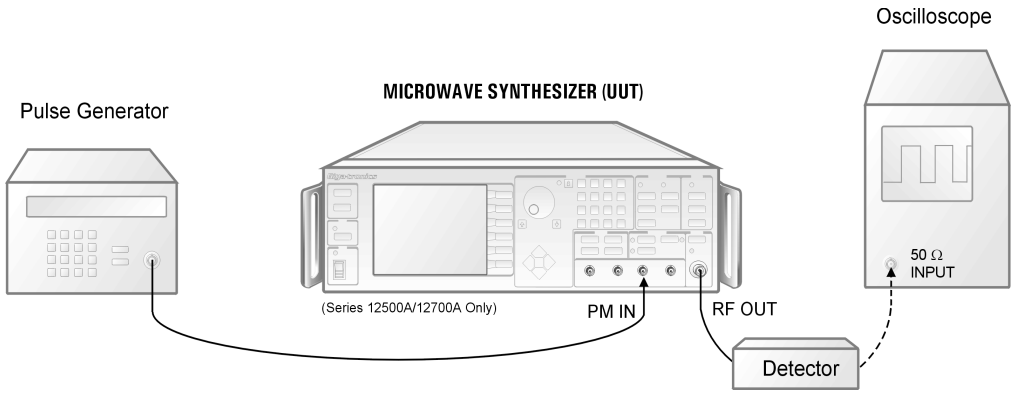


Figure 2-10: PM Overshoot and Setting Time

2.3.5.3 Procedure

1. Connect the equipment as shown in Figure 2-10. The cable from the detector to the oscilloscope should be kept as short as possible.
2. Press **[PRESET]** on the 12000A and set the frequency to the first test data sheet frequency within the operating range of the instrument.
3. Enable external pulse modulation (at a 1 MHz rate and 0.5 ms width) on the 12000A. Press **[PULSE]** and use the softkey to turn on pulse modulation.
4. Set the oscilloscope to 5 mv/div and using the RF Level control of the 12000A and the vertical position of the oscilloscope, adjust the peak to peak oscilloscope display to be from the top of the screen (pulse off) to 2 divisions below the center line (pulse on). Adjust the oscilloscope sweep time to 50 ns/div. Change the level setting of the 12000A by plus and minus 1 dB and note the graticule position of the pulse on level. Return to the original value. Measure and record the time for the pulse to be within 1 dB of its final value.
5. Change the level setting of the 12000A by plus and minus 2 dB and note the graticule position of the pulse on level. Return to the original level. Measure and record any undershoot/ overshoot of the signal.
6. Repeat Steps 4 and 5 for each of the test data sheet frequencies within the operating range of the instrument.

2.3.6 Pulse Modulation Accuracy Test

2.3.6.1 Description

In this test the peak pulse level is compared to the level in the CW mode.

