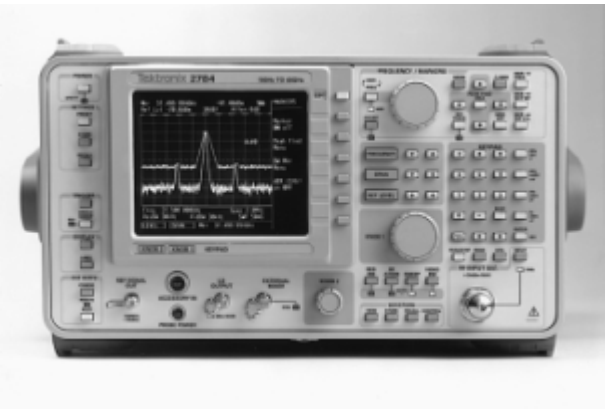
# Tektronix 2784 Spectrum Analyzer



## Features

- 100 Hz to 40 GHz Coaxial Frequency Range
- External Waveguide Mixer Support to 325 GHz
- Full-range Sweep from 0 Hz to 40 GHz
- Resolution BW from 3 Hz to 10 MHz in a 1, 3, 10 Sequence
- 100 dB Display Dynamic Range
- Phase Noise Performance as Low as -105 dBc/Hz at 10 kHz Offset up to 21 GHz
- Built-in Math Functions
- Intelligent Markers/Signal Processing: Search, Sort, and Mark CW, Pulse, or All Signals
- Occupied Bandwidth Mode
- Signal Tracking
- Built-in 100 Hz to 1.2 THz Frequency Counter with Frequency Measurement Accuracy of </=400 Hz at 40 GHz
- Fully Programmable with Two GPIB Interfaces
- Built-in Automation
- Macro Downloading to 40 K of NVRAM
- Store up to 20 Front-panel Key Sequences
- Store up to 20 Waveforms with Readout Information
- Store up to 20 Instrument States

## Applications

- Digital Microwave Radio
- Satellite Communication
- Microwave and RF Source Design
- Avionics
- Millimeter Wave R&D

ISO 9001

Tektronix Measurement products are manufactured in ISO registered facilities.

GPIB
IEEE-488

This product complies with IEEE Standard 488.1-1987, and with Tektronix Standard Codes and Formats.

For addtional information or to order, contact you local Tektronix representative.

## Characteristics

Except as noted, the following tables of electrical characteristics and features apply after a 30-minute warm-up.

### Frequency Related

**Frequency Range:** 100 Hz to 40 GHz in coax, to 325 GHz with external waveguide mixers.

**Frequency Readout Accuracy:**
±[F(RE + 10-10)] + D + (M x N)
F = center frequency.
RE = reference error.
D = 2% of span or 20% of resolution bandwidth, whichever is greater.
M > 2 MHz span = (100N) kHz.
M 3 2 MHz span = (10N) Hz.
N = L.O. harmonic.

**Counter:**
Range: 100 Hz to 1.2 THz.
Resolution: Selectable from 1 Hz to 1 GHz
±[F(RE + 10-10)] + 15N Hz + 1 LSD.
Delta Count Accuracy (S/N >/=20 dB):
±[DeltaF (RE + 10-10)] + 30N Hz + 2 LSD.
F = counter frequency.
RE = reference error.
N = L.O. harmonic.
LSD = least significant digit.

**Frequency Reference Accuracy:**
Aging <1 × 10-6/year <7 × 10-9/day. Drift <5 × 10-7 over instrument temperature range of -10 to +40 degrees C.

**Frequency Span:**
Range: 0, 10 Hz to 40 GHz in coax to 600 GHz in external mixer bands.
Resolution: >/=100 Hz, selectable in 1% increments.
Accuracy: >2 MHz, ±2%, 1 kHz to 2 MHz, ±1%, 100 Hz to 1 kHz, ±7%.

**Resolution Bandwidth (6 dB):**
3 Hz to 10 MHz in 1, 3, 10 sequence.
Accuracy: 10 MHz, 3 MHz ±20%, 1 MHz to 100 Hz ±15%, 30 Hz, 10 Hz ±20%, 3 Hz +50%, -10% (typical).
Selectivity (-60 dB/-6 dB): <10:1.
Shape: Synchronously tuned, six-pole filters.

