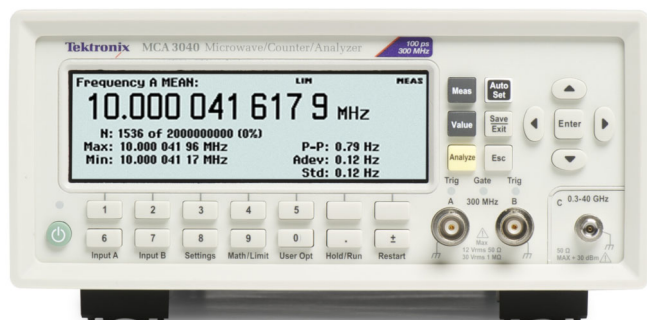


Microwave/Counter/Analyzer & Integrated Power Meter

MCA3000 Series Data Sheet



Features & Benefits

Key Performance Specifications

- 27 GHz and 40 GHz Models
- Microwave Analyzer Channel with CW or Burst
- Two 300 MHz General-purpose Channels
- 100 ps Single-shot Time Resolution
- 12 Digit/s Frequency Resolution, 14 Digit Display
- 25 ms (Auto) or Zero (Manual) Acquisition Time
- 3 mV Voltage Resolution
- Optional 1.5×10^{-8} Ultra High-stability Oven Time Base
- -35 dBm to +10 dBm Power Range

Measurement Throughput

- 250k Sample/s Data Transfer Rate to Internal Memory (Up to 750k samples stored)
- 5k Sample/s Data Transfer Rate over USB/GPIB Bus (Block mode)

Available Functions and Features

- Automated Measurements: Frequency, Period, Ratio, Time Interval, Time Interval Error, Pulse Width, Rise/Fall Time, Phase Angle, Duty Cycle, Maximum Voltage, Minimum Voltage, Peak-to-Peak Voltage
- Integrated Power Meter
- Multi-parameter Display
- Trend Plot Mode
- Measurement Statistics Mode
- Histogram Mode
- Allan Deviation
- Zero Dead-time Frequency/Period Measurements

Connectivity

- USB Device and GPIB Ports on Rear Panel for Quick PC Connectivity
- GPIB Interface Supports Full SCPI-compatible Programmability and offers an Emulation Mode for Plug-and-Play Replacement in Existing ATE Systems
- External Arming Input
- 10 MHz Reference Oscillator Output
- Includes National Instrument's LabVIEW SignalExpress™ TE Limited Edition Software for Connecting Your Bench
- Optional TimeView™ Software Available for Modulation Domain Analysis

3-year Warranty

Feature-rich Tools for Precision Measurements

The MCA3000 Microwave Counter Series outperforms every microwave counter on the market today in terms of resolution, speed, and acquisition time. Including an integrated power meter, the MCA Series packs many different functions into one feature-rich instrument.

With industry-leading frequency and time resolution, the MCA Series comes standard with internal memory and a fast data transfer rate of 250k Samples/s to memory. In addition, the multi-parameter display shows auxiliary measurements alongside your main measurement to provide you with the results you need at a glance. With the industry's most comprehensive analysis modes, including measurement statistics, histograms, and trend plots, you have the tools you need to quickly and accurately analyze your signal.

Besides being an outstanding microwave counter, the MCA3000 Series also serves as a general-purpose timer/counter with two additional 300 MHz inputs.

Industry-leading Performance for Demanding Designs

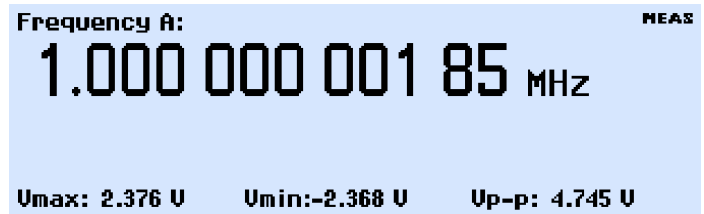
Fast high-resolution frequency or power measurements with a very short acquisition time of 25 ms (Auto) or zero (Manual) is essential for validating today's complex designs. For calibration and metrology applications, the MCA Series offers very high accuracy through a stable internal OCXO time base, low systematic time interval A-B error, and high resolution.

