Vibration Exciter Control

type 1050

USES:

- Swept sine excitation for control of vibration exciter systems
- Engineering development, with specific application to resonance searching
- Quality control
- Environmental testing
- Prototype testing
- Fatigue testing and resonance dwelling
- Calibration of vibration transducers
- Mobility measurement

FEATURES:

- Digitally controlled sine oscillator
- Frequency resolution to 1,19 mHz
- Instant LED digital display
- Built-in charge preamplifier for direct connection of accelerometers and force transducers
- Acceleration, velocity, displacement and force parameter control with selection of SI or Imperial units
- Vibration meter enabling 9 vibration levels to be set for complex test programmes
- Automatic calculation of cross-over frequencies
- Compressor with dynamic range of 100 dB
- Safety control window to protect the test specimen
- Keyboard and thumbwheel control for easy and precise setting of test parameters
- Step-by-step sequence to guide the user through the set-up parameters and simplify operation
- Non-volatile memory for storing 4 complete test set-ups
- Facility for using ancillary equipment for resonance dwell testing, swept narrow band random noise testing, filtering of vibration signals and multi-point test control
- Outputs for remote control of Level Recorder Type 2307 and X-Y Recorder Type 2308
- Synchronized 7 V output for use with stroboscopic motion analyzers
- IEEE interface for versatile input and output of front panel settings and vibration measurements

The Vibration Exciter Control Type 1050 is a digital instrument for use as a sinusoidal sweep controller of electrodynamic vibration exciter systems. The IEEE interface and frequency generation resolution to 1,19 mHz makes the Type 1050 a flexible and highly accurate instrument. It forms the basis of an analyzing system which has specific application to engineering development and prototype testing; quality control; resonance dwell testing and vibration transducer calibration.

The instrument is very easy to use and as an introduction to the operating procedure it uses a step-by-step sequence to guide the user through the test set-up parameters. The provision of both a direct-entry keyboard and thumbwheel control allows fast and precise setting of the test parameters. Test set-up parameters can be stored and recalled instantly from any of the 4 non-volatile memories.

General Description

The Type 1050 is a controller containing a digitally controlled generator, a vibration meter enabling accurate measurement and control of any vibration measurement parameter and a compressor for regulation of the vibration exciter excitation. The front panel is divided into these three sections with each section containing an LED display for use during setting and monitoring of the vibration test parameters.

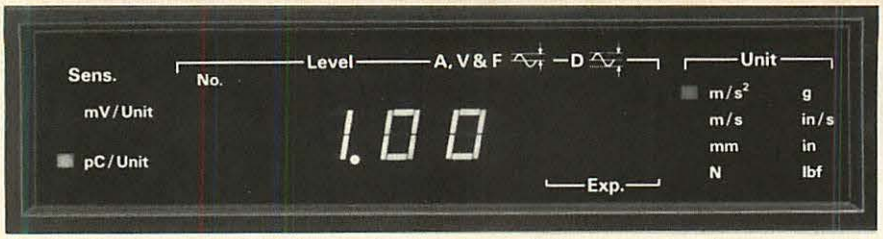


Fig. 1. Vibration meter LED display showing the selected accelerometer charge sensitivity

Easy-to-use Front Panel

The field entry system encorporates a keyboard for direct entry of vibration test parameters, and a thumbwheel for both coarse and fine adjustment of these settings. Each parameter value is shown on the LED display whenever the associated key is pressed. A front panel set-up sequence leads the user through the selectable parameters one at a time in a logical order. Set-up selection can be simplified by storing the parameters in 1 of the 4 front panel memories, allowing instant recall of the required test set-up. Further test set-ups can be stored externally, for example by a digital tape recorder or desk-top calculator, and used to set the front panel test parameters via the IEEE interface bus.

Signal Generation

The generator section of the instrument provides a digitally controlled sinusoidal output which sweeps in frequency between selectable limits. These limits may be chosen within the frequency range 1 Hz to 10kHz. The minimum selectable frequency band is 0,3 Hz. Linear and logarithmic frequency sweeps are available with selectable sweep rates from 0,001 to 100 Hz/s, and 0,001 to 100 oct/min respectively. Frequency control may be either automatic or manual.

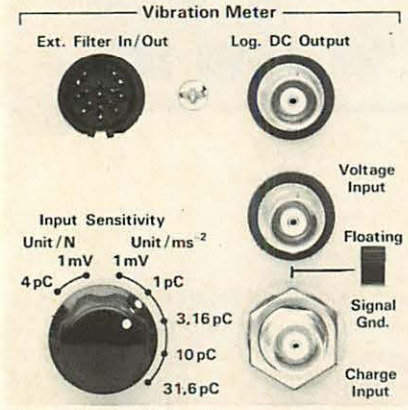


Fig. 2. Preamplifier input connectors and sensitivity selection

Built-in Preamplifier

Inclusion of a charge preamplifier enables direct connection of accelerometers and force transducers. The vibration meter LED display showing the selected charge sensitivity can be seen in Fig. 1. The charge sensitivity is selectable at discrete values in the range 1 to 31,6 pC/ms^{-2} for accelerometers, and is 4 pC/N for force transducers. The charge input is particularly suitable for use with Brüel & Kjær force transducers and Uni-Gain® accelerometers.

Any vibration transducer and preamplifier combination can be used with the controller by connection to the voltage input. The user can select either force or acceleration input sensitivity.

The instrument is provided with a selection of either floating or grounded input for elimination of ground loops. Connection of transducers is made via a TNC connector for charge input and a BNC connector for voltage input. The corresponding sockets and the sensitivity values are shown in Fig. 2. The charge sensitivity values can be finely adjusted from the front panel or via the interface bus.

