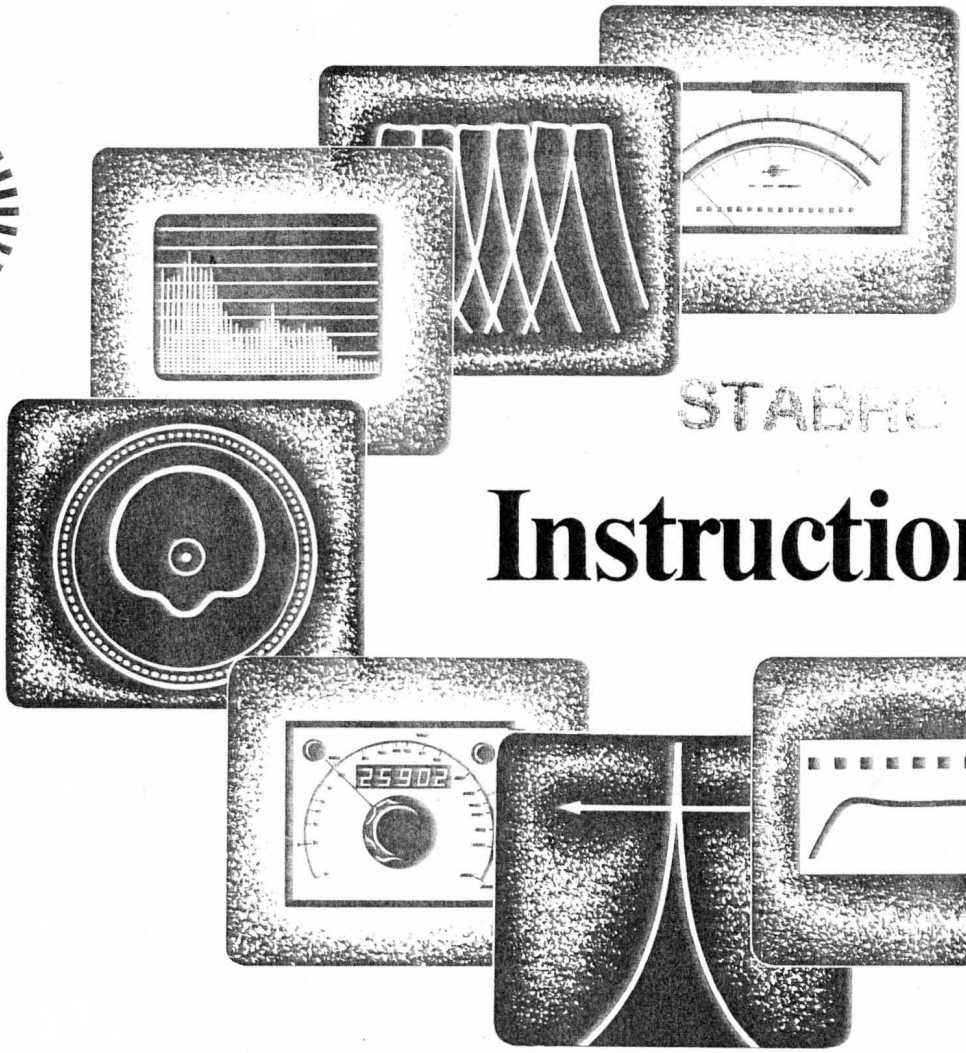
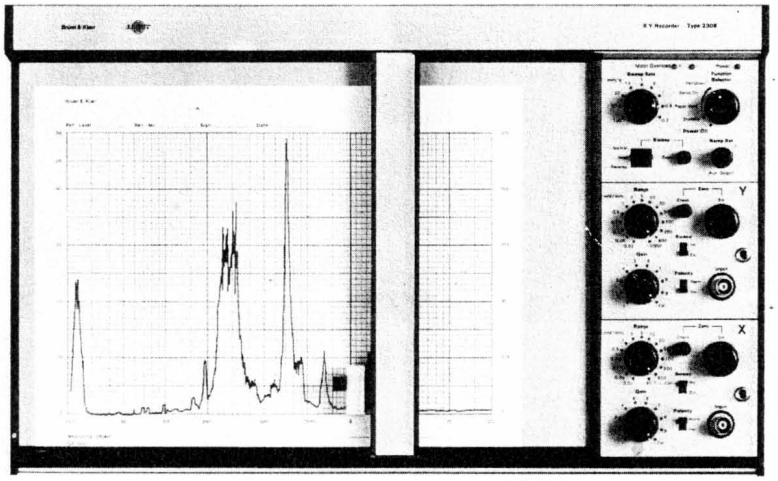


2308

Instruction Manual

X-Y Recorder Type 2308



A simple to use, precision, mains powered instrument for fast, accurate graphic recording of DC signal levels and waveforms etc. Its writing system accepts push fit fibre pens and has electrostatic paper hold accepting most kinds of paper up to A4 DIN (8,3 by 11,7 in) size. Fifteen calibrated sweep sensitivities from 20 μV to 1 V/mm may be selected which may be continuously adjusted between settings. For automatic recording of frequency responses and analyses with remote frequency scanning of signal generators and frequency analyzers, a sweep generator with nine calibrated sweep rate settings from 0,2 to 100 mm/s (8,34 to 4170 mV/s) is built-in.

Brüel & Kjær

2–033 0462–1A

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X-Y RECORDER
TYPE 2308

January 1982

This apparatus has been designed and tested according to class I of IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus, and has been supplied in safe condition. The present instruction manual contains information and warnings which should be followed by the user to ensure safe operation and to retain the apparatus in safe condition.

CONTENTS

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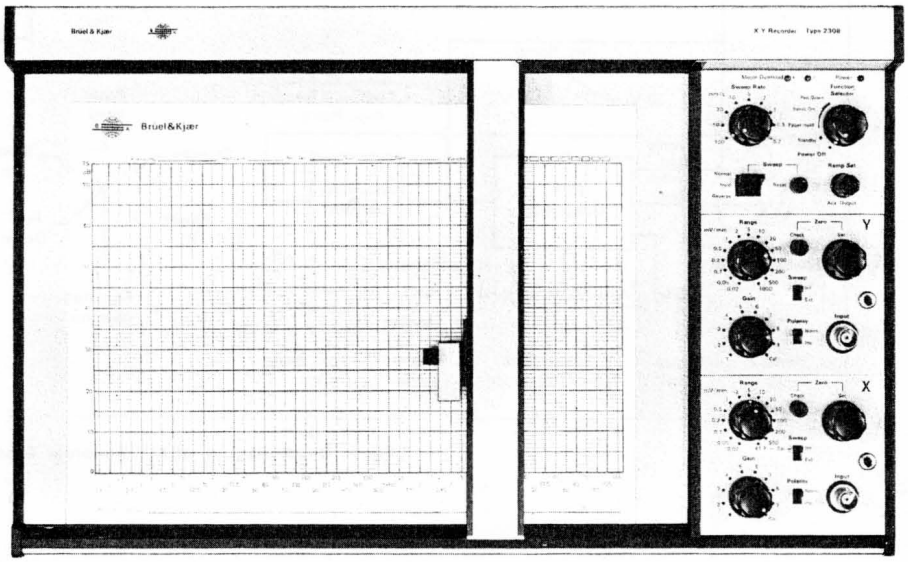
SCANS
BY
ARTEK-MANUALS

type 2308

X-Y Recorder

FEATURES:

- Very fast slewing speed of 1000 mm/s with less than 1% overshoot
- Floating and grounded input modes. Reversible polarity. 1 MΩ impedance
- High common mode rejection
- 15 calibrated X-Y sensitivity ranges from 0,02 to 1000 mV/mm with variable range adjustment
- 9 calibrated sweep rates from 0,2 to 100 mm/s available with internal sweep generator
- Adjustable X-Y zero offset for recording both positive and negative signal excursions
- Versatile remote voltage controlled tuning and synchronization capabilities.
- Large 185 by 270 mm (7,25 by 10,6 in) writing area. Accepts most kinds of paper up to A4 (DIN) size
- Electrostatic paper hold and pen down functions on one selector switch for fast, straight forward operation
- Disposable fibre pens
- Automatic pen lift in event of power failure
- Motor overload protection with LED warning lights
- Rack or bench mounting



USES:

Automatic and semi-automatic recording of:

- DC signals
- Amplitude, frequency and phase responses
- Frequency analyses
- Waveform and Lissajous plots

General Description

X-Y Recorder Type 2308 is designed for fast, accurate, linear DC recording of slow and rapidly changing voltages. Its outstanding dynamic performance and versatility, combined with its simple and straightforward operation, make it the ideal Recorder for most laboratory work where accurate, hard copy, graphic plots of DC signal levels, waveforms, frequency responses and analyses are required.

The 2308 is housed in a robust, easily transported, lightweight metal cabinet that may be rack or bench mounted in either vertical or horizontal planes. Its writing system has a large, 185 by 270 mm (7,25 by 10,6 in) writing area with electrostatic paper hold that firmly grips most kinds of paper up to A4 (DIN) size. It accepts push fit, fibre tipped pens that provide a sharp, clean trace without messy handling problems. The pen and the pen carriage are driven by low inertia, servo motors which are fully protected against excessive drive current and overloads. These give a maximum slewing speed of 1000 mm/s with overshoot less than 1% of full scale.

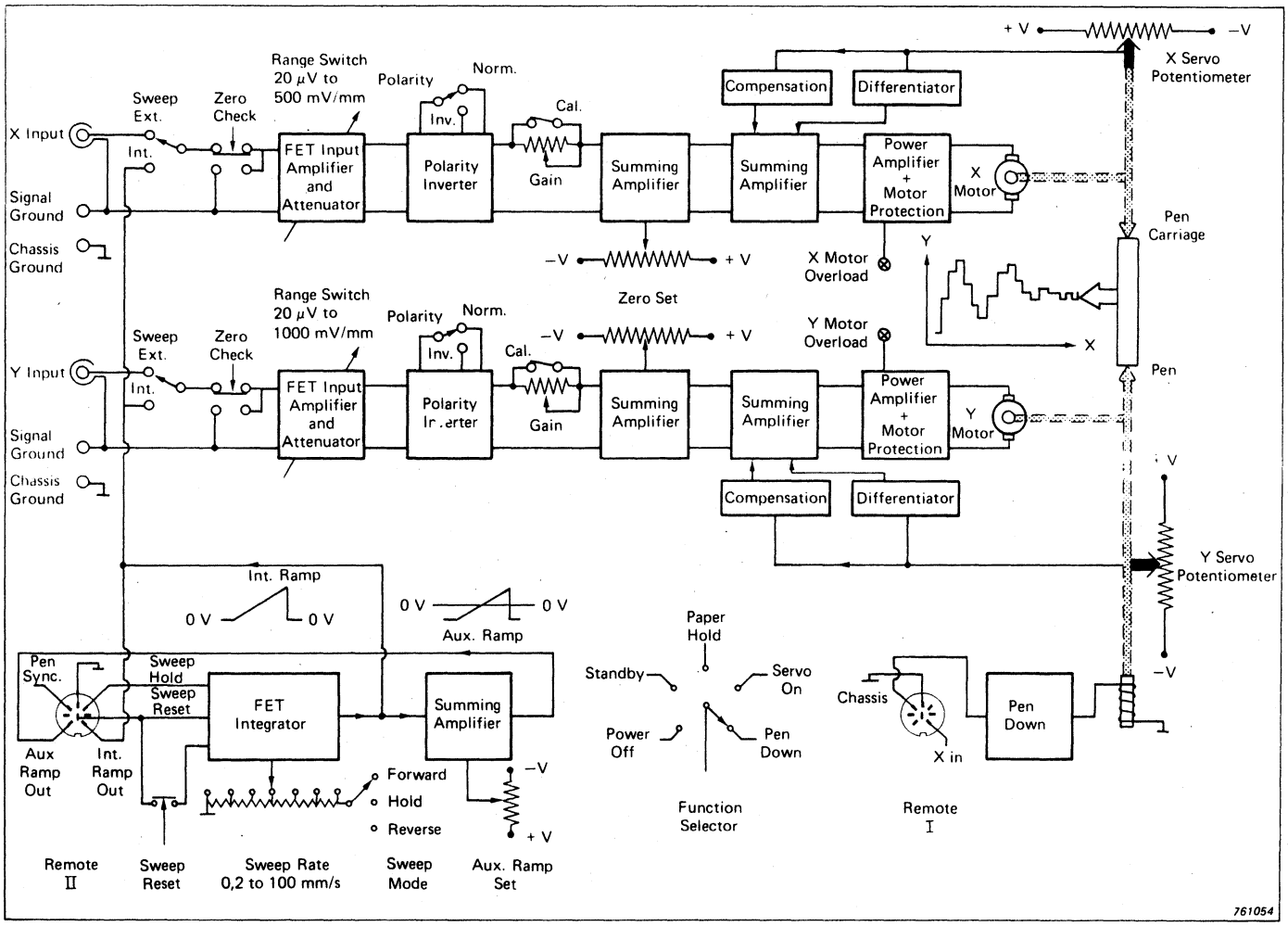


Fig.1. Block diagram of X-Y Recorder Type 2308

Both the X and the Y channels of the Recorder have high input impedance, floating BNC inputs with normal and inverted input modes. 15 calibrated sweep sensitivities between 0,02 and 500 mV*/mm may be selected which may be continuously adjusted between settings. The overall record linearity and accuracy obtained is better than 0,1% and 0,2% of full scale, respectively.

The 2308 also has a built-in sweep generator. This may be used to control the X or Y sweep of the Recorder and has 9 sweep rate settings between 0,2 and 100 mm/s, plus "Forward", "Hold", "Reverse" and "Reset" modes.

