AFG2021
Arbitrary Function Generator
Specifications and Performance Verification

Technical Reference

www.tektronix.com

077-0588-01

Tektronix

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- In North America, call 1-800-833-9200.
- Worldwide, visit www.tektronix.com to find contacts in your area.

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[W2 – 15AUG04]

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General safety summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

To avoid fire or personal injury

Use proper power cord. Use only the power cord specified for this product and certified for the country of use.

Ground the product. This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

Observe all terminal ratings. To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Power disconnect. The power cord disconnects the product from the power source. Do not block the power cord; it must remain accessible to the user at all times.

Do not operate without covers. Do not operate this product with covers or panels removed.

Do not operate with suspected failures. If you suspect that there is damage to this product, have it inspected by qualified service personnel.

Avoid exposed circuitry. Do not touch exposed connections and components when power is present.

Do not operate in wet/damp conditions.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry.

Provide proper ventilation. Refer to the manual's installation instructions for details on installing the product so it has proper ventilation.

Terms in this manual

These terms may appear in this manual:

WARNING. *Warning statements identify conditions or practices that could result in injury or loss of life.*

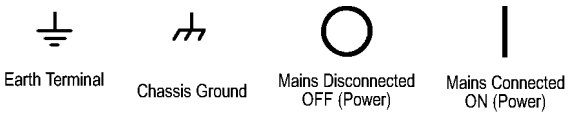
CAUTION. *Caution statements identify conditions or practices that could result in damage to this product or other property.*

Symbols and terms on the product

These terms may appear on the product:

- DANGER indicates an injury hazard immediately accessible as you read the marking.
- WARNING indicates an injury hazard not immediately accessible as you read the marking.
- CAUTION indicates a hazard to property including the product.

The following symbol(s) may appear on the product:



Service safety summary

Only qualified personnel should perform service procedures. Read this *Service Safety Summary* and the *General Safety Summary* before performing any service procedures.

Do not service alone.. Do not perform internal service or adjustments of this product unless another person capable of rendering first aid and resuscitation is present.

Disconnect power. To avoid electric shock, disconnect the mains power by means of the power cord or, if provided, the power switch.

Use care when servicing with power on. Dangerous voltages or currents may exist in this product. Disconnect power, remove battery (if applicable), and disconnect test leads before removing protective panels, soldering, or replacing components.

To avoid electric shock, do not touch exposed connections.

Preface

This manual provides instructions to verify the performance of the AFG2021 Arbitrary Function Generator to the module level.

To prevent personal injury or damage to the arbitrary function generator, consider the following before attempting service:

- The procedures in this manual should be performed only by a qualified service person.
- Read the *General Safety Summary* and the *Service Safety Summary* at the beginning of this document.

When using this manual for servicing, be sure to follow all warnings, cautions, and notes.

The manual consists of the following sections:

- *Specifications* contains a description of the arbitrary function generator and the characteristics that apply to it.
- *Performance Verification* contains procedures for confirming that the arbitrary function generator functions properly and meets warranted limits.

  The procedures described in this document should be performed every 12 months or after module replacement.

  If the instruments do not meet performance criteria, repair is necessary.

Finding other information

This manual focuses on the performance verification of the arbitrary function generator. See the following list for other documents supporting the instrument. All documents except the Online Help are on the AFG2021 Arbitrary Function Generator Documentation CD-ROM that ship with instrument.

Document	Description
AFG2021 Quick Start User Manual	A quick reference to major features of the instrument and how they operate. It also provides several tutorials to familiarize you with basic instrument features.
AFG2021 Programmer Manual	An encyclopedia of topics that describe the arbitrary function generator interface and features, and gives background information on how to use them. It provides Menu Structures, User Interface, and Programming Information.
AFG2021 Online Help	A online help system, integrated with the User Interface application that ships with this product. The help is preinstalled in the instrument.

Manual conventions

This manual uses certain conventions that you should become familiar with.

Modules

Throughout this manual, any replaceable component, assembly, or part of the arbitrary function generator is referred to generically as a module. In general, a module is an assembly (such as a circuit board). Sometimes a single component is a module; for example, the chassis of the arbitrary function generator is a module.

Safety

Symbols and terms related to safety appear in the Safety Summary near the beginning of this manual.

Specifications

These specifications apply to the AFG2021 Arbitrary Function Generator. All specifications are guaranteed unless labeled "typical". Typical specifications are provided for your convenience but are not guaranteed.

Specifications that are check marked with the ✓ symbol are checked directly (or indirectly) in the Performance Verification section.

All specifications apply to the arbitrary function generator unless noted otherwise. These specifications are valid under the following conditions:

- The instrument must have been calibrated/adjusted at an ambient temperature between +20 °C and +30 °C.
- The instrument must be operating at an ambient temperature between 0 °C and +50 °C.
- The instrument must have had a warm-up period of at least 20 minutes.
- The instrument must be in an environment with temperature, altitude, and humidity within the operating limits described in these specifications.

Electrical specifications

Table 1: Operating mode

Characteristic	Description
Run mode	Continuous, Modulation, Sweep, and Burst
Burst count	1 to 1,000,000 cycles or infinite
Internal trigger rate	1.000 µs to 500.0 s

Table 2: Waveforms

Characteristic	Description
Standard	Sine, Square, Pulse, Ramp, More (Sin(x)/x, Noise, DC, Gaussian, Lorentz, Exponential Rise, Exponential Decay, and Haversine)
Arbitrary waveform	
Waveform length	2 to 131,072
Sampling rate	250 MS/s
Resolution	14 bits
Number of non-volatile waveform memories	4

Table 3: Frequency/Period

Characteristic	Description	PV ref page
Frequency range		
Sine	1 µHz to 20 MHz 1 µHz to 10 MHz (Trigger/Gated Burst mode)	
Square	1 µHz to 10 MHz	
Pulse	1 mHz to 10 MHz	
Ramp, Sin(x)/X, Gaussian, Lorentz, Exponential Rise, Exponential Decay, Haversine	1 µHz to 200 kHz	
Arbitrary	1 mHz to 10 MHz 1 mHz to 5 MHz (Trigger/Gated Burst mode)	
Noise bandwidth (-3 dB), typical	20 MHz	
Resolution	1 µHz or 12 digits	
✓ Accuracy (stability)	±1 ppm, 0 °C to 50 °C (except Arb) ±1 ppm ±1 µHz, 0 °C to 50 °C (Arb)	(See page 22, *Frequency/Period test*.)
✓ Accuracy (aging)	±1 ppm/year	

Table 4: Phase (except DC, noise, and pulse)

Characteristics	Description
Range [1]	–360.00° to +360.00°

1 Resolution: 0.01° (sine), 0.1° (other standard waveforms)

Table 5: Lead delay (pulse)

Characteristic	Description
Range	
Continuous mode	0 ps to period
Triggered/Gated Burst mode	0 ps to period – [pulse width + 0.8 * (leading edge time + trailing edge time)]
Resolution	10 ps or 8 digits

Table 6: Amplitude

Characteristic	Description	PV ref page
Range	10 mV_{p-p} to 10 V_{p-p} 20 mV_{p-p} to 20 V_{p-p} (into open circuit load)	
✓ Accuracy	±(1% of setting +1 mV) (at 1 kHz sine waveform), 0 V offset, >10 mV_{p-p} amplitude	(See page 23, *Amplitude test*.)
Resolution	0.1 mV_{p-p}, 0.1 mV_{rms}, 1 mV, 0.1 dBm or 4 digits	
Units [1]	V_{p-p}, V_{rms}, dBm, and Volt (High level and Low level)	
Output impedance	50 Ω	
Isolation [2]	< 42 V_{pk} maximum to earth	

[1] dBm is used only for sine waveform. V_{rms} is not available for Arb and Noise waveforms.