2.3.6.2 Equipment Required

UUT • Oscilloscope • Pulse Generator • Crystal Detector • Coaxial Cable

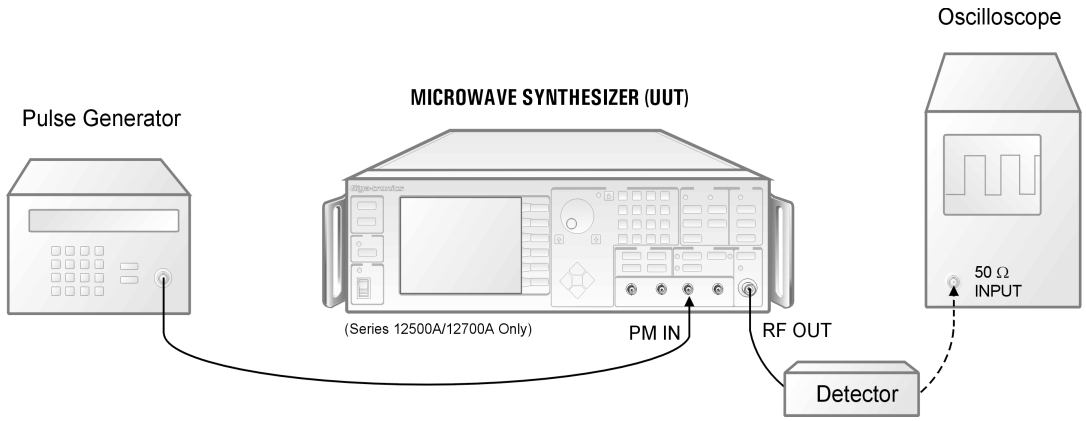


Figure 2-11: Pulse Modulation Accuracy Test

2.3.6.3 Procedure

1. Connect the equipment as shown in Figure 2-11. The oscilloscope input impedance should be 50 Ω. Allow 30 minutes warm-up.
2. Press **[PRESET]** on the 12000A and set the frequency to the first test data sheet frequency within the operating range of the instrument.
3. Set the oscilloscope to 5 mv/div and using the vertical position of the oscilloscope, adjust the trace to the centerline of the screen. Change the level setting of the 12000A by plus and minus 1 dB and note the trace position on the screen. Return to 0 dBm.
4. Enable external pulse modulation (at a 200 kHz rate and 0.1 μs width) on the 12000A. Press **[PULSE]** and use the softkey to turn on pulse modulation.
5. Measure and record the difference between the CW reference level and the negative peak of the pulse.
6. Change the pulse width to 50 ns and again measure and record the difference between the CW reference level and the negative peak of the pulse.
7. Repeat Steps 3-6 for each test data sheet frequency within the operating range of the instrument.

SERIES 12000A MICROWAVE SYNTHESIZERS

Performance Verification Test Data Sheet (Page 1 of 2)

Under Test Result record measured values (if any). In the case of a function check or range check, write OK to indicate that the unit under test meets specifications.

Serial Number:		Tested By:	
Date:		Quality Assurance:	

Frequency Range, Resolution, Accuracy

	Frequency	Harmonics
2.2.2.3	12 MHz	
	24 MHz	
	48 MHz	
	100 MHz	
	200 MHz	
	400 MHz	
	750 MHz	
	1500 MHz	
	3 GHz	
	6 GHz	
	12 GHz	
	18 GHz	

Spurious Signals Tests

	Frequency (MHz)	Harmonics	Non-Harmonics
2.2.3.3	770.550		
	1513.425		
	4004.000		
	9182.433		
	17361.522		

Single Sideband Phase Noise (dBc/Hz)

	Frequency (MHz)	Offset from Carrier				
		100 Hz	1 kHz	10 kHz	100 kHz	1 MHz
2.2.4.3	1513.425					
	4004.000					
	9182.433					
	17361.522					
	23541.349					

RF Output Power

	Test Result		
2.2.5.3	Max. Power Level		
	Power Level		
2.2.5.4	Step Attenuator Test Frequencies	1.0 GHz	
		4.0 GHz	
		12.0 GHz	
		17.0 GHz	

SERIES 12000A MICROWAVE SYNTHESIZERS

Performance Verification Test Data Sheet (Page 2 of 2)

Serial Number:		Tested By:	
Date:		Quality Assurance:	

Amplitude Modulation Test (SERIES 12500A/12700A ONLY)							
AM Depth (+/- 10%)		**30%**		**50%**		**90%**	
2.3.1.3	**Frequency 1.5 GHz**	Int.	Ext.	Int.	Ext.	Int.	Ext.
	Sinewave						
	Square Wave						
	Triangle Wave						
	Frequency 10 GHz	Int.	Ext.	Int.	Ext.	Int.	Ext.
	Sinewave						
	Square Wave						
	Triangle Wave						

AM Bandwidth (Spec. +/- 3 dB)		**Int.**	**Ext.**
2.3.1.4	Frequency 1.5 GHz		
	Frequency 10 GHz		

Frequency Modulation Test (SERIES 12500A/12700A ONLY)					
Parameter		**@1 GHz**	**@4 GHz**	**@12 GHz**	**@20 GHz**
2.3.2.3	Deviation (5.7 - 6.3 div)				
	Bandwidth (5 - 7 div)				
	Bandwidth (4 - 8 div)				
	Deviation (5.7 - 6.3 div)				
	Bandwidth (5 - 7 div)				
	Bandwidth (4 - 8 div)				

Pulse Modulation Test (SERIES 12500A/12700A ONLY)					
Frequency (GHz)		**1.0**	**4.0**	**12.0**	**20**
2.3.3	On/Off				
2.3.4	Rise/Fall				
2.3.5	Overshoot/Settling				
2.3.6	Accuracy				

3

Calibration

3.1 Introduction

Introduction (Calibration)	Model	
	124XXA	125XXA/ 127XXA
	√	√

The Series 12000A features completely 'closed case' calibration. There are no mechanical adjustments anywhere in the instrument and all calibration is done under computer program control. Prior to performing any of the calibration procedures, allow the instrument to operate for at least 30 minutes. The calibration process is divided into sections of related steps. Each section should be performed in its entirety.

☛ ***NOTE:*** *In order to verify performance after calibration, refer to Chapter 2.*

The Calibration Control Program runs on a Pentium based Windows 95/98® PC. The computer may use either a Capital Equipment Corporation CEC488 IEEE 488 interface or a National Instrument IEEE 488 interface. Please refer to the instructions below on installing the program.

