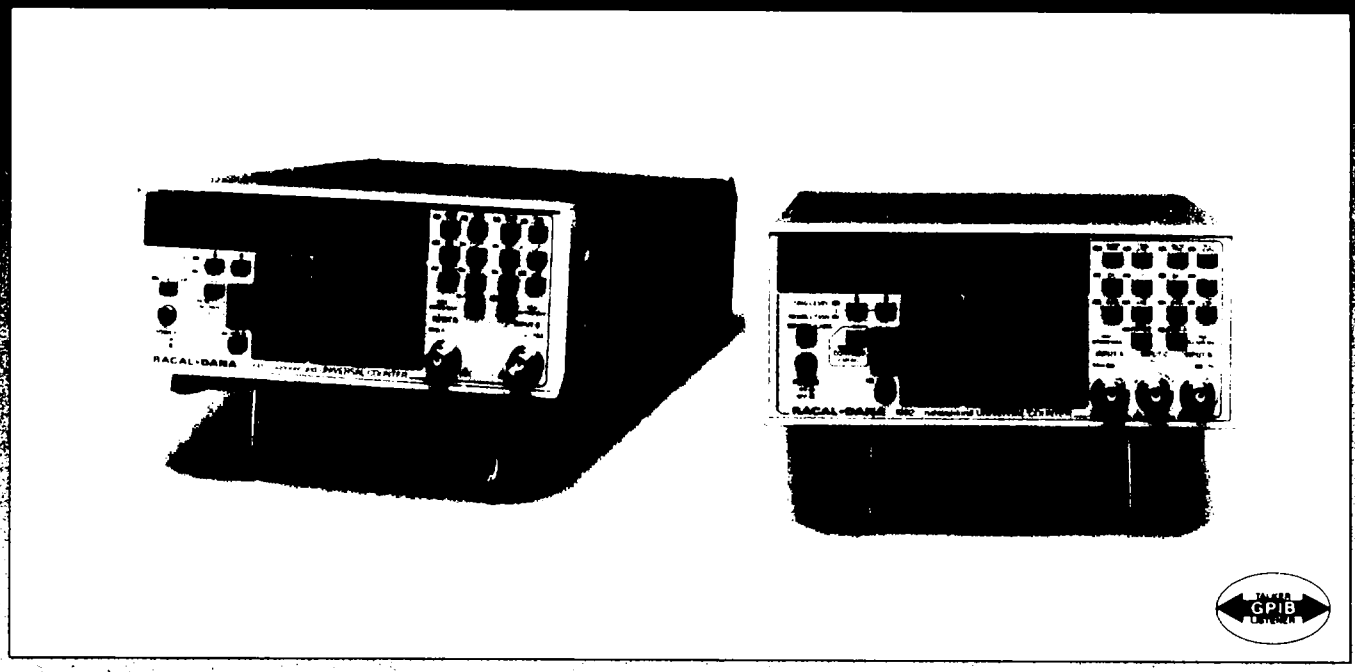
Universal Counters
Models 1991 and 1992



Features

- **Direct Frequency Measurement to 1.3GHz (160MHz Model 1991)**
- **1nSec Single Shot Time Interval**
- **9-Digit Resolution in 1 second**
- **Automatic Triggering**
- **Full GPIB Control**
- **Phase Measurement**
- **Signal Peak Amplitude Measurement**
- **Math Capability**
- **Battery Operation**

Introduction

The Racal-Dana universal counters, Models 1991 and 1992 offer a unique combination of superior performance and measurement capability in a compact, half-rack package.