[2] To prevent electrical shock, use this product so that the sum of the floating voltage and the output voltage of the generator does not exceed 42 V_{pk}. Do not touch the center of the BNC while the equipment is in use.

Table 7: DC offset

Characteristic	Description	PV ref page
Range	±5 $V_{pk\ ac+dc}$ into 50 Ω load ±10 $V_{pk\ ac+dc}$ into open circuit load	
✓ Accuracy [1]	±(1% of |setting| +5 mV + 0.5% of amplitude (V_{p-p})) (|setting| ≤ 5 V)	(See page 25, *DC offset test*.)
Resolution	1 mV	
Output impedance	50 Ω	

[1] Add 0.5 mV per °C for operation outside the range of 20 °C to 30 °C.

Table 8: Internal noise add

Characteristic	Description
Range	0% to 50% of amplitude setting
Resolution	1%

[1] When Noise Add In is selected, the amplitude of the signal will become half of the amplitude.

Table 9: Output characteristics

Characteristic	Description	PV ref page
Sine wave		
✓ Flatness	(at 1.0 V_{p-p} amplitude (+4 dBm), relative to 100 kHz) < 5 MHz: ±0.15 dB 5 MHz ≤ frq ≤ 20 MHz: ±0.3 dB	(See page 26, *AC flatness test*.)
✓ Harmonic distortion	(at 1.0 V_{p-p} amplitude) 10 Hz ≤ frq < 20 kHz: < –70 dBc 20 kHz ≤ frq < 1 MHz: < –60 dBc 1 MHz ≤ frq ≤ 10 MHz: < –50 dBc 10 MHz ≤ frq ≤ 20 MHz: < –40 dBc	(See page 28, *Harmonics distortion test*.)
✓ Total harmonic distortion (THD)	(at 1 V_{p-p} amplitude) 10 Hz to 20 kHz: < 0.2%	(See page 29, *Total harmonic distortion test*.)
✓ Spurious (nonharmonic)	(at 1 V_{p-p} amplitude) 10 Hz ≤ frq < 1 MHz: < –60 dBc 1 MHz ≤ frq ≤ 20 MHz: < –50 dBc	(See page 32, *Spurious test*.)
Phase noise, typical	(at 1 V_{p-p} amplitude) 20 MHz: < –110 dBc/Hz at 10 kHz offset	
Residual clock noise, typical	–63 dBm	
Square wave		
✓ Rise time/fall time	≤ 18 ns	(See page 34, *Rise-Fall time test*.)
Jitter (rms), typical	500 ps	
Pulse		
Pulse width	30 ns to 999.99 s	
Resolution	10 ps or 5 digits	
Pulse duty	0.001% to 99.999%	
Leading edge/trailing edge transition time	(at 10% to 90% of amplitude) 18 ns to 0.625 * pulse period	
Resolution	10 ps or 4 digits	
Overshoot, typical	< 5%	
Jitter (rms), typical	500 ps	
Ramp		
Linearity, typical	(at frequency: 1 kHz, amplitude: 1 V_{p-p}, symmetry: 100%) ≤ 0.1% of peak output at 10% to 90% of amplitude range	
Symmetry	0% to 100%	
Arbitrary		
Rise time/fall time, typical	≤ 20 ns	
Jitter (rms), typical	4 ns	

Table 10: Modulation

Characteristic	Description
AM (Amplitude Modulation)	
Carrier waveforms	Standard waveforms (except Pulse, DC, and Noise) and Arb
Modulation source	Internal or External
Internal modulating waveforms	Sine, Square, Ramp, Noise, and Arb [1]
Internal modulating frequency	2 mHz to 50.0 kHz
Depth	0.0% to 120.0%
FM (Frequency Modulation)	
Carrier waveforms	Standard waveforms (except Pulse, DC, and Noise) and Arb
Modulation source	Internal or External
Internal modulating waveforms	Sine, Square, Ramp, Noise, and Arb [2]
Internal modulating frequency	2 mHz to 50.0 kHz
Peak deviation	DC to 10 MHz
PM (Phase Modulation)	
Carrier waveforms	Standard waveforms (except Pulse, DC, and Noise) and Arb
Modulation source	Internal or External
Internal modulating waveforms	Sine, Square, Ramp, Noise, and Arb [2]
Internal modulating frequency	2 mHz to 50.0 kHz
Phase deviation range	0.0 to 180.0 degrees
FSK (Frequency Shift Keying)	
Carrier waveforms	Standard waveforms (except Pulse, DC, and Noise) and Arb
Modulation source	Internal or External
Internal key rate	2 mHz to 1.0 MHz
Number of keys	2
PWM (Pulse Width Modulation)	
Carrier waveforms	Pulse
Modulation source	Internal or External
Internal modulating waveforms	Sine, Square, Ramp, Noise, and Arb [2]
Internal modulating frequency	2 mHz to 50.0 kHz
Deviation range	0.0% to 50.0% of pulse period
Sweep	
Type	Linear or Logarithmic
Start/stop frequency [3]	1 µHz to 20 MHz
Sweep/hold/return time [4]	

Table 10: Modulation (cont.)

Characteristic	Description
Range	1 ms to 300 s (sweep time) 0 ms to 300 s (hold/return time)
Resolution	1 ms or 4 digits
Total sweep time accuracy, typical	≤ 0.4%

1 The maximum waveform length for Arb is 4,096. Waveform data points over 4,096 are ignored.

2 The maximum waveform length for Arb is 2,048. Waveform data points over 2,048 are ignored.

3 Pulse, DC, and Noise waveforms are not available. Start and stop frequencies depend on the waveform shape.

4 Total sweep time = Sweep time + Hold time + Return time ≤ 300 s

Input and output specifications

Table 11: Front panel

Characteristic	Description
Trigger output	
Level	Positive TTL level pulse into 1 kΩ
Impedance	50 Ω
Jitter (rms), typical	500 ps
Trigger input	
Level	TTL compatible
Pulse width	100 ns minimum
Impedance	10 kΩ
Slope	Positive/negative selectable
Trigger delay	0.0 ns to 85.0 s
Resolution	100 ps or 5 digits
Jitter (rms), typical	<500 ps (Trigger input to Signal output at Burst mode)

Table 12: Rear panel

Characteristic	Description
External modulation input	
Input range	±1.0 V full scale (except FSK) 3.3 V logic level (FSK)
Impedance	10 kΩ
Frequency range	AM, FM, PM, FSK, PWM: DC to 25 kHz (sampling rate: 122 kS/s)
10 MHz Reference input	
Impedance	1 KΩ, AC coupled
⩘ Required input voltage swing	100 mV_{pp} to 5 V_{pp}
⩘ Lock range	10 MHz ±35 kHz

General specifications

WARNING. *To reduce the risk of fire and shock, ensure that the mains supply voltage fluctuations do not exceed 10% fot he operating voltage range.*

Table 13: Power

Characteristic	Description
Source voltage and frequency	100 V to 240 V, 50 Hz to 60 Hz 115 V, 400 Hz
Power consumption	60 W

Table 14: Export control

Characteristic	Description
Effective analog bandwidth, typical	(Arbitrary waveform at 1 V_{pp} amplitude) 34 MHz
Effective maximum frequency out	20 MHz
Effective frequency switching speed, typical	2 ms via remote control
Phase noise	(At 1 V_{pp} amplitude) At 20 MHz: < –110 dBc/Hz at 10 KHz offset

Table 15: Environmental

Characteristic	Description
Temperature range	
Operating	0 °C to +50 °C
Non operating	-30 °C to +70 °C

Table 15: Environmental (cont.)