Vibration Meter Section

The vibration meter is equipped with a facility that allows the user to set 9 vibration levels. This enables complex test programmes to be performed (for example tests conforming to standards IEC 68-2-6 and MIL-STD-810C). For instance, the IEC standard only requires dual parameter control, but the MIL standard requires a more stringent procedure involving a larger number of cross-overs and multi-parameter control.

The measured vibration level can be continuously monitored on the LED display at the touch of a key. It can be displayed on an oscilloscope, measuring amplifier or voltmeter by using the preamp. output on the front panel.

The Vibration Exciter Control Type 1050 is equipped with a facility for automatic calculation of the *smooth cross-over frequencies* when more than one vibration level is set. In addition, the cross-overs may be set directly which is useful when the required test programme includes *steps* in the vibration level. Examples of typical tests are shown in Figs. 3 and 4.

Constant Acceleration, Velocity, Displacement and Force

A constant level of vibration excitation can be attained by using a feedback signal to the compressor section.

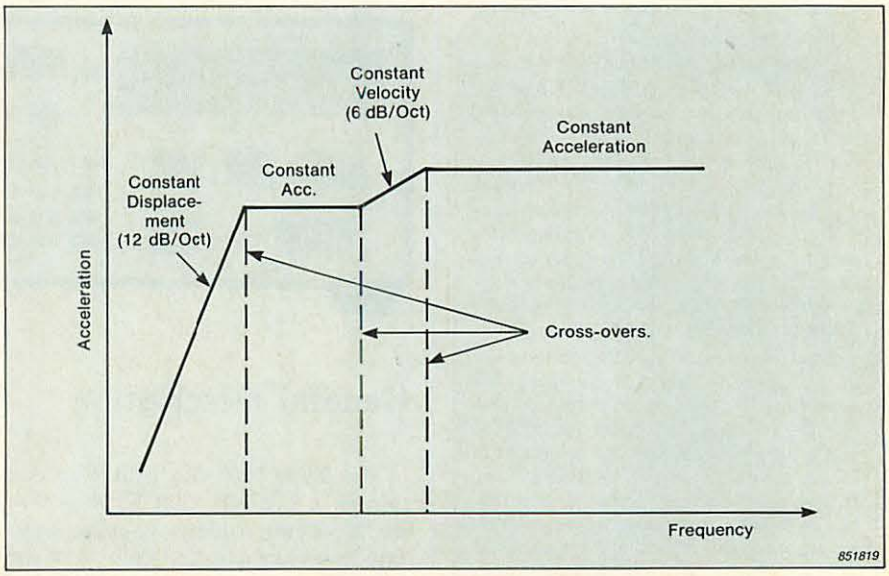


Fig. 3. Multi-parameter test programme control. This test uses 4 pre-set vibration levels requiring 3 cross-overs points which are calculated by the controller

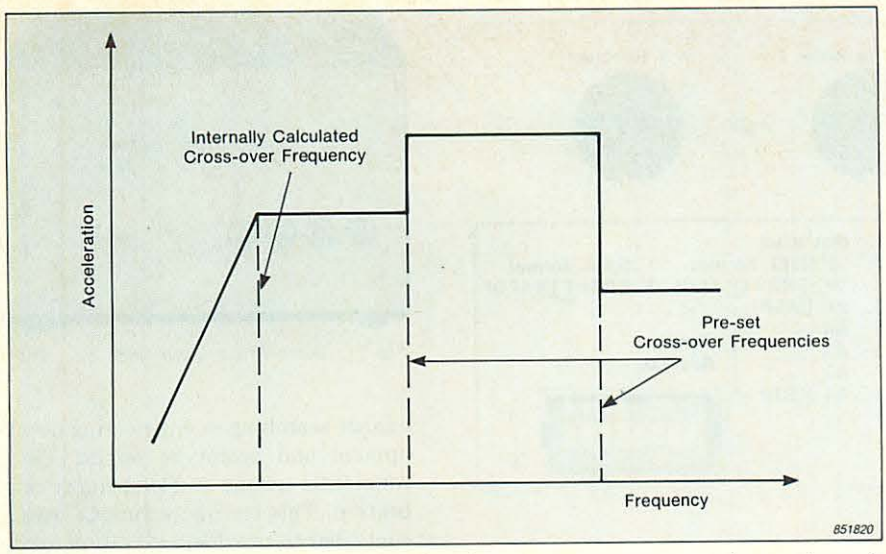


Fig. 4. Test programme using steps in acceleration, two pre-set cross-over frequencies and one cross-over point calculated by the controller