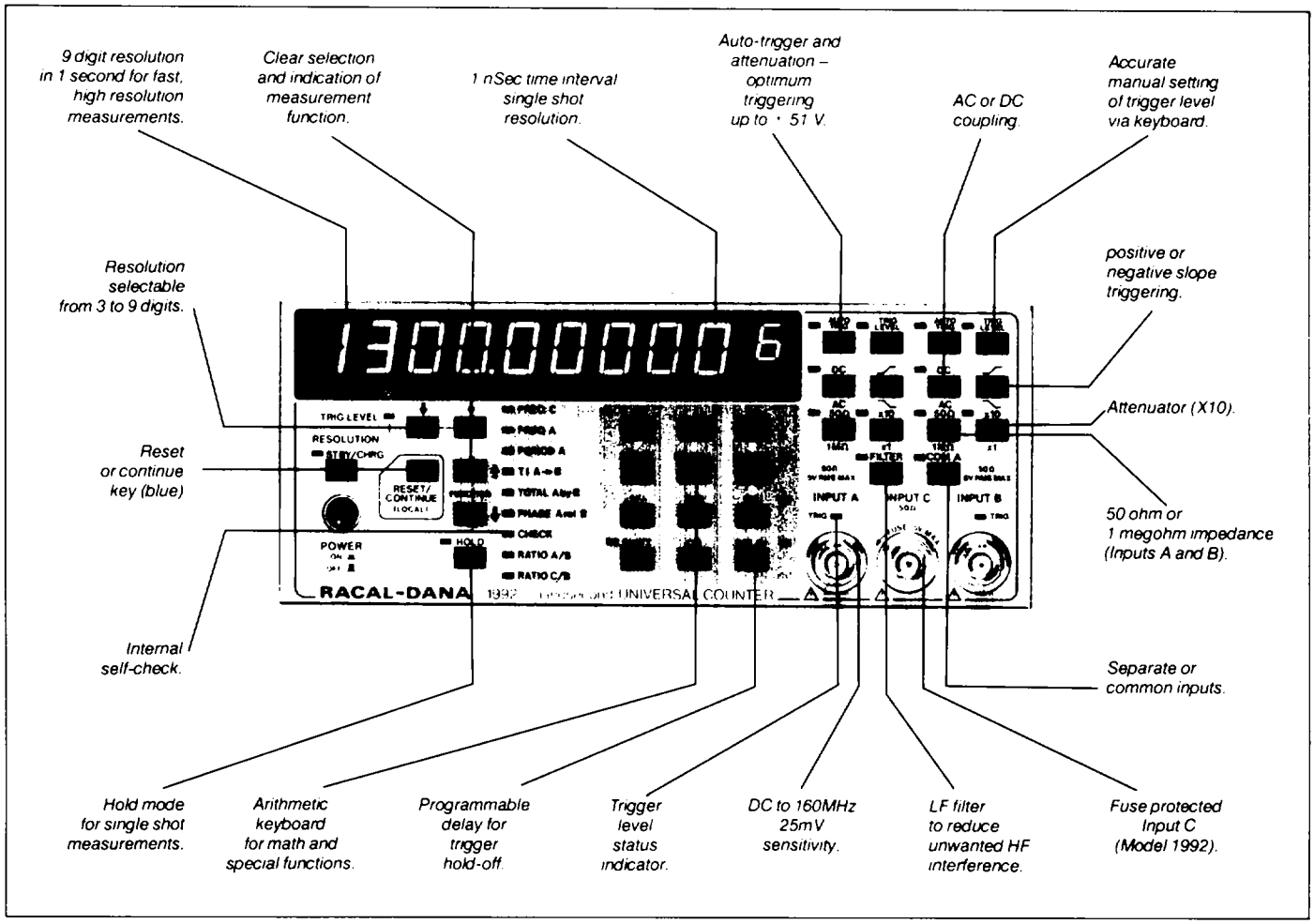
These dual microprocessor-based counters provide outstanding operational simplicity with exceptional versatility. The measurement functions, which include frequency, period, time interval, ratio, totalize, phase and peak amplitude benefit from full GPIB programming, external arming, an internal timing delay generator and math capability.

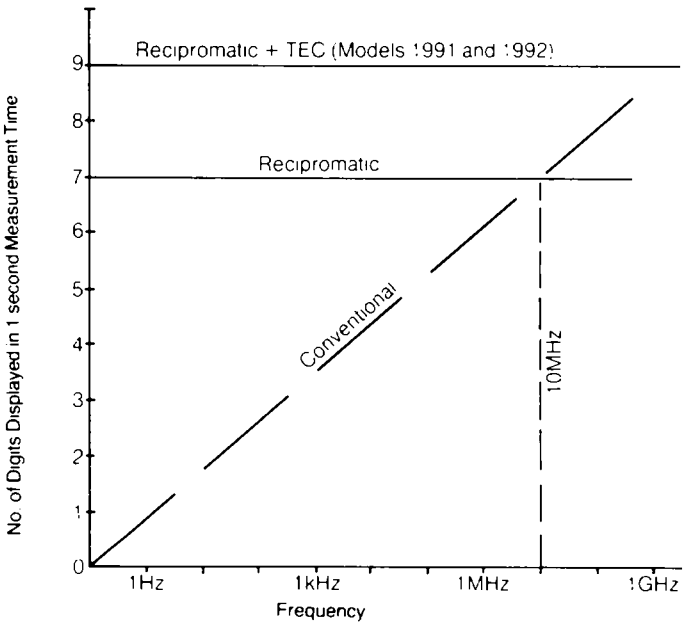
General Description

Outstanding Resolution

Models 1991 and 1992 feature a remarkable 9-digit resolution in 1 second whatever the frequency. This is achieved by using a time error correction (TEC) high resolution counting technique, which extends the capability of reciprocatic measurements by providing an effective clock frequency of 1GHz.