1. Insert CD-ROM into CD-ROM drive.

2. Open the Windows Explorer program by right clicking the **Start** button and selecting **Explore**.

3. Select **(D:)** drive for opening and reading the CD-ROM or the drive used on your PC for reading CD-ROMs.

4. Copy the 12000A Calibration folder, 31232.pdf, 31232.doc and the README.txt files to a directory of your choice.

5. Open the 12000A Calibration folder and click on 12000 **.exe** file. Drag the file onto your desktop to create the 12000A Calibration Program shortcut.

☛ ***NOTE:*** *Do not right click the file and use Send to > Desktop (Create shortcut) feature. It does not create a shortcut for this program.*

6. Open and print the Calibration Procedure 31232.pdf or the 31232.doc prior to performing any calibration sequence.

7. Double click the 12000A Calibration program icon you created in Step # 5 to run the program.

3.2 Equipment & Documentation Required

Equipment & Documentation Required	Model	
	124XXA	125XXA/ 127XXA
	√	√ (See Also 3.2.2)

3.2.1 All Models

- Giga-tronics 12000 Cal Software CD (P/N 32464)
- Pentium™ PC with Windows 95/98™, Equipped with National Instrument IEEE 488™ Interface (Version NI-488/NI-488.2)
- Giga-tronics 8651A or 8652A Power Meter
- Giga-tronics 80313A Sensor
- Giga-tronics Series 12000A Microwave Synthesizer
- Giga-tronics Series 12000A Microwave Synthesizer Service Manual (P/N 31232)
- Male “N” to Female “K” Adapter (Only for Synthesizer Equipped with Option 23)
- 10 MHz Frequency Standard, Accuracy better than 1E-10, .5 to 5 V_{P-P} into 100 ohms (Stanford Research FS 725 or Equivalent)

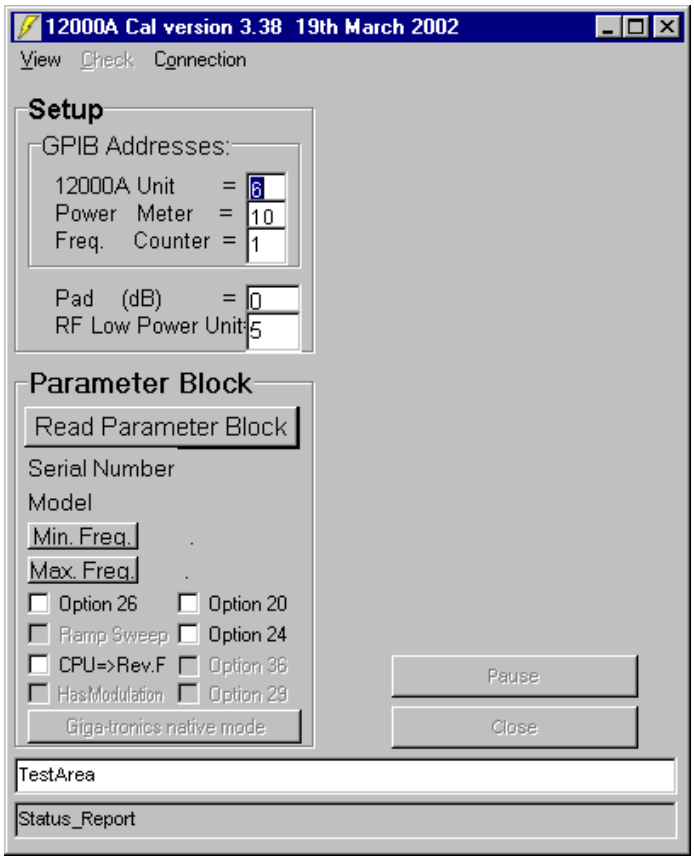
3.2.2 Additional Requirements (Series 125XXA/127XXA Only)

- DC Voltage Source 0-10 VDC, .5% Accuracy, 100 mA (Tektronix™ PS280 or Equivalent)
- Audio Oscillator, 10 Hz-200 kHz, 2 V_{P-P} +/- .01 V into 50 ohm (Stanford Research™ DS-345 or equivalent)
- HP™ 8902A Measuring Receiver
- Giga-tronics Series 12520A or 12720A Synthesizer
- Giga-tronics Mixer/Divider (P/N 002CA04900)
- Digital Voltmeter 3 ½ digits (Fluke™ 8920A or Equivalent)

3.3 Calibration Program Initialization

Calibration Program Initialization	Model	
	124XXA	125XXA/ 127XXA
	√	√

Connect the 12000A to the computer IEEE 488 interface and start the "12000A Calibration Program". The following window will display: Click Connection and select which GPIB Controller card to use.

