PRODUCT DATA

PULSE™ Machine Diagnostics Toolbox — Type 9727
Machine Diagnostics Toolbox Software Bundle — Type 7910

The Machine Diagnostics Toolbox provides a complete suite of tools required to perform machine diagnostics on any type of machine or structure. It consists of Machine Diagnostics Toolbox Type 9727 and the versatile Machine Diagnostics Toolbox Software Bundle Type 7910. Optimal results can be achieved with this toolbox in hand when diagnosing a wide range of machine fault types, including those not caused by faulty rotating parts.

Type 9727 includes the multichannel PULSE data acquisition unit Type 3560-B, and a Dell™ notebook PC packaged in a ruggedized and weatherproof carrying and connector case. Type 7910 is a bundle of PULSE application software dedicated to machine diagnostics. There are three bundles to choose from.

Benefits and Features

Benefits
- Complete and transportable laboratory always ready
- On-site diagnostic precision through correlation of various measuring techniques results obtained for same operating condition
- Recording of complete machine behaviour for post-analysis minimises oversight
- Accurate evaluation of all possible faults on any machine type and component
- Easy storage and retrieval of historical data
- Easy and direct reporting
- Customisable work processes based on required tasks
- Type approved for machine diagnostics on aircraft engines and gearboxes
- Analysis of variable machine speeds even without a tachometer available
- Correlation of sound, vibration and process parameters
- Advanced tools for fault correction, including operating deflection shapes, operational modal analysis, multi-plane balancing, etc.

Features
- Based on PULSE Multi-analyzer System Type 3560
- PC, PULSE front-end and connectors in one water, shock and dust proof carrying case (IP 67 compliant)
- Diagnostic tools for addressing vibration problems in rotating, reciprocating and variable speed machinery
- Measurement and recording of 12 process parameters
- Support for multiple tachometers
- FFT, zoom and Short-term Fourier Transform (STFT) analysis
- Order analysis based on FFT and (auto)tracking
- Signal enhancement, envelope analysis, cepstrum analysis, phase and frequency response function
- Real-time analysis, time data recording and post-processing
- Database, reporting tools, and “live” reports (active cursors and configurable displays) directly in Microsoft® Word or PowerPoint®
- Wide selection of complementary PULSE application software (ODS, OMA, Orbit Plots, etc.)

Machine Diagnostics

Changes in vibration levels measured on the surface of a machine are the result of either changes in internal forces or structural changes. These forces (vibration levels) increase when the condition of the machine deteriorates – due to unbalance, misalignment and bearing and gear tooth wear. High vibration can also arise from resonances or structural modifications such as corrosion, structure and foundation cracks, coupling resonances, etc.

Checking machine vibration levels over a period of time, or permanently as used in on-line monitoring systems, will indicate the development of fault conditions but not the nature of the fault. This process is called Machine Condition Monitoring.

By using various diagnostic techniques that use vibration measurement as an indicator, the root cause of the deteriorating machine condition can be established. You can, therefore, plan the corrective measures at a convenient time and prepare for the availability of suitable spare parts. Diagnostic techniques are extremely effective because they use the information contained in the machine vibration signature directly. The signature is obtained by frequency and time analysis of the machine vibration signal from a sensor fixed on the surface of or inside the machine. It enables troubleshooting of rotor dynamic problems, rotating component deterioration as well as structural problems. This process is called Machine Diagnostics.

PULSE Multi-analyzer System

Machine Diagnostics Toolbox Type 9727 and Basic Machine Diagnostics Toolbox Software Bundle Type 7910 make up a dedicated solution for analysing rotating equipment and structures, and is specifically tailored to fulfil all the fundamental needs of a machine analyst in the field. It is centred on the widely used 5-channel PULSE portable data acquisition unit – either Type 3560-B-020 or the broad-ranged Dyn-X version Type 3560-B-120.

The incorporated PULSE unit is a versatile data acquisition and pre-processing unit for noise and vibration analysis. It accepts signals via BNC/BNT connectors from tacho probes, accelerometers, velocity and proximity probes, as well as direct voltage signals available from condition monitoring systems. Performing rotor dynamics analysis becomes effortless since the proximity probe signals can be obtained from the condition monitoring system simply by using BNC cables.

