type 2977

Phase Meter

FEATURES:

- IEEE–488/IEC 625–1 Standard Interface allows easy interfacing to other similarly equipped instruments
- Built-in delay line with 1 μs max. resolution and up to 163,8 ms delay with 0,1 ms resolution
- Positive or negative slope triggering, AC or DC coupled inputs
- Phase difference displayed in degrees or radians
- Centre zero ($\pm$180°/3,14 rad) or end zero (0–360°/6,28 rad) ranges
- DC output proportional to phase angle, frequency or group delay
- Easy to read, high resolution 4-digit display
- Analogue circuits optically isolated from digital circuits for improved signal-to-noise ratio
- Range of Special Functions extends measurement capabilities

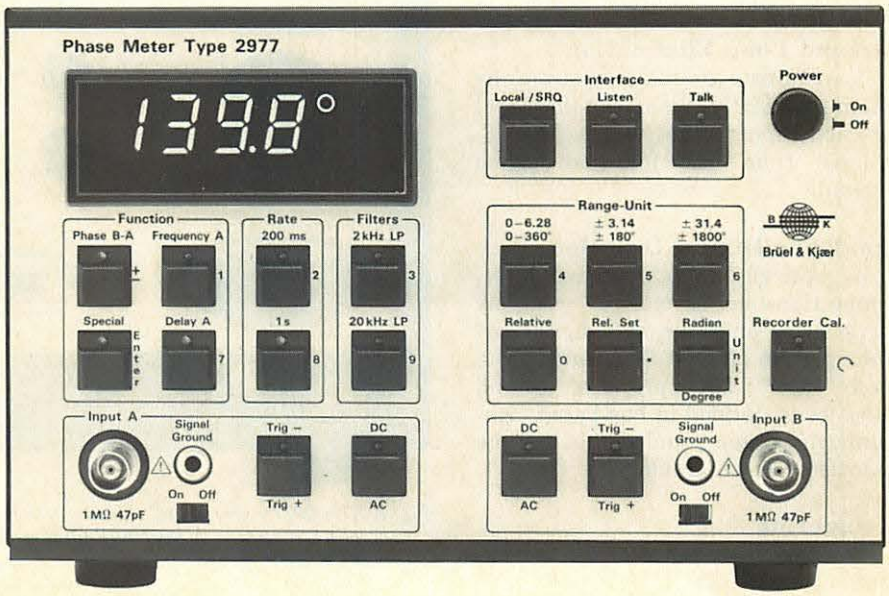
USES:

- IEEE 488/IEC 625–1 bus-based test and measurement systems
- General purpose Phase Meter and Frequency counter
- Measurement of phase response of electronic and audio signal processing equipment (amplifiers, etc.)
- Measurement of loudspeaker phase characteristics
- Phase measurements for vibration analysis
- Special measurement requirements—data logging, go/no-go testing and other Special Functions

The Type 2977 Phase Meter is a versatile and easy-to-use instrument with simple keystroke selection of a wide range of standard and special functions. The wide bandwidth and dynamic range of the 2977 make it useful in a variety of applications in electronic engineering, acoustics and vibration measurements.

Comprehensive triggering facilities include positive or negative slope triggering and AC or DC coupling of either input, allowing accurate measurement on asymmetric or distorted waveforms. Triggering at the reference input can be delayed by up to 163,8 ms using the built-in delay line.

The IEEE/IEC interface gives full remote control of the 2977 and provides for remote processing and recording of measurements. Integrated and automated test and measurement systems can be assembled using the 2977 with other bus-compatible instruments.



The Type 2977 Phase Meter is a compact and versatile instrument suitable for benchtop use with straight-forward front-panel control, or system use, with its IEEE 488/IEC 625–1 Digital Interface. Apart from phase and frequency measurements on signals in the range 2 Hz to 200 kHz, it also features a built-in delay line at the reference phase input and a range of Special Functions providing further measurement storage and processing facilities.

All switch settings, Special Functions and IEEE interface parameters are stored in a continuous memory when the 2977 is switched off, keeping it ready for instant use. When power is re-applied, the 2977 is automatically reset to the condition it was in immediately before being switched off. The continuous memory is powered by long life Ni-Cd cells which are automatically recharged while the instrument is operating.