Characteristic	Description
Humidity	
Operating	≤ 80%, 0°C to +40 °C ≤ 60%, < +40 °C to +50 °C, non-condensing
Altitude	
Operating	Up to 3,000 meters (apx. 9843 feet)
Non operating	Up to 12,000 meters (apx. 39,370 feet)

Table 16: System characteristics

Characteristic	Description		
Warm-up time, typical	20 minutes minimum		
Power on self diagnostics, typical	< 10 s		
Configuration times, typical	*USB*	*LAN*	*GPIB*
Function change	95 ms	103 ms	84 ms
Frequency change	2 ms	19 ms	2 ms
Amplitude change	60 ms	67 ms	52 ms
Select user Arb	88 ms	120 ms	100 ms
Data download, typical	4 K points waveform data (8 Kbytes) GPIB: 42 ms USB: 20 ms LAN: 84 ms		
Acoustic noise, typical	< 50 dBA		
Net weight	2.87 kg (6.3 lbs), approximate		
Dimensions (overall)			
Height	104.24 mm (4.10 in)		
Width	241 mm (9.52 in)		
Depth	419.1 mm (16.50 in), including handle and rear boot		

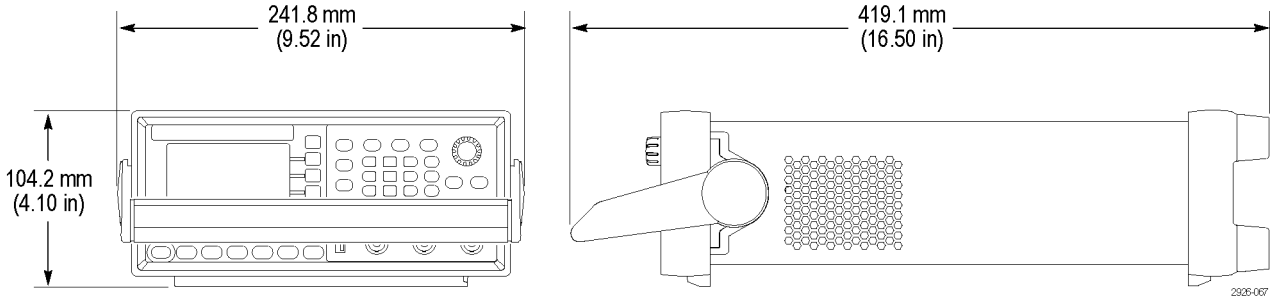


Figure 1: AFG2021 dimensions

Performance verification

Two types of Performance Verification procedures can be performed on this product: Self Tests and Performance Tests. You might not need to perform all of these procedures, depending on what you want to accomplish.

- To quickly confirm that the instrument is operating properly, complete the Self Tests.
  - Advantage: These procedures require minimal time to perform, and test the internal hardware of the instrument.
- To further check functionality and proper calibration, first complete the Self Tests; then complete the Performance Tests.
  - Advantages: These procedures add direct checking of warranted specifications. These procedures require suitable test equipment and more time to execute. (See Table 19 on page 17.)

Self tests

There are two types of tests in this section that provide a quick way to confirm basic functionality and proper adjustment:

- Diagnostics
- Calibration (perform the calibration before the performance tests.)

These procedures use internal diagnostics to verify that the instrument passes the internal circuit tests, and calibration routines to check and adjust the instrument internal calibration constants. Observe the following prerequisites before starting the procedures:

- Power on the instrument and allow a 20 minute warm-up before doing this procedure
- The instrument must be operating at an ambient temperature between +0 °C and +50 °C.

Diagnostics

Do the following steps to run the internal routines that confirm basic functionality and proper adjustment:

1. Select Diagnostics in the Utility menu:

   Utility (front-panel) > -more- (bezel) > Diagnostics/Calibration > Execute Diagnostics

2. Wait until the test is completed.

3. Verify passing of the diagnostics.

   If the diagnostics completes without finding any problems, the message "PASSED" is displayed.

   When an error is detected during diagnostic execution, the instrument displays an error code. Error codes are described in Error codes on (See page 15, *Error codes*.)

4. Press any front-panel button to exit the diagnostics.

Calibration

Do the following steps to run the internal routines that confirm basic functionality and proper adjustment:

1. Select Diagnostics in the Utility menu;

   Utility (front-panel) > -more- (bezel) > Diagnostics/Calibration > Execute Calibration

2. Wait until the test is completed.

3. Verify passing of the calibration.

   If the calibration completes without any problems, the message "PASSED" is displayed.

   When an error is detected during calibration execution, the instrument displays an error code. Error codes are described in Error Codes on (See page 15, *Error codes*.)

4. Press any front-panel button to exit the calibration.

NOTE. *Do not turn off the power while executing calibration. If the power is turned off during calibration, data stored in internal nonvolatile memory may be lost.*

Error codes

If Diagnostics detects a malfunction, it displays the character string “Fail” and the error code. The following table describes the Error code and related modules Category of the Diagnostics/Calibration Error Codes.

Table 17: Error codes

Error code	Description
	— Calibration Error Codes—
1101	Internal offset calibration failure
1103	Output offset calibration failure
1105	Output gain Calibration failure
1201	x3dB attenuator calibration failure
1203	x6dB attenuator calibration failure
1205	x10dB attenuator calibration failure
1207	x20dB 1 attenuator calibration failure
1209	x20dB 2 attenuator calibration failure
1211	Filter calibration failure
1301	Sine Flatness calibration failure
1401	ASIC TINT calibration failure
1403	ASIC SGEN calibration failure
1405	ASIC clock duty calibration failure
	— Diagnostics Error Codes—
2100	Calibration data not found
2101	Calibration data checksum
2102	Calibration data invalid
2201	ASIC1 memory failure
2203	ASIC1 Overheat
	— Output Diagnostics Error Codes —
2301	Internal offset failure
2303	Output offset failure
2305	Output gain failure
2401	x3dB attenuator failure
2403	x6dB attenuator failure
2405	x10dB attenuator failure
2407	x20dB 1 attenuator failure
2409	x20dB 2 attenuator failure
2411	Filter failure
2501	Sine Flatness failure

Performance tests

The Performance Tests include functional tests, such as the interface functional test, in this manual.

- The Functional Tests verify the functions; they verify that the instrument features operate. They do not verify that they operate within limits.
- The Performance Tests verify that the instrument performs as warranted. The Performance Tests check all the characteristics that are designated as checked in Specifications.