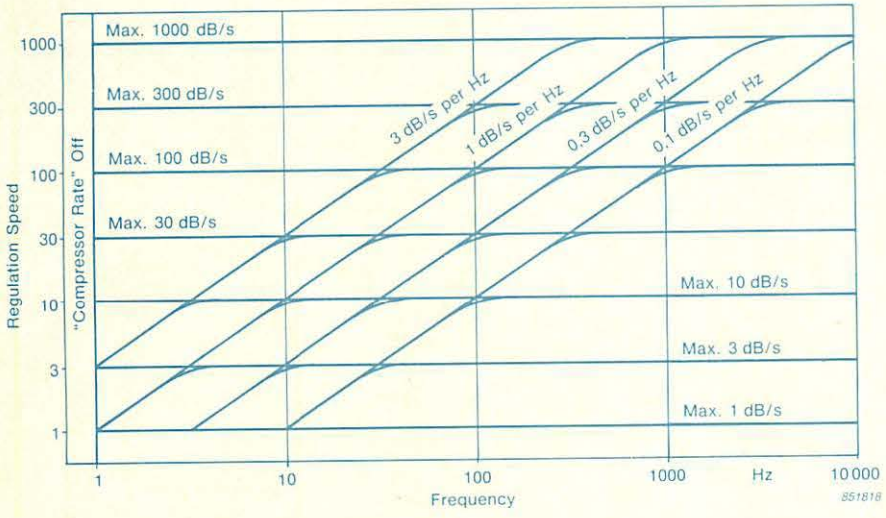


Fig. 5. Compressor regulation speed combinations

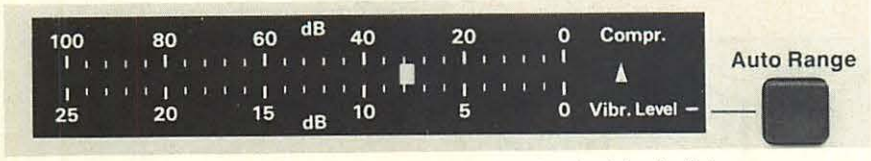


Fig. 6. Compressor LED scale indicating the compression level in decibels

The controlled vibration parameter can be acceleration, velocity, displacement and force.

Compression levels up to 100 dB can be attained to produce a constant vibration level across the entire frequency range. The compressor regulation speed increases in proportion to frequency at a selectable rate up to a selectable maximum regulation speed. Usable combinations of regulation speeds and compression rates are shown in Fig. 5. A separate LED scale displays the compression level in decibels, and is shown in Fig. 6. If the compressor is not used during a test, this display will indicate the input level. In this case the measurement will be brought into the display range by pressing *autorange*.

The compressor has a safety control window around the set vibration level

Fig. 7. Digital Stroboscope Type 4913

with selectable limits from 3 to 6 dB. If the vibration level causes violation of these limits the instrument will revert to stand-by mode. Alternatively the safety control may be switched off.

In complex tests using multi-parameter control the compressor will regulate each parameter to maintain the programmed level. As a consequence, at the cross-overs there may be a *step* in the vibration level. For this reason the Vibration Exciter Control Type 1050 also incorporates a cross-over safety function to avoid safety limit violation at the cross-over frequencies which would result in test abortion.

Automatic Stroboscope Control

A constant output level of 7 V is available from the two fixed outputs. Either of these can provide the control signal for a stroboscopic motion analyzer for visual examination of vibratory motion. The Brüel & Kjær Digital Stroboscope Type 4913 and Fibre-Optic Light Source Type 4915 enable vibratory motion to be *frozen* or offset to provide *slow motion* examination of the structure under test. The Type 4913 is shown in Fig. 7.

Interface

A digital interface, conforming to IEEE 488 and IEC compatable, caters for complete remote control of the Type 1050, e.g. from a desk-top calculator. Set-up parameters or complete test results may be documented or stored. The stored data may later be used by the 1050 to set-up the front panel. The Brüel & Kjær Digital Cassette Recorder Type 7400 is particularly suitable for this purpose.

For documentation of test-runs, the Brüel & Kjær Graphics Recorder Type 2313 can print out sets of frequency, generator level and meter level at periodic intervals. It can also print out the test parameter values.

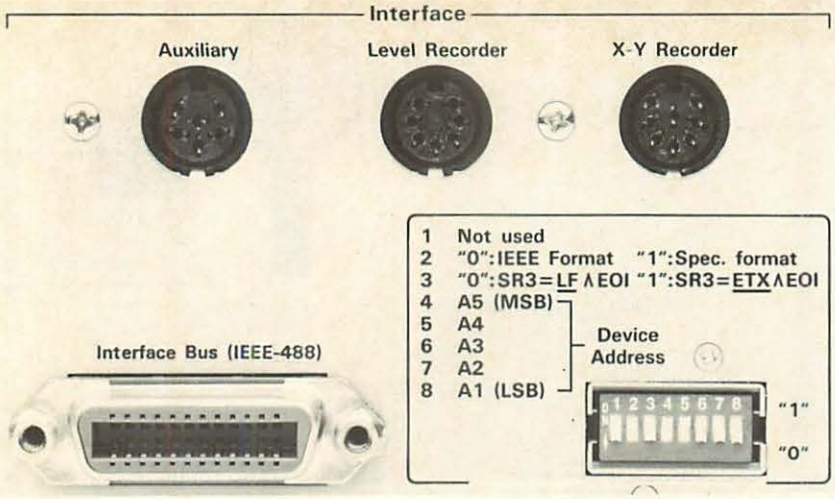


Fig. 8. IEEE interface and output connections

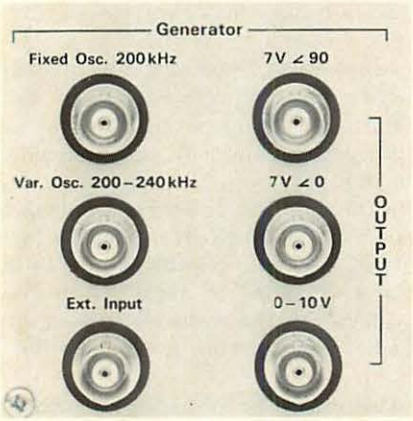


Fig. 9. Generator input and outputs

DIN sockets are also provided for use with Level Recorder Type 2307, X-Y Recorder Type 2308 and other auxiliary equipment. These sockets are shown in Fig. 8.

Generator Outputs

Two constant voltage outputs with 0° and 90° phase are available for use with a multiplier. The multiplier can output the real and imaginary parts of a response signal for producing Nyquist plots. The 200 kHz fixed oscillator and 200-240 kHz variable oscillator output provide the necessary signals for frequency tuning of a tracking filter, for example the Brüel & Kjær Slave Filter Type 5888. The power amplifier control signal can be taken from either of the two 0-10 V outputs situated on the front and rear panels. The rear panel generator input and output connectors are shown in Fig. 9.