The IEEE/IEC interface has full Talker (T 5) and Listener (L 3) capability giving access to all front-panel controls apart from the Power switch and the Signal Ground switches and allowing all measurement data to be transmitted to other instruments for further processing.

Input Amplifier

The two input amplifiers of the 2977 are electrically identical with individual selection of grounded or non-grounded input, positive or negative slope triggering, and DC or AC coupling. Input A is the reference input, Input B is the "unknown" phase.

Ground Loop Elimination

To eliminate ground loops from the input to the 2977, the screen (low side) of each input socket can be disconnected from the internal signal ground.

Analogue/Digital Isolation

By optically coupling signal interconnections and careful power supply design, the analogue and digital circuits remain electrically isolated from each other. This prevents ground loops being formed in bus-based measurement systems and eliminates the associated noise problems.

Triggering

The triggering range of the two inputs extends from 1,4 mV peak to a maximum 10 V peak. The high input impedance (1 MΩ//47 pF) allows high impedance attenuator probes to be coupled to the input for measurements on signals up to 100 V peak.

Triggering always occurs at the zero-crossing point of the waveform. Positive or negative slope triggering of either channel gives maximum versatility in measuring phase differences of complex or noisy waveforms. With the added convenience of centre-zero or end-zero ranges, a direct and meaningful read-out of phase difference can be obtained in any measurement set-up — the 2977 can be configured to suit the measurements being made, no "correction factor" need be added to or subtracted from the indicated measurement.

AC/DC Coupling

Inputs can be AC or DC coupled to suit the type of signal being measured. When an input is AC coupled low-frequency cut-off of the input circuit is 2 Hz. DC coupling ensures triggering off "impulse" type signals such as digital pulse trains, which can have large mark-space ratios and very short rise-times.

High-Frequency Limiting

The high-frequency cut-off of the 2977's input amplifiers is 200 kHz. In situations where high-frequency noise is interfering with the measurements this can be reduced to 20 kHz or 2 kHz using the front-panel "Filters" push-keys.

Phase Measurement

Phase measurements can be scaled in degrees or radians, with end-zero (0 rad to 6,28 rad, 0° to 360°) or centre-zero (±3,14 rad, ±180°) ranges. Phase difference can also be measured over ten periods using the ±31,4 rad/±1800° range. The range is selected by one of three pushkeys, with a separate pushkey to select indication in degrees or radians.

Measurements are displayed with 0,001 rad or 0,1° resolution in the ranges 0 to 6,28 rad/360° and ±3,14 rad/180°, with a Special Function giving 0,01° resolution. In the ±31,4 rad/±1800° range resolution is 0,01 rad or 1°.

Delay Line

A built-in delay line in the reference input (Input A) simplifies measurements such as free-field phase response of microphones and loudspeakers and record/playback characteristics of tape-recorders. The delay line has a maximum resolution of 1 μs up to 9,999 ms (4-digit resolution), with a maximum delay of 163,8 ms. The required delay time is numerically entered using one of the Special Functions, and a front-panel pushkey then toggles the delay line on and off.

Relative Measurement

Phase measurements can be modified by entering a reference value which is subtracted from the measured value to give relative phase dif-