Fast Throughput Reduces Test Time

The MCA Microwave Counter Series offers industry-best throughput, saving you up to 90% on your testing time compared to other microwave timer/counters on the market. Up to 250,000 measurement results per second can be stored in the internal memory. Alternatively, you can transfer up to 5,000 measurement results per second in Block mode through the GPIB or USB interface.

Power Measurements

With an integrated power meter, the MCA Series provides measurement of frequency and power with a single connection at any supported frequency



Multi-parameter Display.

level. For the first time, variations in signal power can be seen, collected, and analyzed in the same manner as frequency, both numerically and graphically. With 0.01 dBm at 100 ms measuring time resolution and a wide power range from -35 dBm to +10 dBm, you have the flexibility for a broad range of power measurement applications.

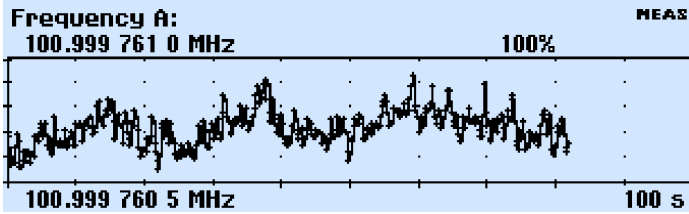
Analyze Your Device with the Industry's Only Graphical Display

With the unique display of the MCA Series, you can measure multiple parameters of the same signal from one test connection. To reveal signal quality issues like drift, intermittent transients, and stability, you can view the data as a real-time trend plot or a histogram with the MCA Series graphical display mode, or you can use measurement statistics to track how signal parameters are changing over time. A single-button Analyze mode gives you fast insight into the behavior of your device right on the timer/counter's display.

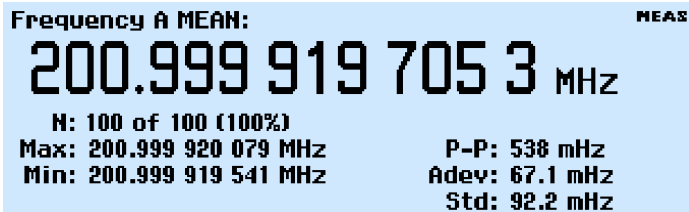
Multi-parameter Display

With the multi-parameter display, you can read important auxiliary measurement values (such as V_{\max} , V_{\min} , V_{p-p} , and more) displayed with your main frequency, time, period, or phase measurements. With one glance, you can see the information you need to quickly assess your device's performance.

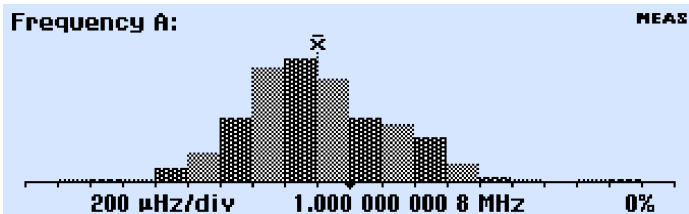
With 3 input channels, you can measure the relationship between different signals. For example, you can measure the phase relationship between the input and output signals of your device. You can read other critical parameters simultaneously, such as the test frequency of the signal and the voltage ratio (in dB), in one glance with the multi-parameter display.



Trend Plot Analysis.



Measurement Statistics.



Histogram Plot.

Measurement Trend Plots

Depending on your test case, your signal parameters may change from instant to instant. With the Trend Plot Analysis mode, you can graphically plot the trend of a measured value over time.

Measurement Statistics

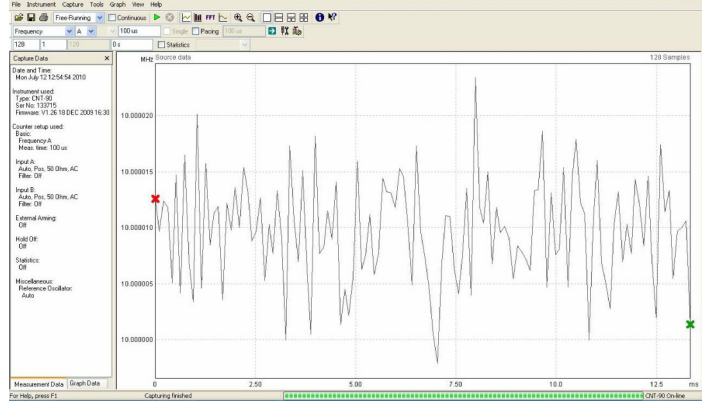
With integrated statistics processing, you can calculate the average, standard, and Allan deviation of a measurement, as well as track the minimum and maximum measured values, all with the push of a button.