Use With Other Instruments

Swept Sine Excitation

Swept sine excitation is used for resonance searching in engineering development and prototype testing, environmental testing and transducer calibration. This testing technique uses a controller to provide a vibration exciter with a control signal which changes in frequency between certain limits at a pre-determined sweep rate.

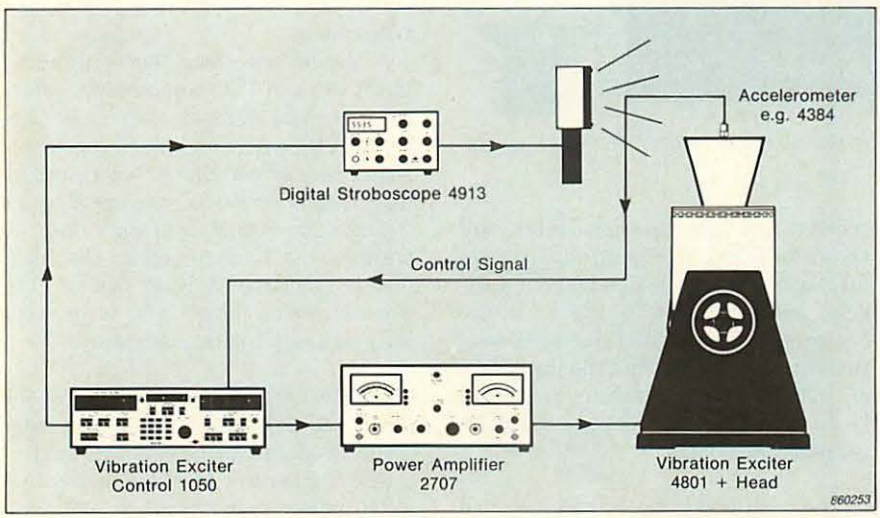


Fig. 10. Instrumentation for swept sine testing and motion analysis of a test object

Fig. 11. Slave Filter Type 5888

Resonances of the test object and exciter system cause the power supplied to the exciter to be frequency dependent. Consequently, the signal must be automatically adjusted if a constant level of vibration is to be maintained. This is attained by using a control accelerometer, mounted on the exciter table or test specimen, in a servo-loop to provide a feedback signal to the compressor section of the controller. The compressor regulation speed is chosen according to the expected Q-values of the system resonances and the sweep rate used during the test.

An instrumentation set-up for swept sine testing is shown in Fig. 10. The Digital Stroboscope Type 4913 is used for analyzing the vibratory motion of the test object, and an Accelerometer Type 4384 is used to provide a feedback signal to the Type 1050 for compressor regulation of the vibration level.

Filtering of Vibration Signals

The Brüel & Kjær Slave Filter Type 5888 is specially designed for use with the Type 1050. It is a 2 channel slave filter which enables simultaneous filtering of the control and response signals.

Band pass filter bandwidths available are 3, 10, and 30% and selection is by remote control from the Type 1050. The Slave Filter Type 5888 is shown in Fig. 11.

Erroneous regulation of the compressor can be caused by harmonics and noise. Use of a tracking filter to-

Fig. 12. Resonance Dwell Unit Type 5885

gether with the controller ensures that the feedback signal is free from noise and is controlled using the excitation frequency alone.

Resonance Dwell Testing

One principle application of sine excitation is fatigue testing, which involves continuous vibration testing at constant, discrete frequencies. However, the repeated stressing of the test structure causes changes in the resonance frequencies during the test due to damage to the structure material.

Resonance dwell testing provides continuous testing of an object at a particular resonance. At resonance the phase angle between the input force and the response acceleration is 90°. For a small change in the resonance frequency there will be a large change in the phase angle. Consequently, monitoring the change in the phase angle is a more accurate method of tracking the resonance frequency than by monitoring the maximum magnitude of the response.

The Resonance Dwell Unit Type 5885 will activate the frequency sweep of the controller so that it increases or decreases the generator frequency to maintain a constant phase angle between the excitation force and response acceleration. The Resonance Dwell Unit tracks the resonance frequency by means of a phase-locked loop. The instrument is shown in Fig. 12.

