Technical Data Sheet

# RF/Microwave Signal Generators

## MG3690C

RF/Microwave Signal Generator, 0.1 Hz to 70 GHz/325 GHz

### Introduction

The MG3690C is the “ideal microwave signal generator” because it offers unsurpassed frequency coverage, the lowest phase noise, leveled output power, spectral purity, switching speed, modulation performance, size, upgradeability, reliability, and service. Our signal generators are configurable for a broad range of applications from R&D to manufacturing and depot repair. Anritsu provides you a total solution including proven reliability and standard 3 year warranty plus pre- and post-sale support that is the best in the industry.


The Ideal Signal Generator

# Specifications

The specifications in the following pages describe the warranted performance of the generator for 25 ± 10 °C. Typical specifications describe expected, but not warranted, performance based on sample testing.

## Frequency Coverage

| Model/Option No. | Frequency Coverage | Output Type |
|---|---|---|
| MG3691C | 2 GHz to 10 GHz | K(f) |
| MG3692C | 2 GHz to 20 GHz | K(f) |
| MG3693C | 2 GHz to 31.8 GHz | K(f) |
| MG3694C | 2 GHz to 40 GHz | K(f) |
| MG3695C | 2 GHz to 50 GHz | V(f) |
| MG3697C | 2 GHz to 67 GHz* | V(f) |
| Option 4 | 8 MHz to 2.2 GHz** | Model No. Dependent |
| Option 5 | 8 MHz to 2 GHz** | Model No. Dependent |
| Option 22 | 0.1 Hz to 10 MHz | Model No. Dependent |

* Operational to 70 GHz
** All specifications apply ≥10 MHz

**Options 4 and 5:** Frequency extension down to 8 MHz
Two options are available to extend the 2 GHz low end frequency limit of the base models down to 8 MHz. Option 4 uses a digital down-converter (DDC) with successive divide-by-two circuitry. It offers the best phase noise performance of the two choices, at the expense of some analog performance < 500 MHz. In that range, analog sweep mode is not available, and pulse modulation performance is specified as typical. In addition, frequency and phase modulation mod index is scaled by the division ratio of each band of the DDC. Option 5 maintains all analog performance by using a heterodyne mixing down-converter, but does not improve phase noise performance.

**Option 22:** Frequency extension down to DC
If frequency coverage down to 0.1 Hz is desired, Option 22 can be added with either Option 4 or 5. Option 22 uses Direct Digital Synthesis (DDS) for CW and Step Sweep modes of operation. Modulation and analog sweep are not available in the DDS band. Frequency resolution < 10 MHz is 0.02 Hz. Output power across the complete instrument frequency range is degraded by 2 dB.

## CW Mode

**Output:** Twenty independent, presettable CW frequencies
(F0 – F9 and M0 – M9).

**Accuracy:** Same as internal or external 10 MHz time base.

**Internal Time Base Stability:**
With Aging: <2 x $10^{-9}$/day (<5 x $10^{-10}$/day with Option 16)
With Temperature: <2 x $10^{-8}$/deg C over 0 ºC to 55 ºC (<2 x $10^{-10}$/deg C with Option 16)

**Resolution:** 0.01 Hz

**Internal Time Base Calibration:** The internal time base can be calibrated via the System Cal menu to match an external reference (10 MHz ± 50 Hz).

**External 10 MHz Reference Input**: Accepts external 10 MHz ±50 Hz (typical), 0 to +20 dBm time base signal. Automatically disconnects the internal high-stability time-base option, if installed. BNC, rear panel, 50 Ω impedance. Selectable Bandwidth for best phase noise immunity or best phase tracking performance.

**10 MHz Reference Output:** 1 Vp-p into 50 Ω, AC coupled.
Rear panel BNC; 50 Ω impedance.

**Phase Offset:** Adjustable in 0.1 degree steps.

**Electronic Frequency Control (EFC) Input**: –4V to +4V input range;
8 x $10^{-8}$.Fout Hz/V sensitivity (typical); ≤ 250 Hz Modulation BW; Rear panel BNC; High Impedance

## Phase-Locked Step Sweep Mode

**Sweep Width:** Independently selected, 0.01 Hz to full range. Every frequency step in sweep range is phase-locked.

**Accuracy:** Same as internal or external 10 MHz time base.

**Resolution (Minimum Step Size):** 0.01 Hz

**Linear/Log Sweep:** User-selectable linear or log sweep.
In log sweep, step size logarithmically increases with frequency.

**Steps:** User-selectable number of steps or the step size.

**Number of Steps:** Variable from 1 to 10,000

**Step Size:** 0.01 Hz to the full frequency range of the instrument.
(If the step size does not divide into the selected frequency range, the last step is truncated)

**Dwell Time Per Step:** Variable from 1 ms to 99 seconds

**Fixed Rate Sweep:** Allows the user to set the total time of the sweep, including lock time. Variable from 20 ms to 99 seconds.

## Analog Sweep Mode (Option 6)

**Sweep Width:** Independently selected from 1 MHz to full frequency range. With Option 4, Digital Down Converter, Analog sweep is only available ≥ 500 MHz. Analog sweep is not available <10 MHz with Option 22.

**Accuracy:** The lesser of ±30 MHz or (±2 MHz + 0.25% of sweep width) for Sweep Speeds of ≤ 50 MHz/ms (typical)

**Sweep Time Range**: 30 ms to 99 seconds

## Alternate Sweep Mode

Sweeps alternately in step sweep between any two sweep ranges. Each sweep range may be associated with a power level.

## Manual Sweep Mode

Provides stepped, phase-locked adjustment of frequency between sweep limits. User-selectable number of steps or step size.

## List Sweep Mode

Under GPIB control or via the front panel, up to 4 tables with 2000 non-sequential frequency/power sets can be stored and then addressed as a phase-locked step sweep. One table of 2000 points is stored in non-volatile memory, all other tables are stored in volatile memory.

## Programmable Frequency Agility

Under GPIB control, up to 3202 non-sequential frequency/power sets can be stored and then addressed as a phase-locked step sweep. Data stored in volatile memory.

## Markers

Up to 20 independent, settable markers (F0 – F9 and M0 – M9).

**Video Markers:** +5V or –5V marker output, selectable from system menus. AUX I/O connector, rear panel.

**Intensity Markers:** Produces an intensity dot on analog display traces, obtained by a momentary dwell in RF sweep, in analog sweeps of <1s.

**Marker Accuracy:** Same as sweep frequency accuracy.

**Marker Resolution:**
**Analog Sweep:** 1MHz or Sweep Width/4096 which ever is greater.
**Step Sweep:** 0.01 Hz.

## Sweep Triggering

Sweep triggering is provided for Analog Frequency Sweep, Step Frequency Sweep, List Frequency Sweep, and CW Power Sweep.

**Auto:** Triggers sweep automatically.

**External:** Triggers a sweep on the low to high transition of an external TTL signal. AUX I/O connector, rear panel.

**Single:** Triggers, aborts, and resets a single sweep. Reset sweep may be selected to be at the top or bottom of the sweep.

## General

**Stored Setups:** Stores front panel settings and nine additional front-panel setups in a non-volatile RAM. A system menu allows saving and recalling of instrument setups. Whenever the instrument is turned on, control settings come on at the same functions and values existing when the instrument was turned off.

**Memory Sequencing Input:** Accepts a TTL low-level signal to sequence through ten stored setups. AUX I/O connector, rear panel.

**Self-Test:** Instrument self-test is performed when Self-Test soft-key is selected. If an error is detected, an error message is displayed in a window on the LCD identifying the probable cause and remedy.

**Secure Mode:** Disables all frequency and power level state displays. Stored setups saved in secure mode remain secured when recalled. Mode selectable from a system menu and via GPIB.

**Parameter Entry:** Instrument-controlled parameters can be entered in three ways: keypad, rotary data knob, or the ∧ and ∨ touch pads of the cursor-control key. The keypad is used to enter new parameter values; the rotary data knob and the cursor-control key are used to edit existing parameter values. The < and > touch pads of the cursor-control key move the cursor left and right one digit under the open parameter. The rotary data knob or the < and > touch pads will increment or decrement the digit position over the cursor. Controlled parameters are frequency, power level, sweep time, dwell time, and number of steps. Keypad entries are terminated by pressing the appropriate soft key. Edits are terminated by exiting the edit menu.

**Reset:** Returns all instrument parameters to predefined default states or values. Any pending GPIB I/O is aborted. Selectable from the system menu.

**Master/Slave Operation:** Allows two output signals to be swept with a user-selected frequency offset. One instrument controls the other via AUX I/O and SERIAL I/O connections. Requires a Master/Slave Interface Cable Set (Part No. ND36329).

**User Level Flatness Correction:** Allows user to calibrate out path loss due to external switching and cables via entered power table from a GPIB power meter or calculated data. When user level correction is activated, entered power levels are delivered at the point where calibration was performed. Supported power meters are Anritsu ML2437A, ML2438A, ML2480A/B, ML2490A, and ML4803A and HP 437B, 438A, and 70100A. Five user tables are available with up to 801 points/table.

**Warm Up Time:**
From Standby: 30 minutes.
From Cold Start (0 deg C): 120 hours to achieve specified frequency stability with aging.
Instruments disconnected from AC line power for more than 72 hours require 30 days to return to specified frequency stability with aging.

**Power:** 85 Vac - 264 Vac, 48 Hz - 440 Hz, 250 VA maximum

**Standby:** With ac line power connected, unit is placed in standby when front panel power switch is released from the OPERATE position.

**Weight:** 18 kg maximum

**Dimensions:** 133 H x 429 W x 450 D mm

**Warranty:** 3 years from ship date

## Remote Operation

All instrument functions, settings, and operating modes (except for power on/standby) are controllable using commands sent from an external computer via the GPIB (IEEE-488 interface bus).

**GPIB Commands:** Native, SCPI

**GPIB Address:** Selectable from a system menu

**IEEE-488 Interface Function Subset:**
**Source Handshake:** SH1
**Acceptor Handshake:** AH1
**Talker:** T6
**Listener:** L4
**Service Request:** SR1
**Remote/Local:** RL1
**Parallel Poll:** PP1
**Device Clear:** DC1
**Device Trigger:** DT1
**Controller Capability:** C0, C1, C2, C3, C28
**Tri-State Driver:** E2

**GPIB Status Annunciators:** When the instrument is operating in Remote, the GPIB status annunciators (listed below) will appear in a window on the front panel LCD.

**Remote:** Operating on the GPIB (all instrument front panel keys except for the SYSTEM key and the RETURN TO LOCAL soft-key will be ignored).

**LLO (Local Lockout):** Disables the RETURN TO LOCAL soft-key. Instrument can be placed in local mode only via GPIB or by cycling line power.