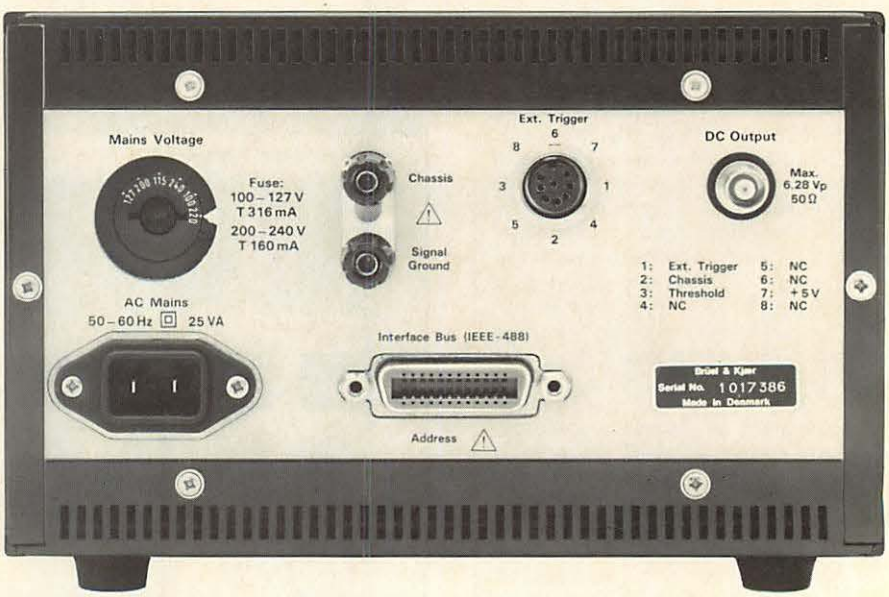


Fig. 1. The 2977's rear panel showing the Ext. Trigger connector, the DC Output and the IEEE interface. A Special Function is provided to allow the interface bus address to be entered as a decimal number using the front-panel pushkeys, an easier method than the more familiar rear-panel binary switch package

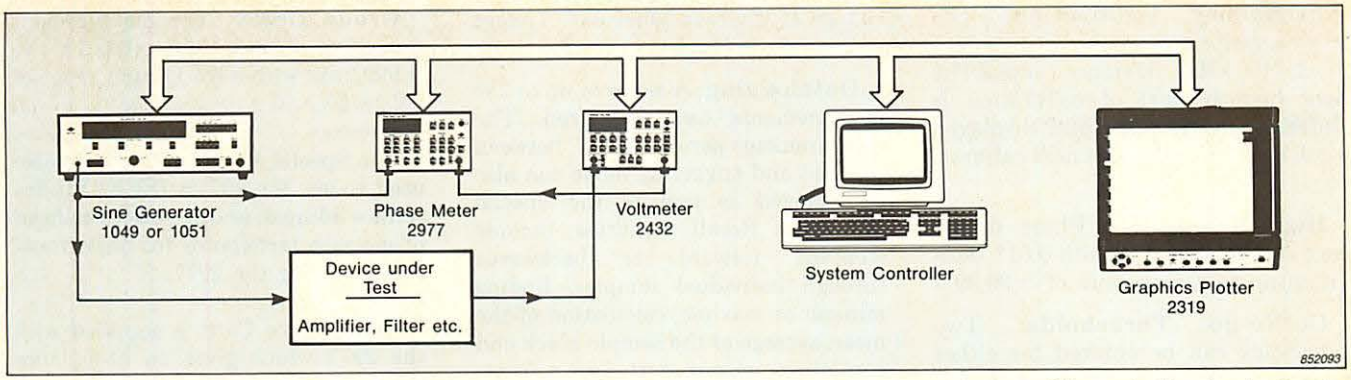


Fig. 2. The 2977 in a typical IEEE interface bus sytem, measuring gain and phase characteristics of an amplifier or similar circuit. Results can be presented on the System Controller's screen or as hard copy on the Type 2319 Graphics Plotter

ference. Any displayed measurement can be entered as the reference, or the reference can be entered numerically using the Special Functions.

Frequency Measurement

A single keystroke selects measurement of the frequency at the reference input (Input A), with the display automatically scaled to the highest possible resolution and indicating "**Hz**" or "**kHz**". The display resolution is four digits, giving a maximum resolution of 0,001 Hz up to 9,999 Hz, and a resolution of 100 Hz for frequencies up to 999,9 kHz.

Relative Measurements

As with phase measurement it is possible to select a reference frequency and have subsequent measurements displayed relative to the reference. The reference can be taken from a measured input signal or numerically entered using the Special Functions.

Display

Measurements are displayed using 7-segment, 15 mm (0,6 in) LED's in a four-digit display, which also carries messages and data concerning the Special Functions. The large bright characters are easily read even in high ambient light and have a wide viewing angle.

The 2977's display also indicates the Units in which the display is scaled and over- or underrange signals in the Input amplifiers. If the 2977 is being controlled via the IEEE/IEC interface, "**Rem.**" is indicated in the bottom right of the display.