**Video Bandwidth:** Range: 0.03 Hz to 7 MHz (Nominal).

**Stability:** Residual FM: 32 MHz span, 1N Hz p-p over one second; >2 MHz span, 25N kHz p-p over 500 ms. Drift (after one hour warm-up): 32 MHz span 5N kHz/minute of sweep time, >2 MHz span 5N kHz/minute of sweep time (typical).

***Notes:*** *N=L.O. Harmonic. Errors due to drift are not cumulative from sweep to sweep.*

**Resolution Filter Bandwidths:**

| 6 dB (Specified) | 3 dB (Typical) | Noise (Typical) Random | Impulse (Typical) |
|---|---|---|---|
| 3 Hz | 2.1 Hz | 2.3 Hz | 3 Hz |
| 10 Hz | 6.9 Hz | 7.6 Hz | 10 Hz |
| 30 Hz | 21 Hz | 23 Hz | 30 Hz |
| 100 Hz | 69 Hz | 76 Hz | 100 Hz |
| 300 Hz | 206 Hz | 227 Hz | 300 Hz |
| 1000 Hz | 686 Hz | 758 Hz | 1 kHz |
| 3 kHz | 2.1 kHz | 2.3 kHz | 3 kHz |
| 10 kHz | 6.9 kHz | 7.6 kHz | 9 kHz |
| 30 kHz | 21 kHz | 23 kHz | 30 kHz |
| 100 kHz | 69 kHz | 76 kHz | 100 kHz |
| 300 kHz | 206 kHz | 227 kHz | 270 kHz |
| 1 MHz | 686 kHz | 758 kHz | 720 kHz |
| 3 MHz | 2.1 MHz | 2.3 MHz | 2.5 MHz |
| 10 MHz | 6.9 MHz | 7.6 MHz | 4.5 MHz |

**Spectral Purity:**

| Noise Sidebands | | | | | |
|---|---|---|---|---|---|
| dBc/Hz | | Center Frequency | | | |
| Freq. Offset | Spec. 6.5 GHz | Spec. 12 GHz | Typical 21 GHz | Typical 33 GHz | Typical 40 GHz |
| 100 Hz | -85 | -80 | -75 | -70 | -65 |
| 1 kHz | -97 | -95 | -90 | -86 | -81 |
| 10 kHz | -105 | -105 | -105 | -97 | -94 |
| 100 kHz | -105 | -105 | -105 | -97 | -94 |
| 1 MHz | -112 | -112 | -112 | -102 | -99 |

### Amplitude Related

**Maximum Amplitude Range:** -135 dBm to +30 dBm.

**Displayed Average Noise Level (10 Hz RBW, 0 dB attn.):**

| Frequency | Level |
|---|---|
| 100 Hz to 50 kHz | -78 dBm |
| 50 kHz to 10 MHz | -105 dBm |
| 10 MHz to 2.5 GHz | -135 dBm |
| 2.5 GHz to 6.5 GHz | -132 dBm |
| 6.5 GHz to 21.25 GHz | -125 dBm |
| 21.25 GHz to 28 GHz | -120 dBm |
| 28 GHz to 40 GHz | -107 dBm |

**Using WM782 Waveguide Mixer Series:**

| (10 Hz RBW) | | | |
|---|---|---|---|
| **Band** | **Frequency** | **Harmonic No.** | **Level** |
| A | 26.5 to 40 GHz | 2/4 | -135 dBm |
| Q | 33 to 50 GHz | 4 | -135 dBm |
| U | 40 to 60 GHz | 4 | -135 dBm |
| V | 50 to 75 GHz | 6 | -130 dBm |
| E | 60 to 90 GHz | 6 | -125 dBm |
| W | 75 to 110 GHz | 8 | -125 dBm |
| (typical with 100 Hz RBW) | | | |
| F | 90 to 140 GHz | 8 | -105 dBm |
| D | 110 to 170 GHz | 10 | -100 dBm |
| G | 140 to 220 GHz | 14 | -95 dBm |
| J | 220 to 325 GHz | 20 | -85 dBm |

**Display Range:**
Log amplifier: 100 dB.
Display Law Range - Log: 1 dB/div to 15 dB/div.
Linear: 5 nV/div to 22 V/div.
Square Law: 2 aW/div to 100 W/div.
Reference Level Range: -140 dBm to +30 dBm.
Resolution: 0.1 dB.