**Emulations:** The instrument responds to the published GPIB commands and responses of the Anritsu Models 6600, 6700,and 6XX00-series signal sources. When emulating another signal source, the instrument will be limited to the capabilities, mnemonics, and parameter resolutions of the emulated instrument.

## Environmental (MIL-PRF-28800F, class 3)

**Storage Temperature Range:** –40 °C to +75 °C

**Operating Temperature Range:** 0 °C to +50 °C

**Relative Humidity:** 5% to 95% at 40 °C

**Altitude:** 4,600 meters, 43.9 cm Hg

**EMI:** Meets the emission and immunity requirements of
EN61326: 1998
EN55011: 1991/CISPR-11:1990 Group 1 Class A
EN61000-4-2: 1995 – 4 kV CD, 8 kV AD
EN61000-4-3: 1997 – 3 V/m
EN61000-4-4: 1995 – 0.5 kV SL, 1 kV PL
EN61000-4-5: 1995 – 1 kV – 2 kV L-E
EN61000-4-6: 1996
EN61000-4-11: 1994

**Vibration:** Random, 5 Hz - 500 Hz, 0.015-0.0039$g^2$/Hz PSD
Sinusoidal, 5 Hz - 55 Hz, 0.33 mm displacement

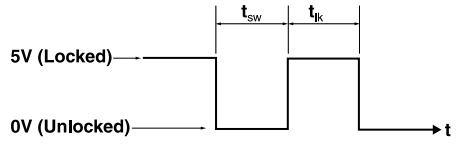
**Safety Directive:** EN 61010-1: 1993 + A1: 92 + A2: 95

# Frequency Switching Time

## Definitions

**Free Running Mode:**
(Step or List Sweep)

$t_{sw}$ = Switching Time, Unlocked



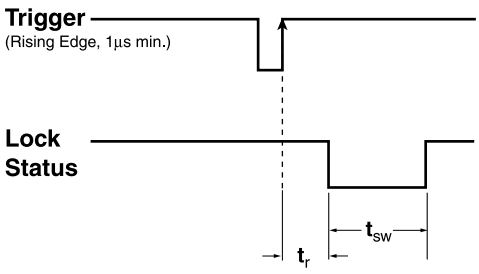

Lock Status Indicator
Rear Panel Aux I/O Connector (Pin 11)
(The lock status indicator goes high, when the output is within 1 kHz of the final frequency.)

$t_{lk}$ = Locked Time = 1ms + $t_{dw}$

$t_{dw}$ = Dwell Time, after locking. Selectable, 1 ms minimum

$t_{lk}$ (min) = 2 ms

**Single Frequency Trigger Mode:**
(List, non-sequential, and CFx modes)




$t_r$ = Trigger Response Time = 2 ms
(applies to both GPIB and External TTL triggers)

## Switching Time ($t_{sw}$)

| $t_{sw}$* (ms) | Condition |
|---|---|
| 5 ms + 1 ms/GHz | step not starting at, or crossing dwell frequencies |
| 7 ms + 1 ms/GHz (typical) | step not starting at, or crossing band switching frequencies |
| 8 ms + 1 ms/GHz (typical) | step starting at, or crossing band switching frequencies |

**Band Switching Dwell Frequencies:** 2 (2.2 w/Opt. 4), 10, 20, 40 GHz

**Filter Switching Dwell Frequencies:** 3.3, 5.5, 8.4, 13.25, 25, 32 GHz

**< 2.2 GHz w/Opt. 4:** 12.5, 15.625, 22.5, 31.25, 43.75, 62.5, 87.5, 125, 175, 250, 350, 500, 700, 1050, 1500 MHz

*Not applicable with FM mode active

# Spectral Purity

All specifications apply at the lesser of +10 dBm output or maximum specified leveled output power, unless otherwise noted.

## Spurious Signals

**Harmonic and Harmonically-related:**

| Frequency Range | Standard |
|---|---|
| 0.1 Hz to 10 MHz (Option 22) | < –30 dBc |
| 10 MHz to ≤ 100 MHz (Option 4) | < –40 dBc |
| > 100 MHz to ≤ 2.2 GHz (Option 4) | < –50 dBc |
| 10 MHz to ≤ 50 MHz (Option 5) | < –30 dBc |
| > 50 MHz to < 2 GHz (Option 5) | < –40 dBc |
| 2 GHz (> 2.2 GHz w/Option 4) to ≤ 20 GHz | < –60 dBc* |
| > 20 GHz to ≤ 40 GHz | < –40 dBc*† |
| > 40 GHz to ≤ 50 GHz (MG3695B) | < –40 dBc* |
| > 40 GHz to ≤ 67 GHz (MG3696B) | < –25 dBc |

* –30 dBc typical with high power Option 15
† 20 GHz to 21 GHz and 39 GHz to 40 GHz, –20 dBc typical (Option 15 only)

**Non-harmonics:**

| Frequency Range | Standard |
|---|---|
| 0.1 Hz to 10 MHz (Option 22) | < –30 dBc |
| 10 MHz to ≤ 2.2 GHz (Option 4) | < –60 dBc |
| 10 MHz to ≤ 2 GHz (Option 5) | < –40 dBc |
| > 2 GHz (2.2 GHz w/Option 4) to ≤ 67 GHz | < –60 dBc |

**Power Line and Fan Rotation Spurious Emissions (dBc):**

| Frequency | 300 Hz | Offset from Carrier | |
|---|---|---|---|
| | | 300 Hz to 1 kHz | > 1 kHz |
| 10 MHz to ≤ 500 MHz (Option 4) | < –68 | < –72 | < –72 |
| > 500 MHz to ≤ 1050 MHz (Option 4) | < –62 | < –72 | < –72 |
| > 1050 MHz to ≤ 2200 MHz (Option 4) | < –56 | < –66 | < –66 |
| 0.01 GHz to ≤ 8.4 GHz | < –50 | < –60 | < –60 |
| > 8.4 GHz to ≤ 20 GHz | < –46 | < –56 | < –60 |
| > 20 GHz to ≤ 40 GHz | < –40 | < –50 | < –54 |
| > 40 GHz to ≤ 67 GHz | < –34 | < –44 | < –48 |

**Residual FM* (CW and Step Sweep modes, 50 Hz - 15 kHz BW) (typical):**

| Frequency Range | Residual FM (Hz RMS) | |
|---|---|---|
| | Option 3/3X | Standard |
| ≤ 8.4 GHz | < 40 | < 120 |
| > 8.4 GHz to 20 GHz | < 40 | < 220 |
| > 20 GHz to ≤ 40 GHz | < 80 | < 440 |
| > 40 GHz to ≤ 67 GHz | < 160 | < 880 |

**Residual FM* (Analog Sweep and Unlocked FM modes, 50 Hz - 15 kHz BW) (typical):**

| Frequency Range | Residual FM (kHz RMS) | |
|---|---|---|
| | Unlocked Narrow FM mode | Unlocked Wide FM mode or Analog Sweep (typ.) |
| 0.01 GHz to ≤ 20 GHz | < 10 | < 25 |
| > 20 GHz to ≤ 40 GHz | < 20 | < 50 |
| > 40 GHz to ≤ 67 GHz | < 40 | < 100 |

*Residual FM is not applicable with FM locked mode

**AM Noise Floor:**

Typically < –145 dBm/Hz at 0 dBm output and offsets > 5 MHz from carrier.

## Single-Sideband Phase Noise*

**Single-Sideband Phase Noise (dBc/Hz): (Typical)**

| Frequency Range | 10 Hz | 100 Hz | 1 kHz | 10 kHz | 100 kHz | 1 MHz |
|---|---|---|---|---|---|---|
| 0.1 Hz to <10 MHz (Option 22) | –80 (–100) | –90 (–110) | –120 (–125) | –130 (–139) | –130 (–141) | –130 (–141) |
| 10 MHz to 15.625 MHz (Option 4) | –102 (–113) | –128 (–133) | –142 (–149) | –145 (–152) | –145 (–153) | –145 (–153) |
| >15.625 Mhz to 31.25 MHz (Option 4) | –97 (–109) | –125 (–130) | –142 (–147) | –144 (–149) | –144 (–153) | –145 (–155) |
| >31.25 MHz to 62.5 MHz (Option 4) | –92 (–104) | –122 (–128) | –140 (–146) | –142 (–146) | –143 (–150) | –145 (–155) |
| >62.5 MHz to 125 MHz (Option 4) | –87 (–98) | –114 (–118) | –133 (–139) | –130 (–140) | –130 (–143) | –145 (–155) |
| >125 MHz to 250 MHz (Option 4) | –82 (–93) | –108 (–113) | –126 (–134) | –124 (–134) | –124 (–138) | –145 (–153) |
| >250 MHz to 500 MHz (Option 4) | –75 (–87) | –102 (–109) | –120 (–128) | –118 (–127) | –118 (–130) | –143 (–149) |
| >500 MHz to 1050 MHz (Option 4) | –70 (–80) | –94 (–100) | –115 (–123) | –115 (–122) | –116 (–126) | –138 (–144) |
| >1050 MHz to 2200 MHz (Option 4) | –65 (–74) | –86 (–96) | –113 (–117) | –111 (–116) | –114 (–120) | –133 (–139) |
| 10 MHz to <2000 MHz (Option 5) | –62 (–72) | –85 (–95) | –100 (–104) | –102 (–106) | –102 (–106) | –111 (–114) |
| 2 GHz to 6 GHz | –54 (–64) | –81 (–88) | –102 (–109) | –103 (–110) | –106 (–114) | –128 (–133) |
| >6 GHz to 10 GHz | –52 (–62) | –75 (–85) | –98 (–106) | –104 (–109) | –106 (–113) | –126 (–132) |
| >10 GHz to 20 GHz | –45 (–55) | –69 (–78) | –92 (–101) | –98 (–103) | –98 (–106) | –124 (–131) |
| >20 GHz to 40 GHz | –38 (–48) | –62 (–72) | –86 (–94) | –92 (–100) | –92 (–100) | –118 (–124) |
| >40 GHz to 67 GHz | –32 (–42) | –56 (–66) | –80 (–88) | –87 (–94) | –82 (–91) | –112 (–118) |

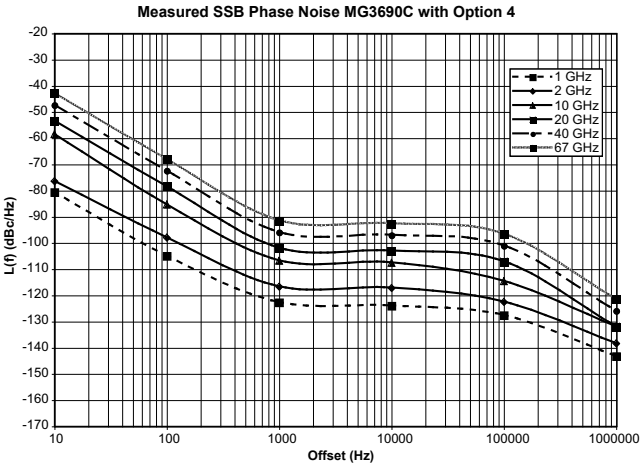
**Single-Sideband Phase Noise (dBc/Hz) - Option 3: (Typical)**