For automatic recording of frequency responses and frequency analyses etc., the ramp voltage output of the generator may be used to remotely tune voltage controlled types of frequency analyzer and signal generator. Separate zero set and ramp set controls permit synchronous tuning with the X or Y sweep of the Recorder and enable zero and full scale pen deflections to be set anywhere within the 185 by 270 mm writing area.

Power for the 2308 may be provided by any 100, 115, 127, 200, 220 or 240 V (50 to 400 Hz) AC mains supply.

* Y channel also includes a 1000 mV/mm sensitivity setting

Electrical Description

The X and Y channels of the 2308 Recorder are virtually identical. Each channel acts as a servo controlled recording voltmeter. The X channel controls the horizontal sweep of the pen carriage, whilst the Y channel controls the vertical sweep of the pen. This is illustrated by the block diagram of the Recorder shown in Fig.1.

Inputs

The X and Y channels have identical inputs. These are on the top panel of the Recorder and are for application of external sweep signals. They accept standard coaxial input cables with BNC plugs and are floating with centre connector and screen isolated from chassis. An alternative set of inputs is provided on the rear panel, together with terminals and sockets for connecting the X and Y signal ground lines of the Recorder to chassis.

The inputs have a maximum common mode input voltage rating of 50 V pk (in accordance with IEC R 348), but can withstand test voltages as high as 300 V pk without breakdown. AC and DC common mode signal rejection is better than 110 and 130 dB respectively, degrading by 20 dB/decade decrease in channel range sensitivity from 0,02 mV/mm.

Input Section

For a high input impedance of 1 MΩ, with minimum sensitivity to temperature and line voltage variations, the X and Y channels have dual FET, differential amplifier input stages. These have precision thick film attenuator and feedback networks regulating their gain, which with the RANGE switches provided may be switched enabling 14 calibrated sweep sensitivity settings between 0,02 and 500 mV/mm to be selected with each channel. The RANGE switches also include a 1000 mV/mm Y channel sensitivity setting and a 41,7 mV/mm X channel "Cal" sensitivity setting; the latter permitting synchronous recording of frequency responses and analyses on frequency graduated paper when using B & K Signal Generators and Frequency Analyzers with the Recorder.

The final stage of the input section is a unity gain amplifier. This may be switched using the POLARITY switches to provide an output signal in phase or 180° out of phase with the input signal and thus may be used to reverse the direction of the X and Y sweep. So that full scale sweep or pen deflection can be made to correspond with any particular input level, a GAIN potentiometer is provided at the output. This has a click-stop "Cal." position and is for continuous adjustment of sweep sensitivity between range settings.

To prevent the writing system of the Recorder responding to mains frequency or other AC components which may be present with external sweep signals, the channels are designed with an upper limiting frequency of 25 Hz.

Zero Set and Check

In order that zero deflection on the X and Y axes may be individually set anywhere within the writing area, the sweep signal from the input section is combined with a DC offset voltage from the ZERO SET potentiometers of the channels. Negative as well as positive offsets up to three times full scale deflection may be applied so that zero deflection may be adjusted to correspond with virtually any input level, as well as, enabling both positive and negative amplitude excursions to be recorded. For checking the position of zero deflection when setting up the Recorder, there is a ZERO CHECK push button at the input of each channel.

Writing System

The writing system has separate drive motors and servo potentiometers for the X and Y sweep of the pen. The voltage at the contact slider of the potentiometers is dependent on the pen position and is detected and compared with the sweep signal voltage. After amplification, the difference voltage is applied to the drive motors, moving the pen and potentiometer contact sliders until zero difference voltage is produced. The direction of motion depends on the polarity of the difference voltage, which for a maximum slewing speed of 1000 mm/s is made velocity dependent by differentiating the potentiometer contact slider voltage. For resettability and record accuracy better than 0,1 and 0,2% of full scale respectively, the servo potentiometers are conductive plastic types which have an exceptionally good linearity and long operating life.

To prevent damage to the writing system, servo clamping rapidly decelerates the pen and pen carriage so that they do not bang against the ends of their guide runners when full scale sweep is reached. Also an analogue of the motor armature temperature is monitored which automatically shuts down the power amplifiers in the writing system and lights an overload warning LED, if the pen or pen carriage sweep is mechanically inhibited.

Internal Sweep Generator

The X and Y channel inputs may be individually switched to connect them with an internal sweep generator. This has "Forward", "Hold", "Reverse" and "Reset" control functions and produces a DC ramp voltage from a potential divider. The sweep speed is determined by the slope of the ramp which may be switched using the SWEEP RATE knob of the generator. This has 9 calibrated sweep speed settings from 0,2 to 100 mm/s which are for recording on B & K frequency calibrated paper when the "Cal." mode of the X channel RANGE switch is used. When other RANGE switch settings are employed sweep speeds from 8,34 μm/s to 834 mm/s may be selected.

For automatic recording of frequency responses and analyses etc., the sweep generator ramp voltage is made available at a DIN socket on the rear panel of the Recorder. This may be used to remotely tune the types of frequency analyzer and signal generator shown on page 6.

Since tuning of the instruments is voltage controlled, a relatively simple electrical remote control cable may be used instead of mechanical drive couplings. Also setting up is made exceedingly simple as the analyzer or generator may be tuned to the required starting frequency simply by adjusting the AUX. RAMP SET potentiometer of the Recorder. When preprinted, frequency graduated recording paper is used, the X sweep of the pen may be synchronized with the frequency sweep of the analyzer or generator simply by adjusting the ZERO SET and GAIN potentiometers of the Recorder. Further, if analyses covering a very narrow or very wide frequency range are to be recorded then the X channel RANGE switch may be used to expand or compress the recording so that it fills the complete width of the recording paper.

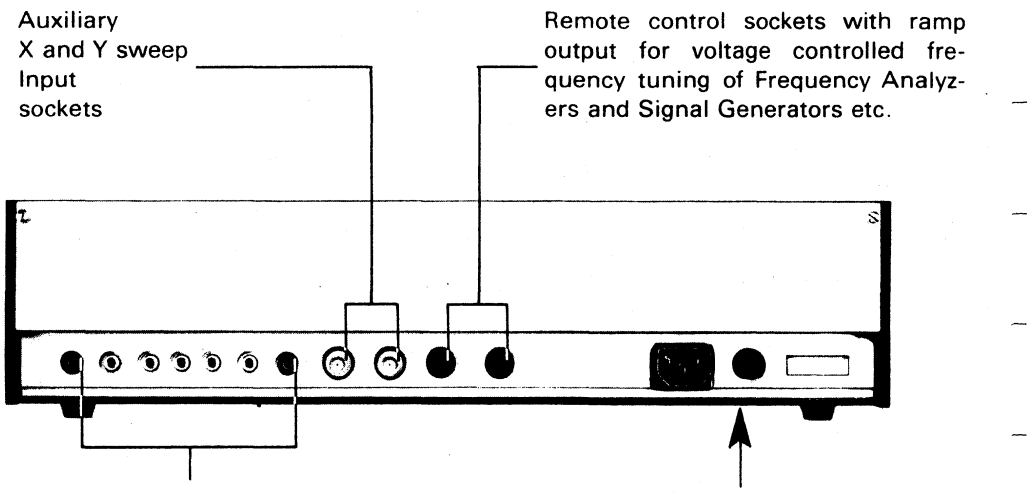
Control Functions

"Power Off", "Standby", "Paper Hold", "Servo On" and "Pen Down" control functions are on one selector switch on the Recorder. This permits fast, straight forward setting up, making it virtually impossible to select control functions in the wrong sequence.