For applications where speed is vital, the resolution may be varied between 3 and 9 digits to provide optimum speed/resolution performance. In addition, the ability to reduce resolution is a highly desirable feature when making measurements on noisy or unstable signals.





A comparison of different counting techniques shows the exceptional resolution achieved at all frequencies by the combined TEC and reciprocmatic techniques used in models 1991 and 1992. This outstanding resolution also applies to timing measurements which is not the case using other techniques.

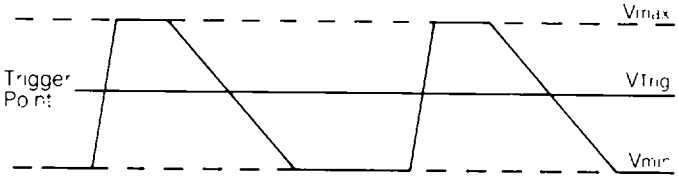
One Nanosecond Single Shot Time Interval

The TEC technique enables Models 1991 and 1992 to make single shot time interval measurements to an exacting one nanosecond resolution. High accuracy measurements may be made on single pulses as narrow as five nanoseconds while genuine zero nanosecond time intervals are made possible by the superb input conditioning circuits. Propagation delays in as little as one meter of cable may be measured using this feature. For single pulse systems, including radar, sonar and satellite communications, these instruments are the only realistic choice in the price range.

Auto Trigger

Fast, fully automatic trigger control guarantees optimum triggering for the vast majority of measurement applications. The attenuator is selected automatically when required allowing any input waveform to be handled over the instrument's full operating range of −51V to +51V.

Manual control of trigger level is provided by direct entry of the desired trigger voltage or by 'UP' and 'DOWN' slew controls. The display may be programmed from the front panel to show the trigger voltage or, in auto-trigger mode, the mean, positive peak or negative peak of the input signal. This provides a peak reading capability up to a full 20MHz.



Automatic triggering guarantees optimum triggering for the majority of applications. Models 1991 and 1992 may be used to display the maximum, minimum and trigger levels of the input signal. The trigger level is set to the mid point between the maximum and minimum voltages.

Full GPIB Control (IEEE-STD-488 (1978))

For use in rack-and-stack or full ATE configurations a highly versatile GPIB option is available making all front panel function and signal conditioning controls fully programmable. The exceptionally user-friendly interface follows the guidelines and conventions recommended in IEEE-STD-728 (1982) and IEC 625-2.

These remarkable counters provide more measurement power than any other low cost counter and more capability than many sophisticated, expensive systems instruments.

Math Capability

The 1991 and 1992 have the capability to offset and scale measurements to provide a readout in whatever units are most convenient to the user. Examples include miles-per-hour, feet-per-second, litres-per-second, gallons-per-hour, r.p.m., percent, parts-per-million or any exponent format, thereby allowing results to be interpreted quickly and easily – no conversions, no calculations.

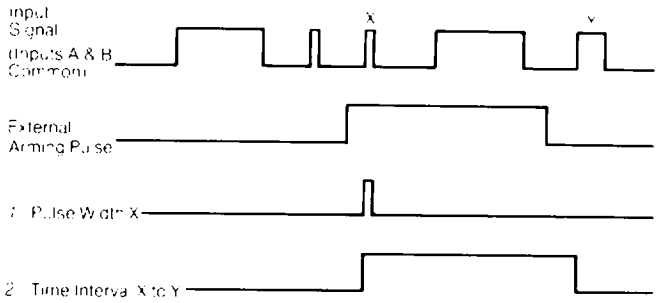
Offset and scaling when used in conjunction with the exceptionally high resolution and read rate are particularly useful when adjusting crystal controlled frequency standards.

Special Functions

The front panel keypad provides access to a range of special functions which further extend and enhance the superb measurement capability and versatility. These functions include Frequency B, Period B, single shot auto trigger and an increased read rate – all vital in an ATE role. Other important features offered by the special function capability are the self check and diagnostic routines which enable the operator to verify correct functioning and provide rapid fault identification.