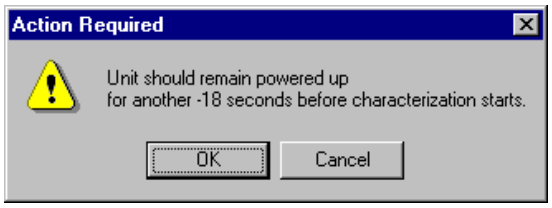


1. Be sure that the 12000A address is set to the same value as the setting in the GPIB Address block. Similarly, set the power meter address. Leave the counter address set to 1 (At this time, a counter is not needed).

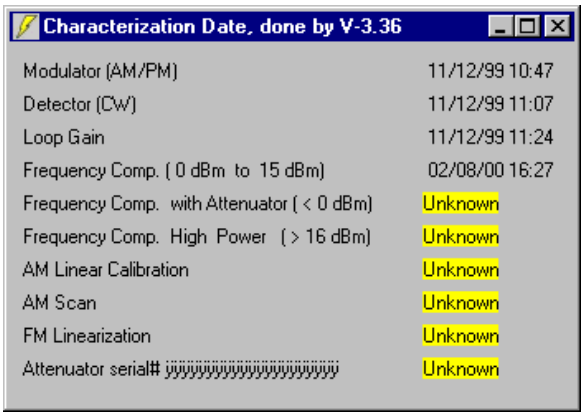
2. Click on Connection and select the PC GPIB controller which will be used: National Instrument or CEC.

3. Click on the "Read Parameter Block" bar and the program interrogates the 12000A. The 12000A display will be blank. The program puts the 12000A in 'DU7' mode which only displays communication errors.

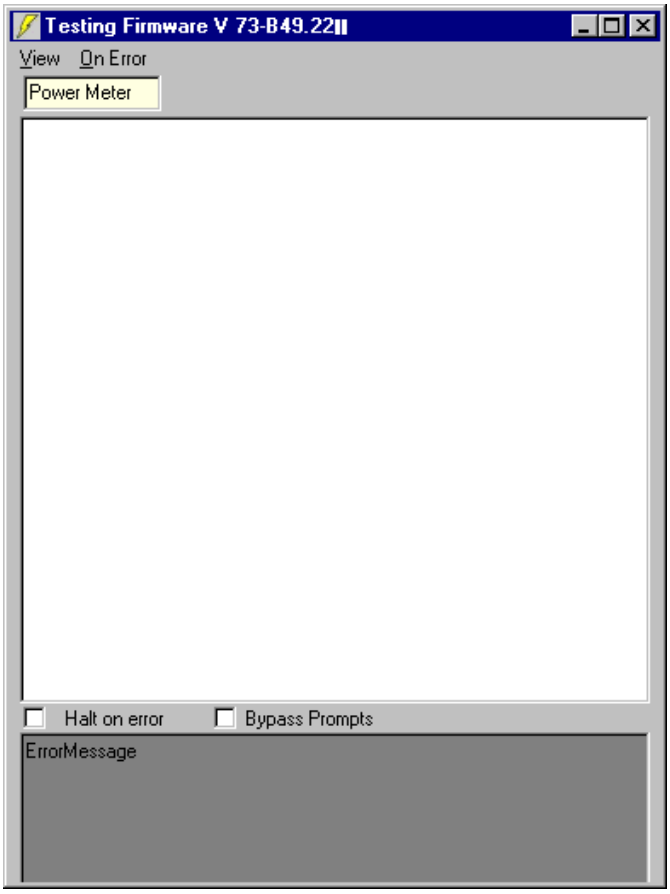
4. When this process starts, a 'timer' window will appear to insure that the 12000A is fully stabilized before measurements are made. Click 'OK' button to see how much time remains.



A window will now appear that lists the dates for the current calibration. Note that the "Detector (CW)" and "Loop Gain" dates are always the same since this data is loaded from a generic table and is not instrument specific.