Table 18: Performance test items

Titles	Test items	Reference Page
Frequency/Period Test	Internal clock output frequency accuracy	(See page 22, *Frequency/Period test*.)
Amplitude Test	Amplitude accuracy	(See page 23, *Amplitude test*.)
DC Offset Test	Amplitude accuracy	(See page 25, *DC offset test*.)
AC Flatness Test	AC Flatness	(See page 26, *AC flatness test*.)
Harmonic Distortion Test	Harmonic Distortion	(See page 28, *Harmonics distortion test*.)
THD (Total Harmonic Distortion) Test	Total Harmonic Distortion	(See page 29, *Total harmonic distortion test*.)
Spurious Test	Spurious	(See page 32, *Spurious test*.)
Rise-Fall Time Test	Rise-Fall Time	(See page 34, *Rise-Fall time test*.)

Performance conditions

The tests in this section comprise an extensive, valid confirmation of performance and functionality when the following requirements are met:

- The cabinet covers must be on the Series.
- The instrument must have been performed and passed the procedures under calibration and diagnostics.
- The instrument must have been calibrated/adjusted at an ambient temperature between +20 °C and +30 °C.
- The instrument must be operating at an ambient temperature between +0 °C and +50 °C.
- The instrument must have had a warm-up period of at least 20 minutes.

Equipment required

The following table lists the required equipment used to complete the performance tests.

Table 19: Test equipment

Description	Minimum requirements	Recommended equipment	Purpose
1. Digital Multi Meter (DMM)	AC volts, true rms, AC coupled Accuracy: ±0.1% to 1 kHz DC volts Accuracy: 50 ppm, resolution 100 µV Resistance Accuracy: ± 0.05 Ω	Agilent 3458A	Measures voltage. Used in multiple procedures.
2. Power Meter	100 kHz to 250 MHz 1 µW to 100 mW (-30 dBm to +20 dBm) Accuracy: 0.02 dB Resolution: 0.01 dB	R&S NRVS	Measures voltage. Used in multiple procedures.
3. Power Head	100 kHz to 250 MHz 1 µW to 100 mW (-30 dBm to +20 dBm)	R&S NRV-Z5	Measures voltage. Used in multiple procedures.
4. Frequency Counter	Accuracy: 0.01 ppm Phase measurement	Agilent 53132A	Checks clock frequency.
5. Oscilloscope	2.5 GHz Bandwidth 50 Ω input termination	Tektronix TDS7254B	Checks output signals. Used in multiple procedures.
6. Spectrum Analyzer	20 kHz to 1.25 GHz	Tektronix RSA3303A	Checks output signals. Harmonics Spurious.
7. BNC Coaxial Cable	50 Ω, male to male BNC connector, 91 cm	Tektronix part number 012-0482-00	Signal interconnection
8. BNC terminator	50 Ω, ±1 Ω, 2 W, DC to 1 GHz, BNC	Tektronix part number 011-0049-02	Signal termination
9. Attenuator	50 Ω, x10, BNC	Tektronix part number 011-0059-03	Signal attenuation

Table 19: Test equipment (cont.)

Description	Minimum requirements	Recommended equipment	Purpose
10. Adapter Dual-Banana Plug	BNC (female) to dual banana	Tektronix part number 103-0090-00	Signal interconnection to a DMM
11. Adapter BNC(female)-N(male)	BNC (female) to N (male)	Tektronix part number 103-0045-00	Signal interconnection to a Spectrum Analyzer
12. BNC-SMA coaxial cable	BNC (male) to SMA, 200 cm	Tektronix part number (174-1428-00)	Signal interconnection
13. Tek Connector SMA	50 Ω, DC ≥ 18 GHz	Tektronix TCA-SMA	Signal interconnection

Test record

Photocopy the test records and use them to record the performance test results for your instrument.

Table 20: Series Performance Test Record

Instrument Serial Number:	**Certificate Number:**
Temperature:	**RH %:**
Date of Calibration:	**Technician:**

Frequency, Amplitude, DC Offset, and AC Flatness Test Record

Frequency	Minimum	Test result	Maximum
Sine at 1.000000 MHz	0.999999 MHz		1.000001 MHz
Pulse at 1.000000 MHz	0.999999 MHz		1.000001 MHz

Amplitude

		CF = 2 / (1 + 50 Ω / Measurement Ω) =	
CH1 Amplitude	**Minimum**	**Test result**	**Maximum**
30.0 mVrms at 1.00 kHz	(30.0 × CF - 0.654) mVrms		(30.0 × CF + 0.654) mVrms
300.0 mVrms at 1.00 kHz	(300.0 × CF - 3.35) mVrms		(300.0× CF + 3.35) mVrms
800.0 mVrms at 1.00 kHz	(800.0 × CF - 8.35) mVrms		(800.0 × CF + 8.35) mVrms
1.500 Vrms at 1.00 kHz	(1.500 × CF - 0.0154) Vrms		(1.500 × CF + 0.0154) Vrms
2.000 Vrms at 1.00 kHz	(2.000 × CF - 0.0204) Vrms		(2.000 × CF + 0.0204) Vrms
2.500 Vrms at 1.00 kHz	(2.500 × CF - 0.0254) Vrms		(2.500 × CF + 0.0254) Vrms
3.500 Vrms at 1.00 kHz	(3.500 × CF - 0.0354) Vrms		(3.500 × CF + 0.0354) Vrms

DC Offset

		CF = 2 / (1 + 50 Ω / Measurement Ω) =	
CH1 DC Offset	**Minimum**	**Test result**	**Maximum**
+5.000 Vdc	(+5.000 × CF - 0.055) Vdc		(+5.000 × CF + 0.055 Vdc
0.000 Vdc	-0.005 Vdc		+0.005 Vdc
-5.000 Vdc	(-5.000 × CF - 0.055) Vdc		(-5.000 × CF + 0.055) Vdc

AC Flatness

CH1 AC Flatness	**Minimum**	**Test result**	**Maximum**
Frequency 100.00 kHz (Ampl: +4.0 dBm)	———-	dB (= Reference)	———-
Frequency 500.00 kHz	Reference - 0.15 dB	dB	Reference + 0.15 dB
Frequency 1.00 MHz	Reference - 0.15 dB	dB	Reference + 0.15 dB
Frequency 5.00 MHz	Reference - 0.30 dB	dB	Reference + 0.30 dB
Frequency 15.00 MHz	Reference - 0.30 dB	dB	Reference + 0.30 dB
Frequency 20.00 MHz	Reference - 0.30 dB	dB	Reference + 0.30 dB

Harmonic Distortion Test Record

Harmonic Distortion	Fundamental = reference	2nd	3rd	4th	5th	Limit
	Spectrum Analyzer reading					
Sine 20 kHz	20 kHz	40 kHz	60 kHz	80 kHz	100 kHz	
CH1 Harmonic Distortion	dBc	dBc	dBc	dBc	dBc	
reading - reference	0 dBc	dBc	dBc	dBc	dBc	Nth - reference < -60 dBc
Sine 100 kHz	100 kHz	200 kHz	300 kHz	400 kHz	500 kHz	
CH1 Harmonic Distortion	dBc	dBc	dBc	dBc	dBc	
reading - reference	0 dBc	dBc	dBc	dBc	dBc	Nth - reference < -60 dBc
Sine 1 MHz	1 MHz	2 MHz	3 MHz	4 MHz	5 MHz	
CH1 Harmonic Distortion	dBc	dBc	dBc	dBc	dBc	
reading - reference	0 dBc	dBc	dBc	dBc	dBc	Nth - reference < -50 dBc
Sine 20 MHz	20 MHz	40 MHz	60 MHz	80 MHz	100 MHz	
CH1 Harmonic Distortion	dBc	dBc	dBc	dBc	dBc	
reading - reference	0 dBc	dBc	dBc	dBc	dBc	Nth - reference < -40 dBc