External Arming

Comprehensive external arming ensures total measurement control. With the START and STOP selectively inhibited by the application of an external arming signal, individual pulses or bursts may be extracted from a complex waveform for special attention. By synchronizing the measurement process in this way radar or pulse code modulated signals may be fully characterized. External arming may also be combined with the internal timing generator 'STOP DELAY' function to further increase the ability to characterize complex waveforms.



1 External Arm (+ve edge) with Internal Stop.
2 External Arm enable (+ve edge) with External Arm disable (ve edge)

The nine arming modes available in Models 1991 and 1992 enable complex waveforms to be fully characterized. Individual pulses with pulsewidths down to 5nS can be extracted and measured as can the time interval between two pulses. In waveforms which include tone bursts, the frequency of bursts may be measured quickly and easily.

Choice of Frequency Standards

A wide range of frequency standards is available to provide Models 1991 and 1992 with the perfect standard for any application. Crystal controlled, temperature controlled crystal oscillators (TCXO) and proportionally controlled oven timebase standards are available for bench, system, battery portable or precision measurement applications. A standby mode ensures that power is supplied continuously to the timebase to maintain maximum stability.

For maximum accuracy and to ensure synchronization to a master standard, a 10MHz external standard input is included. An internally fitted frequency standard multiplier option is available for use with external standards operating at submultiples of 10MHz ensuring complete systems compatibility.

DC Supply Operation

For field applications an internal rechargeable battery option provides a 'go-anywhere' capability. A battery economizer feature maximizes battery life by shutting down to the standby mode when the instrument is not in continuous use.

An external DC input of 11-16V is also provided with the battery option allowing the counters to be powered from a vehicle or other external DC supply.

Universal Counters
Models 1991 and 1992

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Technical Specification
Model 1991

Input Characteristics

Inputs A and B

Frequency Range

Input A	DC to 160MHz DC coupled 10Hz to 160MHz AC coupled
Input B	DC to 100MHz DC coupled 10Hz to 100MHz AC coupled

Sensitivity

Sine Wave	25mVrms DC to 100MHz 50mVrms to 160MHz
Pulse	75mV p-p, 5nS min. width
Dynamic Range (× 1 attenuation)	75mV to 5V p-p to 50MHz 75mV to 2.5V p-p to 100MHz 150mV to 2.5V p-p to 160MHz

Signal Operating Range

× 1 attenuation	± 5.1V
× 10 attenuation	± 51V

Input Impedance (nominal)
(× 1 and × 10 atten.)

Separate Mode	50ohms or 1 Megohm //≤45pf
Common Mode	50ohms or 1 Megohm //≤55pf

Maximum Input (without damage)

50 ohms	5V(DC + ACrms)
1 Megohm (× 1 attenuation)	260V(DC + ACrms), DC to 2kHz Decreasing to 5V rms, at 100kHz and above.
1 Megohm (× 10 attenuation)	260V(DC + ACrms), DC to 20kHz Decreasing to 50Vrms at 100kHz and above.

Coupling	AC or DC.
Low Pass Filter	50kHz nominal (Input A selectable).
Trigger Slope	+ve or −ve
Attenuator	×1 or ×10. In Auto Trigger mode, attenuator selected automatically if necessary.

Trigger Level Range

Manual	
× 1 attenuation	± 5.1V in 20mV steps.
× 10 attenuation	± 51V in 200mV steps.
Automatic	± 51V.

Trigger Level Accuracy

Manual and Automatic	
× 1 attenuation	± 30mV ± 1% of trigger level reading.
× 10 attenuation	± 300mV ± 1% of trigger level reading.

Auto Trigger

Frequency Range	DC and 50Hz to 100MHz (Typically 160MHz)
Min. Amplitude (AC)	Typically 150mV p-p*
× 10 attenuator	Automatically selected if input signal exceeds ±5.1V or 5.1V p-p*

Trigger Level Outputs (Rear Panel)

Range	± 5.1V
Accuracy (Relative to true trigger level)	
× 1 attenuation	± 1% V output ± 10mV
× 10 attenuation	± 1% V output ± 100mV
Impedance	10 kohm nominal.

External Arming

A comprehensive external arming capability to determine the START and/or STOP point of a measurement. Available on all measurement functions except phase.

Input Signal (via Rear Panel)	TTL compatible (min. pulse width 200ns).
Slope	+ve or −ve independently selectable on START or STOP arm.
Impedance	1kohm nominal.