The Dyn-X version provides the widest technically available dynamic measurement range (160 dB). It is especially useful when getting the measurement right the first time is vital, or when unknown signals are involved and it is essential to measure phenomena not easily reproducible.

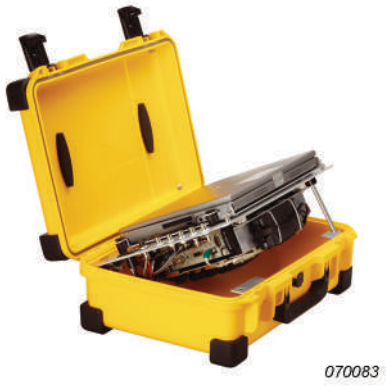
For more information on PULSE hardware, see “IDA^{e} Hardware Configurations for PULSE” (BU-0228).

Easy-to-use Diagnostics Software

Additionally, the Machine Diagnostics Toolbox offers a comprehensive range of software tools for diagnosing various machine faults. The modularity of the software and the freedom to choose the desired software packages allow for complete adaptation of the Machine Diagnostics Toolbox to fit any diagnostics task. Type 7910 basic software bundle is the foundation for all diagnostic needs. All bundles have an easy-to-use and task-oriented graphical user interface, therefore, performing measurement and analysis can be done by following a predefined workflow.

The Toolbox – Type 9727

Fig. 1
The PULSE Machine Diagnostics Toolbox with the front-end installed in the bottom compartment



Type 9727 is a compact and portable case containing all the hardware required for field testing and analysis, including:
- PULSE data acquisition unit Type 3560-B
- Notebook PC
- Batteries for both the PC and PULSE front-end
- Mains adaptors
- RS–232 cable
- Input, tacho and BNC sockets and connectors

The 5-channel front-end is a compact data acquisition system for industrial and everyday use operating on battery or DC-power. It is installed at the bottom of the case with the notebook PC fastened to a separate plate on top. In adverse conditions or to minimise the length of the transducer cables, the PC can be removed and the case with the acquisition unit can remain next to the machine under test. The connection, in that case, can be wireless or by means of a long LAN cable.

Access to the unit can be obtained by simply loosening the screws on the top plate. When necessary, a support bar can be pulled up to hold the top plate during servicing or setup of an alternative IP address (using the included RS–232 cable).

Fig. 2
Top panel connectors and indicators

The five input sockets (Ch. 1 to Ch. 5) on the top plate are duplicates of the connectors on the PULSE front-end, providing easy access without having to lift the top plate. All connections between the top plate, acquisition unit and PC are factory installed.

Ch. 1 on the top plate connects to the Tacho socket on the front-end, which is a BNT type in parallel with Input 1, but also carries a tacho supply. To connect to Ch. 1, use the optional cable AO-0158 or an AO-0587*.

Ch. 2 to Ch. 5 are BNC sockets, and are connected to Inputs 2 to 5 on the front-end.

For applications requiring a larger number of channels, a customised system using a Type 3560-C unit, in a slightly larger carrying case that supports up to 17 channels simultaneously, can be ordered. It is also possible to connect or stack more toolboxes (or front-ends) for large multichannel applications.

In addition to the PULSE data acquisition unit, the bottom compartment includes two mains adaptors, enabling all equipment to be powered from a single mains socket on the top panel. Alternatively, the unit can be powered using its built-in batteries†. Both the batteries in the unit and in the PC are charged every time the mains are connected with internal overcharge protection and overheat detection system.

The entire unit is silent and can operate without fans up to 35°C (95°F). Above this temperature, the fans start-up automatically and can be controlled by the system software. The rugged carrying case and integrated vibration dampers protect the equipment from impacts and shaking during transport. The closed case is able to withstand shocks up to 50 g.

The Software Bundles – Type 7910

The standard software bundle available is Basic Machine Diagnostics Toolbox Software Bundle Type 7910-A-N5.