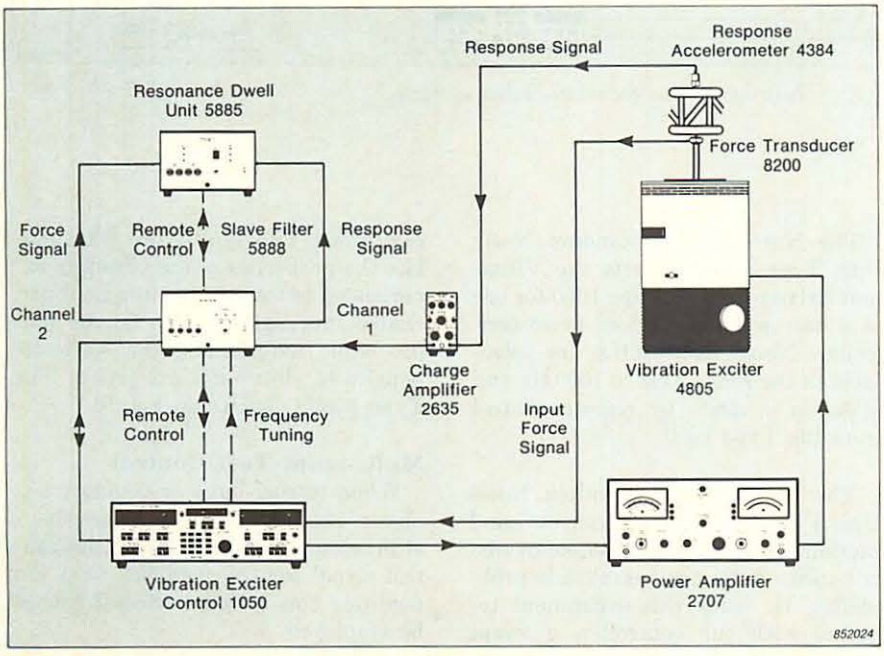


Fig. 13. Instrumentation for resonance dwell testing

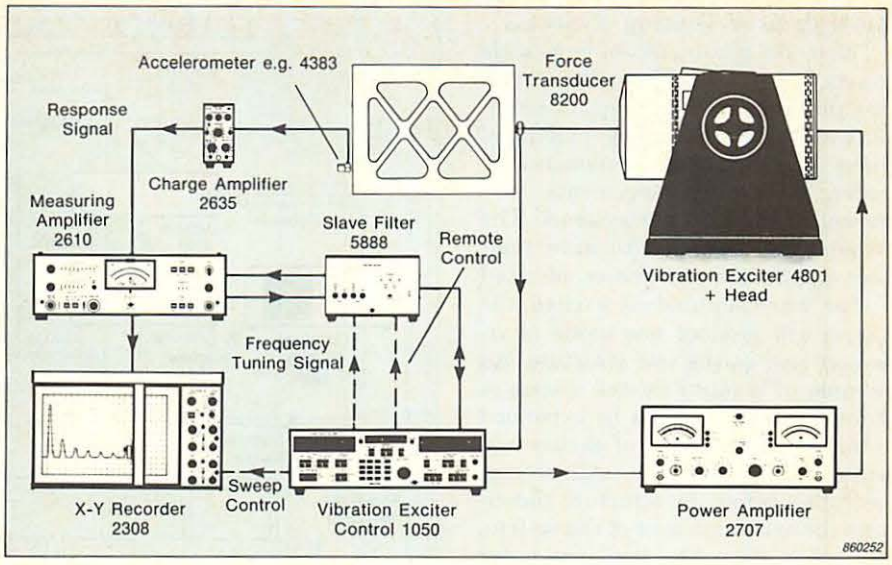


Fig. 14. Instrumentation for mobility measurement

An instrumentation set-up for resonance dwell testing is shown in Fig. 13. A Force Transducer Type 8200 measures the input force which is used in a feedback loop to provide constant force excitation. The force signal is supplied to the charge input of the controller and is filtered by the Slave Filter Type 5888 before controlling the compressor regulation. The filtered force signal is also used by channel 2 of the Type 5885.

An Accelerometer Type 4384 measures the frequency response. The response signal is conditioned by the Charge Amplifier Type 2635 and is filtered by channel 1 of the Slave Filter. The filtered response signal is then used by channel 1 of the Type 5885.

The Type 1050 provides the frequency tuning signal for the Type 5888 and selects the bandwidth by remote control, while the Type 5885 controls the frequency tuning of the Type 1050.

Mobility Measurement

An instrumentation set-up for mobility measurement is shown in Fig. 14. The input force to the test object is controlled by using the Force Transducer Type 8200 to provide the feedback signal to the compresssor. The acceleration of the test object is measured using an Accelerometer Type 4383 which supplies a signal to the X-Y Recorder Type 2308 for hard copy of the frequency response. Because the input force is controlled, the frequency response directly represents the system's accelerance.

Multi-exciter Testing Systems

The modal parameters of large scale objects can be found by using several vibration exciters operating in parallel, each being driven by individual power amplifiers and a common controller. These arrangements are known as multi-exciter systems. The exciters are controlled to have their force amplitudes and phases adjusted so that, when sinusoidally excited, the system will produce one mode of vibration only in the test structure. An example of a multi-exciter system is shown in Fig. 15. It can be expanded to include any number of exciter and accelerometer channels. All instrumentation below the structure constitutes the excitation part of the system, while that above the structure is for data aquisition, processing and analysis of results.

Due to the large number of instruments used in the set-up, automatic system control is desirable although manual operation is possible. This can be achieved by using a digital system controller, for example a desk-top calculator. The amplitude and phase of the force applied to the test structure must be accurately controlled by a controller with a high frequency resolution. A suitable control signal can be supplied by the Vibration Exciter Control Type 1050 via a power amplifier and a level/phase controller.