**Accuracy:** Log (measurements marker): 0.2 dB/1 dB incremental, ±1.5 dB cumulative over 90 dB range, +2/ -3.5 dB cumulative over 100 dB range at self-correcting temp.

**Accuracy:**
Lin: ±5%.
Square Law: ±8%.

**Frequency Response:** (.10 dB RF attenuation) -20 to 30 degrees C.

| Frequency Range | Variation |
|---|---|
| 100 Hz to 6.5 GHz | ±1.0 dB |
| 6.5 GHz to 28 GHz | ±4.0 dB |
| 28 GHz to 33 GHz | ±4.5 dB |
| 33 GHz to 40 GHz | ±5.0 dB |

*(Attenuator accuracy over frequency included in frequency response.)*

**Attenuator:**
Range: 0 to 70 dB, 10 dB steps.
Accuracy @ 100 MHz: ±0.5 dB.

**IF Gain:**
Range: 0 to 140 dB.
Resolution: 0.1 dB.
Accuracy: ±1.0 dB, 0 to 50 dB; ±1.5 dB, 0 to 100 dB; at self-correction temperature.

**Gain Variation Between Resolution Filters:** (Measured at -20 dBm reference level, 10 dB RF attn., and after two-hour warmup at self-correction temperature).

**Frequency:**
10 MHz to 30 Hz: 0.5 dB p-p
10 MHz to 10 Hz: 0.75 dB p-p
10 MHz to 3 Hz: 2.0 dB p-p

**Reference Level Calibration Error:**
±0.25 dB (Ref. level -20 dBm, with respect to -20 reference in 3 MHz RBW at self-correction temperature).

**Band Switching Uncertainty:** ±1.5 dB referred to 100 MHz reference signal.

## Spurious Responses

**Spurious Responses:** <-80 dBc + 20 Log N except as noted below.
Residual Signals: <-77 dBm, 100 Hz to 10 MHz;
Mixer Level: -30 dBm:
<-70 dBm at 2 MHz with 10 kHz and wider resolution bandwidth;
<-100 dBm, 10 MHz to 6.5 GHz;
<-92 dBm, 6.5 GHz to 21 GHz;
<-82 dBm, 21 GHz to 28 GHz;
<-80 dBm, 28 GHz to 40 GHz.

**Maximum Dynamic Range:**
Compression-to-Noise: 132 dB (10 MHz to 6.5 GHz);
117 dB (to 28 GHz); 101 dB (to 40 GHz).
Signal-to-Harmonic Distortion: 80 dB (50 MHz to 6.5 GHz);
100 dB (6.5 GHz to 40 GHz).
Signal-to-Intermodulation Distortion: 98 dB (10 MHz to 6.5 GHz);
83 dB (to 28 GHz); 81 dB (to 40 GHz).

**1 dB Gain Compression:**
100 Hz to 21 GHz: 0 dBm.

21 GHz to 28 GHz: -3 dBm.
28 GHz to 40 GHz: -6 dBm.

**Intermodulation Rejection:**
Second Order Intercept: >+28 dBm, 1 MHz to 6.5 GHz.
Third Order Intercept: With signal separation <150 MHz and >20 kHz.
Mixer Level -30 dBm: >+15 dBm, 1 MHz to 6.5 GHz, (-90 dBc); >+10 dBm, 6.5 GHz to 28 GHz (-80 dBc).

**Second Harmonic Distortion:**
Mixer Level: -40 dBm; <-70 dBc, 50 MHz to 6.5 GHz;
<-100 dBc (typical), 6.5 GHz to 40 GHz.