Histogram Plots

To graphically see the average and standard deviation of a set of measurements, you can use the histogram function to see the distribution of measurement results.

Optional Modulation Domain Analysis

With the optional Tektronix TimeView™ software (TVA3000), the MCA Series products become high-performance modulation domain analyzers. With high measurement speeds (up to 250k measurement/s) and memory



Tektronix TimeView™ Software.

depth at 750k, fast frequency changes can be captured in real time and then analyzed with TimeView. This comprehensive software tool allows for remote instrument control, and the analysis and display of measurement results in a choice of graphs. For example, results can be displayed as raw data, statistical histogram, waveform graph (as if you were using an oscilloscope), or as an FFT spectrum graph. TimeView further allows analysis of modulation parameters like modulation depth or frequency modulation index.

Designed to Make Your Work Easier

The MCA Microwave Counter Series are designed with the ease of use and familiar operation you have come to expect from Tektronix.

Intuitive Operation

Menu-oriented settings reduce the risk of mistakes. With dedicated and menu-driven front-panel buttons, you will have fast access to frequently used functions and parameters, reducing setup time. For example, a single-touch Analyze key toggles you between Statistics, Trend Plot, and Histogram modes.

Autoset Function

Similar to Tektronix oscilloscopes, the front-panel Autoset button will automatically set optimum trigger levels and hysteresis adapted to the actual signal applied.

Easy PC Connectivity

Connect to your PC with the rear-panel GPIB or USB device ports. The GPIB interface operates in SCPI/GPIB for plug-and-play replacement in existing ATE systems or easy integration into larger test systems. If desired, an emulation mode for existing timer/counters is available.

Connect Your Bench for Intelligent Debug

Easily capture, save, and analyze measurement results from your MCA Microwave Counter Series with the special Tektronix Edition of National Instruments LabVIEW SignalExpress™ software. Every MCA3027 and MCA3040 ships with a free copy of the Limited Edition version of SignalExpress for basic instrument control, data logging, and analysis. The optional Professional Edition offers over 200 built-in functions that provide additional signal processing, advanced analysis, sweeping, limit testing, and user-defined step capabilities.

SignalExpress supports the range of Tektronix bench instruments*1 enabling you to connect your entire test bench. You can then access the feature-rich tools packed into each instrument from one intuitive software interface. This allows you to automate complex measurements requiring multiple instruments, log data for an extended period of time, time-correlate data from multiple instruments, and easily capture and analyze your results, all from your PC. Only Tektronix offers a connected test bench of intelligent instruments to simplify and speed debug of your complex design.

Performance You Can Count On

In addition to industry-leading service and support, every MCA Series Microwave/Counter/Analyzer comes backed with a three-year standard warranty.

*1 For a complete listing of Tektronix instruments supported by NI LabVIEW Signal Express, visit www.tektronix.com/signalexpress.

Characteristics

Measuring Functions

All measurements are displayed with a large main parameter value and smaller auxiliary parameter values (with less resolution). Some measurements are only available as auxiliary parameters.