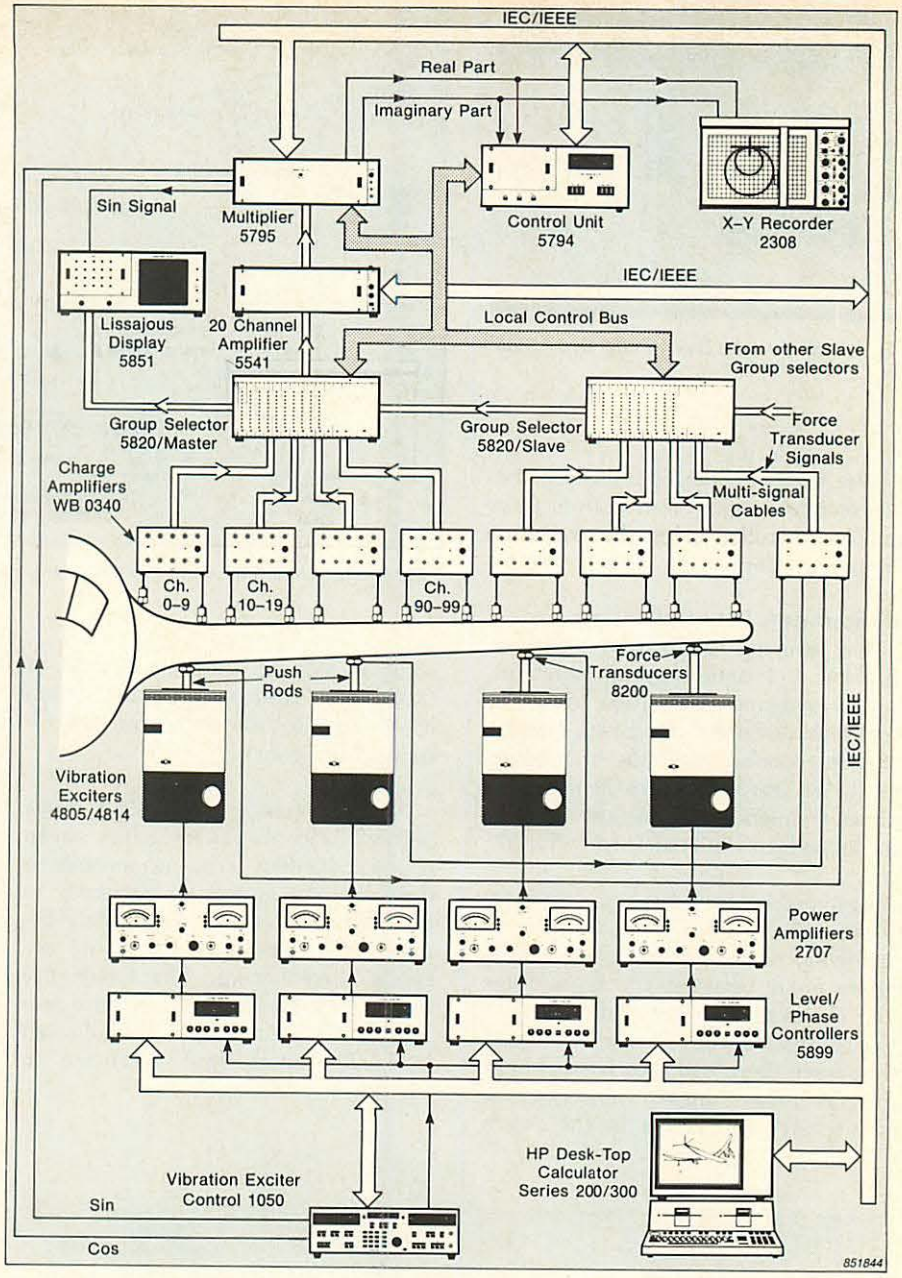


Fig. 15. Instrumentation for multi-exciter systems

Narrow Band Random Noise Testing

Narrow band random noise testing can be used to simulate real environments in which the excitation is random vibration confined to a narrow frequency band. Such environments can be caused by mechanical filtering and resonance amplification of broadband random noise resulting in narrow band random noise.

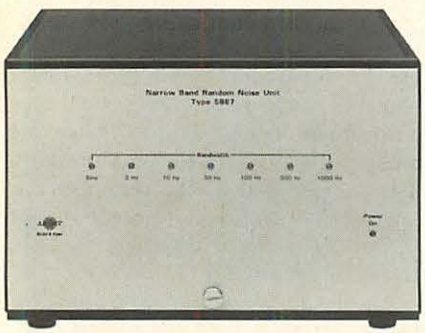


Fig. 16. Narrow Band Random Noise Unit Type 5887

The Narrow Band Random Noise Unit Type 5887 converts the Vibration Exciter Control Type 1050 for use as a narrow band random noise controller. Noise bandwidths are selectable in the range 3 Hz to 1000 Hz and selection is made by remote control from the Type 1050.

The Narrow Band Random Noise Unit Type 5887 produces narrow band random noise having a Gaussian distribution of the peak amplitude probability. By using this instrument together with the controller, a swept narrow band random noise test can be performed. This type of test will simulate the properties of the vibration experienced in the real environment and enable investigation into fatigue failure while maintaining the economic benefit of sinusoidal excitation. The Type 5887 is shown in Fig. 16.

Multi-point Test Control

When testing large or complex test objects it is advantageous to use several accelerometers to provide the control signal for the feedback loop. To facilitate this a signal selector should be employed.

Fig. 17. Control Signal Selector Type 5686

The Control Signal Selector Type 5686 will select the highest, lowest or mean vibration level from 6 input channels for use as the compressor control signal. The sampling time is equal to the time period of the vibration frequency. The instrument is shown in Fig. 17.

A set-up for multi-point testing is shown in Fig. 18. Four accelerometers measure the vibration in the structure at four points of interest. After conditioning by Charge Amplifiers Type 2651 the control signals are input to the Type 5686 which then supplies the selected signal to the 1050 compressor section.

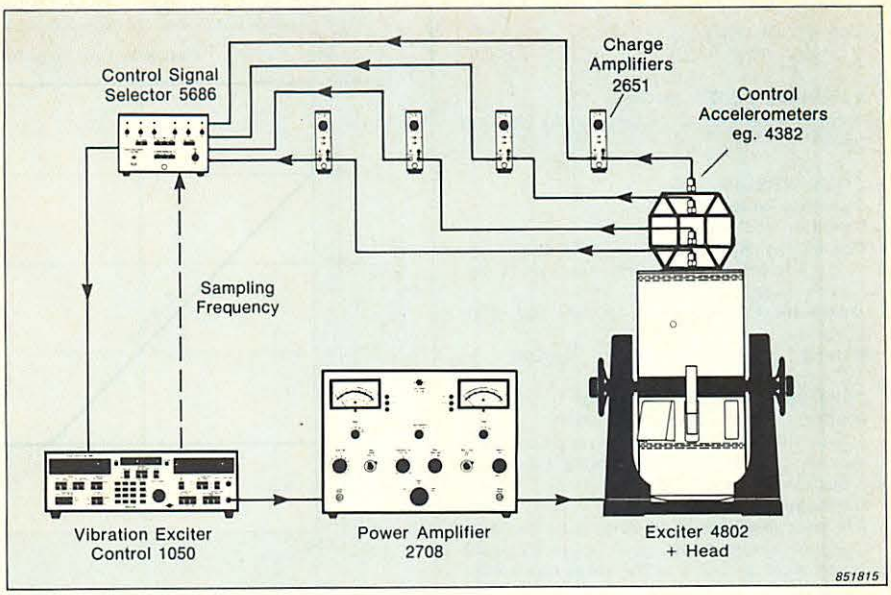


Fig. 18. Instrumentation for multi-point control testing

The Vibration Exciter Control Type 1050 is supplied in a lightweight metal cabinet (model A), or in the same cabinet with flanges for 19″ rack mounting (model C).