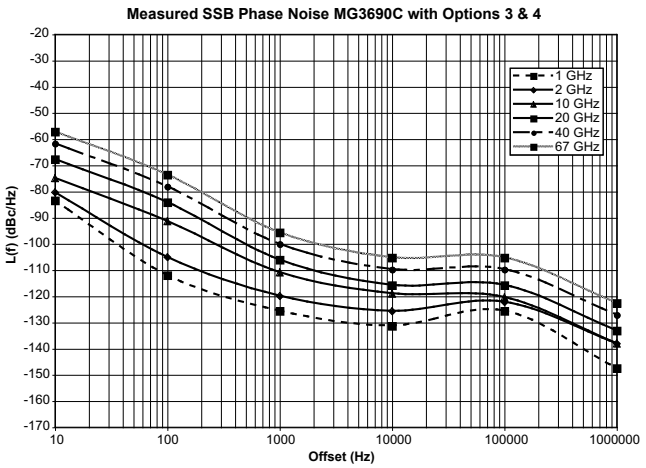
| Frequency Range | 10 Hz | 100 Hz | 1 kHz | 10 kHz | 100 kHz | 1 MHz |
|---|---|---|---|---|---|---|
| 0.1 Hz to <10 MHz (Option 22) | –80 (–100) | –90 (–110) | –120 (–125) | –130 (–139) | –130 (–141) | –130 (–141) |
| 10 MHz to 15.625 MHz (Option 4) | –102 (–120) | –128 (–140) | –142 (–150) | –145 (–152) | –148 (–153) | –148 (–152) |
| >15.625 Mhz to 31.25 MHz (Option 4) | –97 (–108) | –123 (–128) | –141 (–149) | –145 (–153) | –148 (–153) | –148 (–155) |
| >31.25 MHz to 62.5 MHz (Option 4) | –92 (–109) | –118 (–131) | –139 (–146) | –145 (–153) | –148 (–153) | –148 (–156) |
| >62.5 MHz to 125 MHz (Option 4) | –87 (–98) | –113 (–118) | –134 (–139) | –142 (–147) | –143 (–148) | –148 (–155) |
| >125 MHz to 250 MHz (Option 4) | –82 (–93) | –108 (–113) | –129 (–134) | –138 (–143) | –137 (–142) | –148 (–153) |
| >250 MHz to 500 MHz (Option 4) | –77 (–91) | –102 (–114) | –124 (–130) | –132 (–137) | –128 (–137) | –144 (–153) |
| >500 MHz to 1050 MHz (Option 4) | –72 (–83) | –98 (–103) | –119 (–123) | –126 (–132) | –122 (–132) | –139 (–150) |
| >1050 MHz to 2200 MHz (Option 4) | –63 (–77) | –92 (–101) | –113 (–119) | –121 (–126) | –117 (–125) | –134 (–146) |
| 10 MHz to <2000 MHz (Option 5) | –62 (–72) | –85 (–95) | –100 (–104) | –102 (–106) | –102 (–106) | –111 (–114) |
| 2 GHz to 6 GHz | –54 (–77) | –82 (–93) | –106 (–111) | –115 (–119) | –112 (–119) | –138 (–142) |
| >6 GHz to 10 GHz | –52 (–73) | –75 (–88) | –102 (–109) | –113 (–119) | –115 (–120) | –134 (–140) |
| >10 GHz to 20 GHz | –45 (–66) | –69 (–82) | –97 (–105) | –109 (–115) | –109 (–115) | –130 (–137) |
| >20 GHz to 40 GHz | –38 (–59) | –62 (–75) | –90 (–98) | –104 (–108) | –103 (–109) | –122 (–131) |
| >40 GHz to 67 GHz | –32 (–51) | –56 (–68) | –84 (–91) | –97 (–103) | –97 (–103) | –118 (–125) |

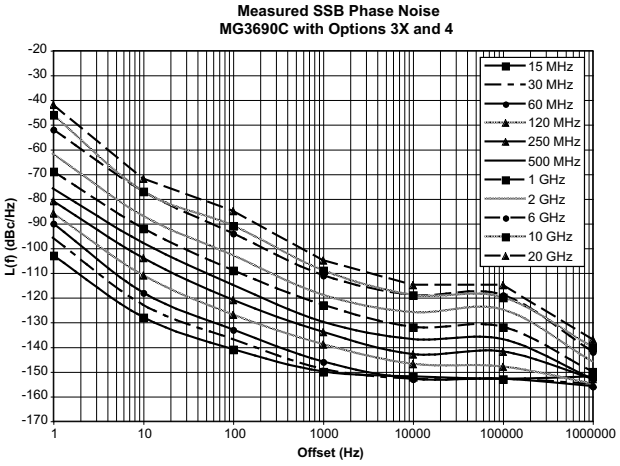
**Single-Sideband Phase Noise (dBc/Hz) - Option 3X: (Typical)**

| Frequency Range | Offset from Carrier | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 Hz | 10 Hz | 100 Hz | 1 kHz | 10 kHz | 100 kHz | 1 MHz |
| 0.1 Hz to <10 MHz (Option 22) | –60 (–70) | –80 (–100) | –90 (–110) | –120 (–125) | –130 (–139) | –130 (–141) | –130 (–141) |
| 10 MHz to 15.625 MHz (Option 4) | –89 (–103) | –111 (–128) | –135 (–141) | –142 (–150) | –145 (–152) | –148 (–153) | –148 (–152) |
| >15.625 MHz to 31.25 MHz (Option 4) | –85 (–96) | –107 (–123) | –130 (–137) | –141 (–149) | –145 (–153) | –148 (–153) | –148 (–155) |
| >31.25 MHz to 62.5 MHz (Option 4) | –80 (–90) | –101 (–118) | –124 (–133) | –139 (–146) | –145 (–153) | –148 (–153) | –148 (–156) |
| >62.5 MHz to 125 MHz (Option 4) | –74 (–86) | –96 (–111) | –117 (–127) | –134 (–139) | –142 (–147) | –143 (–148) | –148 (–155) |
| >125 MHz to 250 MHz (Option 4) | –68 (–81) | –92 (–104) | –111 (–121) | –129 (–134) | –138 (–143) | –137 (–142) | –148 (–153) |
| >250 MHz to 500 MHz (Option 4) | –62 (–76) | –88 (–98) | –105 (–115) | –124 (–130) | –132 (–137) | –128 (–137) | –144 (–153) |
| >500 MHz to 1050 MHz (Option 4) | –56 (–69) | –79 (–92) | –99 (–109) | –119 (–123) | –126 (–132) | –122 (–132) | –139 (–150) |
| >1050 MHz to 2200 MHz (Option 4) | –49 (–62) | –71 (–87) | –93 (–103) | –113 (–119) | –121 (–126) | –117 (–125) | –134 (–146) |
| 10 MHz to <2000 MHz (Option 5) | –38 (–45) | –68 (–78) | –85 (–95) | –100 (–104) | –102 (–106) | –102 (–106) | –111 (–114) |
| 2 GHz to 6 GHz | –41 (–52) | –65 (–77) | –81 (–94) | –106 (–111) | –115 (–119) | –112 (–119) | –138 (–142) |
| >6 GHz to 10 GHz | –34 (–46) | –62 (–77) | –83 (–91) | –102 (–109) | –113 (–119) | –115 (–120) | –134 (–140) |
| >10 GHz to 20 GHz | –29 (–42) | –59 (–72) | –77 (–85) | –97 (–105) | –109 (–115) | –109 (–115) | –130 (–137) |
| >20 GHz to 40 GHz | –23 (–36) | –53 (–65) | –70 (–79) | –90 (–98) | –104 (–108) | –103 (–109) | –122 (–131) |
| >40 GHz to 67 GHz | –17 (–30) | –47 (–59) | –64 (–73) | –84 (–91) | –97 (–103) | –97 (–103) | –118 (–125) |

*Phase noise is specified and guaranteed only with internal reference. In External Reference mode, the phase noise of the external supplied reference, and the selected external reference bandwidth, will dictate the instrument phase noise performance. Phase noise is not degraded when adding high power Option 15.




# RF Output

Power level specifications apply at 25 ± 10 ºC.

**Maximum Leveled Output Power***:**

| Model Number | Configuration | Frequency Range (GHz) | Output Power (dBm) | Output Power With Step Attenuator (dBm) | Output Power With Electronic Step Attenuator (dBm) |
|---|---|---|---|---|---|
| MG3691C | w/opt 4 or 5 | < 2 GHz* | +19.0 | +18.0 | +15.0 |
| | STD | ≥ 2 GHz** to ≤ 10 GHz | +19.0 | +18.0 | +13.0 |
| MG3692C | w/opt 4 or 5 | < 2 GHz* | +19.0 | +18.0 | Not Available |
| | STD | ≥ 2 GHz** to ≤ 10 GHz | +19.0 | +18.0 | |
| | STD | > 10 GHz to ≤ 20 GHz | +17.0 | +15.0 | |
| MG3693C | w/opt 4 or 5 | < 2 GHz* | +15.0 | +14.0 | Not Available |
| | STD | ≥ 2 GHz** to ≤ 10 GHz | +15.0 | +14.0 | |
| | STD | > 10 GHz to ≤ 20 GHz | +12.0 | +10.0 | |
| | STD | > 20 GHz to ≤ 31.8 GHz | +9.0 | +6.0 | |
| MG3694C | w/opt 4 or 5 | < 2 GHz* | +15.0 | +14.0 | Not Available |
| | STD | ≥ 2 GHz** to ≤ 10 GHz | +15.0 | +14.0 | |
| | STD | > 10 GHz to ≤ 20 GHz | +12.0 | +10.0 | |
| | STD | > 20 GHz to ≤ 40 GHz | +9.0 | +6.0 | |
| MG3695C | w/opt 4 or 5 | < 2 GHz* | +12.0 | +10.0 | Not Available |
| | STD | ≥ 2 GHz** to ≤ 20 GHz | +10.0 | +8.0 | |
| | STD | > 20 GHz to ≤ 40 GHz | +6.0 | +3.0 | |
| | STD | > 40 GHz to ≤ 50 GHz | +3.0 | +0.0 | |
| MG3697C | w/opt 4 or 5 | < 2 GHz* | +12.0 | +10.0 | Not Available |
| | STD | ≥ 2 GHz** to ≤ 20 GHz | +10.0 | +8.0 | |
| | STD | > 20 GHz to ≤ 40 GHz | +6.0 | +3.0 | |
| | STD | > 40 GHz to ≤ 67 GHz | +3.0 | +0.0**** | |