**Out of Band Responses for Input Frequencies <35 GHz:**

| Center Frequency Range | | |
|---|---|---|
| | 100 Hz to 28 GHz | 28 to 40 GHz |
| Image Response | <-65 dBc | <-65 dBc |
| Harmonic | <-65 dBc | <-55 dBc |
| Conversions | (typical) | (typical) |

## Sweep Generator And Triggering

**Sweep Generator:**
Sweep Speed Range: 200 s to 2 µs.
Accuracy: ±5%, 50 µs and slower; ±10%, 20 µs and faster.

**Triggering:** Adjustable trigger level and slope.
Internal: AC coupled; 10 Hz to 1 MHz.
External: DC coupled; 0 Hz to 5 MHz or 0 Hz to 1.5 kHz.
Line: Copy of AC line.

## Display Related

**Display Type:** Liquid Crystal color shutter, 10 x 10 division graticule.

**Digital Storage:** Maximum Sweep Rate: 10 ms with 10-Bit resolution, 2 ms with reduced horizontal resolution. Vertical Digitizer Uncertainty: ±0.4%.

**Non-volatile Memory:** CMOS battery backed-up RAM, memory retention guaranteed to -10 degrees C. Battery Type: Lithium cells. Battery Life (typical): 1.8 years @ 20 degrees C, 1 year @ 50 degrees C. (Batteries are not used when instrument is connected to power source.) Waveforms: 20 waveforms with screen readouts and labels or date/time stamps. Front-panel Setups: 20 complete front-panel setups. Front-panel Sequences: 20 sequences, 64 keystrokes/sequence. Macros: 40 K of RAM. Instrument Calibration Data: Separate EEPROM.

## Inputs and Outputs

**RF Input:** Frequency Range: 100 Hz to 40 GHz. Coupling: DC. Connector: Planar crown system connector with K compatible and N-type adapters as standard accessories. Impedance: 50 ohms.

| VSWR | Center Frequency Ranges | | | |
|---|---|---|---|---|
| RF Attn. | 100 Hz to 65 GHz | 6.5 GHz to 28 GHz | 28 GHz to 33 GHz | 33 GHz to 40 GHz |
| ≥10 dB | <1.4:1 | <1.7:1 | <2.0:1 | <2.25:1 |

**Maximum Safe Input Power:**
AC Average Power: +30 dBm with >/=10 dB attenuation.
Pulse Power: 50 W peak, 1 µs and <0.005 duty factor with >/=50 dB attenuation.
DC: 0 V, <100 mA.

**Local Oscillator Emission (at 0 dB RF attenuation):** </= -75 dBm, 100 Hz to 6.5 GHz; </= -65 dBm, 6.5 GHz to 40 GHz.

**External Mixer Input (diplexer built in):**
Impedance: 50 ohms; VSWR <1.9:1 at 525 MHz and <2.2:1 at 3.525 GHz (typical).
LO Output Power: >/=15 dBm at 8.1 to 17.9 GHz.

**LO Output:** Provides access to output of 1st LO at +4 dBm (typical).

**Reference Signal Out:**
Amplitude: -20 dBm.
Amplitude Accuracy: ±0.3 dB.
Frequency: 100 MHz (derived from reference oscillator).

**Ref. In/Out:**
Impedance: 50 ohms nominal.
Input Frequency: 10 MHz ±5 Hz.
Input Signal Amplitude Range: 0 dBm minimum to +15 dBm maximum.
Output Signal (when selected): Nominally 0 dBm at 10 MHz.
Allowable Phase Noise: </=-100 dBc/Hz at 1 Hz offset (without degrading instrument phase noise performance).

**Ext. Trig/Horiz:** External Trigger input, or external sweep input.

**Accessory Connector:** 15-Pin connector for external inputs and outputs. Ext. in Display Blanking: Provides external access to CRT beam blanking. Ext. in Display Horizontal and Vertical: Provides external access to real-time channel of the instrument; DC coupled; Vert -5 MHz bandwidth (typical). Sweep Output: Provides copy of analog sweep. Ext. in Video: Provides external access to instrument's video processing system; 7.5 MHz bandwidth (typical). Penlift: TTL level output to lift plotter pen. YIG Coil Tune Voltage and return: Provides external output of the YTO coil tuning voltage and a return path.