Frequency A, B, C

Characteristic	Description
Range	
Input A, B	DC to 300 MHz
Input C	300 MHz to 27 GHz or 40 GHz
Resolution	12 digits in 1 s measuring time
Acquisition C	Auto or Manual
Acquisition time	25 ms in Auto (typical)
Aux Parameters	
Input A, B	V_{max} , V_{min} , V_{p-p}
Input C	Power C in dBm or W

Frequency Burst A, B, C

Characteristic	Description
Range	
Input A, B	0.001 Hz to 300 MHz
Input C	300 MHz to 27 GHz or 40 GHz
Acquisition C	Manual
Minimum Burst Duration	Down to 40 ns
Minimum Pulses in Burst	
Input A, B	3 (6 above 160 MHz)
Input C	3 × prescaler factor
PRF Range	0.5 Hz to 1 MHz
Start Delay	10 ns to 2 s, 10 ns resolution
Aux Parameters	PRF

Period A, B (Single or Average), C (Average)

Characteristic	Description
Mode	
Single, Average	
Range	
Input A, B	3.3 ns to 1000 s (single, average)
Input C	3.3 ns down to 37 ps (27 GHz) or 25 ps (40 GHz)
Resolution	100 ps (single); 12 digit/s (average)
Acquisition C	Auto or Manual (within ±40 MHz)
Acquisition time	25 ms in Auto (typical)
Aux Parameters	
Input A, B	V_{max} , V_{min} , V_{p-p}
Input C	Power C in dBm or W

Ratio A/B, B/A, C/A, C/B

Characteristic	Description
Range	
(10 ⁻⁹) to 10 ¹¹	
Input Frequency	
Input A, B	0.1 Hz to 300 MHz
Input C	300 MHz to 27 GHz or 40 GHz
Aux Parameters	Freq 1, Freq 2

Time Interval A to B, B to A, A to A, B to B

Characteristic	Description
Range	
Normal calculation: 0 ns to +10 ⁶ s Smart calculation: -10 ⁶ s to +10 ⁶ s	
Resolution	100 ps single
Min Pulse Width	1.6 ns
Smart Calculation	Smart Time Interval to determine sign (A before B or A after B)

Positive and Negative Pulse Width A, B

Characteristic	Description
Range	
2.3 ns to 10 ⁶ s	
Min Pulse Width	2.3 ns
Aux Parameters	V_{max} , V_{min} , V_{p-p}

Rise and Fall Time A, B

Characteristic	Description
Range	
1.5 ns to 10 ⁶ s	
Trigger Levels	10% and 90% of signal amplitude
Min Pulse Width	1.6 ns
Aux Parameters	Slew rate, V_{max} , V_{min}

Positive and Negative Duty Factor A, B

Characteristic	Description
Range	0.000001 to 0.999999
Frequency Range	0.1 Hz to 300 MHz
Aux Parameters	Period, pulse width

Phase A Relative B, B Relative A

Characteristic	Description
Range	-180° to +360°
Resolution	Single cycle: 0.001° to 10 kHz, decreasing to 1° >10 MHz. Resolution can be improved by averaging (statistics)
Frequency Range	Up to 160 MHz
Aux Parameters	Freq (A), Va/Vb (in dB)

V_{max}, V_{min}, V_{p-p} A, B

Characteristic	Description
Range	-50 V to +50 V, -5 V to +5 V Range is limited by the specification for max input voltage without damage (see input A, B)
Frequency Range	DC, 1 Hz to 300 MHz
Mode	V _{max} , V _{min} , V _{p-p}
Resolution	3 mV
Uncertainty (5 V range, typical)	
DC, 1 Hz to 1 kHz	1% + 15 mV
1 kHz to 20 MHz	3% + 15 mV
20 to 100 MHz	10% + 15 mV
100 to 300 MHz	30% + 15 mV
Aux Parameters	V _{min} , V _{max} , V _{p-p}

Time Stamping A, B, C

Raw time-stamp data together with pulse counts on inputs A, B, or C, accessible through GPIB or USB only.

Characteristic	Description
Max Sample Speed	See GPIB specifications
Max Frequency	160 MHz
Time-stamp Resolution	100 ps

Power C

Characteristic	Description
Range	
Power	-35 dBm to +10 dBm
Frequency	300 MHz to 27 GHz or 40 GHz
Display Units	dBm (default) or W
Resolution	0.01 dBm at 100 ms measuring time
Accuracy (Typical)	<1 dBm to 27 GHz <4 dBm to 40 GHz (MCA3040 only)
Acquisition	Auto or Manual (within ±40 MHz)
Acquisition Time	20 to 30 ms in Auto (typical)
Aux Parameters	Frequency C