Further detailed specifications of Brüel & Kjær instruments Type 5686, 5885, 5887 and 5888 are available in individual System Development sheets.

Specifications 1050

FREQUENCY GENERATION:
Frequency Range: 1 Hz to 10 kHz
Frequency Resolution: 1,19 mHz
Frequency Stability: <25 PPM Drift (5 to 40 °C), <5 PPM Aging per year.
Frequency Display Unit: Hz, including 0 to 3 decimals.
Frequency Control: Manual, automatic or via the interface bus.

SWEEP:
Sweep Modes: Linear or logarithmic with start, stop and reverse at any frequency.
Sweep Count: Sweep total is selectable from 1 to 9999, or may be continuous. Display includes elapsed number of sweeps.
Sweep Limits: Selectable upper and lower sweep limits having 0,1 Hz display resolution. The upper limit must exceed the lower limit by 0,3 Hz.
Sweep Rate: 0,001 to 100 Hz/s (lin)
0,001 to 100 oct/min (log)
3 digit resolution.

VARIABLE OUTPUT (low frequency):
0 to 10 V RMS, amplitude controlled manually, by the compressor or via the interface bus.
Output Level: Displayed in dB relative to 10 V RMS in operate (1 V RMS in operate –20 dB) with 0,1 dB resolution.

Amplitude Linearity: ± 0,1 dB (1 Hz to 10 kHz)
Distortion: < –74 dB (compressor off)
Signal/Noise: > 5 dB at output level of –100 dB
Max Load: 10 kΩ/3 nF

FIXED OUTPUT (low frequency):
10 V peak. Two outputs with 7 V RMS amplitudes and 90° phase difference.
Phase Shift Accuracy: ±1° (1 Hz to 1 kHz), ±5° (1 Hz to 10 kHz)
Signal/Noise: > 74 dB
Max Load: 10 kΩ/1 nF

FIXED OSCILLATOR OUTPUT (high frequency):
200 kHz squarewave (open collector TTL).

VARIABLE OSCILLATOR OUTPUT (high frequency):
200 to 240 kHz squarewave (open collector TTL).

PREAMPLIFIER INPUTS:
Voltage: BNC connector on rear panel.
Input Impedance: 1 MΩ
Charge: TNC connector on rear panel, suitable for use with B&K force transducers and Uni-Gain® accelerometers.

INPUT SENSITIVITIES:
Vibration: 1 mV/ms^{-2}, 1 pC/ms^{-2}, 3,16 pC/ms^{-2}, 10 pC/ms^{-2}, 31,6 pC/ms^{-2}
Force: 1 mV/N, 4 pC/N,
All charge sensitivities can be adjusted + 5 to –8%

MEASUREMENT RANGES:
Acceleration: 0,1 to 9990 ms^{-2} (1 Hz to 10 kHz)
Velocity: 0,1 mms^{-1} to 9,99 ms^{-1}
Displacement: 10 μm to 99,9 mm
Force: 0,1 to 7900 N (1 Hz to 10 kHz)
The frequency limitations for the velocity and displacement ranges are shown on page 8.

PREAMP OUTPUT:
Sensitivities: +5%, –8% (in accordance with input sensitivity adjustment)
Vibration: 1 mV/ms^{-2}
Force: Direct 1 mV/N, Charge 1,26 mV/N

METER RECTIFIER:
Type: RMS
Dynamic Range: 50 dB (including 10 dB top-factor range)
Time Constant: 0,3, 1, 3, 10 s (controlled by generator frequency or direct setting)

LOG DC OUTPUT:
0 to 10 V (200 mV/dB)

EXTERNAL FILTER IN/OUT:
8-pin DIN socket for connection to tracking filter.

COMPRESSOR:
Dynamic Range: 100 dB
Rectifier: RMS
Regulation Speed: 0,1 to 1000 dBs^{-1} (increases in proportion to frequency up to the maximum speed)
Maximum Speed: 1, 3, 10, 30, 100, 300, 1000 dBs^{-1}
Rate: 0,1 - 0,3 - 1 - 3 $dBs^{-1}Hz^{-1}$ or OFF

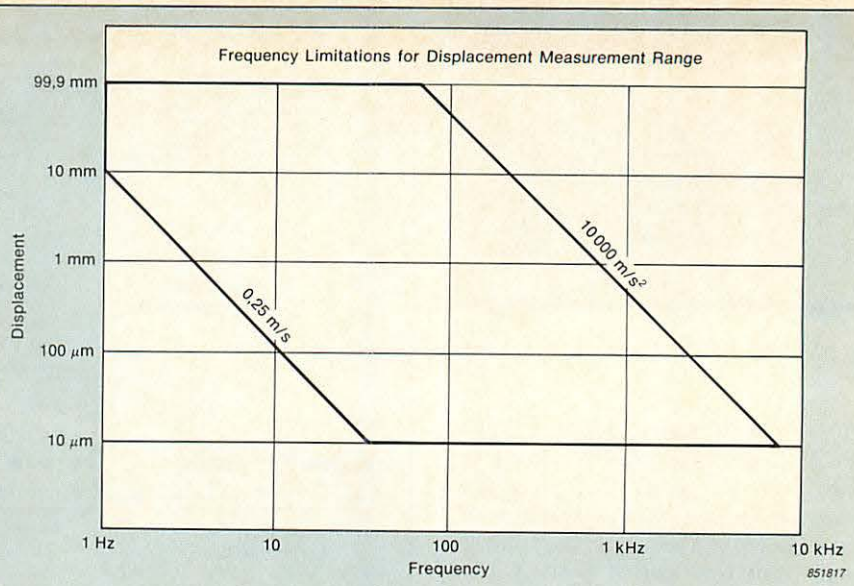
TEST PROGRAMME CONTROL:
Profile: Constant force or constant acc/vel/disp, programmed in any combination with up to eight frequency controlled cross-over points.
Cross-over Frequencies:
Internal calculation of cross-over frequencies or direct setting. Cross-over frequency separation must be > 7% of the lower cross-over frequency.