For automatic recording, a "Pen Down" remote control line is available at one of two rear panel DIN sockets which also have control lines for remote control of the X sweep of the Recorder and for remote tuning of frequency analyzers and signal generators. Automatic pen lift ensures that recordings are not spoilt if the power line is inadvertently disconnected whilst recording.

Bench and Rack Mounting

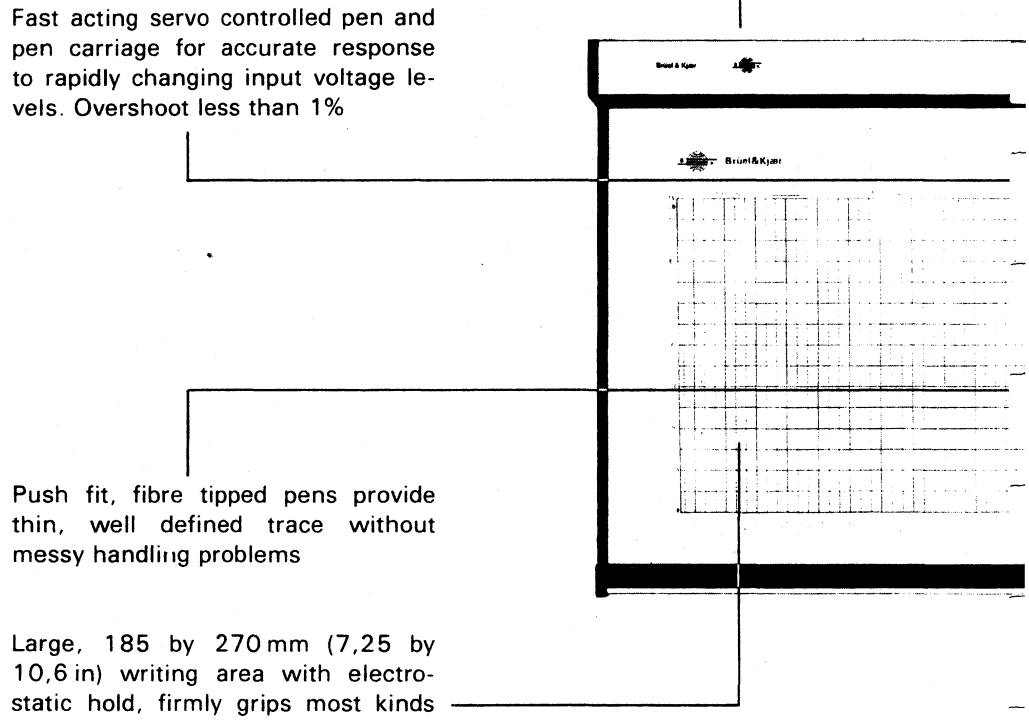
The 2308 is available in A and C models. Model A is the 2308 mounted in a lightweight metal cabinet suitable for free standing bench use, whilst model C is similar to model A, but with the addition of flanges for mounting the 2308 in a 19 inch instrumentation rack. If necessary, the rear panel sockets may be conveniently shifted to the bottom panel so that they are readily accessible when the 2308 is rack mounted.



Accessories

Pens

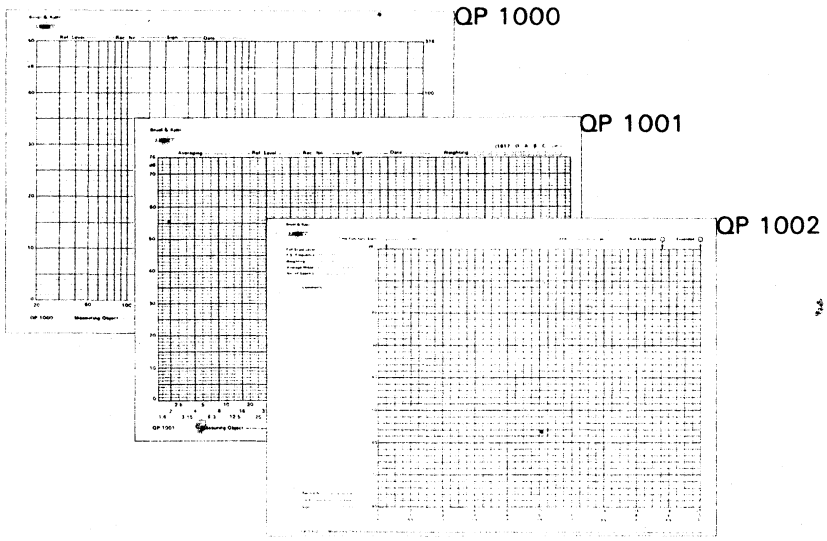
The 2308 is supplied with a pen set QI 0003. This contains 2 black, 2 red and 2 green fibre tipped pens. Extra pens in single or multi-coloured sets of 6, are available on separate order. See Specifications.



Recording Paper

Almost any kind of paper up to A4 (DIN) size, may be used. However, in order that recordings of frequency analyses, frequency and phase response etc., may be quickly and easily interpreted, it is generally convenient to use frequency graduated paper. For this purpose the preprinted recording paper shown in the scheme opposite may be employed.

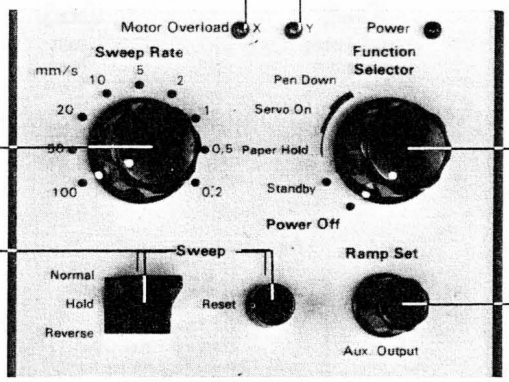
Recording paper QP 1000 and QP 1002 have logarithmic and linear frequency scales respectively, which match frequency analyzers and signal generators with a continuous frequency sweep, whilst QP 1001 has a logarithmic frequency scale matching frequency analyzers and filters with discrete octave and third octave frequency sweep. Like QP 1000 which is supplied with the 2308, QP 1001 and QP 1002 are available separately in 200 sheet booklets.