Measurement Modes

Frequency A

Range	DC to 160MHz.
Digits Displayed	3 to 9 digits plus overflow
LSD Displayed (Hz)	F × 10^−D (D = No. of digits, F = Freq. rounded up to next decade)*.
Resolution *(Hz)	± LSD† ± (Trig. Error* × Freq.) /Gate Time.
Accuracy *(Hz)	± Resolution ± (Timebase Error × Frequency)

Time Interval

Range

Separate Mode	0 to 8 × 10^5 sec. Typically 2nS to 8 × 10^5 Sec.
Common Mode	5nS to 8 × 10^5 Sec.

Input

Common	Input A START and STOP
Separate	Input A START Input B STOP

Trigger Slopes	−ve or −ve Selectable START and STOP.
LSD Displayed	1nS min.
Resolution *(Sec)	± LSD + 1nS ± Trig Error*
Accuracy *(Sec)	± Resolution ± (Timebase Error × TI) * Trigger Level Timing Error* ± 2nS**

Time Delay

Available on Time Interval and Totalize.

Range	200 μS to 800 mS nominal.
Step Size	25 μS nominal.
Accuracy	± 0.1% Rdg ± 50μS

** A differential delay which may be reduced by numerical offset or external compensation
† 2LSD for 6–9 digits displayed
* See Definitions

Period A

Range	6.25nS to 1.7×10^3 Sec
Digits Displayed	3 to 9 digits plus overflow.
LSD Displayed (Sec)	$P \times 10^{-D}$ (D = No. of digits, P = Period rounded up to next decade)*.
Resolution *(Sec)	± LSD† ± (Trig. Error* × Period) /Gate Time.
Accuracy *(Sec)	* Resolution ± (Timebase Error × Period).

Ratio A/B

Specified for higher frequency applied to Input A.

Range	DC to 100MHz on both inputs.
LSD Displayed (for 6–9 digits selected)	$\left(\frac{10}{\text{Freq. B} \times \text{Gate Time}}\right)$, rounded to nearest decade*.
Resolution*	+ LSD ± (Trig. Error B */Gate Time) × Ratio.
Accuracy*	± Resolution.

Totalize A by B

Accumulative or single totalize.

Input	Input A.
Range	$10^{18} - 1$ (Max. 9 most significant digits displayed).
Maximum Rate	10^8 events/Sec.
Minimum Pulse Width	5nS min. at trigger points.
Accuracy	± 1 count.
Start/Stop	Electrical (Input B) or Manual.

Phase (A rel. to B)

Range	0.1 to 360°.
LSD Displayed	0.1° to 1MHz. 1.0° to 10MHz. 10° to 100MHz.
Resolution *(degrees)	± LSD * (TI Resolution/Period A) × 360°
Accuracy *(degrees)	± LSD ± (TI Accuracy/Period A) × 360

Amplitude Measurement

Peak*

Frequency Range	50Hz to 20MHz.
Amplitude Range	160mV p-p to 51V p-p.
Resolution	
× 1 attenuation	20mV
× 10 attenuation	200mV
Accuracy	
× 1 attenuation	± 50mV ± 6% V p-p. (Typically ± 40mV ± 2% V p-p.)
× 10 attenuation	± 500mV ± 10% V p-p. (Typically ± 400mV ± 3% V p-p.)

DC (<15mV p-p AC)

Amplitude Range	±51V.
Resolution	
× 1 attenuation	20mV
× 10 attenuation	200mV
Accuracy	
× 1 attenuation	± 40mV ± 1% Rdg.
× 10 attenuation	± 400mV ± 1% Rdg.

Math

Available on all measurements except Phase and Check.

Function	(Result − X)/Z.
Entry Range	$\pm 1 \times 10^{-10}$ to $+ 1 \times 10^{10}$ to 9 significant figures.

General

Internal Timebase
Crystal Controlled

Frequency	10MHz.
Aging	2×10^{-6} in the first year.
Temperature Stability	1×10^{-5} over the range 0 to + 50°C.
Adjustment	Via rear panel.

Frequency Standard Output

Frequency	10MHz.
Amplitude	TTL levels giving approx. 1V p-p into 50 ohms.
Impedance	90 ohms nominal.
Max. Reverse Input	± 15V.