This 5-channel node-locked license makes full use of the five physical channels available on Type 9727 and is ideal for the most typical test applications, including:
- Four radial accelerometers and single axial measurement on four bearings, for a complete machine train, or complete gearbox

* Note that any of the channels can be used to connect a tacho signal, but only Ch. 1 provides a DC power supply via the BNT socket.
† Requires that both the PC and data acquisition unit batteries are fully charged.

- Four simultaneous radial measurements synchronised with the key phasor on machines with variable speed
- Analysis of two dual-proximity probes and a key phasor on a machine with journal bearings. **Note:** Simultaneous and synchronous measurement on more than one machine bearing is essential to obtain a precise diagnostic

The bundle includes the following software:

- **FFT Analysis Type 7770:**
  - *Baseband & Zoom FFT Analysis*: FFT analysis provides the vibration 'signature' of the machine as a vibration level vs. frequency, also known as vibration spectrum. Predominant frequency components such as unbalanced rotors, misalignment, bent shaft, damaged or worn gears, are easily identifiable
  - *Simultaneous Real-time Multi-analysis*: Provides data consistency and reduced test time by performing different types of analysis simultaneously on all input channels
  - *Tachometer & Trigger*: Facilitates measurement of RPM value from tacho signals (for example, from a key phasor). Measurements can be triggered for start/stop by RPM signal or vibration signal
  - *Signal Enhancement*: By using a trigger, unwanted non-periodic components in the time signal and related spectrum can be suppressed, for example, for separation of adjacent machines or different shafts
  - *Auxiliary Parameter Logging*: Facilitates the input and logging of process parameters such as temperature, pressure and load for correlation with vibration inputs
  - *Cepstrum Analysis*: Especially useful for identifying and quantifying a series of 'harmonics' or 'sidebands' in the vibration spectrum originating from gearbox shafts and gears, and rolling element bearings, thus identifying machine faults in these sources. It also allows separation of transmission path effects from excitation forces (liftered spectrum). Cepstrum analysis may also be used for variable-speed machines with the additional use of Order Analysis Type 7702
  - *Frequency Response Function (FRF)*: The level of vibration measured on the surface of a machine is a function of both the excitation forces and the mobility (structural resonances) of the machine. The FRF identifies the structural resonances, thus avoiding faulty diagnosis and changing of good rotating parts
- **Envelope Analysis Type 7773:**
  Faults in rolling element bearings, gear tooth, and turbine blades are often difficult to detect with low-energy signals. Envelope analysis enables detection of these signals and gives information about the precise fault frequencies before they become too severe. In the case of reciprocating machines, it gives the precise location in the machine rotation cycle and therefore, the probable cause at an early stage of the fault
- **PULSE Data Manager Type 7767:**
  When measuring on many different machines, the vibration data gathered can quickly become cumbersome and hard to retrieve. With PULSE Data Manager, measurement data can be saved together with associated labels and meta-data. Data query and retrieval is intuitive and allows easy display, comparison and reporting in addition to easy comparison of data from several measurement points, machines and operating conditions. Data Manager includes a Microsoft® SQL-based database and a reporting tool which uses Microsoft® Word to generate live reports
- **Order Analysis Type 7702:**
  Order analysis is essential when examining vibrations from machines with variable speeds, such as in non-stationary conditions. A tachometer probe signal ensures that the analyzer follows changes in the machine. Order analysis allows for the identification of critical speeds during run-up/down, analysis of variable speed machines and separation of rotationally related components from structurally related components. If a tacho probe signal is not available, the Autotracking functionality allows the extraction of a tacho signal directly from a vibration signal. Order Analysis Type 7702 provides all the tools necessary to clearly identify vibration components at multiples of rotating speed ('orders' or 'harmonics'), and is especially useful for high order harmonics.
  Type 7702 features all the classical plots used to display measurements during transient operation, such as Bode Plots, Polar Plots and Contour Plots (also known as Campbell Plots).
- **Data Recorder Type 7708:**
  Type 7708 replaces a traditional data recorder. If required, the vibration time signal is recorded to the PC hard disk. The time signal recording can be performed in parallel with real-time analysis using PULSE FFT or order analysis software. Alternatively, the whole system can act as a high dynamic, stand-alone data recorder enabling an operator to gather high quality data for further analysis
- **PULSE Time Type 7789:**
  Includes functionality that simplifies the selection, viewing and listening of time data recordings in order to help choose the most interesting parts for analysis. This is invaluable for data from variable speed and cyclic machines, where different parts of the cycle can be identified and analysed separately. It is also essential in situations where random phenomena occur, as it allows the correlation of all input signals with the event, and the examination of prior operation to find the origin of the event