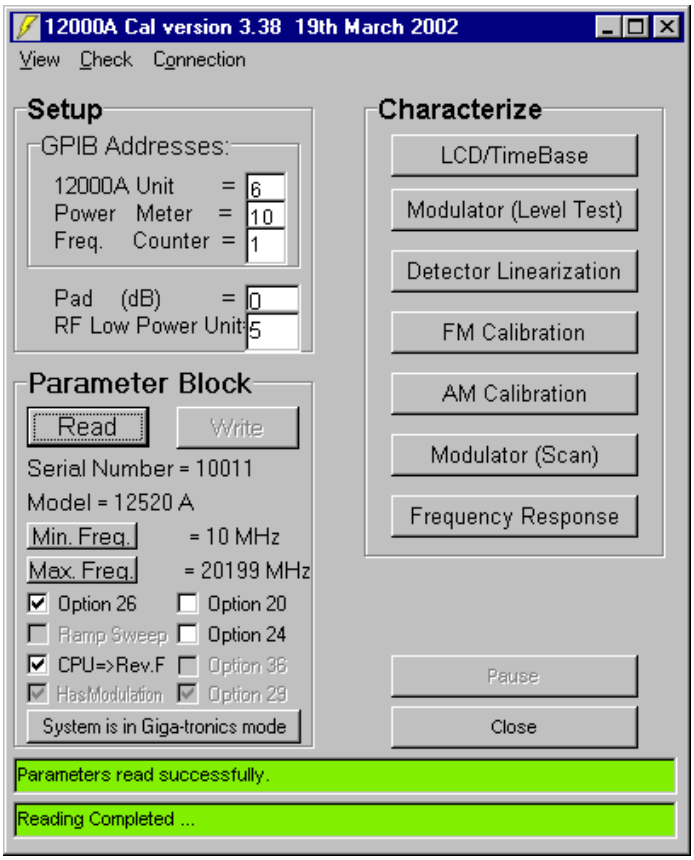


Another window is also displayed to allow viewing a variety of data. See the addendum in section 3.8 for a description of the monitor features.



When the Read Parameter process is complete, the main window will look approximately like this (after clicking on it) (The FM, AM or Modulator (Scan) Characterize buttons are not applicable to the Series

124XXA as depicted in the illustration below):



The window now has control 'buttons' to select which calibration process is to be performed. The Parameter block also changes and shows the serial number, frequency range and which options are present.

This completes the initialization of the Calibration Control Program. The various calibration processes may now be performed.

The top "button" allows calibrating the timebase and setting the contrast of the LCD, if desired. These functions may also be performed at any time from the 'Config' menu on the instrument. See the next page for a detailed description of the process to calibrate the timebase.

☛ ***NOTE:*** *The 'Modulator (Level Test)' must be performed prior to performing 'AM Calibration' or 'Frequency Response'.*

3.4 Timebase Calibration

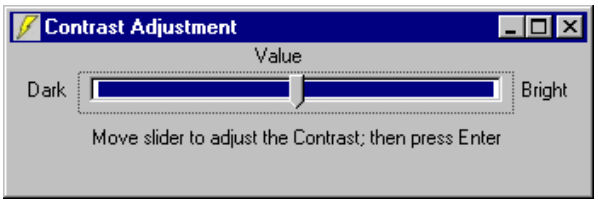
Timebase Calibration	Model	
	124XXA	125XXA/ 127XXA
	√	√

The timebase oscillator used in the 12000A operates at a frequency of 10 MHz and uses Electronic Frequency Control to adjust its output frequency. The calibration is performed entirely by the 12000A without the need for an external computer. Prior to performing this calibration the instrument should be connected to the mains for at least 24 hours. It is not necessary to have the instrument on. Note that calibration accuracy is directly related to the accuracy of the external standard.

☛ ***NOTE:*** *Updating firmware may clear the calibration data.*

☛ ***NOTE:*** *Use the 'LCD/Timebase' button for units with firmware V073-B49-22 and higher. Otherwise, just perform the steps listed under 3 below.*

1. Click on the LCD/Timebase button.
2. Per the action required window, set the timebase as described next.
3. To set the timebase:
   a. Press the front panel **[LOCAL]** button.
   b. Connect the frequency standard to the rear panel 'Ref In' BNC connector and make sure the instrument has had at least a 15 minute warm-up.
   c. Press the **[CONFIG]** button, then the *Service* softkey, then the *Hardware Testing* softkey.
   d. Now press the *Timebase Cal* softkey. Either a 5 or 10 MHz reference frequency may now be selected using the up/down buttons.
   e. Press the *Cal Timebase* softkey to calibrate the timebase.
   f. Press the *Store Cal* to store the calibration.
4. The Contrast Adjustment window will now appear.



   a. Click on the window. Use the mouser (or the keyboard left and right arrow keys) to move the slider pointer. The word 'value' will change to a number showing the contrast value.
   b. Press Enter after a good viewing contrast is attained.

c. A message window will show Characterization Complete. Click OK. Power the 12000A down and back up.

d. After the Fixed Frequency screen is displayed on the 12000A, click the Read button under the parameter block to re-establish program control.