External Standard Input

Frequency	10MHz (see also Option 10 for other frequencies).
Signal Amplitude (Sine Wave)	Min. 100mV rms Max. 10V rms
Impedance	1 kohm nominal at 1V p-p 500 ohms nominal at 10V p-p

Gate Time
(Frequency, Period and Ratio modes).

Automatically determined by resolution selected (Range 1 msec – 10sec)*.

Resolution Selected	Gate Time (seconds)
9 + overflow	10
9	1
8	0.1
7	0.01
6,5,4,3	0.001

Single Cycle (Hold)	Enables a single measurement to be initiated and held.
Display	9-digit, high brightness, 14mm LED display in engineering format with exponent digit.

† 2LSD for 6–9 digits displayed
* See Definitions

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Power Requirements

Voltage	90–110 103–127 193–237 207–253 VAC
Frequency	45–450Hz
Rating	35VA Max.

Operating Temperature Range	0° to + 50°C. (0° to + 40°C with battery pack).
Storage Temperature Range	−40°C to +70°C (−40°C to +60°C with battery pack).
Safety	Designed to meet the requirements of IEC348 and follow the guidelines of UL1244.
Dimensions	3.5H x 8.4W x 12.4D inches (88H x 212W x 413D mm)
Weight	Net 3.63kg (8lb.) excl. battery 6.8kg (15lb.) inc. battery Shipping 5.5kg (11lb.) excl. battery 8.75kg (19.3lb.) inc. battery
Shipping Dimensions	430 × 360 × 280mm (16.91 × 14.2 × 11.0 ins.)

Model 1992

Specification identical to that for Model 1991 with the addition of the following:-

Input Characteristics

Input C

Frequency Range	40MHz to 1.3GHz.
Sensitivity	
Sine Wave	<10mV rms, 40MHz to 1GHz <75mV rms to 1.3GHz.
Dynamic Range	10mV rms to 5V rms to 1GHz. 75mV rms to 5V rms to 1.3GHz.
Input Impedance	50 ohms nominal AC coupled.
VSWR	≤ 2:1 at 1GHz.
Maximum Input	7V rms (fuse protected). Fuse located in BNC connector.
Damage Level	25W.

Measurement Modes

Frequency C

Range	40MHz to 1.3GHz.
LSD	As for Frequency A*.
Resolution* and Accuracy*	As for Frequency A.

Ratio C/B

Specified for higher frequency applied to Input C.

Range	Input C 40MHz to 1.3GHz. Input B DC to 100MHz.
LSD Displayed (for 6–9 digits selected)	$\left(\frac{640}{\text{Freq. B} \times \text{Gate Time}}\right)$, rounded to nearest decade*.
Resolution* and Accuracy*	As for Ratio A/B.

Options

Option 01 Rear Panel Inputs

A rear panel input, factory fitted option, is available for ATE applications. Inputs A and B are in parallel with those on the front panel while input C (Model 1992 only) is fitted in place of the front panel input.

Option 04T

Temperature Controlled Crystal Oscillator

Frequency	10MHz.
Aging Rate	3×10^{-7}/month. 1×10^{-6} in the first year.
Temperature Stability	1×10^{-6} over the range 0 to +40°C (operable to +50°C).
Adjustment	Via rear panel.

Option 04A

Ovened Oscillator

Frequency	10MHz
Aging Rate	3×10^{-9}/day averaged over 10 days after 3 months continuous operation.
Temperature Stability	$\pm 3 \times 10^{-9}$/°C averaged over range 0° to +45°C (operable to +50°C).
Warm Up	Typically $\pm 1 \times 10^{-7}$ within 6 minutes.
Adjustment	Via rear panel.

Option 04B

High Stability Ovened Oscillator

Frequency	10MHz
Aging Rate	5×10^{-10}/day averaged over 10 days after 3 months continuous operation.
Temperature Stability	$\pm 6 \times 10^{-10}$/°C averaged over range 0° to +45°C (operable to +50°C).
Warm Up	$\pm 1 \times 10^{-7}$ within 20 minutes.
Adjustment	Via rear panel.

Option 07

Rechargeable Battery Pack and External DC Operation.

Battery Type	Sealed lead-acid cells.
Battery Life	Typically 4 hours at +25°C (10 hrs on standby).
Battery Condition	Display indicates battery low.
External DC	11–16V via socket on rear panel (−ve ground, not isolated).

Option 10

Reference Frequency Multiplier

Input Frequency	1, 2, 5 or 10MHz ($\pm 1 \times 10^{-5}$).
Input Amplitude and Impedance	As for external standard input.