Input and Output Specifications

Inputs A and B

Characteristic	Description
Frequency Range	DC Coupled: DC to 300 MHz AC Coupled: 10 Hz to 300 MHz
Impedance	1 MΩ / 20 pF or 50 Ω (VSWR ≤ 2:1)
Trigger Slope	Positive or negative
Max Channel Timing Difference	500 ps
Sensitivity	15 mV _{RMS} (DC-200 MHz) 25 mV _{RMS} (200-300 MHz)
Attenuation	X1, X10
Dynamic Range (X1)	30 mV _{p-p} to 10 V _{p-p} within ±5 V window
Trigger Level	Readout on display
Resolution	3 mV
Uncertainty (X1)	±(15 mV + 1% of trigger level)
AUTO trigger level	Trigger level is automatically set to 50% point of input signal (10% and 90% for rise/fall time)

Auto Hysteresis

Time	Min hysteresis window (hysteresis compensation)
Frequency	One-third of input signal amplitude
Analog LP Filter	Nominal 100 kHz, RC type
Digital LP Filter	1 Hz to 50 MHz cutoff frequency
Max Voltage without Damage	
1 MΩ	350 V (DC + AC peak) to 440 Hz, falling to 12 V _{RMS} (X1) at 1 MHz
50 Ω	12 V _{RMS}
Connector	BNC

Input C – 27 GHz or 40 GHz (MCA3027, MCA3040)

Characteristic	Description
Frequency Range	0.3 to 27 GHz or 40 GHz
Operating Input Voltage Range	
0.3 to 18 GHz	-33 to +13 dBm
18 to 20 GHz	-29 to +13 dBm
20 to 27 GHz	-27 to +13 dBm
27 to 40 GHz	-23 to +13 dBm
Impedance	50 Ω nominal, AC coupled
VSWR	
0.3 to 27 GHz	< 2.0:1 (typ.)
27 to 40 GHz	< 2.5:1 (typ.)
FM Tolerance	
Manual acq.	50 MHz _{p-p} ; Frequency C >3.5 GHz 30 MHz _{p-p} ; Frequency C <3.5 GHz
Auto acq.	20 MHz _{p-p} ; for any Frequency C and modulation frequency >0.1 MHz
AM Tolerance	Any modulation index (minimum signal must be within sensitivity range)
Automatic Amplitude Discrimination	10 dB separation between 2 signals within 30 MHz, 20 dB otherwise
Max Voltage without Damage	+27 dBm (27 and 40 GHz models)
Overload Indication	ON when Input C power > +10 dBm
Connector	2.92 mm spark plug female

Rear Panel Inputs and Outputs

Characteristic	Description
Reference Input	1, 5, or 10 MHz; 0.1 to 5 V _{RMS} sine; impedance ≥ 1 k Ω
Reference Output	10 MHz; >1 V _{RMS} sine into 50 Ω
Arming Input	Arming of all measuring functions
Impedance	Approx. 1 k Ω
Frequency range	DC to 80 MHz

Auxiliary Functions**Trigger Holdoff**

Characteristic	Description
Time Delay Range	20 ns to 2 s, 10 ns resolution

External Start and Stop Arming

Arming can be used to synchronize the frequency and power measurements with the start of a burst signal. Minimum burst length must exceed 100 μ s.

Characteristic	Description
Modes	Start and Stop Arming
Input Channels	A, B, or E (Ext. arming input)
Max Rep. Rate for Arming Signal	
Channel A, B	160 MHz
Channel E	80 MHz
Start-time Delay Range	20 ns to 2 s, 10 ns resolution

Statistics

Characteristic	Description
Functions	Maximum, Minimum, Mean, Δ Max-Min, Standard Deviation, and Allan Deviation
Display	Numeric, histograms, or trend plots
Sample Size	2 to 2×10^9 samples
Limit Qualifier	Off, or capture values above, below, inside, or outside limits
Measurement Pacing	Pacing Time Range: 4 μ s to 500 s

Mathematics

Characteristic	Description
Functions	$(K \cdot X + L) / M$, $(K / X + L) / M$, or $X / M - 1$. X is current reading and K, L, and M are constants; set using the keyboard or as frozen reference value (X_0)