**Ext. V Out:** External display horizontal signal output; jumper selectable between full deflection amplifier signal or the real-time signal.

Ext. H Out: External display horizontal signal output; jumper selectable between full deflection amplifier signal or the real-time signal.

Ext. Z Out: External display blanking signal output.

IF Output:
Frequency: 25 MHz (3 MHz and 10 MHz resolution bandwidth).

Amplitude: 3 dBm nominal (-30 dBm reference level, 0 dB RF attenuation, -30 dBm RF input).
Frequency: 4 MHz (1 MHz or less resolution bandwidth).
Amplitude: +9 dBm nominal (-30 dBm reference level, 0 dB attenuation, -30 dBm RF input).
Impedance: Nominal 50 ohms.
VSWR: </=1.5:1 (Typical).

## External Interface Ports

Two GPIB ports (IEEE Std. 488-1978) are standard.

**GPIB Interface:**
Port 1: SH1, AH1, T5, L3, SR1. Functions: RLO/RL1, PPO, DC1, DT1, CO.
Port 2: SH1, AH1, T5, L3, SRO, RLO, PPO, DCO, DTO, C1, C2, C3, C27, (CO selectable).

**Probe Power:** Provides operating voltage for active probes; output voltages are:
pin 1: +5 V ±5% @ 100 mA max
pin 2: ground
pin 3: -15 V ±5% @100 mA max
pin 4: +15 V ±5% @ 100 mA max.

**Power Requirements:**
Input Voltage: 90 to 132 VAC, 47 to 440 Hz, 180 to 250 VAC, 47 to 63 Hz.
Power: at 115 VAC, 60 Hz, 250 W maximum, 2.8 A.
Standby Power: 25 W maximum.
Leakage Current: 3.5 mA maximum.

## Environmental Characteristics

(Per MIL-T-28800C, Type III, Class 3, Style C)

Temperature:
Operating: -10 to +55 degrees C.
Nonoperating: -62 to +85 degrees C.

Humidity: 5 cycles per MIL-STD 810D Procedure III (modified).

Altitude:
Operating: 15,000 ft.
Nonoperating: 40,000 ft.

Vibration: Resonant search in all axes from 5 to 15 Hz with displacements up to 0.060 inch, 15 to 25 Hz with displacements up to 0.040 inch, and 25 to 55 Hz with displacements up to 0.020 inch.

Shock: Operating and Nonoperating: Tested to withstand three shocks of 30 g, one-half sine, 11 ms duration each direction along each major axis.

Transit Drop: Tested to withstand eight-inch drops, one per each of six faces and eight corners.

## Electromagnetic Interference

**MIL-STD 461C Part 4:**
Conducted Emissions: CE01 - 60 Hz to 15 kHz, 15 dB relaxation below 2 kHz;
CE03 - 15 kHz to 50 MHz power leads; narrowband and broadband full limits (Navy).

Conducted Susceptibility: CS01 - 30 Hz to 50 kHz power leads, full limits;
CS02 - 50 kHz to 400 MHz power leads, 10 dB relaxation at the IF frequencies;
CS06 - Spike power leads, full limits.

Radiated Emissions: RE01 - 30 Hz to 50 kHz magnetic field, 5 dB relaxation below 1 kHz and 10 dB relaxation from 1 kHz to 50 kHz;
RE02 - 14 kHz to 1 GHz; meets MIL-STD 461C Part 7 to full limits.

Radiated Susceptibility: RS01 - 30 Hz to 50 kHz magnetic field, full limits;
RS02 - magnetic induction, 30 dB relaxation at 60 Hz; 20 dB @ 440 Hz;
RS03 - limited to 1 V/m from 14 kHz to 1 GHz, with 20 dB relaxation at IF frequencies.

**VDE:** Meets VDE 0871 Class 1B - Regulations for RFI Suppression of High Frequency Apparatus and Installations.

**FCC:** Meets FCC Part 15 Subpart J Class A - EMI Compatibility.

**German RöV:** Meets German RöV, X-Ray Decree, Section 5, March 1973.

## Physical Characteristics

**Dimensions:**
Without front cover, handle, or feet.
Width: 327.66 mm (12.90 in.)
Height: 204.47 mm (8.05 in.)
Depth: 472.19 mm (18.59 in.)