- **Time Capture Type 7705:**
  For the analysis of transients and non-stationary signals, Time Capture facilitates the selection of a short time signal around a transient and transforms it to the Time/Frequency domain using STFT. The latter is very efficient, for example, for examining vibration signals from reciprocating machines
- **Analysis Engine Type 7707*:**
  With Analysis Engine Type 7707, you can increase the 'real-time channel × bandwidth' analysis power of your PULSE system without having to add dedicated DSP hardware

See Table1 for an overview of common machine faults and the software applications that can be used to diagnose the problem.

Other Software Bundles

Additionally, the following software bundles are available:

Type 7910-A-N3

This 3-channel node-locked license is ideal for basic applications in which a total of three transducers or inputs are used simultaneously, for example, measuring a bearing in three directions with a triaxial accelerometer, or analysing the signal from two proximity probes positioned at 90° on a bearing relative to the key phasor. It can also be used to perform radial measurements on the inboard and outboard bearings of a rotor and single axial measurement on the thrust bearing.

Type 7910-A-N16

This 16-channel node-locked license supports an unlimited number of channels and is intended for applications with PULSE front-ends other than Type 3560-B, for example, Type 3560-C (up to 17-channels) and Type 3560-D (up to 65-channels). A typical application would be an analysis on large machine trains (more than four bearings) such as turbo generators or turbo compressors during site acceptance tests or post-processing of output signals of an on-line monitoring system.

In some situations, multiple, distributed smaller PULSE front-ends (Type 9727 with Type 3560-B) can be used, thereby taking advantage of the use of shorter transducer cables. This keeps the acquisition units close to the measurement points while operating the PC remotely using a long LAN cable or a wireless connection.

* Included only with the 16-channel bundle Type 7910-N16

Table 1 *Diagnostic tools for common machine faults*

	Common Machine Faults														
Software Tool	Rotor unbalance	Misalignment	Rotor rub	Journal bearing wear- and run-out	Oil film instability in journal bearings	Rolling element bearing defects	Bearings loose in housings	Gear tooth wear & cracks	Turbine blade wear & cracks	Blade cavitation, turbulence	Electric motor-specific rotor faults	Cyclic machinery fault diagnosis	Critical speed	Loose foundations	Structural resonances
Baseband FFT Analysis	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Zoom FFT Analysis	✓								✓	✓	✓	✓			
Envelope Analysis						✓		✓			✓	✓			
Signal Enhancement	✓	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓	
Cepstrum Analysis						✓		✓	✓		✓	✓			
Order Analysis	✓	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Frequency Response Function (FRF)															✓
Orbit Plot	✓	✓	✓	✓	✓										
Shaft Centre Line Plot	✓	✓	✓	✓	✓										
Two-plane Balancing	✓														
Displacement Velocity Acceleration	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RMS, Peak, Peak-to-Peak Level	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tolerance Curves	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Analysis Bandwidth & Resolution	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Multi-analysis	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tachometer & Trigger	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Auxiliary Parameter Logging	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time Data Recorder	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time Data Editing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Data Manager	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Operating Deflection Shapes (ODS)														✓	✓
Operational Modal Analysis (OMA)														✓	✓

Further Information

Further information about software for Machine Diagnostics can be found in the “Machine Diagnostics Toolbox Brochure” (BG-1605), in the various product data for the referenced application software, and also in the System Data for PULSE Software (BU-0229).