* ≤ 2.2 GHz with Option 4

** > 2.2 GHz with Option 4

*** For output power with Option 22, 0.1 Hz to 10 MHz coverage, derate all specifications by 2 dB

**** Typical 60 GHz to 67 GHz

**Maximum Leveled Output Power With Option 15 (High Power) Installed***:**

| Model Number | Configuration | Frequency Range (GHz) | Output Power (dBm) | Output Power With Step Attenuator (dBm) | Output Power With Electronic Step Attenuator (dBm) |
|---|---|---|---|---|---|
| MG3691C | w/opt 4 or 5 | < 2 GHz*<br>≥ 2 GHz** to ≤ 10 GHz | +19.0<br>+25.0 | +18.0<br>+24.0 | +15.0<br>+16.0 |
| | w/o opt 4 or 5 | ≥ 2 GHz to ≤ 10 GHz | +26.0 | +25.0 | +16.0 |
| MG3692C | w/opt 4 or 5 | < 2 GHz*<br>2 GHz to 10 GHz<br>> 10 GHz to 16 GHz<br>> 16 GHz to 20 GHz | +19 dBm<br>+25 dBm<br>+22 dBm<br>+21 dBm | +18 dBm<br>+24 dBm<br>+20 dBm<br>+19 dBm | Not Available |
| | w/o opt 4 or 5 | 2 GHz to 10 GHz<br>> 10 GHz to 16 GHz<br>> 16 GHz to 20 GHz | +26 dBm<br>+25 dBm<br>+23 dBm | +25 dBm<br>+23 dBm<br>+21 dBm | |
| MG3693C | w/opt 4 or 5 | < 2 GHz*<br>≥ 2 GHz** to ≤ 20 GHz<br>> 20 GHz to ≤ 3 GHz | +17.0<br>+21.0<br>+17.0 | +16.0<br>+19.0<br>+15.0 | Not Available |
| | w/o opt 4 or 5 | ≥ 2 GHz to ≤ 20 GHz<br>> 20 GHz to ≤ 31.8 GHz | +23.0<br>+19.0 | +21.0<br>+17.0 | |
| MG3694C | w/opt 4 or 5 | < 2 GHz*<br>≥ 2 GHz** to ≤ 20 GHz<br>> 20 GHz to ≤ 40 GHz | +17.0<br>+21.0<br>+17.0 | +16.0<br>+19.0<br>+15.0 | Not Available |
| | w/o opt 4 or 5 | ≥ 2 GHz to ≤ 20 GHz<br>> 20 GHz to ≤ 40 GHz | +23.0<br>+19.0 | +21.0<br>+17.0 | |
| MG3695C | w/opt 4 or 5 | < 2 GHz*<br>≥ 2 GHz** to ≤ 20 GHz<br>> 20 GHz to ≤ 40 GHz<br>> 40 GHz to ≤ 50 GHz | +16<br>+21<br>+17<br>+11 | +14<br>+19<br>+15<br>+8 | Not Available |
| | w/o opt 4 or 5 | ≥ 2 GHz to ≤ 20 GHz<br>> 20 GHz to ≤ 40 GHz<br>> 40 GHz to ≤ 50 GHz | +23<br>+19<br>+13 | +21<br>+17<br>+10 | |
| MG3697C | w/opt 4 or 5 | < 2 GHz*<br>≥ 2 GHz** to ≤ 20 GHz<br>> 20 GHz to ≤ 40 GHz<br>> 40 GHz to ≤ 67 GHz<br>> 67 GHz to ≤ 70 GHz | +16<br>+19<br>+16<br>+9<br>+3***** | +15<br>+18<br>+14<br>+6****<br>0***** | Not Available |
| | w/o opt 4 or 5 | ≥ 2 GHz to ≤ 20 GHz<br>> 20 GHz to ≤ 40 GHz<br>> 40 GHz to ≤ 67 GHz<br>> 67 GHz to ≤ 70 GHz | +21<br>+19<br>+9<br>+3***** | +19<br>+16<br>+6****<br>0***** | |

* ≤ 2.2 GHz with Option 4
** > 2.2 GHz with Option 4
*** For output power with Option 22, 0.1 Hz to 10 MHz coverage, derate all specifications by 2 dB
**** Typical 60 GHz to 67 GHz
***** Typical

## Minimum Settable Power

**Without an Attenuator:** –20 dBm

**With an Attenuator**: –120 dBm

## Minimum Leveled Output Power

**Without an Attenuator:** –15 dBm (–20 dBm, typical)

**With an Attenuator**: –115 dBm (MG3691C, MG3692C, MG3693C, and MG3694C)
–105 dBm (MG3695C, and MG3697C)

**With an Electronic Attenuator:** –125 dBm (MG3691C)

## Unleveled Output Power Range (typical)

**Without an Attenuator:** > 40 dB below max power.

**With an Attenuator:** > 130 dB below max power.

## Power Level Switching Time (to within specified accuracy)

**Without Change in Step Attenuator:** < 3 ms typical

**With Change in Step Attenuator:** < 20 ms typical

**With Change in Electronic Step Attenuator:** < 3 ms typical. Power level changes across –70 dB step will result in 20 ms delay.

## Step Attenuator (Option 2)

Adds a 10 dB/step attenuator, with 110 dB range on models ≤ 40 GHz, and 90 dB range on models > 40 GHz. Option 2E adds an electronic version with 120 dB range, only available on an MG3691C. Option 2E is not available on units with Option 22, coverage down to 0.1 Hz.

## Accuracy and Flatness

Accuracy specifies the total worst case accuracy. Flatness is included within the accuracy specification.

**Step Sweep and CW Modes:**

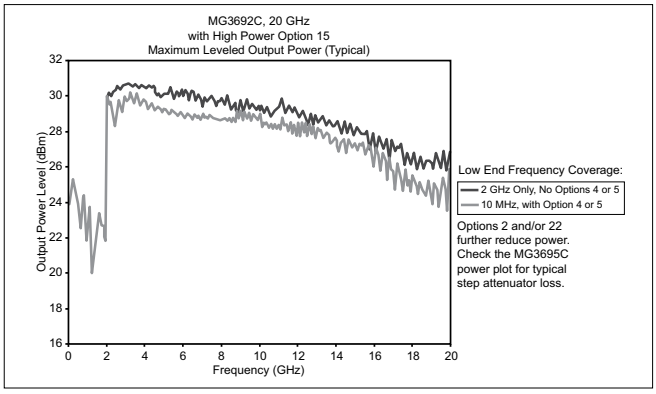
| Attenuation Below Max Power | Frequency (GHz) | | | |
|---|---|---|---|---|
| | ≤ 40** | 40-50 | 50-60 | 60-67 |
| Accuracy: | | | | |
| 0 dB - 25 dB | ± 1.0 dB | ± 1.5 dB | ± 1.5 dB | ± 1.5 dB |
| 25 dB - 60 dB | ± 1.0 dB | ± 1.5 dB | ± 3.5 dB* | N/A |
| 60 dB - 100 dB | ± 1.0 dB | ± 2.5 dB* | ± 3.5 dB* | N/A |
| Flatness: | | | | |
| 0 dB - 25 dB | ± 0.8 dB | ± 1.1 dB | ± 1.1 dB | ± 1.1 dB |
| 25 dB - 60 dB | ± 0.8 dB | ± 1.1 dB | ± 3.1 dB* | N/A |
| 60 dB - 100 dB | ± 0.8 dB | ± 2.1 dB* | ± 3.1 dB* | N/A |

*Typical

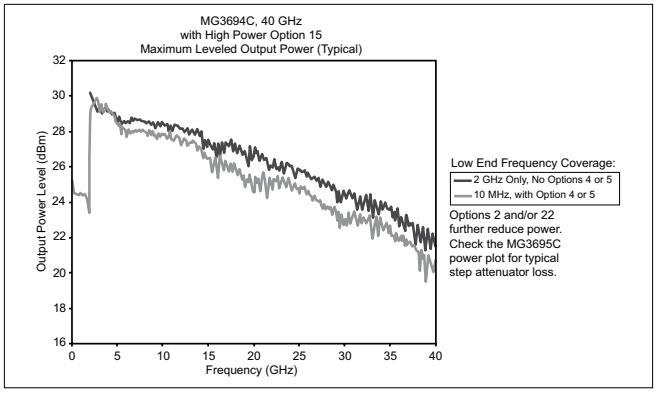
**Accuracy and Flatness with high power Option 15, is ±1.5 dB. It is also ±1.5 dB below 20 MHz, with or without Option 15.

**Analog Sweep Mode (typical):**

| Attenuation Below Max Power | Frequency (GHz) | | | |
|---|---|---|---|---|
| | 0.01-0.05 | 0.05-20 | 20-40 | 40-67 |
| Accuracy: | | | | |
| 0 dB - 12 dB | ± 2.0 dB | ± 2.0 dB | ± 2.0 dB | ± 3.0 dB |
| 12 dB - 30 dB | ± 3.5 dB | ± 3.5 dB | ± 4.6 dB | ± 5.6 dB |
| 30 dB - 60 dB | ± 4.0 dB | ± 4.0 dB | ± 5.2 dB | ± 6.2 dB |
| 60 dB - 122 dB | ± 5.0 dB | ± 5.0 dB | ± 6.2 dB | ± 7.2 dB |
| Flatness: | | | | |
| 0 dB - 12 dB | ± 2.0 dB | ± 2.0 dB | ± 2.0 dB | ± 2.5 dB |
| 12 dB - 30 dB | ± 3.5 dB | ± 3.5 dB | ± 4.1 dB | ± 5.1 dB |
| 30 dB - 60 dB | ± 4.0 dB | ± 4.0 dB | ± 4.6 dB | ± 5.6 dB |
| 60 dB - 122 dB | ± 5.0 dB | ± 5.0 dB | ± 5.2 dB | ± 6.2 dB |




*Typical MG3692C maximum available output power*




*Typical MG3694C maximum available output power*

## Other Output Power Specifications

**Output Units:** Output units selectable as either dBm or mV. Selection of mV assumes 50 Ω load. All data entry and display are in the selected units.

**Output Power Resolution:** 0.01 dB or 0.001 mV

**Source Impedance:** 50 Ω nominal

**Source SWR (Internal Leveling):** < 2.0 typical

**Power Level Stability with Temperature:** 0.04 dB/deg C typical

**Level Offset**: Offsets the displayed power level to establish a new reference level.

**Output On/Off**: Toggles the RF output between an Off and On state. During the Off state, the RF oscillator is turned off. The On or Off state is indicated by two LEDs located below the OUTPUT ON/OFF key on the front panel.

**RF On/Off Between Frequency Steps:** System menu selection of RF On or RF Off during frequency switching in CW, Step Sweep, and List Sweep modes.