Option 55

GPIB Interface	Designed to comply with IEEE-STD-488 (1978) and to conform with the guidelines of IEEE-STD-728 (1982).
Control Capability	All functions and controls programmable except power on/off and standby charge.
Output	Engineering format (11 digits and exponent).

* See Definitions

IEEE-STD-488 Subsets SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E2.

Handshake Time 250μS to 1mS/character dependent on message content.

Read Rate Typically 20/sec dependent upon measurement function.

Definitions

LSD (Least Significant Digit).
In Frequency and Period modes display automatically upranges at 1.1 × decade and downranges at 1.05 × decade, except on Input C for input frequency > 1GHz.

Accuracy and Resolution Expressed as an RMS value.

Trigger Error RMS.

$$\text{Trigger Error (seconds)} = \sqrt{\frac{(e_{i1}^2 + e_{n1}^2)}{S1^2} + \frac{(e_{i2}^2 + e_{n2}^2)}{S2^2}}$$

where e_i = input amplifier RMS noise (typically 150μV RMS in 160MHz bandwidth).
e_n = input signal RMS noise in 160MHz bandwidth.
S = Slew rate at trigger point V/Sec.
Suffix 1 denotes START edge
Suffix 2 denotes STOP edge
In Frequency A, Period A, Frequency B and Period B modes triggering is always on positive going edge.

Trigger Level Timing Error

$$\text{Trigger Level Timing Error (Seconds)} = 0.035 \left(\frac{1}{S1} - \frac{1}{S2}\right)$$

$$\text{typically} = 0.018 \left(\frac{1}{S1} - \frac{1}{S2}\right)$$

S1 = Slew rate on START edge V/Sec.
S2 = Slew rate on STOP edge V/Sec.

Gate Time
The nominal gate time indicated is set by the resolution selected in Frequency Period Ratio and Check modes. It is the value which is used in the calculation of LSD and Resolution. The true gate time will be extended from this value by up to:

(a) One period of the input signal(s) on Frequency B, Period B and Ratio A/B.
(b) Two periods of the input signal on Frequency A and Period A.
(c) One period of input signal B on Ratio C/B.

Peak and Peak-to-Peak Amplitudes
Peak is defined as being the highest or lowest point at which the signal width is 5nS. Similarly, Peak-to-Peak is the difference between the highest and lowest points at which the signal width is 5nS.

Supplied Accessories

Power Cord
Spare Fuse
Operator's Manual
Spare 1.3GHz Fuse (Model 1992 only).

Ordering Information

1991	160MHz Universal Counter
1992	1300MHz Universal Counter

Options and Accessories

01*	Rear Panel Inputs	11–1709 (Model 1991)
01*	Rear Panel Inputs	11–1732 (Model 1992)
04T**	TCXO	11–1713
04A**	Oven Oscillator	11–1710
04B**	High Stability Oven Oscillator	11–1711
07†	Battery Pack	11–1625
10	Reference Frequency Multiplier	11–1645
55†	GPIB Interface	11–1626
60	Handles	11–1730
60A	Rack Mounting Kit (Fixed, Single)	11–1648
60B	Rack Mounting Kit (Fixed, Double)	11–1649
61	Carrying Case	15–0773
61M	Protectomuff Case	15–0736
65	Chassis Slides (incl. Rack Mounts)	11–1716
	Thru-line Connector	11–0167
	Telescopic Antenna	23–9020
	High Impedance Probe	23–9104
	1.3GHz Fuse (Pkt. 5)	11–1718

** Fitting Option 01 may affect certain specification parameters.*

*** Only one frequency standard may be fitted at any one time. The standard reference will be supplied unless option 04T, 04A or 04B is specified.*

† The battery pack and GPIB options cannot both be fitted.