Other Functions

Characteristic	Description
Measuring Time	20 ns to 1000 s for frequency, burst, and period average. Single cycle for other measuring functions
Time-base Reference	Internal, external, or automatic
Display Hold	Freezes the result, until a new measurement is initiated through a restart
Limit Alarm	Graphical indication on front panel and/or SRQ through GPIB
Limit Values	Lower limit, upper limit
Settings	Off, or alarm if value is above, below, inside, or outside limits
On Alarm	Stop or Continue
Display	Numeric + Graphic
Stored Instrument Setups	20. Instrument setups can be saved/recalled from internal nonvolatile memory. 10 can be user protected
Display	Backlit LCD graphics screen for menu control, numerical readout, and status information
Number of digits	14 digits in Numerical mode
Resolution	320 \times 97 pixels

GPIB Interface

Characteristic	Description
Compatibility	IEEE 488.2-1987, SCPI 199953131A Compatibility mode
Interface Functions	SH1, AH1, T6, L4, SR1, RL1, DC1, DT1, E2
Max Measurement Rate	
GPIB	5k readings/s (Block mode) 500 readings/s (individual GET triggered)
To internal memory	250k readings/s
Internal Memory Size	750k readings

USB Interface

Characteristic	Description
USB Version	2.0 full speed (11 Mb/s)

Calibration

Characteristic	Description
Mode	Closed case, menu controlled
Calibration Frequencies	0.1, 1, 5, 10, 1.544, and 2.048 MHz

General Specifications**Environmental Data**

Characteristic	Description
Class	MIL-PRF-28800F, Class 3
Operating Temp	0 $^{\circ}$ C to +50 $^{\circ}$ C
Storage Temp	-40 $^{\circ}$ C to +71 $^{\circ}$ C
Humidity	5-95% (10-30 $^{\circ}$ C) 5-75% (30-40 $^{\circ}$ C) 5-45% (40-50 $^{\circ}$ C)
Altitude	Operating: 2,000 m Storage: 12,000 m
Safety	Directive 2006/95/EC, EN61010-1, UL61010-1, CAN/CSA C22.2 No. 61010-1
EMC	EU Directive 2004/108/EC, EN61326-1, EN61326-2-1, Class A

Power Requirements

Characteristic	Description
Basic Version	90 to 265 V _{RMS} , 45 to 440 Hz, <40 W

Time-base Options

Characteristic	Standard, Medium Stability	High Stability (HS)	Ultra High Stability (US)
Time-base Type	OCXO	OCXO	OCXO
Uncertainty Due to –			
Aging			
Per 24h	<5×10 ⁻⁹ *1	<5×10 ⁻¹⁰ *1	<3×10 ⁻¹⁰ *1
Per month	<6×10 ⁻⁸	<1×10 ⁻⁸	<3×10 ⁻⁹
Per year	<2×10 ⁻⁷	<5×10 ⁻⁸	<1.5×10 ⁻⁸
Temperature variation (typ. values)			
0-50 °C	<5×10 ⁻⁸	<5×10 ⁻⁹	<2.5×10 ⁻⁹
20-26 °C	<2×10 ⁻⁸	<1×10 ⁻⁹	<4×10 ⁻¹⁰
Short-term Stability: t = 1 s	<1×10 ⁻¹⁰	<1×10 ⁻¹¹	<5×10 ⁻¹²
Root Allan Variance: t = 10 s	<1×10 ⁻¹⁰	<1×10 ⁻¹¹	<5×10 ⁻¹²
Power-on Stability	<1×10 ⁻⁷	<1×10 ⁻⁸	<5×10 ⁻⁹
Deviation versus final value after 24h ON time, after a warm-up time of:	30 min	10 min	10 min
Total Uncertainty, for Operating Temperature 20 °C to 26 °C, at 2σ (95%) Confidence Interval			
1 year after calibration	<2.4×10 ⁻⁷	<0.6×10 ⁻⁷	<1.8×10 ⁻⁸
2 years after calibration	<4.6×10 ⁻⁷	<1.2×10 ⁻⁷	<3.5×10 ⁻⁸

*1 After 1 month of continuous operation.