Total Harmonic Distortion (THD) Test Record

	Spectrum Analyzer reading						
	Fundamental = reference	2nd	3rd	4th	5th	6th	7th
Sine 20.0 kHz	20 kHz	40 kHz	60 kHz	80 kHz	100 kHz	120 kHz	140 kHz
CH1 reading (dBm)	A_1=	A_2=	A_3=	A_4=	A_5=	A_6=	A_7=
reading - reference (A_n - A_1) (dBc)	B_1= 0	B_2=	B_3=	B_4=	B_5=	B_6=	B_7=
$C_n = 10^{Bn/20}$	C_1= 1	C_2=	C_3=	C_4=	C_5=	C_6=	C_7=
$THD = \frac{\sqrt{\sum_{n=2} C_n^2}}{C_1}$							**Limit** < 0.2%

Spurious Test Record

	Spectrum Analyzer			Measurement		
Frequency	**Center Frequency**	**Span**	**RBW**	**Spurious Frequency**	**Spurious (Max)**	**Limit**
Sine 100 kHz	10 MHz / 300 MHz	20 MHz / 600 MHz	20 kHz / 20 kHz	MHz MHz	dBc dBc	< -60 dBc
Sine 1.00 MHz	10 MHz / 300 MHz	20 MHz / 600 MHz	20 kHz / 20 kHz	MHz MHz	dBc dBc	< -50 dBc
Sine 10.00 MHz	10 MHz / 300 MHz	20 MHz / 600 MHz	20 kHz / 20 kHz	MHz MHz	dBc dBc	< -50 dBc
Sine 20.00 MHz	10 MHz / 300 MHz	20 MHz / 600 MHz	20 kHz / 20 kHz	MHz MHz	dBc dBc	< -50 dBc

Rise/Fall Time Test Record

	Minimum	Test result	Maximum
CH1 Rise Time Amplitude: 1.0 Vpp	- - - - -		18 ns
Fall Time Amplitude: 1.0 Vpp	- - - - -		18 ns
Rise Time Amplitude: 10.0 Vpp	- - - - -		18 ns
Fall Time Amplitude: 10.0 Vpp	- - - - -		18 ns

Frequency/Period test

This test verifies the frequency accuracy of the instrument. All output frequencies are derived from a single generated frequency. Only one frequency point of channel 1 is required to be checked.

1. Connect the arbitrary function generator to the frequency counter as shown in the following figure.

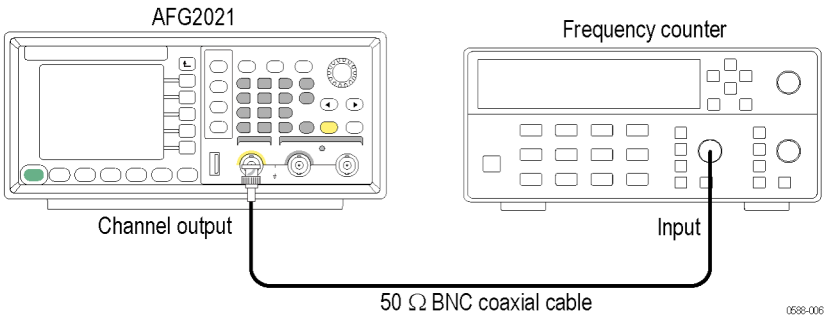


Figure 2: Frequency/Period tests

2. Push the following buttons to recall the arbitrary function generator default setup:

   Save/Recall > **Setup** > **Recall** > **Default**.

3. Set up the arbitrary function generator as follows:

   a. Push the **Sine** button on the front panel

   b. Push the **Frequency/Period/Phase Menu** bezel button.

   c. Push the **Frequency** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the frequency to 1.000000 MHz.

   d. Push the ↵ button on the front panel to return to the top menu.

   e. Push the **Amplitude/Level Menu** bezel button.

   f. Push the **Amplitude** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the amplitude to 1.000 Vp-p.

   g. Check that the **Channel On/Off** front panel button LED is lit. If it is not lit, then the channel output is off. Push the **Channel On/Off** button to turn it on.

4. Check that reading of the Frequency Counter is between 0.999999 MHz and 1.000001 MHz.

5. Push the **Pulse** button on the front panel.
6. Check that reading of the frequency counter is between 0.999999 MHz and 1.000001 MHz.

Amplitude test

This test verifies the amplitude accuracy of the arbitrary function generator. All output amplitudes are derived from a combination of attenuators and 3 dB variable gain. Some amplitude points are checked. This test uses a 50 Ω terminator. It is necessary to know the accuracy of the 50 Ω terminator in advance of this amplitude test. This accuracy is used as a calibration factor.

1. Connect the 50 Ω terminator to the DMM as shown in the following figure and measure the register value.

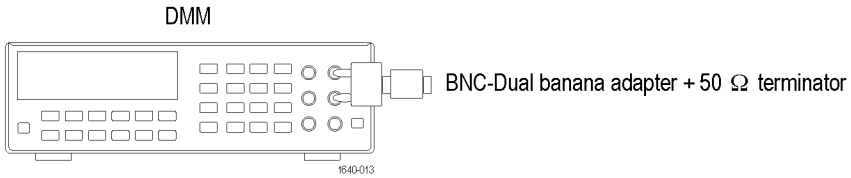


Figure 3: 50 Ω terminator accuracy

2. Calculate the 50 Ω calibration factor (CF) from the reading value and record as follows:

CF (Calibration Factor) = 2 / (1 + 50 Ω / Measurement Ω)

Measurement (reading of the DMM)	CF
Ω	
Examples	
50.50 Ω	1.0050 (= 2 / (1 + 50 / 50.50))
49.62 Ω	0.9962 (= 2 / (1 + 50 / 49.62))

3. Connect the arbitrary function generator to the DMM as shown in the following figure. Be sure to connect the 50 Ω terminator to the arbitrary function generator Output connector side.

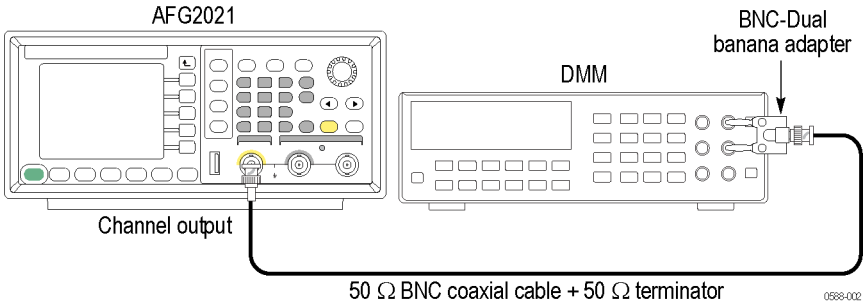


Figure 4: Amplitude tests

4. Set up the arbitrary function generator as follows:
   a. Push the **Sine** button on the front panel.
   b. Push the **Frequency/Period/Phase Menu** bezel button.
   c. Push the **Frequency** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the frequency to 1.000000 kHz.
   d. Push the ↵ button on the front panel to return to the top menu.
   e. Push the **Amplitude/Level Menu** bezel button.
   f. Push the **-more-** bezel button.
   g. Push the **Units Vpp** bezel button and then push the **Vrms** bezel button to change the voltage units to rms.
   h. Check that the **Channel On/Off** front panel button LED is lit.