Compliance with Standards

CE, C-Tick	CE-mark indicates compliance with: EMC Directive and Low Voltage Directive. C-Tick mark indicates compliance with the EMC requirements of Australia and New Zealand.
Safety	EN/IEC 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use. ANSI/UL 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.
EMC Emission	EN/IEC 61000–6–4: Generic emission standard for industrial environments. CISPR 22: Radio disturbance characteristics of information technology equipment. Class A Limits. FCC Rules, Part 15: Complies with the limits for a Class A digital device. **Caution:** This is a Class A product. In a domestic environment this product may cause radio interference in which case, the user may be required to take adequate measures.
EMC Immunity	EN/IEC 61000–6–1: Generic standards – Immunity for residential, commercial and light industrial environments. EN/IEC 61000–6–2: Generic standards – Immunity for industrial environments. EN/IEC 61326: Electrical equipment for measurement, control and laboratory use – EMC requirements. **Note:** The above is only guaranteed using access listed in this Product Data sheet.
Temperature	IEC 60068–2–1 & IEC 60068–2–2: Environmental Testing. Cold and Dry Heat. Operating Temperature: –10 to + 50°C (14 to 122°F) Storage Temperature: –25 to +70°C (–13 to +158°F)
Humidity	IEC 60068–2–78: Damp Heat: 93% RH (non-condensing at 40°C (104°F)).
Mechanical	Non-operating: IEC 60068–2–6: Vibration: 0.3 mm, 20 m/s^{-2}, 10–500 Hz IEC 60068–2–27: Shock: 1000 m/s^{-2} IEC 60068–2–29: Bump: 3000 bumps at 250 m/s^{-2}
Enclosure	IEC 60529: Protection provided by enclosures: IP 67

Specifications – PULSE Machine Diagnostics Toolbox – Type 9727

For environmental specifications and compliance with standards for PCs, see the specifications given by their respective manufacturers. For specifications on PULSE data acquisition unit Type 3560-B, see System Data BU-0228.

Weight

(incl. carrying case, front-end and notebook PC):
Total Weight: Approx. 14 kg (30.8 lb.)
Dimensions: 466 × 344 × 172 mm (18.35 × 13.54 × 6.77 in.)

Ordering Information

SOFTWARE
Machine Diagnostics Toolbox Software Bundle Type 7910 is available in three versions: Types 7910-N 3, 7910-N 5 and 7910-N 16, where 'N' denotes a node-locked license and the following numeral denotes the number of channels (for example, 'N 3' is a 3-channel node locked license). Note that Type 7910-N 16 allows analysis/recording on an unlimited number of channels.

	PULSE Order Analysis Type No.	PULSE Time Capture Type No.	PULSE Analysis Engine Type No.	PULSE Time Data Recorder Type No.	PULSE Data Manager Type No.	PULSE FFT Analysis Type No.	PULSE Envelope Analysis Type No.	PULSE Time Type No.	M 1 Contract Type No.
7910-A-N3	7702-N 1	7705-N	–	7708-N 5	7767-A-N	7770-N 3	7773-N	7789-N	M1-7910-A-N3
7910-A-N5	7702-N 1	7705-N	–	7708-N 5	7767-A-N	7770-N 5	7773-N	7789-N	M1-7910-A-N5
7910-A-N16	7702-N 1	7705-N	7707-N	7708-N 16	7767-A-N	7770-N 16	7773-N	7789-N	M1-7910-A-N16

HARDWARE

Type 9727 — PULSE Machine Diagnostics Toolbox, incl. Type 3560-B-020, 2 Batteries (QB-0048), Notebook PC (Type 7205-B-GB) and Carrying Case (WU-0642) and battery chargers

Type 9727-X — PULSE Machine Diagnostics Toolbox, Dyn-X version, incl. Type 3560-B-120, 2 Batteries (QB-0048), Notebook PC (Type 7205-B-GB), Carrying Case (WU-0642) and battery chargers