**RF On/Off During Retrace:** System menu selection of RF On or RF Off during retrace.

**Internal Leveling:** Power is leveled at the output connector in all modes.

**External Leveling:**

**External Detector:** Levels output power at a remote detector location. Accepts a positive or negative 0.5 mV to 500 mV input signal from the remote detector. L1 adjusts the input signal range to an optimum value. BNC connector, rear panel.

**External Power Meter:** Levels output power at a remote power meter location. Accepts a ± 1 V full scale input signal from the remote power meter. L1 adjusts the input signal range to an optimum value. BNC connector, rear panel.

**External Leveling Bandwidth:** 30 kHz typical in Detector mode. 0.7 Hz typical in Power Meter mode.

**User Level Flatness Correction:**

**Number of points:** 2 to 801 points per table
**Number of tables:** 5 available
**Entry modes:** GPIB power meter or computed data

## CW Power Sweep

**Range:** Sweeps between any two power levels at a single CW frequency.
**Resolution:** 0.01 dB/step (Log) or 0.001 mV (Linear)

**Accuracy:** Same as CW power accuracy.

**Log/Linear Sweep:** Power sweep selectable as either log or linear. Log sweep is in dB; linear sweep is in mV.

**Step Size:** User-controlled, 0.01 dB (Log) or 0.001 mV (Linear) to the full power range of the instrument.

**Step Dwell Time:** Variable from 1 ms to 99 seconds. If the sweep crosses a step attenuator setting, there will be a sweep dwell of approximately 20 ms to allow setting of the step attenuator.

## Sweep Frequency/Step Power

A power level step occurs after each frequency sweep. Power level remains constant for the length of time required to complete each sweep.

## Internal Power Monitor (Option 8)

**Sensors:** Compatible with Anritsu 560-7, 5400-71, or 6400-71 series detectors. Rear panel input.

**Range:** +16 dBm to –35 dBm

**Accuracy:** ± 1 dBm, (+16 dBm to –10 dBm)
± 2 dBm, (–10 dBm to –35 dBm)

**Resolution:** 0.1 dBm minimum

# Modulation

## Frequency/Phase Modulation (Option 12)

Option 12 adds frequency and phase modulation, driven externally via a rear panel BNC connector, 50 Ω. For internal modulation, add Internal LF Generator and Pulse Generator Option 27. Frequency/Phase Modulation is not available <10 MHz with Option 22.

For the most accurate FM and ΦM measurements, Bessel Null methods are used. When verifying FM and ΦM, the use of the "carrier null" technique is recommended. Measured residual FM effects must be subtracted from modulation meter measurements.

**Frequency Generator Multiplication/Division Ratios:**

| Frequency Range | Divide Ratio, n |
|---|---|
| < 10 MHz (Option 22) | modulation not available |
| ≥ 10 MHz to ≤ 15.625 MHz (Option 4) | 256 |
| > 15.625 MHz to ≤ 31.25 MHz (Option 4) | 128 |
| > 31.25 MHz to ≤ 62.5 MHz (Option 4) | 64 |
| > 62.5 MHz to ≤ 125 MHz (Option 4) | 32 |
| > 125 MHz to ≤ 250 MHz (Option 4) | 16 |
| > 250 MHz to ≤ 500 MHz (Option 4) | 8 |
| > 500 MHz to ≤ 1050 MHz (Option 4) | 4 |
| > 1050 MHz to ≤ 2200 MHz (Option 4) | 2 |
| > 10 MHz to ≤ 2000 MHz (Option 5) | 1 |
| > 2 GHz to ≤ 20 GHz | 1 |
| > 20 GHz to ≤ 40 GHz | 1/2 |
| > 40 GHz to ≤ 67 GHz | 1/4 |

**Frequency Modulation:**

| Parameter | Modes | Conditions | Specifications | Conditions | Specifications |
|---|---|---|---|---|---|
| | | for all Frequencies other than < 2.2 GHz with Option 4 | | for Frequencies < 2.2 GHz with Option 4 | |
| Deviation | Locked | Rate= 1 kHz to 8 MHz | ± [Lesser of 10 MHz or 300 * (mod rate)]/n | Rate = 1 kHz to (Lesser of 8 MHz or 0.03 * Fcarrier) | ± [Lesser of 10 MHz or 300 * (mod rate)]/n |
| | Locked Low-noise | Rate= 50 kHz to 8 MHz | ± [Lesser of 10 MHz or 3 * (mod rate)]/n | Rate = 50 kHz to (Lesser of 8 MHz or 0.03 * Fcarrier) | ± [Lesser of 10 MHz or 3 * (mod rate)]/n |
| | Unlocked Narrow | Rate= DC to 8 MHz | ± 10 MHz/n | Rate = DC to (Lesser of 8 MHz or 0.03 * Fcarrier) | ± (10 MHz)/n |
| | Unlocked Wide | Rate= DC to 100 Hz | ± 100 MHz/n | Rate = DC to 100 Hz | ± (100 MHz)/n |
| Bandwidth (3 dB) | Locked | | 1 kHz to 10 MHz | | 1 kHz to (Lesser of 10 MHz or 0.03 * Fcarrier) |
| | Locked Low-noise | | 30 kHz to 10 MHz | | 30 kHz to (Lesser of 8 MHz or 0.03 * Fcarrier) |
| | Unlocked Narrow | | DC to 10 MHz | | DC to (Lesser of 10 MHz or 0.03 * Fcarrier) |
| | Unlocked Wide | | DC to 100 Hz | | DC to 100 Hz |
| Flatness | Locked | Rate= 10 kHz to 1 MHz | ± 1 dB relative to 100 kHz | Rate = 10 kHz to (Lesser of 1 MHz or 0.01 * Fcarrier) | ± 1 dB relative to 100 kHz |
| Accuracy | Locked and Low-noise<br>Unlocked Narrow | Rate= 100 kHz sinewave Int. or 1 Vpk Ext. | 10% (5% typical) | Rate= 100 kHz sinewave Int. or 1 Vpk Ext. | 10% (5% typical) |
| Incidental AM | Locked and Low-noise<br>Unlocked Narrow | 1 MHz Rate, ± 1 MHz Dev. | < 2% typical | Rate and Dev.= Lesser of 1 MHz or 0.01 * Fcarrier | < 2% typical |
| Harmonic Distortion | Locked | 10 kHz Rate, ± 1 MHz Dev. | < 1% | Rate = 10 kHz, Dev.= ± (1 MHz)/n | < 1% |
| External Sensitivity | Locked<br>Locked Low-noise<br>Unlocked Narrow<br>Unlocked Wide | (± 1V maximum input) | ± (10 kHz/V to 20 MHz/V)/n<br>〃<br>〃<br>± (100 kHz/V to 100 MHz/V)/n | (± 1 Vpk maximum input) | ± (10 kHz/V to 20 MHz/V)/n<br>〃<br>〃<br>± (100 kHz/V to 100 MHz/V)/n |

**Phase Modulation:**

| Parameter | Modes | Conditions | Specifications | Conditions | Specifications |
|---|---|---|---|---|---|
| | | for all Frequencies other than < 2.2 GHz with Option 4 | | for Frequencies < 2.2 GHz with Option 4 | |
| Deviation | Narrow | Rate= DC to 8 MHz | ± [Lesser of 3 rad or (5 MHz/mod rate)]/n | Rate = DC to (Lesser of 8 MHz or 0.03 * Fcarrier) | ± [Lesser of 3 rad or (5 MHz/mod rate)]/n |
| | Wide | Rate= DC to 1 MHz | ± [Lesser of 400 rad or (10 MHz/mod rate)]/n | Rate = DC to (Lesser of 1 MHz or 0.03 * Fcarrier) | ± [Lesser of 400 rad or (10 MHz/mod rate)]/n |
| Bandwidth (3 dB) | Narrow | | DC to 10 MHz | | DC to (Lesser of 10 MHz or 0.03 * Fcarrier) |
| | Wide | | DC to 1 MHz | | DC to (Lesser of 1 MHz or 0.03 * Fcarrier) |
| Flatness | Narrow | Rate= DC to 1 MHz | ± 1 dB relative to 100 kHz | Rate = DC to (Lesser of 1 MHz or 0.01 * Fcarrier) | ± 1 dB relative to 100 kHz rate |
| | Wide | Rate= DC to 500 kHz | ± 1 dB relative to 100 kHz | Rate = DC to (Lesser of 500 kHz or 0.01 * Fcarrier) | ± 1 dB relative to 100 kHz rate |
| Accuracy | Narrow and Wide | 100 kHz Internal or 1Vpk External, sine | 10% | 100 kHz Internal or 1 Vpk External, sine | 10% |
| External Sensitivity | Narrow<br>Wide | (± 1 V maximum input) | ± (0.0025 rad/V to 5 rad/V)/n<br>± (0.25 rad/V to 500 rad/V)/n | (± 1 Vpk maximum input) | ± (0.0025 rad/V to 5 rad/V)/n<br>± (0.25 rad/V to 500 rad/V)/n |

## Amplitude Modulation (Option 14)

Option 14 adds amplitude modulation, driven externally via a rear panel BNC connector 50 Ω. For internal modulation, add Internal LF and Pulse Generators Option 27.

All amplitude modulation specifications apply at 50% depth, 1 kHz rate, with RF level set 6 dB below maximum specified leveled output power, unless otherwise noted. Amplitude Modulation is not available < 10 MHz with Option 22.

**AM Depth (typical):** 0-90% linear; 20 dB log

**AM Bandwidth* (3 dB):**
DC to 50 kHz minimum
DC to 100 kHz typical

**Flatness (DC to 10 kHz rates):** ± 0.3 dB

**Accuracy:** Reading ± 5%

**Distortion:** < 5% typical

**Incidental Phase Modulation (30% depth, 10 kHz rate):**
<0.2 radians typical

**External AM Input:** Log AM or Linear AM input, rear-panel BNC, 50 Ω input impedance. For internal modulation, add LF Generator Option 27.

**Sensitivity:**

**Log AM:** Continuously variable from 0 dB per volt to 25 dB per volt.
**Linear AM:** Continuously variable from 0% per volt to 100% per volt.

**Maximum Input:** ± 1 Vpk

*Typical below 2.2 GHz, when ordered with Options 4 and 15.

## Pulse Modulation (Option 26)

Option 26 adds pulse modulation, driven externally via a rear panel BNC connector, TTL. For internal modulation, add Internal LF and Pulse Generators Option 27.

Pulse modulation specifications apply at maximum rated power, unless otherwise noted. Pulse modulation is not available < 10 MHz with Option 22.