With front cover, handle folded back, and feet.
Width: 400.05 mm (15.75 in.)
Height: 213.36 mm (8.05 in.)
Depth: 549.11 mm (21.64 in.)

With front cover, handle fully extended, and feet.
Width: 400.05 mm (15.75 in.)
Height: 204.47 mm (8.05 in.)
Depth: 624.28 mm (24.75 in.)

Net Weight: 20 kg (44 lb.)
With standard accessories, cover, and no manuals

**Safety:** Meets the following industry safety standards:
CSA Standard C22.2 No. 231 - Electrical and Electronic Measurement and Testing Equipment.
ANSI/ISA S82 - Safety Requirements for Electronic Measuring and Controlling Instrumentation.
IEC 348, 2nd Edition - Safety Requirements for Electronic Measuring Apparatus.
FM - Electrical Utilization Standard Class 3810.
UL 1244, 2nd Edition - Electrical and Electronic Measuring and Testing Equipment.

## Ordering Information

**2784 Microwave Spectrum Analyzer**
**Includes:** N-male to BNC-female Adapter (103-0045-00); N to Planar Crown Adapter (131-4329-00); 50 ohm SMA Cable (012-0649-00); Line Fuses: 4 A, 125 VAC (159-0319-00); 4 A, 250 VAC (159-0320-00); Power Cord (161-0104-00). Operator's Manual (070-8240-00); Operator's Reference Guide (070-8249-00); Programmer's Manual (070-8241-00); Programmer's Reference Guide (070-8242-00); Installation and Performance Verification Manual (070-8067-00).

**Opt. 16:** 49X/275X/279X Series GPIB Language

**Opt. 18:** WM782 Bands Q, U, V, E, and W (frequency coverage from 33-110 GHz)

**Opt. 19:** WM782 Bands A, U, E, F, G, and J (frequency coverage from 26-325 GHz)

**Opt. 20:** Utility Software for PC, includes GPIB Card

**Opt. 30:** Rackmount Adapter (19 in.)

**Opt. B1:** Service Manual prepared to module level

**Opt. B2:** Complete set of manuals, including Service Manual

### International Power Plug Options

**Opt. A1:** Universal Euro 220 V, 50 Hz

**Opt. A2:** United Kingdom 240 V, 50 Hz

**Opt. A3:** Australian 240 V, 50 Hz

**Opt. A4:** North American 240 V, 60 Hz

**Opt. A5:** Switzerland 220 V, 50 Hz

### Service Assurance Options

**Opt. R2:** Adds two years of post-warranty Repair Protection

### Software

**2784 PC Utility.** Order S26UT00.

### Active Probes

**900 MHz, 1.5 pF/100 kilohm:** Order P6201.

**4 GHz, 0.4 pF/100 kilohm (Requires 1103 Power Supply):** Order P6217.

**Power Supply:** Order 1103

### Cameras/Plotters/Printers

**Camera, Low Cost:** Order C-9 Opt. 1A and Opt. 20

**Plotter. Four Color:** Order HC100 Opt. 01

**Cart:** Order K420

**GPIB Cables:**
0.5 m. Order 012-1282-00
1 m. Order 012-0991-01
2 m. Order 012-0991-00
4 m. Order 012-0991-02

**Waveguide Mixer Cables:** Use with WM782 Waveguide Mixers. Order 012-1346-00

### GPIB Cards

**PC-GPIB Card:** IBM PC, AT, and Compatibles. Order S3FG210

**AT-GPIB Card:** IBM AT Bus (High-speed Card). Order S3FG220

**MC-GPIB Card:** IBM PS/2 with Microchannel Bus. Order S3FG230

### Additional Accessories

**EMC Ancillary Devices:**
Rackmount Adapter: Order 016-1019-00
Optical-to-electrical Converter: Order SA-42
Service Manual, Module Level. Order 070-8244-00
Transit Case: Order 016-0658-00
Soft Side Case: Order 016-0659-00