Built-in sweep generator with 9 calibrated sweep speeds, lets you sweep X or Y scales as well as tune external Frequency Analyzers and Signal Generators

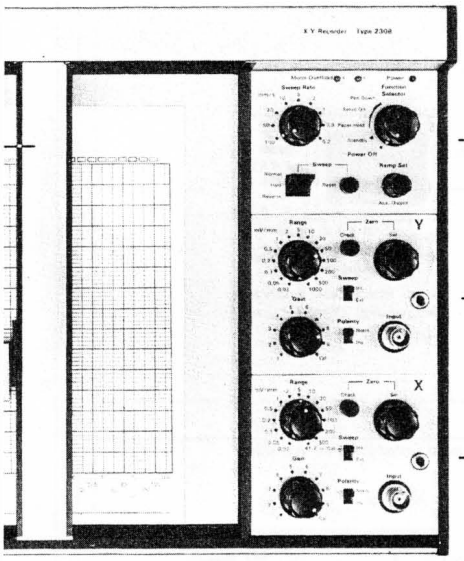
Motor overload warning

"Power Off", "Standby", "Paper Hold", "Servo On" and "Pen Down" functions at the turn of a single switch



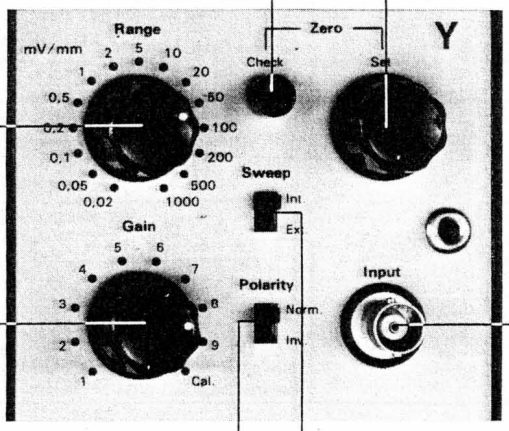
"Normal", "Hold", "Reverse" sweep modes with push-button "Reset" mode. Remote selection of "Hold" and "Reset" also provided

RAMP SET control for adjustment of auxilliary ramp offset. Lets you remotely tune external Frequency Analyzers and Generators so that their start frequency corresponds with the start frequency on the recording paper



ZERO SET control permits zero on the X and Y sweep axis to be set anywhere within 3 × writing area, enabling both positive or negative signal excursions to be recorded

15 calibrated sweep sensitivity ranges let you compress or expand the sweep so that the recorded signal fills the complete writing area



Gain control with click-stop "Cal." position for continuous adjustment of sweep sensitivity between ranges

EXT. SWEEP input with floating and grounded modes

"Normal" and "Inverted" input modes

"Int" and "Ext" sweep modes. "Int" selects built-in sweep generator

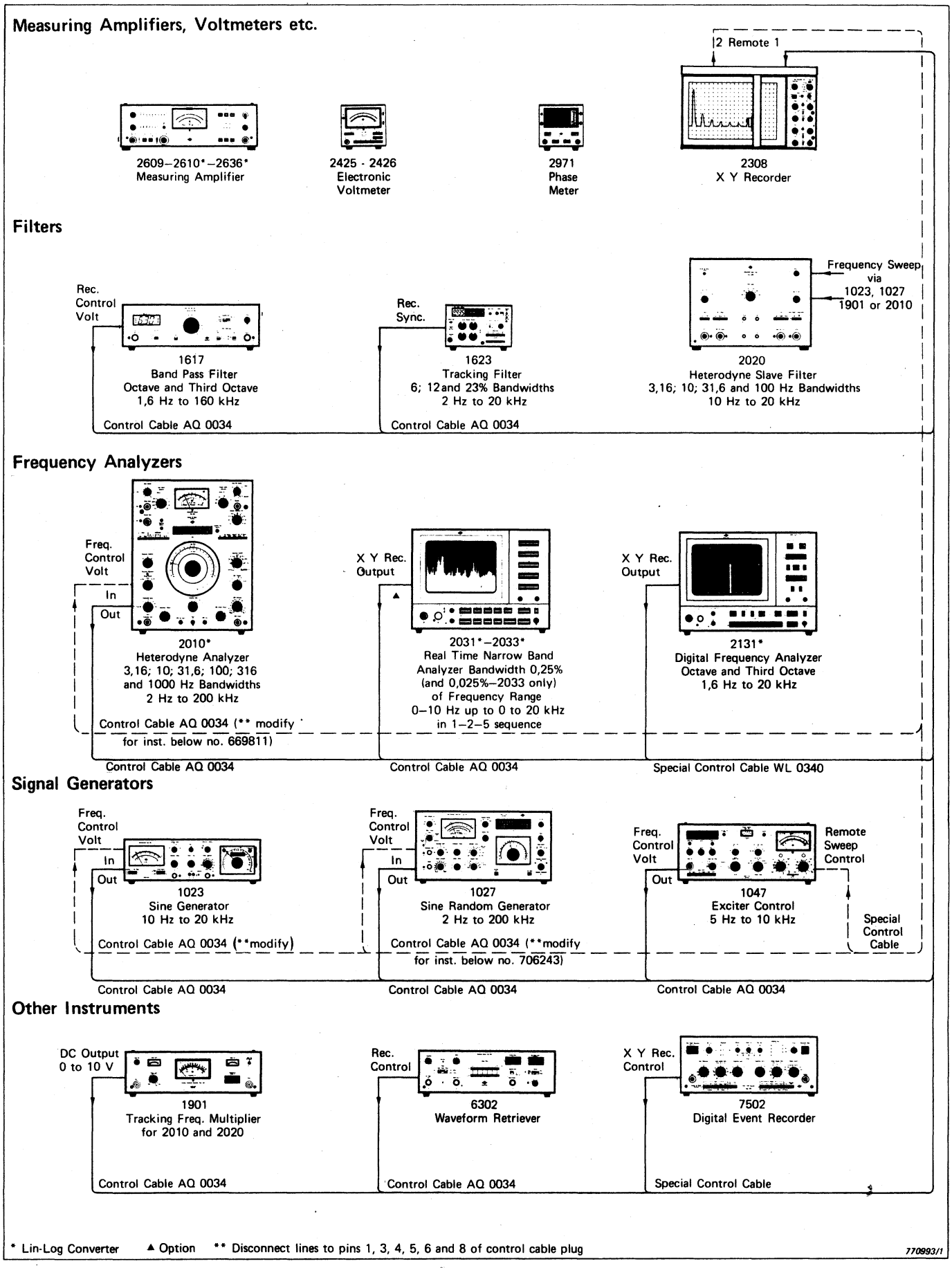


Fig.2. B & K range of measuring and analyzing instrumentation which may be used with the 2308 X-Y Recorder

Examples of Use

The range of B & K measuring and analyzing instrumentation which may be used with the 2308 is shown in Fig.2.

It should be noted that the linear record range of the 2308 may be adjusted to suit almost any DC signal, whatever dynamic range it represents. However, if signals are to be plotted with a linear dB scale, giving the same detailed resolution over the entire paper width, then they must be recorded from the DC output of a measuring or analyzing instrument that includes a Lin-Log converter. B & K instruments that include this facility are shown in Fig.2 and are indicated by an asterisk * beside their type number.