**On/Off Ratio:** > 80 dB (> 70 dB with high power Option 15)

**Minimum Leveled Pulse Width:**
100 ns, ≥1 GHz
1 µs, <1 GHz

**Minimum Unleveled Pulse Width:** < 10 ns

**Level Accuracy Relative to CW (100 Hz to 1 MHz PRF):**
± 0.5 dB, ≥ 1 µs pulse width
± 1.0 dB, < 1 µs pulse width

**Pulse Delay (typical):** 50 ns in External Mode

**PRF Range:**
DC to 10 MHz, unleveled
100 Hz to 5 MHz, leveled

| Frequency Range | Rise and Fall Time (10% to 90%) | Overshoot | Pulse Width Compression | Video Feedthrough |
|---|---|---|---|---|
| ≥ 10 MHz to < 31.25 MHz (Opt. 4) | 400 ns* | 33%* | 40 ns* | ± 70 mV* |
| ≥ 31.25 MHz to < 125 MHz (Opt. 4) | 90 ns* | 22%* | 12 ns* | ± 130 mV* |
| ≥ 125 MHz to < 500 MHz (Opt. 4) | 33 ns* | 11%* | 12 ns* | ± 70 mV* |
| ≥ 500 MHz to < 2200 MHz (Opt. 4) | 15 ns* | 10% | 12 ns* | ± 50 mV* |
| ≥ 10 MHz to < 1000 MHz (Opt. 5) | 15 ns, 10 ns* | 10% | 8 ns* | ± 30 mV* |
| ≥ 1 GHz to < 2 GHz (Opt. 5) | 10 ns, 5 ns* | 10% | 8 ns* | ± 30 mV* |
| ≥ 2 GHz to 67 GHz③ | 10 ns, 5 ns* | 10%① | 8 ns* | ± 30 mV* |

**External Input:** Rear-panel BNC. For internal modulation, add Pulse Generator Option 27

**Drive Level:** TTL compatible input

**Input Logic:** Positive-true or negative-true, selectable from modulation menu.

## Internal LF and Pulse Generators (Option 27)

An internal pulse generator and two internal waveform generators are added, one providing a frequency or phase modulating signal and the other an amplitude modulating signal. This Internal LF and Pulse Generators option can only be ordered in combination with either FM/ΦM, AM, or Pulse options, 12, 14, and 26 respectively.

**Waveforms:** Sinusoid, square-wave, triangle, positive ramp, negative ramp, Gaussian noise, uniform noise. (Check Option 10 for User-Defined)

**Rate:**
0.1 Hz to 10 MHz sinusoidal
0.1 Hz to 1 MHz square-wave, triangle, ramps

**Resolution:** 0.1 Hz

**Accuracy:** Same as instrument timebase ± 0.014 Hz

**Waveform Outputs:** Two BNC connectors on the rear panel, FM/ΦM OUT and AM OUT

**Pulse Modes:** Singlet, doublet, triplet, quadruplet

**Pulse Triggers:** Free-run, triggered, gated, delayed, triggered with delay, swept-delay

**Pulse Inputs/Outputs:** Video pulse and sync out, rear-panel BNC connectors

| Pulse Parameter | Selectable Clock Rate | |
|---|---|---|
| | Narrow (100 MHz) | Wide (10 MHz) |
| Pulse Width | 10 ns to 160 ms | 100 ns to 1.6 s |
| Pulse Period② | 100 ns to 160 ms | 600 ns to 1.6 s |
| Variable Delay | | |
| Singlet | 0 ms to 160 ms | 0 s to 1.6 s |
| Doublet | 100 ns to 160 ms | 300 ns to 1.6 s |
| Triplet | 100 ns to 160 ms | 300 ns to 1.6 s |
| Quadruplet | 100 ns to 160 ms | 300 ns to 1.6 s |
| Resolution | 10 ns | 100 ns |
| Accuracy | 10 ns (5 ns typical) | 10 ns (5 ns typical) |

① For 50 GHz and 67 GHz units, overshoot > 40 GHz is 20% typical at rated power.
② Period must be longer than the sum of delay and width by 5 clock cycles minimum.
③ Rise time and Pulse Width Compression, > 20 GHz, degrades by 2 ns, with High Power Option 15.
* Typical

## IF Up-Conversion (Option 7)

Option 7 adds an internal mixer that can be used for the generic up-conversion of an IF signal. The mixer's RF, LO, and IF ports are made available at the rear panel of the MG3690C, via three female K-Connectors. The typical application will feed the MG3690C microwave output, which can be moved to the rear panel via option 9K, to the mixer's LO port. An external IF signal will be fed to the mixer's IF port. The new up-converted signal will be available at the mixer's RF port.

| | |
|---|---|
| Mixer Type | Double Balanced |
| RF, LO Range | 1 GHz to 40 GHz |
| IF Range | DC to 700 MHz |
| Conversion Loss | 10 dB Typical |
| Max Power into any Port | 30 dBm |
| Isolation, RF to LO | 23 dB |
| LO Drive Level (recommended) | +10 dBm to +13 dBm |
| Input P1 dB | +3 dBm Typical |

The IF Up-Conversion option is particularly useful to create a microwave frequency IQ-modulated signal. Lower frequency IQ-modulated RF sources are readily available, such as the Anritsu MG3700A. Option 7's IF input can be used to feed in an IQ-modulated signal from an MG3700A, up-converting it to as high as 40 GHz with an MG3694C. A typical setup is shown below.

## User-Defined Modulation Waveform Software (Option 10)

An external software package provides the ability to download user-defined waveforms into the internal LF Generator's (Option 27) memory. The MG3690C provides as standard with the LF Generator sinusoidal, square-wave, triangle, positive ramp, Gaussian noise, and uniform noise waveforms.

Two look-up tables of 65,536 points can be used to generate two pseudo-random waveforms, one for amplitude modulation and the other for frequency or phase modulation. The download files are simple space-delimited text files containing integer numbers between 0 and 4095, where 0 corresponds to the minimum modulation level and 4095 the maximum.

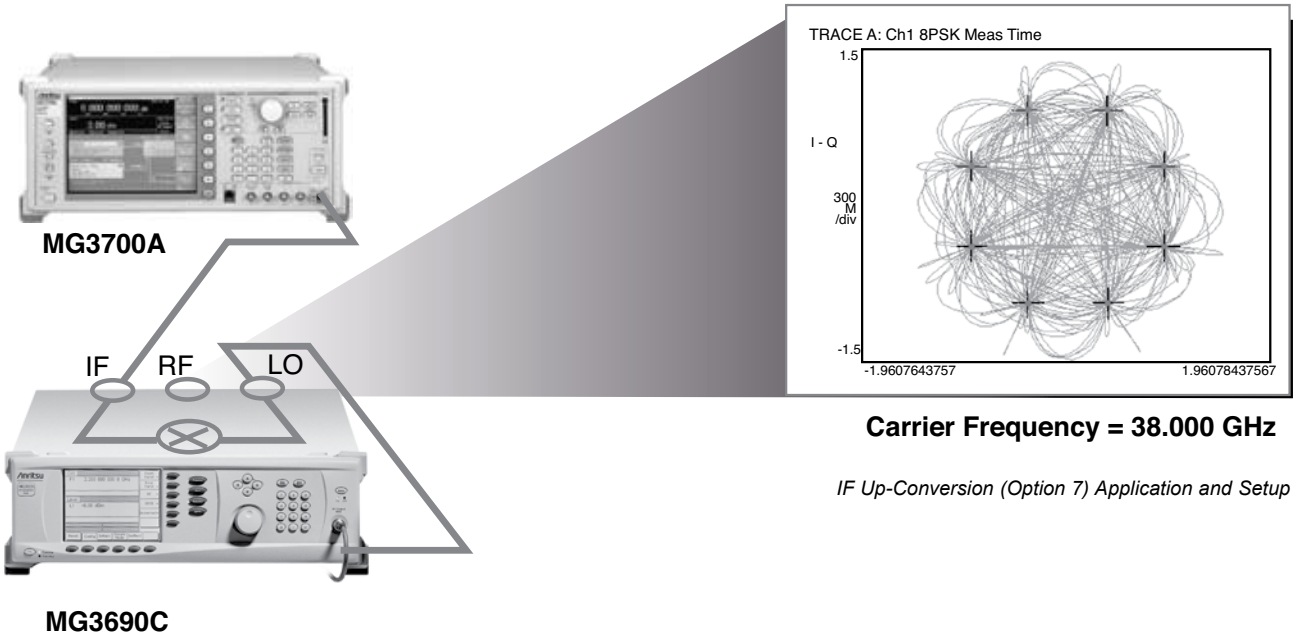
In addition to the capability of downloading custom waveforms, the software offers a virtual instrument modulation panel. Custom modulation setups with user waveforms can be stored for future use. For IFF signal simulation, the internal generators can be synchronized. They can also be disconnected from the internal modulators, making the low frequency waveforms available at the rear panel for external purposes.

## Scan Modulation (Option 20)

Option 20 adds a microwave linearly controlled attenuator to provide deep AM capability. This modulator is inserted outside the leveling loop but before the optional step attenuator. It is switched in and out of the RF path. Scan modulation is driven externally only.

One application of this feature is storing an antenna pattern wave form in memory and using it to feed the external input to the scan modulator, Option 20.

| | |
|---|---|
| Frequency Range | 2 GHz to 18 GHz |
| Attenuation Range | 0 dB to 60 dB |
| Flatness/Accuracy | ± 1.5 dB/± 1.5 dB, 0 to 40 dB<br>± 3 dB/± 2 dB, 40 to 60 dB |
| Step Response | < 1 µs |
| Sensitivity | –10 dB/V |
| Modulation Bandwidth | 20 kHz (small signal)<br>5 kHz (large signal) |
| Insertion Loss | < 6 dB (when engaged) |
| Input | Rear Panel BNC connector<br>High Impedance |




*IF Up-Conversion (Option 7) Application and Setup*

# mmW Frequency Coverage

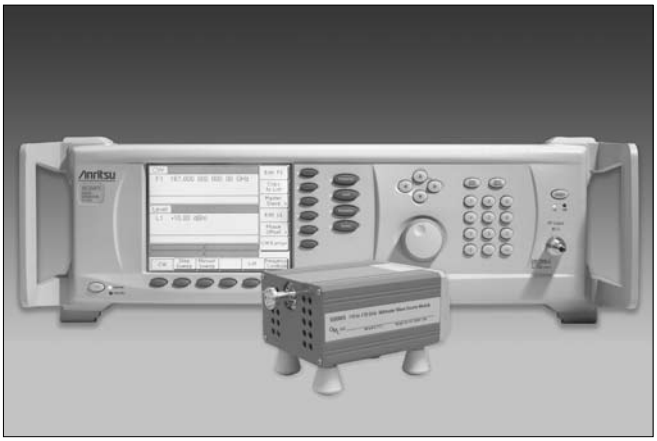
## Millimeter Wave Multipliers[1] - 63850 series
## (Option 18 recommended for DC bias.)

63850 series external, waveguide output, multipliers are available for banded frequency coverage up to 325 GHz.