      If it is not lit, then the channel output is off. Push the **Channel On/Off** button to turn it on.

5. Verify that each amplitude measurement is within the range specified in the following table.

Function	Frequency	Amplitude	Measurement	Range
Sine	1.000 kHz	30.0 mVrms	mVrms	(30.0 × CF ± 0.654) mVrms
Sine	1.000 kHz	300.0 mVrms	mVrms	(300.0 × CF ± 3.35) mVrms
Sine	1.000 kHz	800.0 mVrms	mVrms	(800.0 × CF ± 8.35) mVrms
Sine	1.000 kHz	1.500 Vrms	Vrms	(1.500 × CF ± 0.0154) Vrms
Sine	1.000 kHz	2.000 Vrms	Vrms	(2.000 × CF ± 0.0204) Vrms
Sine	1.000 kHz	2.500 Vrms	Vrms	(2.500 × CF ± 0.0254) Vrms
Sine	1.000 kHz	3.500 Vrms	Vrms	(3.500 × CF ± 0.0354) Vrms

DC offset test

This test verifies the DC offset accuracy of the arbitrary function generator. This test uses a 50 Ω terminator. It is necessary to know the accuracy of a 50 Ω terminator in advance of this test. This accuracy is used as a calibration factor.

1. Connect the 50 Ω terminator to the DMM as shown in the following figure and measure the register value.

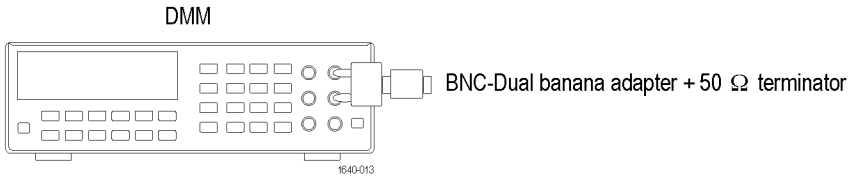


Figure 5: 50 Ω terminator accuracy

2. Calculate the 50 Ω calibration factor (CF) from the reading value and record as follows:

CF (Calibration Factor) = 2 / (1 + 50 Ω / Measurement Ω)

Measurement (reading of the DMM)	CF
Ω	
Examples	
50.50 Ω	1.0050 (= 2 / (1 + 50 / 50.50))
49.62 Ω	0.9962 (= 2 / (1 + 50 / 49.62))

3. Connect the arbitrary function generator to the DMM as shown in the following figure. Be sure to connect the 50 Ω terminator to the arbitrary function generator Output connector side.

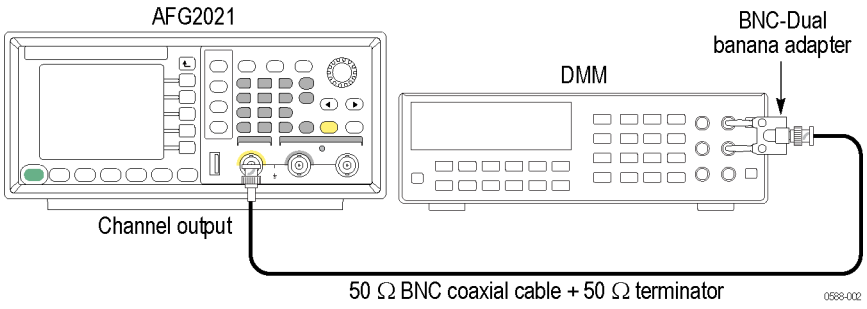


Figure 6: DC offset tests

4. Set up the arbitrary function generator as follows:
   a. Push the **More** waveform button on the front panel.
   b. Push the **More Waveform Menu** bezel button.
   c. Push the **DC** bezel button.

d. Push the ↵ button on the front panel to return to the top menu.

e. Push the **Amplitude/Level Menu** bezel button.

f. Push the **Offset** bezel button and use the numeric keypad or general purpose knob to set the offset value.

g. Check that the **Channel On/Off** front panel button LED is lit. If it is not lit, then the channel output is off. Push the **Channel On/Off** button to turn it on.

5. Verify that each offset measurement is within the range specified in the following table.

		Measurement	Range
Function	**Offset**		
DC	+ 5.000 Vdc	Vdc	(5.000 × CF ± 0.055) Vdc
DC	0.000 Vdc	Vdc	± 0.005 Vdc
DC	- 5.000 Vdc	Vdc	(- 5.000 × CF ± 0.055) Vdc

AC flatness test

This test verifies the flatness of a sine wave to 100 kHz sine wave.

1. Connect the arbitrary function generator to the power meter with a power head as shown in the following figure.

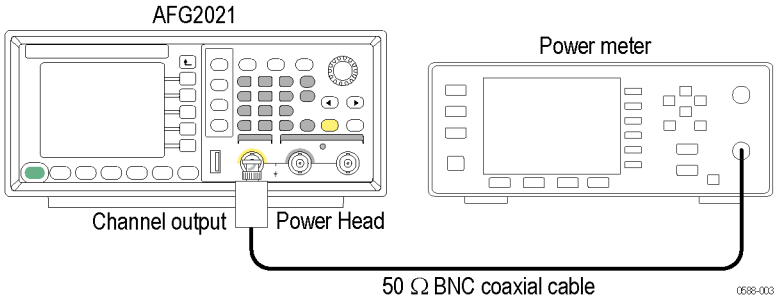


Figure 7: AC flatness tests

2. Set up the arbitrary function generator as follows:

a. Push the **Sine** button on the front panel.

b. Push the **Frequency/Period/Phase Menu** bezel button.

c. Push the **Frequency** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the frequency to 100.0000 kHz.

d. Push the ↵ button on the front panel to return to the top menu.

e. Push the **Amplitude/Level Menu** bezel button.

f. Push the **-more-** bezel button.

g. Push the **Units** bezel button and then push the **dBm** bezel button to change the voltage units to dBm.

h. Push the **-more-** bezel button.

i. Push the **Amplitude** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the amplitude to +4.0 dBm.

j. Check that the **Channel On/Off** front panel button LED is lit.

If it is not lit, then the channel output is off. Push the **Channel On/Off** button to turn it on.

3. Set the frequency of the Power Meter to 100 kHz.
4. Write the Power Meter reading of the 100 kHz sine wave as a reference power value.
5. Verify that the power measurement at each frequency is within the error specified in the following table.

			Measurement	Range
Function	**Amplitude**	**Frequency**	**(dB)**	**(dB)**
Sine	+ 4.0 dBm	100.00 kHz	= Reference	- - - - - -
Sine	+ 4.0 dBm	500.00 kHz		Reference ± 0.15
Sine	+ 4.0 dBm	1.00 MHz		Reference ± 0.15
Sine	+ 4.0 dBm	5.00 MHz		Reference ± 0.30
Sine	+ 4.0 dBm	10.00 MHz		Reference ± 0.30
Sine	+ 4.0 dBm	20.00 MHz		Reference ± 0.30

Harmonics distortion test

This test verifies the harmonic distortion using a spectrum analyzer.