Optional

HARDWARE

Type 3560-B-020	5/1-channel Input/Output PULSE Data Acquisition Unit with BNC connectors
Type 3560-B-120	5/1-channel Input/Output PULSE Data Acquisition Unit (Dyn-X) with BNC connectors
Type 7205-B-GB	Dell-D-420 Notebook
QB-0048	Rechargeable nickel-metal hydride battery
UA-1590	Fast Charger Kit for QB-0048
WU-0642	Carrying & Connection Case for Type 9727 (incl. HW/PC Installation)

OPTIONAL TRANSPORTATION AND CARRYING CASES

WU-0648-W-002	Ruggedized Case for Type 3560-C & Notebook, 12 Dyn-X Ch./Sub-D, 12 × Aux.Ch./Sub-D
WU-0656	Ruggedized Case for Type 3560-B & Notebook, 5 Dyn-X Ch./BNC/BNT, 12 × Aux.Ch./Sub-D
WE-0143-W-001	Waterproof Transportation Case for Type 3560-D
WE-0144	Waterproof case with foam for Type 3560-E

OPTIONAL ACCESSORIES

UL-0230	Wireless LAN Bridge point (Linksys WET 54 G)

Service Products

ACCREDITED CALIBRATION

3560-B-CAF	3560-B Controller Module, Accredited Calibration
3560-B-CAI	3560-B Controller Module, Initial Accredited Calibration

TRACEABLE CALIBRATION

3560-B-CTF	3560-B Controller module, Traceable Calibration

HARDWARE MAINTENANCE

3560-B-EW 1	3560-B, Extended Warranty, 1-year extension
3560-B-REF	3560-B, Repair incl. Conformance Test with Certificate

Recommended Optional Software and Hardware

Recommended Software
Order Tracking
PULSE Order Analysis Type 7702-N 1, to complete Type 7910-A-N3
PULSE Order Analysis Type 7702-N 3, to complete Type 7910-A-N5
PULSE Order Analysis Type 7702-N 15, to complete Type 7910-A-N16
Operating Deflection Shapes
PULSE ODS Test Consultant Type 7765-A-N
PULSE Run-up/down ODS Test Consultant Type 7765-B-N
Upgrade from ODS Test Consultant Type 7765 to Modal Test Consultant Type 7753, BZ-5455-N
Modal Analysis
PULSE Modal Test Consultant Type 7753-N
PULSE Operational Modal Analysis Pro Type 7760-A-N
PULSE Operational Modal Analysis Standard Type 7760-C-N
Other
Orbit, Polar and Shaft Centerline Plots for PULSE, WT-9695
PULSE Two-plane Balancing Consultant Type 7790-A-N
PULSE Data Recorder Type 7708-N 11, to complete Type 7910-A-N16

Recommended Hardware
Transducers
Monitoring DeltaTron® Accelerometer Type 8341, 100 mV/g, top connector, hermetic. Cable not included
Charge Accelerometer Type 8324-G, with high temperature cable and integrated charge converter/filter and TEDS
Piezoelectric DeltaTron® Accelerometer Type 8325-A, top connector. Cable not included
Industrial DeltaTron® Accelerometer Type 8326-B, top connector
Industrial DeltaTron® Accelerometer Type 8327-B, top connector, no cable integration
CCLD Laser Tacho probe MM-0360, without cables
Cables
Cable for Monitoring Accelerometers AO-0608-D-030, 2-pin MIL-C-5015 connector to BNC connector, 3 m (10 ft)
Cable for Monitoring Accelerometers AO-0608-D-050, 2-pin MIL-C-5015 connector to BNC connector, 5 m (17 ft)
Cable for Monitoring Accelerometers AO-0608-D-100, 2-pin MIL-C-5015 connector to BNC connector, 10 m (33 ft)
Aux. I/O Break-out Cable AO-1472-D-006 (6 m/2 ft) + 16 BNC Female to 37-pin D-sub Cable AO-0594, for auxiliary parameter logging
SMB Straight Connector to BNC Cable, 3 m (10 ft) AO-0587-D-030
Other
Magnet Mounting Kit UA-1282, 1/4″-28 UNF
Heavy-load Calibration Exciter Type 4294-002
20 dB Attenuator Adaptor WB-1497, for use with proximity probe signals

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