DC Output

The DC Output connection on the rear panel of the 2977 provides a DC output voltage proportional to phase, frequency or group delay. When phase difference is being measured the DC Output is scaled at 1 mV/°, 10 mV/° or 1 V/rad, according to the units selected for the display. Frequency measurements are scaled logarithmically at 1 V/decade from 2 Hz to 200 kHz (five decades). Group delay is measured using a Special Function which allows the output voltage to be scaled to suit the measurement range.

Digital Interface

The 2977's IEEE–488 standard interface has full Talker (T 5) and Listener (L 3) capability for remote control of all instrument functions, including the Special Functions, and remote recording of measurements and status information. "Talk" and "Listen" pushkeys allow data transfers in systems operating without a System Controller. When enabled, the "Local/SRQ" pushkey can be used to reassert front-panel control after remote operation, or to generate a bus "SRQ" (Service Request).

System Use

A typical interface-bus-based measurement system is illustrated in Fig. 2, where the 2977 is illustrated in conjunction with the Type 2432 Voltmeter and the Type 1049 or 1051 Signal Generator. Measurement results can be stored and presented in a variety of ways; here, the Type 2319 Graphics Plotter is shown as an example of a suitable output device.

Address

The 2977's interface address is user-selected, and is set using one of the Special Functions. Like all other instrument settings the address is retained in the non-volatile memory when the 2977 is switched off.

Special Functions

The Special Functions of the Type 2977 add a number of operational and data-processing facilities to make it an exceptionally powerful and versatile instrument. Special Functions can be selected using the numbered pushkeys on the front panel or via the IEEE interface. A Quick Reference Guide with brief details of the Special Functions and their parameters is supplied with the 2977.

The following are some of the Special Functions included in the 2977:

Delay Line: The reference signal trigger point can be delayed by up to 163,8 ms, allowing measurements in situations where differences in transmission media cause delays to the "B" Input — for instance in vibration measurements or free-field acoustics.

Averaging: A "running average", updated with each new measurement, of up to 35 measurements; or a "block average" of up to 1999 samples with the display updated after each complete block.

Phase and Frequency References: The phase or frequency measurement is indicated relative to a keyed-in reference value. This works similarly to the front-panel "Relative" and "Rel. Set" function, but allows the reference to be entered numerically.

Frequency Calibration: The 2977 is calibrated against a user-supplied 100 kHz reference input.The date (month/year) of calibration is stored, to be recalled and displayed when the Phase Meter is next calibrated.

High Resolution: Phase difference can be displayed with 0,01° resolution up to a maximum of ±99,99°.

Go/No-go Thresholds: Two thresholds can be entered for either phase or frequency measurements. Out-of-range measurements are indicated on the display and by a logic change at the rear-panel Ext. Trigger socket.

Datalogging: A series of up to 256 measurements can be stored. The measurement period, delay between samples and triggering mode can also be changed as part of the Special Function. Recall facilities include stepping forward or backwards through individual samples, finding minima or maxima, calculation of the mean average of the sample block and continuous output started by a front-panel pushkey or an external trigger signal.

Group Delay: The measurement range for group delay is ±0,001 ms to ±999,9 ms, with a DC Output range of 0 V to 6 V.

The Special Function format is also used to set the 2977's IEEE/IEC Interface address, and to select the form of message terminator for data transfers involving the 2977.

A Reference Card is supplied with the 2977 which gives an at-a-glance guide to the Special Functions, with brief details of any parameters required.

Specifications 2977

INPUTS:
Two BNC sockets, mating plug JP 0035. Switch selection of AC or DC coupling of either input
Input A: Reference input
Input B: Unknown phase input
Input Impedance: 1 MΩ//47 pF
Max. Safe Input Voltage: 42 V (to comply with IEC 348)
The input is protected for voltages up to 350 V (DC+peak AC); 250 V DC, 220 V RMS 50/60 Hz AC; at higher frequencies, $V_{max}=10^7/f(Hz)$