Physical

Dimension	mm	in.
Height	90	3.6
Width	210	8.25
Depth	395	15.6
Weight	kg	lb.
Net	2.7	5.8
Shipping	3.5	7.5

Ordering Information

Models

Model	Description
MCA3027	Microwave/Counter 27 GHz / 100 ps
MCA3040	Microwave/Counter 40 GHz / 100 ps

MCA3000 Series Includes: Microwave/Counter, line cord, calibration certificate, Quick Start User Manual, CD-ROM with user manual (English, French, German, Spanish, Simplified Chinese, Traditional Chinese, Korean, Russian, Japanese), Programmer's Guide, Technical Specifications, Trial version of TimeView™ Software, and CD-ROM with National Instruments LabVIEW SignalExpress™ Tektronix Edition, Limited Edition Software.

Note: Please specify power plug when ordering.

Instrument Options

Option	Description
HS	High-stability Oven Time Base
US	Ultra High-stability Oven Time Base

Power Plug Options

Option	Description
A0	North America
A1	Universal Euro
A2	United Kingdom
A3	Australia
A5	Switzerland
A6	Japan
A10	China
A11	India

- ASEAN / Australasia (65) 6356 3900
- Austria 00800 2255 4835*
- Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777
- Belgium 00800 2255 4835*
- Brazil +55 (11) 3759 7627
- Canada 1 800 833 9200
- Central East Europe and the Baltics +41 52 675 3777
- Central Europe & Greece +41 52 675 3777
- Denmark +45 80 88 1401
- Finland +41 52 675 3777
- France 00800 2255 4835*
- Germany 00800 2255 4835*
- Hong Kong 400 820 5835
- India 000 800 650 1835
- Italy 00800 2255 4835*
- Japan 81 (3) 6714 3010
- Luxembourg +41 52 675 3777
- Mexico, Central/South America & Caribbean 52 (55) 56 04 50 90
- Middle East, Asia, and North Africa +41 52 675 3777
- The Netherlands 00800 2255 4835*
- Norway 800 16098
- People's Republic of China 400 820 5835
- Poland +41 52 675 3777
- Portugal 80 08 12370
- Republic of Korea 001 800 8255 2835
- Russia & CIS +7 (495) 7484900
- South Africa +41 52 675 3777
- Spain 00800 2255 4835*
- Sweden 00800 2255 4835*
- Switzerland 00800 2255 4835*
- Taiwan 886 (2) 2722 9622
- United Kingdom & Ireland 00800 2255 4835*
- USA 1 800 833 9200

Service Options

Option	Description
C3	Calibration Service 3 Years
C5	Calibration Service 5 Years
D1	Calibration Data Report
R5	Repair Service 5 Years

Recommended Accessories and Software

Accessory	Description
RMU2U	Rackmount Shelf Kit for 2 Units
HCTEK4321	Hard Carrying Case
ACD4000	Soft Carrying Case
174-4401-xx	USB Host to Device Cable, 3 ft.
012-0991-xx	GPIB Cable, Double Shielded
012-1256-xx	BNC Male to BNC Male, Cable Shielded, 9 ft., 50 Ω
012-0482-xx	BNC Male to BNC Male, Cable Shielded, 3 ft., 50 Ω
SIGEXPTE	National Instruments SignalExpress™ Tektronix Edition Interactive Measurement Software – Professional Version
TVA3000	TimeView™ Modulation Domain Analysis Software



Product(s) are manufactured in ISO registered facilities.



Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.

* European toll-free number. If not accessible, call: +41 52 675 3777

Updated 10 February 2011

For Further Information. Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit www.tektronix.com



Copyright © Tektronix, Inc. All rights reserved. Tektronix products are covered by U.S. and foreign patents, issued and pending. Information in this publication supersedes that in all previously published material. Specification and price change privileges reserved. TEKTRONIX and TEK are registered trademarks of Tektronix, Inc. All other trade names referenced are the service marks, trademarks, or registered trademarks of their respective companies.

14 Mar 2011

3CW-25557-1



S J ELECTRONICS
POWER • TEST & MEASUREMENT

0800 583 44 55

Tel: +44 1536 416 200

Fax: 0800 583 55 66

sales@sjelectronics.co.uk

www.sjelectronics.co.uk