1. Connect the arbitrary function generator to the spectrum analyzer as shown in the following figure.

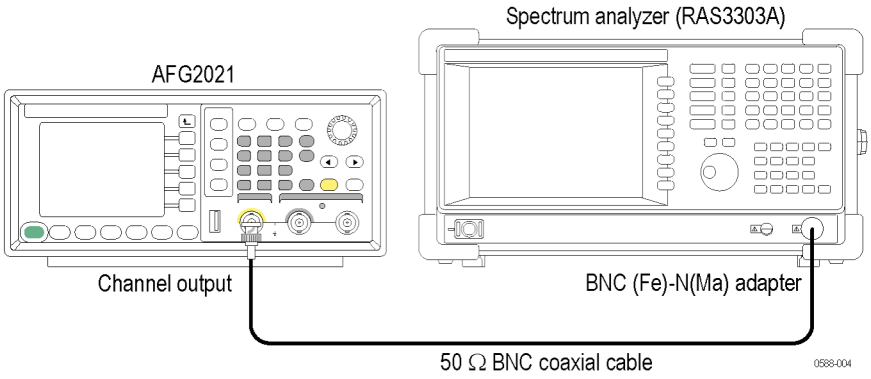


Figure 8: Harmonic distortion tests

2. Push the following buttons to recall the arbitrary function generator default setup:

   Save/Recall > **Setup** > **Recall** > **Default**.

3. Set up the arbitrary function generator as follows:

   a. Push the **Sine** button on the front panel.

   b. Push the **Frequency/Period/Phase Menu** bezel button.

   c. Push the **Frequency** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the frequency to 20.00 kHz.

   d. Push the ↵ button on the front panel to return to the top menu.

   e. Push the **Amplitude/Level Menu** bezel button.

   f. Push the **-more-** bezel button.

   g. Push the **Units** bezel button and then push the **Vpp** bezel button to change the voltage units to Vpp.

   h. Push the **-more-** bezel button.

   i. Push the **Amplitude** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the amplitude to 1.00 Vpp.

   j. Check that the **Channel On/Off** front panel button LED is lit.

      If it is not lit, then the channel output is off. Push the **Channel On/Off** button to turn it on.

4. Set up the spectrum analyzer according the frequency setup of the arbitrary function generator.
5. Set the Ref Level of the spectrum analyzer to 8 dBm.
6. Read the signal level in the Fundamental frequency for each signal. Use this level as a Reference value in step 4.
7. Verify that the differences between the reference level and the signal level in the frequency of higher-order at each frequency are below the limit specified in the following table.

	Spectrum Analyzer			Measurement					Limit
Frequency	Center Frequency	Span	RBW	Fundamental (= Reference)	2nd	3rd	4th	5th	Nth - Reference
20.00 kHz	100 kHz	200 kHz	500 Hz	20 kHz	40 kHz	60 kHz	80 kHz	100 kHz	< -60 dBc
100.00 kHz	500 kHz	1 MHz	2 kHz	100 kHz	200 kHz	300 kHz	400 kHz	500 kHz	< -60 dBc
1.00 MHz	5.00 MHz	10 MHz	20 kHz	1 MHz	2 MHz	3 MHz	4 MHz	5 MHz	< -50 dBc
20.00 MHz	100 MHz	200 MHz	20 kHz	20 MHz	40 MHz	60 MHz	80 MHz	100 MHz	< -40 dBc

Total harmonic distortion test

This test verifies the total harmonic distortion (THD) using a spectrum analyzer.

1. Connect the arbitrary function generator to the spectrum analyzer as shown in the following figure.

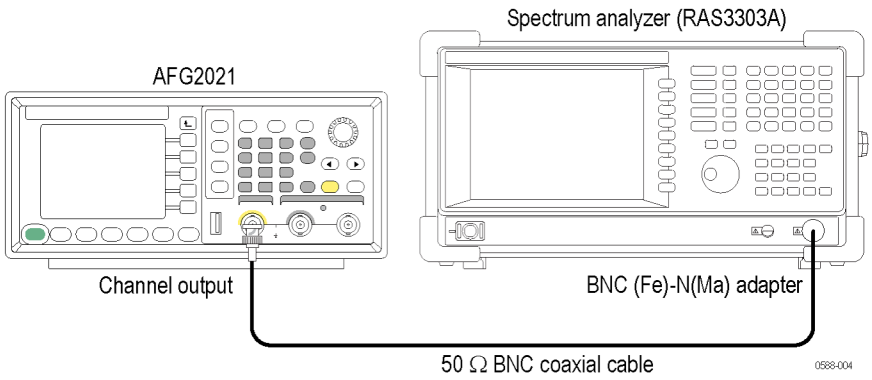


Figure 9: Total harmonic distortion tests

2. Set up the arbitrary function generator as follows:
   a. Push the **Sine** button on the front panel.
   b. Push the **Frequency/Period/Phase Menu** bezel button.

c. Push the **Frequency** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the frequency to 20.00 kHz.

d. Push the ↵ button on the front panel to return to the top menu.

e. Push the **Amplitude/Level Menu** bezel button.

f. Push the **-more-** bezel button.

g. Push the **Units** bezel button and then push the **Vpp** bezel button to change the voltage units to Vpp.

h. Push the **-more-** bezel button.

i. Push the **Amplitude** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the amplitude to 1.00 Vpp.

j. Check that the **Channel On/Off** front panel button LED is lit.

If it is not lit, then the channel output is off. Push the **Channel On/Off** button to turn it on.

3. Set up the spectrum analyzer according to the following table:

Center Frequency	Span	RBW
100 kHz	200 kHz	500 Hz

4. Set the Ref Level of the spectrum analyzer to 8 dBm.

5. When the THD cannot be measured directly, it is obtained by using the following calculation:

$$THD = \frac{\sqrt{\sum_{n=2} C_n^2}}{C_1}$$

6. Measure and record each level (A1 to A7) to the seventh harmonics of the 20 kHz sine wave.

7. Calculate the each B1 to B7, C1 to C7 value and the THD.

		Measurement						
Function	Frequency	Fundamental = reference	2nd	3rd	4th	5th	6th	7th
sine	20.00 kHz	20 kHz	40 kHz	60 kHz	80 kHz	100 kHz	120 kHz	140 kHz
reading (dBm)		A1 =	A2 =	A3 =	A4 =	A5 =	A6 =	A7 =
reading - reference Bn = An - A1 (dBc)		B1 = 0	B2 =	B3 =	B4 =	B5 =	B6 =	B7 =
Cn = 10 Bn/20		C1 = 1	C2 =	C3 =	C4 =	C5 =	C6 =	C7 =

	Measurement						
$THD = \frac{\sqrt{\sum_{n=2} C_n^2}}{C_1}$	THD =						Limit < 0.2%
Sample: reading	1.5 dBm	-58.5 dBm	-58.5 dBm	-63.5 dBm	-58.5 dBm	-63.5 dBm	-63.5 dBm
reading - reference	0	-60 dBm	-60 dBm	-65 dBm	-60 dBm	-65 dBm	-65 dBm
Cn =	1.000	0.001	0.001	0.000562	0.001	0.000562	0.000562
$THD = \frac{\sqrt{\sum_{n=2} C_n^2}}{C_1}$	0.1987%						Limit < 0.2%

NOTE. *When all the harmonic components are -62 dBm or less, the calculation of THD can be skipped because it is THD < 0.2%.*

8. Verify that the THD is less than 0.2%.

Spurious test

This test verifies the spurious using a spectrum analyzer.