These external multipliers require at a minimum an MG3692C, with 20 GHz coverage. The output power required to drive the modules is +10 dBm. They can be powered up by an external power supply (+12 Vdc, 1.5A typ.) using the supplied double banana power cord. It is recommended to purchase an MG3690C with option 18, which adds the capability to bias these modules without the need of an additional power supply. Option 18 adds a rear panel Twinax connector that supplies the proper DC bias for these modules, and a cable to power them up. Option 18 is not available with options 7 and 15.

63850 series multipliers have a saturated, unleveled, output power, yet their inherent flatness is exceptional. Modulating the input drive will indeed modulate the output, except for the case of Amplitude Modulation. Since the output is saturated, Amplitude Modulation is not recommended with these mmW modules. Frequency and Phase Modulation is possible, but the achieved deviation will be multiplied based on the multiplication factor of the module. Pulse modulation is also possible, with even sharper rise and fall times than the input. All modulation performances are not specified.

For ease of operation, the MG3690C allows the user to enter a frequency scaling factor, the module's multiplication factor, which will be used only for purposes of displaying the proper frequency at the output of the mmW module, on the MG3690C front panel display.




*MG3690C with 63850 Series Millimeter Wave Multiplier*

| **Multiplier p/n[1]** | **63850-15** | **63850-12** | **63850-10** | **63850-08** | **63850-06** | **63850-05** | **63850-03** |
|---|---|---|---|---|---|---|---|
| Frequency | 50 GHz - 75 GHz | 60 GHz - 90 GHz | 75 GHz - 110 GHz | 90 GHz - 140 GHz | 110 GHz - 170 GHz | 140 GHz - 220 GHz | 220 GHz - 325 GHz |
| Waveguide Output | WR-15 | WR-12 | WR-10 | WR-08 | WR-06 | WR-05 | WR-03 |
| Flange[2] | (008) | (009) | (010) | (M08) | (M06) | (M05) | (M03) |
| Output Power (typical) | +8 dBm | +6 dBm | +5 dBm | –5 dBm | –13 dBm | –15 dBm[3] | –25 dBm[4] |
| Output Flatness (typical) (Unleveled) | ± 2 dB | ± 2 dB | ± 3 dB | — | — | — | — |
| Output Match | > 12 dB | > 12 dB | > 12 dB | > 12 dB | > 12 dB | > 12 dB | 6 dB (typical) |
| Multiplication Factor (m) | x4 | x6 | x6 | x8 | x12 | x12 | x18 |
| Input Frequency | 12.5 GHz - 18.75 GHz | 10.0 GHz - 15.0 GHz | 12.5 GHz - 18.4 GHz | 11.2 GHz - 17.5 GHz | 9.1 GHz - 14.2 GHz | 11.6 GHz - 18.4 GHz | 12.2 GHz - 18.1 GHz |
| Frequency Accuracy | (LO Synthesizer's Accuracy x m) | | | | | | |
| Frequency Resolution | (LO Synthesizer's Resolution x m) | | | | | | |
| Harmonics & Spurious | –15 dBc (typical) | | | | | | |
| Input Power Required | +10 dBm | | | | | | |
| RF Input Connector | SMA (female) | | | | | | |
| DC Power | 12 Vdc, 1.5A (double banana power cord included) Option 18 is recommended on the synthesizer, to supply the necessary bias. | | | | | | |
| Dimensions | 120 mm x 110 mm x 70 mm (not including feet or interfaces) | | | | | | |
| Weight | < 1 kg | | | | | | |
| Temperature | +20 ºC to +30 ºC | | | | | | |

[1] These mmW modules are produced by OML Inc. (Oleson Microwave Labs), located in Morgan Hill, CA., with mutual collaborative experiences over many years. For detailed and up-to-date specifications, please call OML, Inc. or visit their website at www.oml-mmw.com.
[2] Waveguide output flanges are per MIL.F-3922/67B-(xxx)
[3] Power rolls off from –15 dBm at 200 GHz, to –25 dBm typical at 220 GHz.
[4] Output power is estimated.

# Inputs and Outputs*

**EXT ALC IN**
Provides for leveling the RF output signal externally with either a detector or power meter. Signal requirements are shown in the RF Output specifications. BNC type, rear panel.

**RF OUTPUT** (Option 9)**
Provides for RF output from 50 Ω source impedance. Option 9 moves the RF Output connector from the front to the rear panel. K Connector (female) fmax ≤ 40 GHz V Connector (female) fmax ≥ 40 GHz.

**10 MHz REF IN**
Accepts an external 10 MHz ± 50 Hz, 0 dBm to +20 dBm time-base signal. Automatically disconnects the internal high-stability time-base option, if installed. 50 Ω impedance. BNC type, rear panel.

**10 MHz REF OUT**
Provides a 1 Vp-p, AC coupled, 10 MHz signal derived from the internal frequency standard. 50 Ω impedance. BNC type, rear panel.

**HORIZ OUT (Horizontal Sweep Output)**
Provides 0V at beginning and +10V at end of sweep, regardless of sweep width. In CW mode, the voltage is proportional to frequency between 0V at low end and +10V at the high end of range. In CW mode, if CW RAMP is enabled, a repetitive, 0V to +10V ramp is provided. BNC type, rear panel.

**EFC IN**
Provides the capability to frequency modulate the internal crystal oscillator, allowing phase locking the synthesizer inside an external lock loop. Specifications on page 2. BNC type, rear panel.

**AUX I/O (Auxiliary Input/Output)**
Provides for most of the rear panel BNC connections through a single, 25-pin, D type connector. Supports master-slave operation with another synthesizer or allows for a single-cable interface with the Model 56100A Scalar Network Analyzer and other Anritsu instruments (see figure below). 25 pin D-type, rear panel.

**SERIAL I/O**
Provides access to RS-232 terminal ports to support service and calibration functions and master-slave operations. RJ45 type, rear panel.

**IEEE-488 GPIB**
Provides input/output connections for the General Purpose Interface Bus (GPIB). Type 57, rear panel.

**mmW BIAS** (Option 18)**
Provides the bias for the external waveguide multipliers for coverage up to 325 GHz. Twinax, rear panel.

**RF, LO, IF** (Option 7)**
Provides access to an internal IF up-conversion mixer. K Connector (female) 3X, rear panel.

**PULSE TRIG IN (Option 26)**
Accepts an external TTL compatible signal to pulse modulate the RF output signal or to trigger or to gate the optional internal pulse generator. BNC type, rear panel.

**PULSE SYNC OUT (Option 27)**
Provides a TTL compatible signal, synchronized to the internal pulse modulation output. BNC type, rear panel.

**PULSE VIDEO OUT (Option 27)**
Provides a video modulating signal from the internal pulse generator. BNC type, rear panel.

**AM IN (Option 14)**
Accepts an external signal to amplitude modulate the RF output signal, 50 Ω impedance. BNC type, rear panel.

**FM/ΦM IN (Option 12)**
Accepts an external signal to frequency or phase modulate the RF output signal. 50 Ω impedance. BNC type, rear panel.

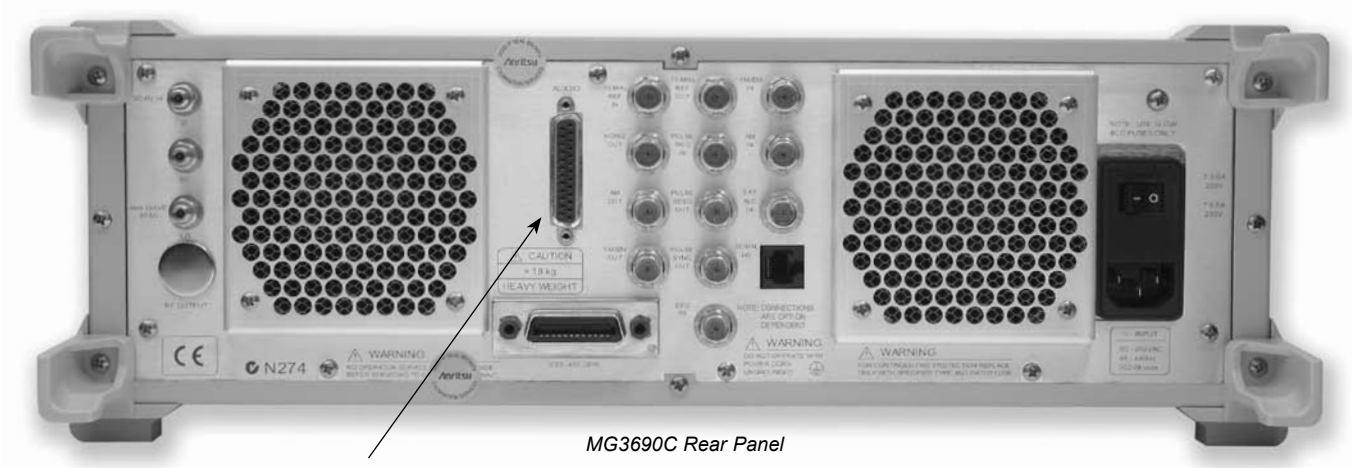
**AM OUT (Option 27)**
Provides the amplitude modulation waveform from the internal LF generator. BNC type, rear panel.

**FM/ΦM OUT (Option 27)**
Provides the frequency or phase modulation waveform from the internal LF generator. BNC type, rear panel.

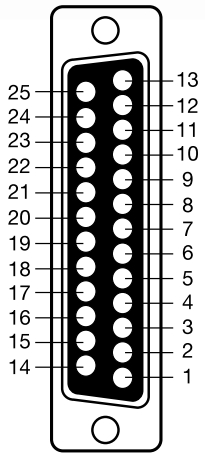
**SCAN MOD IN** (Option 20)**
Accepts an external signal to scan modulate the RF output signal. High Impedance. BNC type, rear panel.

**POWER MONITOR IN (Option 8)**
Accepts an external detector for power monitoring. Custom type, rear panel.

*Connectors may be available but not active, if option is not ordered.
**Options (7 & 18), (7 & 20), (8 & 9) are mutually exclusive, as they share the same rear panel space.