Level Recording

Using the 2308 any function which may be converted to a DC voltage may be recorded. For example with the internal sweep generator controlling the X sweep of the pen and the Y channel connected to a suitable measurement transducer and/or measuring instrument equipped with a DC output, sound pressure, — vibration acceleration, velocity and displacement — strain — load — temperature variations etc. may be recorded as a function of time. The slowest calibrated sweep rate which may be selected is 0,2 mm/s, giving up to 20 minutes of uninterrupted recording.

Waveform Plots

The 2308 has a very fast slewing speed of 1000 mm/s. It can therefore respond to relatively fast changing input voltages, enabling a wide variety of voltage waveforms to be plotted. However, for recording waveforms with very rapid voltage excursions, the time scale of the waveform must be expanded before being applied to the 2308. For this purpose the Digital Event Recorder Type 7502 shown in Fig.2 may be employed. This is designed to capture short duration events such as sonic booms, drop hammer noise and speech, and then reproduce them whenever desired with almost any speed transformation ratio, suitable for recording their waveform or for frequency analysis.

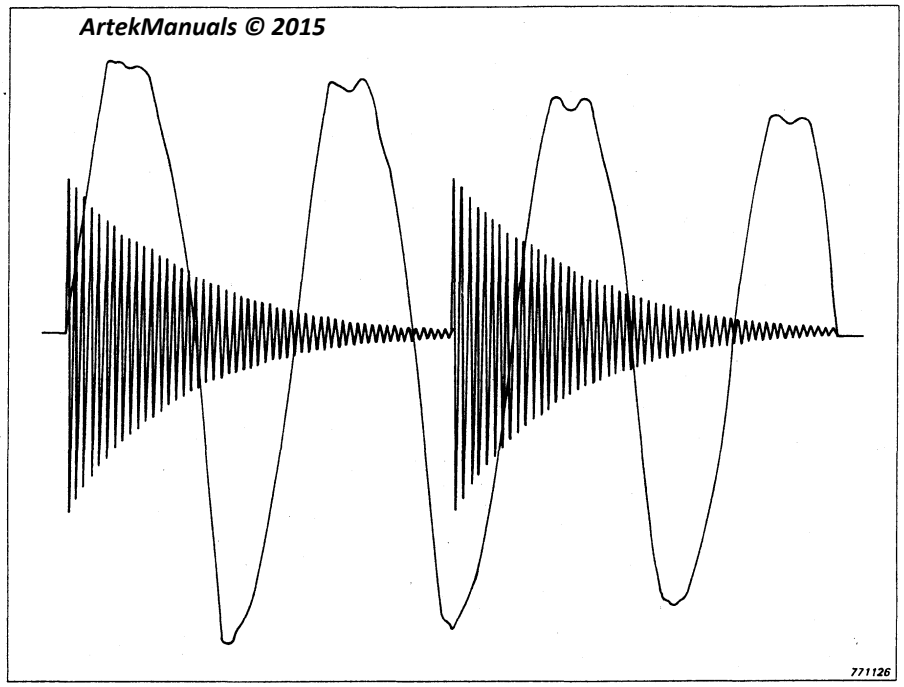


Fig.3. Waveform plots of exponentially decaying vibration signal recorded with the 2308 X-Y Recorder

Also shown in Fig.2 is the Waveform Retriever Type 6302. This is designed to scan continuous signals and produces a DC analog of the signal waveform, eliminating noise and other components not related to its fundamental. Sweep periods of 1 to 999 s may be selected for expanding the time scale of the reproduced waveform for recording. Detailed waveforms of bearing resonances, gear wheel meshing and turbine resonances can be plotted, making the 6302 and 2308 a powerful combination for machine fault diagnosis.

Frequency Analysis

B & K produces a wide variety of filters and frequency analyzers, most of which may be used with the 2308, enabling accurate, hard copy, graphic plots of frequency analyses to be obtained on frequency graduated recording paper. With the appropriate remote control cable connected (AQ 0034 unless otherwise specified. See Fig.2) the auxil-

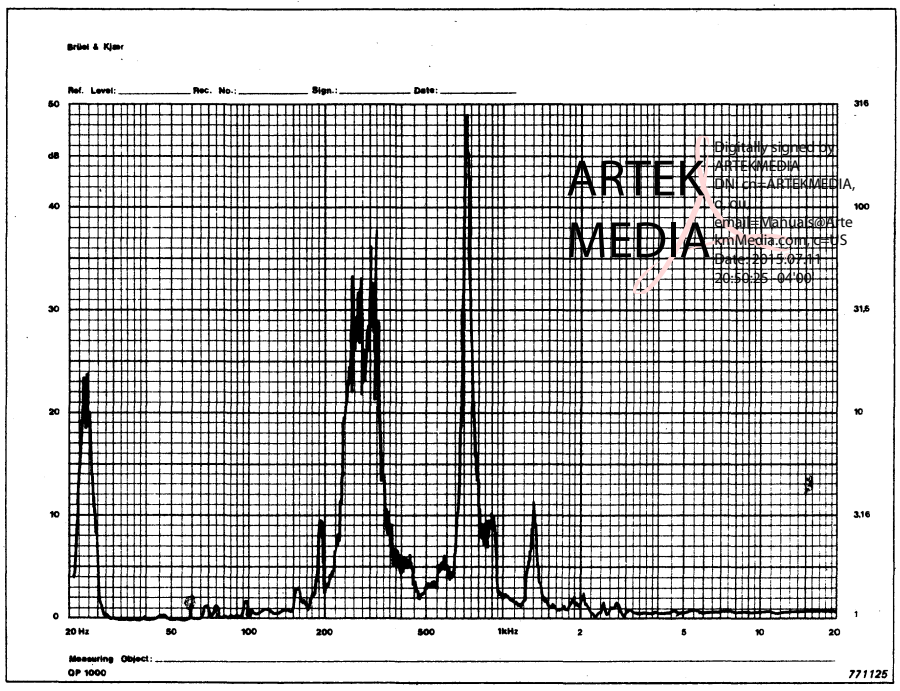


Fig.4. Narrow band analysis of machine vibration recorded with the 2308 X-Y Recorder

iary ramp output of the recorder may be used to tune the centre frequency of the analyzing instrumentation, or alternatively the analyzing instrumentation may be used to control the X sweep of the recorder pen. In either case recording of frequency analyses may be made completely automatically with frequency correspondance between the analyzing instrumentation centre frequency and the frequency graduations of the recording paper.