1. Connect the arbitrary function generator to the spectrum analyzer as shown in the following figure.

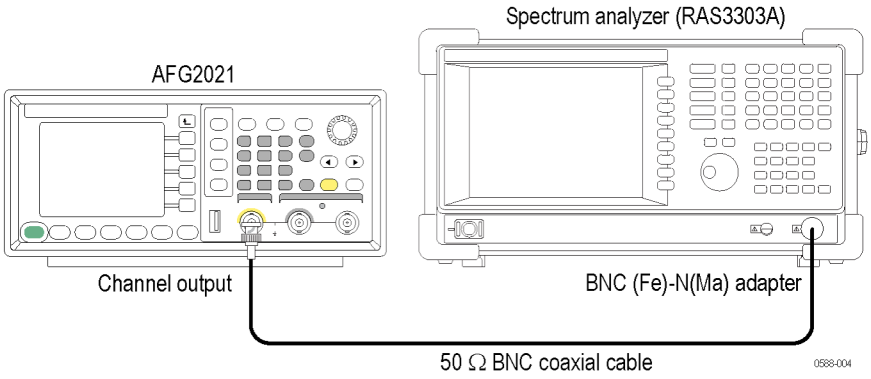


Figure 10: Spurious tests

2. Set up the arbitrary function generator as follows:
   a. Push the **Sine** button on the front panel.
   b. Push the **Frequency/Period/Phase Menu** bezel button.
   c. Push the **Frequency** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the frequency to 100.00 kHz.
   d. Push the ↵ button on the front panel to return to the top menu.
   e. Push the **Amplitude/Level Menu** bezel button.
   f. Push the **-more-** bezel button.
   g. Push the **Units** bezel button and then push the **Vpp** bezel button to change the voltage units to Vpp.
   h. Push the **-more-** bezel button.
   i. Push the **Amplitude** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the amplitude to 1.00 Vpp.
   j. Check that the **Channel On/Off** front panel button LED is lit.

      If it is not lit, then the channel output is off. Push the **Channel On/Off** button to turn it on.
3. Set the center frequency of the spectrum analyzer to 10 MHz. Other settings are shown in the following table.
4. Set the Ref Level of the spectrum analyzer to 8 dBm.

5. Measure the maximum spurious level other than harmonic distortion of 1 Vpp sine wave in each frequency.
6. Set the center frequency of the spectrum analyzer to 300 MHz. Other settings are shown in the following table.
7. Measure the maximum spurious level other than harmonic distortion of 1 Vpp sine wave in each frequency.
8. Verify that the spurious signal at each frequency is equal to or less than the limit specified in the following table.

	Spectrum analyzer			Measurement		
Frequency	Center Frequency	Span	RBW	Spurious Frequency	Spurious (Max)	Limit
100.00 kHz	10 MHz 300 MHz	20 MHz 600 MHz	20 kHz 20 kHz	MHz MHz	dBc dBc	< -60 dBc
1.00 MHz	10 MHz 300 MHz	20 MHz 600 MHz	20 kHz 20 kHz	MHz MHz	dBc dBc	< -50 dBc
10.00 MHz	10 MHz 300 MHz	20 MHz 600 MHz	20 kHz 20 kHz	MHz MHz	dBc dBc	< -50 dBc
20.00 MHz	10 MHz 300 MHz	20 MHz 600 MHz	20 kHz 20 kHz	MHz MHz	dBc dBc	< -50 dBc

Rise-Fall time test

This test verifies the pulse rise time of the arbitrary function generator.

1. Connect the arbitrary function generator to the oscilloscope as shown in the following figure.

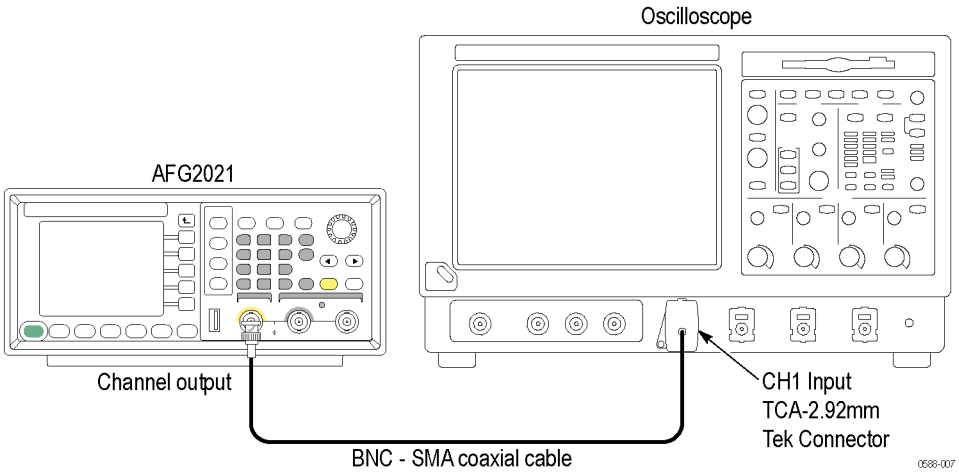


Figure 11: Rise-Fall time tests

2. Set up the arbitrary function generator as follows:
   a. Push the **Square** button on the front panel.
   b. Push the **Frequency/Period/Phase Menu** bezel button.
   c. Push the **Frequency** bezel button (it will turn dark when activated) and use the numeric keypad or general purpose knob to set the frequency to 10.00 MHz.
   d. Push the button on the front panel to return to the top menu.
   e. Push the **Amplitude/Level Menu** bezel button.
   f. Push the **-more-** bezel button.
   g. Push the **Units** bezel button and then push the **Vpp** bezel button to change the voltage units to Vpp.
   h. Push the **-more-** bezel button.
   i. Push the **Amplitude** bezel button and use the numeric keypad or general purpose knob to set the amplitude to 1.00 Vpp.
   j. Push the **Offset** bezel button and use the numeric keypad or general purpose knob to set the value to 0.0 mV.
   k. Check that the **Channel On/Off** front panel button LED is lit. If it is not lit, then the channel output is off. Push the **Channel On/Off** button to turn it on.

3. Set up the Oscilloscope so the square waveform of 5 division amplitude is displayed.
4. Verify that the rise/fall time of the square waveform on the oscilloscope at each amplitude is equal to or less than the limit specified in the following table. Use 10-90% reference level for rise/fall time measurement.

				Oscilloscope		Measurement
Function	**Frequency**	**Offset**	**Amplitude**	**Vertical**	**Horizontal**	**Limit**
Square	10.00 MHz	0.0 V	1.0 Vpp	200 mV/div	5 ns/div	≤ 18 ns
Square	10.00 MHz	0.0 V	10.0 Vpp	200 mV/div with x10 attenuator	5 ns/div	≤ 18 ns