*MG3690C Rear Panel*




**Aux I/O pins:**

1. Horizontal Output
2. Chassis Ground
3. Sequential Sync Output
4. Low Alternate Enable Output
5. Marker Output
6. Retrace Blanking Output
7. Low Alternate Sweep Output
8. Chassis Ground
9. -
10. Sweep Dwell Output
11. Lock Status Output
12. Penlift
13. External Trigger Input
14. V/GHz Output
15. End-of-Sweep Input
16. End-of-Sweep Output
17. -
18. Sweep Dwell Input
19. -
20. Bandswitch Blanking Output
21. Master Reset
22. Horizontal Sweep Input
23. Horizontal Sweep Input Return
24. Chassis Ground
25. Memory Sequencing Input

# Ordering Information

## *Models*

| | |
|---|---|
| MG3691C | 2 GHz - 10 GHz Signal Generator |
| MG3692C | 2 GHz - 20 GHz Signal Generator |
| MG3693C | 2 GHz - 31.8 GHz Signal Generator |
| MG3694C | 2 GHz - 40 GHz Signal Generator |
| MG3695C | 2 GHz - 50 GHz Signal Generator |
| MG3697C | 2 GHz - 67 GHz Signal Generator (operational to 70 GHz) |

## *Options and Accessories*

| | |
|---|---|
| MG3690C/1A | Rack Mount with slides – Rack mount kit containing a set of track slides (90 degree tilt capability), mounting ears, and front panel handles to let the instrument be mounted in a standard 19-inch equipment rack. |
| MG3690C/1B | Rack Mount without slides – Modifies rack mounting hardware to install unit in a console that has mounting shelves. Includes mounting ears and front panel handles. |
| MG3690C/2A<br>MG3690C/2B<br>MG3690C/2C | Mechanical Step Attenuator – Adds a 10 dB/step attenuator. Rated RF output power is reduced. (This option comes in different versions, based on instrument configuration) |
| MG3690C/2E | Electronic Step Attenuator – Adds a 10 dB/step electronic attenuator with a 120 dB range for the MG3691C. Rated RF output power is reduced. (Not available with Option 20 or 22) |
| MG3690C/3 | Ultra Low Phase Noise – Adds new modules to significantly reduce SSB phase noise. (Not available with Option 3X) |
| MG3690C/3X | Premium Phase Noise, improves Option 3 (< 1 kHz offset). (Not available with Option 3) |
| MG3690C/4 | 8 MHz to 2.2 GHz RF coverage, Ultra-Low Phase Noise version – Uses a digital down converter to significantly reduce SSB phase noise. All specifications apply ≥ 10 MHz. |
| MG3690C/5 | 8 MHz to 2 GHz RF coverage – Uses an analog down converter. All specifications apply ≥ 10 MHz. |
| MG3690C/6 | Analog Sweep Capability – (limited to ≥ 500 MHz when used with Option 4) |
| MG3690C/7 | IF Up-Conversion – Adds an internal 40 GHz mixer for up-converting an IF signal. (Not available with MG3695C, MG3696C, or with Options 18 or 20) |
| MG3690C/8 | Power Monitor – Adds internal power measurement capability. (Not available with Option 9) |
| MG3690C/9K<br>MG3690C/9V | Rear Panel Output – Moves the RF output connector to the rear panel. (This option comes in different versions, based on instrument configuration) (Not available with Option 8) |
| MG3690C/10 | User-Defined Modulation Waveform Software – External software package provides the ability to download user-defined waveforms into the memory of the internal waveform generator, serially or via GPIB. External PC and an instrument with LF Generator, Option 27, are required. |
| MG3690C/12 | Frequency and Phase Modulation – External, via a rear panel BNC connector. For internal modulation capability, requires additionally LF Generator, Option 27. |
| MG3690C/14 | Amplitude Modulation – External, via a rear panel BNC connector. For internal modulation capability, requires additionally LF Generator, Option 27. |
| MG3690C/15A<br>MG3690C/15B<br>MG3690C/15C<br>MG3690C/15D | High Power – Adds high-power RF components to the instrument to increase its output power level. (This option comes in different versions, based on instrument configuration) |
| MG3690C/16 | High Stability Time Base – Adds an ovenized, 10 MHz crystal oscillator as a high-stability time base. |
| MG3690C/17 | Delete Front Panel – Deletes the front panel for use in remote control applications where a front panel display and keyboard control are not needed. (Only available with Options 1A or 1B) |
| MG3690C/18 | mmW Bias Output – Adds a rear panel BNC Twinax connector required to bias the 63850 series millimeter wave source modules, sold separately. Includes DC bias cable. (Not available with Option 7 or 15x) |
| MG3690C/20 | Scan Modulation – Adds an internal Scan modulator for simulating high-depth amplitude modulated signals. Requires an external modulating signal input capability. (Not available on models MG3693C, MG3694C, MG3695C, MG3696C, or with Options 2E, 7, 15X, or 22) |
| MG3690C/22 | 0.1 Hz to 10 MHz Audio coverage – Uses a DDS for coverage down to approximately DC. When adding Option 22, the output power is derated by 2 dB. The frequency resolution below 10 MHz is 0.02 Hz. No modulation is available in the 0.1 Hz to 10 MHz band. (Not available without Option 4 or 5, or with Option 20 or 2E) |
| MG3690C/26A<br>MG3690C/26B | Pulse Modulation – External, via a rear panel BNC connector. For internal modulation capability, requires additionally Pulse Generator, Option 27. (This option comes in different versions, based on instrument configuration) |
| MG3690C/27 | Internal LF and Pulse Generators – Provides modulation waveforms for internal AM, FM, ΦM and Pulse. (Not available without Option 12, 14, or 26) |
| MG3690C/28A<br>MG3690C/28B | Analog Modulation Suite – For ease of ordering and package pricing, this option bundles Options 12, 14, 26 and 27, offering internal and external AM, FM, ΦM, and Pulse Modulation. (This option comes in different versions, based on instrument configuration) |

## *Millimeter Wave Accessories (Option 18 recommended for DC bias)*

| | |
|---|---|
| 63850-15 | 50 GHz - 75 GHz V band Multiplier Source Module, WR-15 |
| 63850-12 | 60 GHz - 90 GHz E band Multiplier Source Module, WR-12 |
| 63850-10 | 75 GHz - 110 GHz W band Multiplier Source Module, WR-10 |
| 63850-08 | 90 GHz - 140 GHz F band Multiplier Source Module, WR-08 |
| 63850-06 | 110 GHz - 170 GHz D band Multiplier Source Module, WR-06 |
| 63850-05 | 140 GHz - 220 GHz G band Multiplier Source Module, WR-05 |
| 63850-03 | 220 GHz - 325 GHz H band Multiplier Source Module, WR-03 |
| 806-121 | SMA male-male flexible cable, 90 cm (3 ft) (could be used to connect the MG3690C output to the module's LO input) |

## *Accessories*

| | |
|---|---|
| 34RKNF50 | DC to 20 GHz, Ruggedized Type N female adapter for units with a K connector output |
| ND36329 | MASTER/SLAVE interface cable set |
| 63270 | Transit case (16 kg, 66 cm x 41 cm x 81 cm, roll-away on four wheels) |
| 2300-469 | IVI Driver, includes LabView® driver |
| 806-97 | Aux I/O Cable, 25 pin to BNC: Provides BNC access to Aux I/O Data Lines: Sequential Sync, Marker Out, Bandswitch Blanking, Retrace Blanking, Sweep Dwell In, V/GHz, Horizontal Out. |

## *Upgrades*

Economical upgrades are available to upgrade any model to any higher performing model. Consult Anritsu for details.

**MG3690C OPTION CONFIGURATION GUIDE – Important: Please see footnotes where applicable**

| MODELS | OPTIONS | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OPT 1 | | OPT 2 | | | | OPT 3 | OPT 3X | OPT 4 | OPT 5 | OPT 6 | OPT 7 | OPT 8 | OPT 9 | | OPT 10 | OPT 12 | OPT 14 |
| | 1A | 1B | 2A | 2B | 2C | 2E | | | | | | | | 9K | 9V | | | |
| MG3691C | • | • | • | | | • 9,11 | • 13 | • 13 | • 1 | • 1 | • | • 2,12 | • 8 | • 8 | | • 3 | • | • |
| MG3692C | • | • | • | | | | • 13 | • 13 | • 1 | • 1 | • | • 2,12 | • 8 | • 8 | | • 3 | • | • |
| MG3693C | • | • | | • | | | • 13 | • 13 | • 1 | • 1 | • | • 2,12 | • 8 | • 8 | | • 3 | • | • |
| MG3694C | • | • | | • | | | • 13 | • 13 | • 1 | • 1 | • | • 2,12 | • 8 | • 8 | | • 3 | • | • |
| MG3695C | • | • | | | • | | • 13 | • 13 | • 1 | • 1 | • | | • 8 | | • 8 | • 3 | • | • |
| MG3697C | • | • | | | • | | • 13 | • 13 | • 1 | • 1 | • | | • 8 | | • 8 | • 3 | • | • |

| MODELS | OPTIONS | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OPT 15 | | | | OPT 16 | OPT 17 | OPT 18 | OPT 20 | OPT 22 | OPT 26 | | OPT 27 | OPT 28 | | OPT 98 | OPT 99 |
| | 15A | 15B | 15C | 15D | | | | | | 26A | 26B | | 28A | 28B | | |
| MG3691C | • 12 | | | | • | • 10 | • 2,12 | • 9 | • 5,11 | • | | • 6 | • 7 | | • | • |
| MG3692C | • 12 | | | | • | • 10 | • 2,12 | • 9 | • 5 | • | | • 6 | • 7 | | • | • |
| MG3693C | | • 12 | | | • | • 10 | • 2,12 | | • 5 | • | | • 6 | • 7 | | • | • |
| MG3694C | | • 12 | | | • | • 10 | • 2,12 | | • 5 | | • | • 6 | | • 7 | • | • |
| MG3695C | | | • 12 | | • | • 10 | • 12 | | • 5 | | • | • 6 | | • 7 | • | • |
| MG3697C | | | | • 12 | • | • 10 | • | | • 5 | | • | • 6 | | • 7 | • | • |

**Footnote 1** **Options 4** and **5 CAN NOT** be ordered together

**Footnote 2** **Options 7** and **18 CAN NOT** be ordered together
**Options 7** and **20 CAN NOT** be ordered together

**Footnote 3** **Option 10 CAN ONLY** be ordered **with either Options 27 or 28**

**Footnote 5** **Option 22 CAN ONLY** be ordered **with either Options 4 or 5**
**Option 22 CAN NOT** be ordered **with Option 20**

**Footnote 6** **Option 27 CAN ONLY** be ordered **with either Options 12, 14 or 26 (in any combination)**

**Footnote 7** **Option 28 CAN NOT** be ordered along with either **Options 12, 14, 26, or 27**

**Footnote 8** **Option 8 CAN NOT** be ordered along with **Option 9**

**Footnote 9** **Option 20 CAN NOT** be ordered with **Option 2E, Option 7, Option 15 or Option 22**

**Footnote 10** **Option 17 CAN ONLY** be ordered with either **Option 1A or 1B**

**Footnote 11** **Option 2E CAN NOT** be ordered with **Option 22**

**Footnote 12** **Option 18 CAN NOT** be ordered with **Option 15 or 7,**
**Option 15 CAN NOT** be ordered with **Option 20**

**Footnote 13** **Option 3 CAN NOT be ordered with Option 3X and visa versa.**

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