Specifications 2308

X Sensitivity:
0,02 to 500 mV/mm over 15 calibrated range steps, with variable adjustment overlapping all ranges

Y Sensitivity:
0,02 to 1000 mV/mm over 15 calibrated range steps with variable adjustment overlapping all ranges

Accuracy:
0,2% of full scale

Input Type:
Floating BNC sockets on front and rear panels with provision for grounding socket screens

Input Polarity:
Normal and Inverted

Input Impedance:
1 MΩ with all ranges

Common Mode Rejection:
130 dB DC 110 dB AC (mains frequency) degrading by 20 dB/decade decrease in range sensitivity from 20 μV/mm. Measured with 1 kΩ source impedance

Maximum Common Mode Voltage:
50 V peak (including DC component) in accordance with IEC R 348, but can withstand test voltages up to 300 V peak without breakdown

Slewing Speed:
1000 mm/s — X and Y axes

Maximum Acceleration:
70 m/s^2 — X axis
100 m/s^2 — Y axis

Linearity and Resettability:
0,1% of full scale

Overshoot:
1% of full scale

Motor Overload:
Overload indicators light and X-Y motor drive disconnected when max. operating temperature of motors exceeded

Sweep Rates:
0,2; 0,5; 1; 2; 5; 10; 20; 50 and 100 mm/s steps
Accuracy: ± 1% of full scale for all settings except 0,2 mm/s which has ± 2% accuracy

Sweep Modes:
"Normal", "Hold", "Reverse" and "Reset" switch modes with "Hold" and "Reset" remote control lines available at rear panel DIN socket

Output:
DIN socket providing 10 V ramp for remote voltage controlled tuning of frequency analyzers and signal generators. Using the AUX. RAMP SET potentiometer offsets between —10 and + 10 V may be applied. For maximum output the minimum load impedance which may be connected is 100 kΩ

Zero Offset:
Zero on X-Y axes may be individually set anywhere within writing area

Writing Area:
185 by 270 mm (7,25 by 10,6 in)

Paper Size:
A4 (DIN) size — 8,5 by 11 in

Paper Hold:
Electrostatic

Pens:
Disposable fibre tipped pen cartridges. Colour — green, red or black

Control Functions:
"Power Off", "Standby", "Paper Hold", "Servo" and "Pen Down" selected in correct sequence using one control switch "Pen Down", "Sweep Hold" and "Sweep Reset" remote control lines are available at DIN sockets on rear panel
Automatic pen lift in event power failure

Environmental Conditions:
Temperature: 0 to + 40°C (+ 32 to + 104°F) operating —25 to + 70°C (—13 to + 158°F) storage
Humidity: 0 to 90% RH

Power Requirements:
100; 115; 127; 200; 220 and 240 V AC ± 10% (50 to 400 Hz), 20 VA. Complies with safety class I of IEC 348

Cabinet:
Supplied as model A (lightweight metal cabinet) or C (as A but with flanges for standard 19" racks)

Dimensions:
Height: 100,5 mm (3,96 in)
Width: 430 mm (16,93 in)
Depth: 266 mm (10,47 in)

Weight:
7,7 kg (17 lb)

Accessories Included:
1 Power Cable AN 0010
2 Input Adaptors for Banana Plugs JJ 0148
2 BNC Plugs JP 0035
2 8 pin DIN Plugs JP 0802
6 Fibre pens: 2 black, 2 green 2 red QI 0003
200 Sheet Packs of Recording Paper QP 1000

Accessories Available:
Set of 6 Black Fibre Pens QI 0004
Set of 6 Red Fibre Pens QI 0005
Set of 6 Green Fibre Pens QI 0006
Recording Paper QP 1000, QP 1001 and QP 1002 in separate 200 Sheet Packs

2. CONTROLS

2.1. TOP PANEL

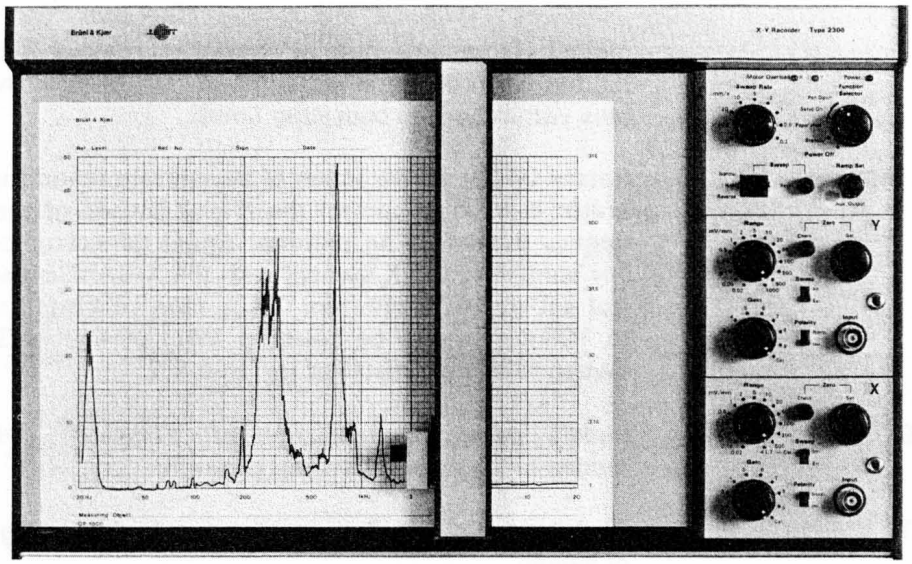


Fig.2.1. Top panel of 2308

2.1.1. Writing System and Sweep Generator

FUNCTION SELECTOR: Rotary switch for selection of the following functions:

"Power Off". AC mains power is disconnected from the Recorder.

"Standby". AC mains power is connected with servo drive set to standby, enabling pen carriage to be moved by hand ready for insertion of the recording paper.

"Paper Hold". Electrostatic paper hold operative with servo drive still in standby mode.

"Servo On". Servo drive operative, but with pen lifted from recording paper, ready for adjustment of zero and full scale sweep of the pen using the X and Y channel controls of the Recorder.

"Pen Down". Record mode of 2308.

POWER LED: Red light, indicating Recorder is powered.

MOTOR OVERLOAD LEDS: Yellow lights indicating shut-down of servo drive when movement of pen and pen carriage is obstructed, causing thermal overload of drive

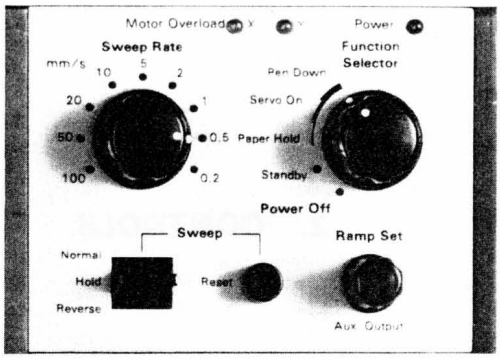


Fig.2.2. Writing system and sweep generator controls of the 2308

motors. To resume normal operation, remove the obstruction and wait for the Recorder to reset automatically when drive motor temperature falls within normal operating limits.

SWEEP RATE mm/s: Rotary switch for selection of sweep rate when the internal sweep generator is used to control the X or Y sweep of the pen and/or the frequency sweep of an external signal generator or frequency analyzer. For control of the X sweep, with the X-RANGE switch and X-GAIN control set to "41,7 mV/mm-Cal.", nine calibrated sweep rates from 0,2 to 100 mm/s may be selected. With other RANGE switch settings the sweep rate is as specified in Table 5.2.

SWEEP MODE: Paddle switch for selection of "Forward", "Hold" and "Reverse" modes of the internal sweep generator.