Signal Ground/Input Socket Screen Separation:
Impedance: 10 kΩ//0,1 μF
Max. Voltage: ±0,6 V (DC + peak AC; diode-clamped)
Signal Ground/Chassis Separation:
Max. Voltage: ±42 V (to comply with IEC 348)
Common Mode Voltage Rejection: 42 V RMS at 50/60 Hz will not affect measurements

TRIGGERING:
Triggered by zero-crossing at the input; switch selection of positive or negative slope triggering of either input
Min. Trigger Voltage: 1,4 mV peak
Max. Trigger Voltage: 10 V peak
Over- and Under-range inputs are indicated on the display

DELAY LINE:
Range: 1 μs to 163,8 ms
Resolution: 1 μs maximum, 100 μs minimum (4 digits)

LOW-PASS FILTER:
200 kHz; front-panel switches select 20 kHz or 2 kHz
Cut-Off Slope: 6 dB/octave

PHASE ACCURACY:
±0,1° absolute error, plus the following signal- and environment-related errors:
Frequency-related Error: <0,02°/kHz
Voltage-related Error: <0,03°/dB (ref. 1 V RMS)
Temperature: <0,003°/°C at 1 V RMS; <0,3°/°C at 10 mV RMS
DC-coupling: <0,01° at 1 V RMS, <1° at 10 mV RMS

FREQUENCY ACCURACY:
±1 count plus:
5 ppm, 20°C to 25°C
20 ppm, 5°C to 40°C (relative to calibration signal frequency)

DC OUTPUT:
Output Voltage:
0–360° & ±180°: 0 V to 3,6 V, 10 mV/°
±1800°: 0 V to 3,6 V, 1 mV/°
0–6,28 rad & ±3,14 rad: 0 V to 6,28 V, 1 V/rad
2 Hz to 200 kHz: 0,3 V to 5,3 V, 1 V/decade (logarithmic)
Output Impedance: 50 Ω
Resolution: 0,1% of full-scale measurement

MEASUREMENT PERIOD:
200 ms or 1 s, selected by front-panel "Rate" switches; or one full input cycle, if longer than the "Rate" setting

IEEE INTERFACE:
Conforms with IEEE Std. 488–1978, compatible with IEC 625–1. Provides remote control of all front-panel functions and Special Functions except Signal Ground and Power switches. Output of measurement data and status information
Functions Implemented:
Talker — T 5
Listener — L 3
Remote/Local — RL 1
Device Trigger — DT 1
Device Clear — DC 1
Service Request — SR 1
Address: Set to 23 (decimal) on delivery; can be altered using Special Function

ELECTROMAGNETIC INTERFERENCE:
Complies with US FCC requirements for Class B computing devices

EXTERNAL MAGNETIC FIELD:
Maximum phase error due to 80 A/m (1 ørsted), 50 Hz external magnetic field:
At 1 V RMS input, <0,003°
At 10 mV RMS input, <0,3°

ENVIRONMENTAL LIMITS:
Operating Temperature: +5°C to +40°C (41°F to 114°F)
Storage Temperature: –25°C to +70°C (–13°F to +158°F)
Humidity: 90% RH non-condensing at 40°C

POWER SUPPLY:
100; 115; 127; 200; 220; 240 V AC 50-60 Hz, 25 VA
Complies with Safety Class II of IEC Publication 348

DIMENSIONS:
Metal cabinet, excluding connectors and feet
Height: 133 mm (5,3 ins)
Width: 210 mm (8,3 ins)
Depth: 200 mm (7,9 ins)

WEIGHT:
3,7 kg (8,2 lb)

ACCESSORIES INCLUDED:

Mains Cable	AN 0020
4 mm Wonder Plug (2)	JB 0002
BNC Plugs (2)	JP 0035
8-pin DIN plug	JP 0808
IEEE–488 connector kit	UA 0814
Fuses T160 mA (2)	VF 0051
Fuses T316 mA (3)	VF 0042
Quick Reference Guide (Special Functions) (2)	QH 0023

ACCESSORIES AVAILABLE:

BNC–BNC Cable	AO 0087
IEEE 488 Interface Cable (2 m)	AO 0265
25-pin IEC 625–1 to IEEE 488 Interface Cable (2 m)	AO 0264
Adaptor to convert IEEE 488 instrument to 25-pin IEC 625–1	AO 0195