Universal Counter Models 1993/1994

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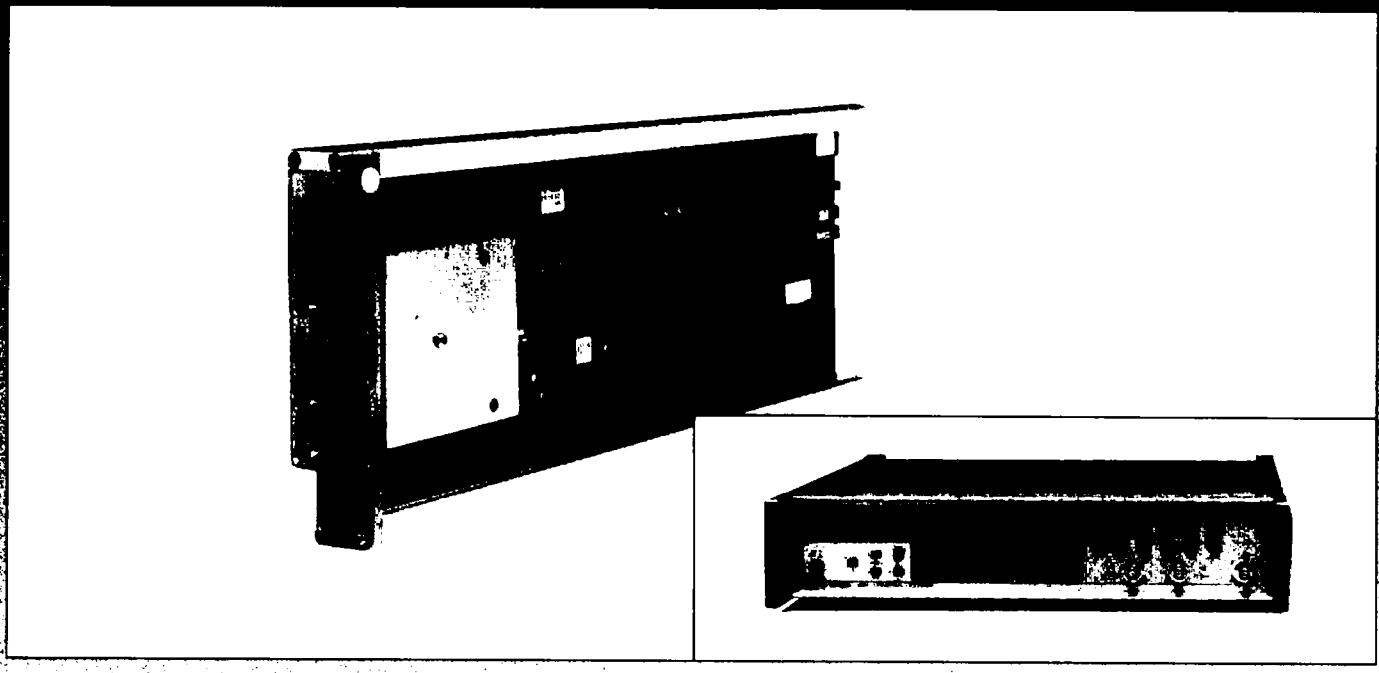

Features

- 1 nSec single-shot time interval resolution
- 9-digit resolution in 1 second
- Direct frequency measurement to 160 MHz (optional 1.3 GHz)
- Peak signal amplitude measurement
- Auto trigger within ±51 volt range
- Phase measurement
- Complete digital control

Cost-Effective System Capability

Racal-Dana Models 1993 and 1994 are completely programmable counter/timers designed for use on the bench or in automatic test systems.

The 1993 Instrument-on-a-Card brings the latest in counter technology to modular systems. It is compatible with the Wavetek 680 Multifunction System and is the result of technological advances which focus on reducing the size and number of instruments in a system. It provides all of the sophisticated measurement functions the industry has come to expect from full-sized counter/timers.

The Model 1994 is also a full-function counter/timer configured in a discrete box with GPIB programmability for rack-and-stack systems. As with the 1993, complete digital control of all measurement parameters is provided with the ability to program gate time and set trigger levels. Automatic measurements such as signal peak amplitude and phase angle are available with the press of one button or a single GPIB command.

The Model 1994 also offers the additional capabilities of a non-volatile memory and high-speed data output rate which make it ideal for integration into automatic test systems.

Outstanding Resolution

Models 1993 and 1994 feature frequency and period resolution of 9 digits in one second. This exceptional resolution permits evaluation of precision frequency standards: 1 Hz resolution at 1 GHz and 10 nHz resolution at 10 Hz are obtainable in just one second.

Timing Capability Equivalent to a 1 GHz Clock

Racal-Dana's time error correction (TEC) circuit improves measurement resolution over that of normal recipromatic counters, and up to one hundred times that of other counters.

By using time error correction in combination with traditional recipromatic techniques, long gate times may be eliminated. The TEC technique permits single-shot time interval measurements to be made with one nanosecond resolution or averaged measurements with 100 picosecond resolution on pulses as narrow as five nanoseconds. This capability allows measurement of rise/fall times, propagation delay through integrated circuits, and even computer memory access times to be examined quickly and easily.