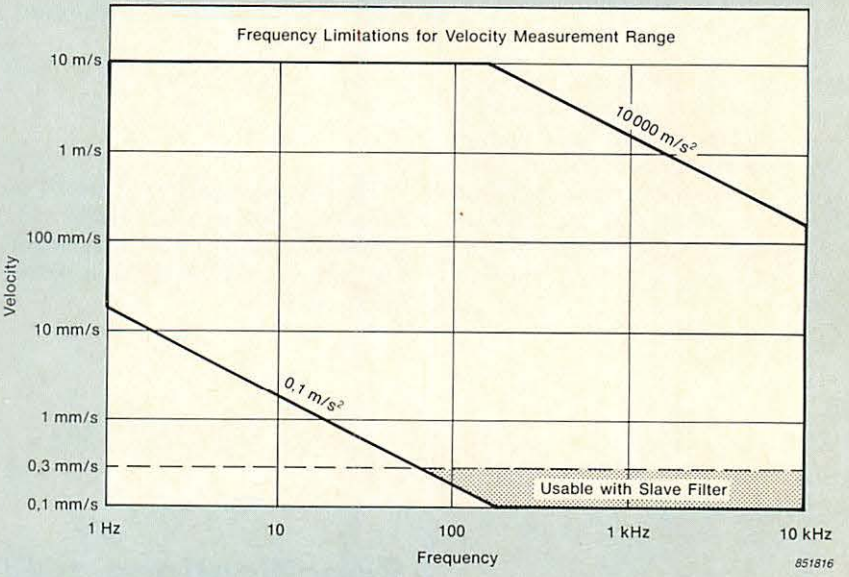
SAFETY CONTROL:
At the transition to operate, control set-up compatibility is checked. Error indication is given for incompatibility.
Safety Limits: 3, 4, 5, 6 dB or OFF. Independent setting of upper and lower limit.
System Start-up: Selectable max output level and attenuated operating level of –20 dB.
System Shut-down: 20 dB per period of frequency signal.

DIGITAL INTERFACE:
Conforms to IEEE 488 and IEC 625-1 standards.
Functions Implemented:
Source handshake SH 1
Acceptor handshake AH 1
Talker T 5
Listener L 3
Service request SR 1
Remote local RL 1
Parallel poll PP 0
Device clear DC 1
Device trigger DT 1
Controller C 0
Data Output: Generator frequency, generator level, meter level and number of elapsed sweeps.
Remote Control: Input and output of front panel set-up (manually or remotely controlled) via the digital interface.
Code: ISO 7-bit code
Status: Besides the service request status byte, an error code can be output to give further information in case of an abnormal event.

AUXILIARY:
Serial interface used to control setting of auxiliary instruments. When connected these act as an expansion of the front panel, both manually and remotely controllable.

RECORDER INTERFACE:
X-Y Recorder: Remote control of pen up/down and X-deflection (0 to 10 V lin or log dc output).
Lin: 0 V at lower sweep limit and 10 V at upper sweep limit.
Log: 0 V at 1 Hz and 10 V at 10 kHz (2,5 V/decade).





Level Recorder: Remote control of start, stop, automatic stop and pen lift.

POWER REQUIREMENTS:
Power Supply: 100, 115, 127, 200, 220 or 240 V AC ±20%, 50/60 Hz
Consumption: 42 VA approx.
Fuse Requirements: 200 mA (200 to 240 V), 400 mA (100 to 127 V)

ENVIRONMENTAL:
Safety: Complies with IEC 348 Safety Class II
Operating Temperature: +5 °C to +40 °C (+41 °F to 104 °F)
Storage Temperature: –25 °C to +70 °C (–13 °F to 158 °F)
Humidity Range: 90% RH (non-condensing at 30 °C)
Electromagnetic Compatibility: Complies with requirements for Class B computing device of American FCC (Federal Communication Commission) Rules.

GENERAL:
Cabinet: Supplied as model A (lightweight metal cabinet) or C (as A but with flanges Type KS 0023 for 19 in racks)
Height: 133 mm (5,2 in)
Width: 430 mm (16,9 in)
Depth: 320 mm (12,6 in)
Weight: 10 kg (22 lb)

ACCESSORIES INCLUDED:

1 mains cable	AN 0020
1 UNF to TNC cable	AO 0231
2 spare fuses	VF 0012
3 spare fuses	VF 0039
1 8-pin DIN plug	JP 0802
1 7-pin DIN plug	JP 0703
1 6-pin DIN plug	JP 0606
3 BNC plugs	JP 0035
1 IEEE Bus Connection Kit	UA 0814

ACCESSORIES AVAILABLE:

Resonance Dwell Unit	Type 5885
Control Signal Selector	Type 5686
Narrow Band Random Noise Unit	Type 5887
Slave Filter	Type 5888
Rack Mounting Flanges	KS 0023
IEEE 488 interface cable (2 m)	AO 0265
25-pin IEC 625-1 to IEEE 488 interface cable (2 m)	AO 0264