SWEEP RESET: Push button switch for resetting internal sweep generator back to start of sweep.

AUX. RAMP SET: 10 turn potentiometer for adjustment of DC offset at auxiliary ramp output line of REMOTE II control socket on rear panel. Permits independent adjustment of start of frequency sweep when an external signal generator or frequency analyzer is tuned using the internal sweep generator. See section 4.3.

2.1.2. X-Y Sweep Channels

The controls of one of the sweep channels of the 2308 are shown in Fig.2.3. The X channel controls the horizontal sweep of the writing system pen carriage and the Y channel controls the vertical sweep of the pen.

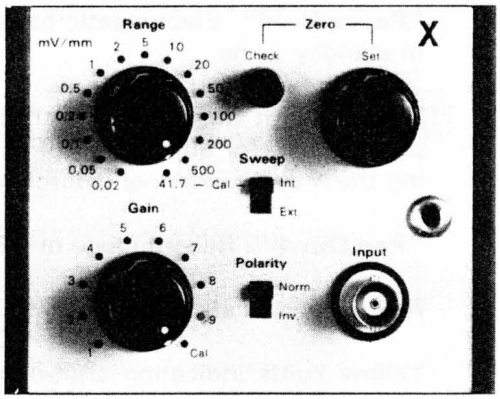


Fig.2.3. X sweep channel controls of the 2308

INPUT: Floating input socket, accepting BNC cables and the Banana Plug Adaptors JJ 0148 provided, for application of external DC signal to control the X or Y sweep of the pen. It has an input impedance of approximately 1 MΩ and can withstand voltages as high as 300 V pk. However, for safe operation in accordance with IEC 348 the input current of signals exceeding 50 V pk should be restricted to 0,7 mA pk. Alternatively, the socket screen should be connected to chassis as in section 3.1.4.

INT — EXT SWEEP: Slider switch with "Int." and "Ext." modes for connecting the internal or external sweep signal to the channel input.

POLARITY: Slider switch with "Norm." and "Inv." modes for reversing the direction of the sweep.

RANGE mV/mm: Rotary switch for selection of fourteen calibrated sweep sensitivities from 0,02 to 500 mV/mm. The Y channel RANGE switch also has a 1000 mV/mm setting, whilst the X channel RANGE switch has a "41,7 mV/mm - Cal." setting for calibrated X sweep with the internal sweep generator.

GAIN: Single turn potentiometer, with click-stop "Cal." position for continuous adjustment of sweep sensitivity between range settings.

ZERO SET: 10 turn potentiometer enabling zero pen deflection to be set anywhere within 3 times the writing area so that it corresponds with any required input level.

ZERO CHECK: Push-button switch disconnecting internal and external sweep signal from channel input. Is used for checking pen position against that corresponding to zero chassis potential.

2.2. REAR PANEL

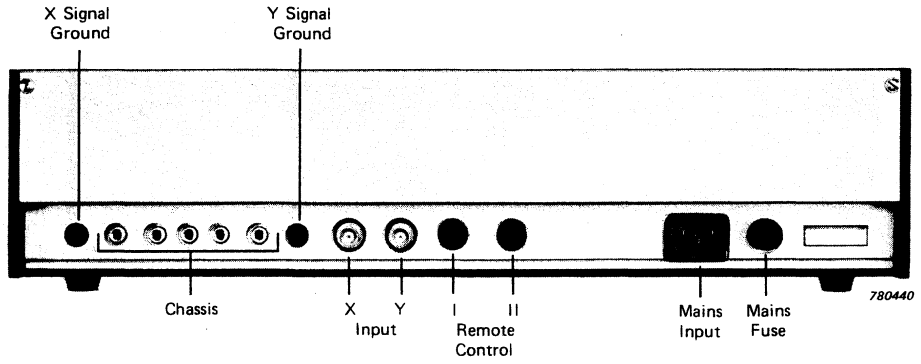


Fig.2.4. Rear panel of 2308

CHASSIS X-Y GROUND: Seven sockets, accepting the 2 pin connectors JN 0005 provided for connection of the XY INPUT socket screens to chassis. See Grounding Considerations, section 3.1.4.

INPUTS: Floating BNC input sockets for application of external sweep signal to control X or Y deflection of pen. Are connected in parallel with X-Y INPUT sockets on top panel.

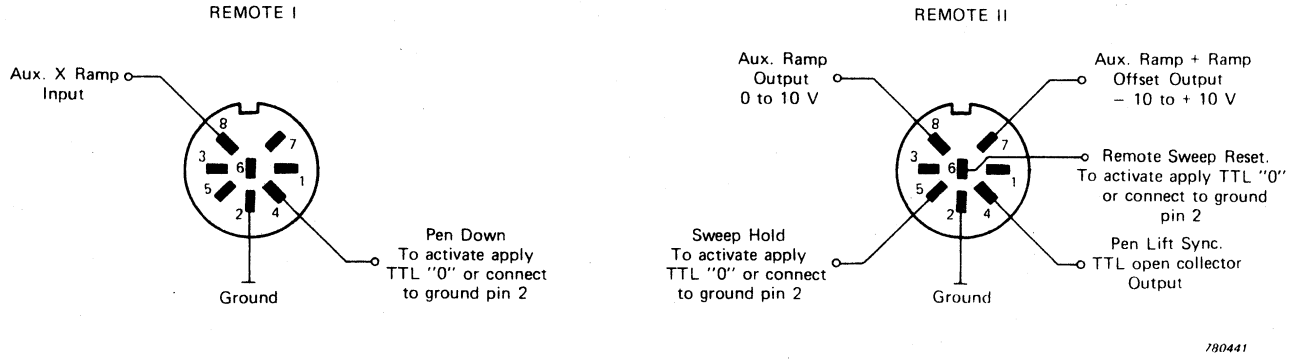


Fig.2.5. External view of the REMOTE I and REMOTE II control sockets of the 2308

REMOTE I-II: Two 8 pin sockets accepting the DIN plugs (B & K No. JP 0802) provided, for remote control of the Recorder, as well as for remote voltage controlled tuning of signal generators and frequency analyzers. For connections see Fig.2.5.

MAINS INPUT: Input socket, accepting the Power Cable AN 0010 provided, for connection of a 100, 115, 127, 200, 220 or 240 V (50 to 400 Hz) AC mains supply. Before connecting a supply the mains voltage setting and fuse checks given in section 3.1 should be carried out.

MAINS FUSE: Accepts an 800 mA slow blow fuse (B & K No. VF 0050) for 100 to 127 V operation, or a 400 mA slow blow fuse (B & K No. VF 0039) for 200 to 240 V operation.

3. OPERATION

3.1. PRELIMINARY

3.1.1. Mounting

The X-Y Recorder Type 2308 is available in A and C models. Model A is the 2308 in a lightweight metal cabinet suitable for free standing bench use, whilst model C is similar to model A, but has Flanges KS 0039 for mounting the Recorder in a 19 inch instrumentation rack. The Flanges KS 0039 are also available separately and screw onto the Recorder in place of the carrying handles provided on its side panels.

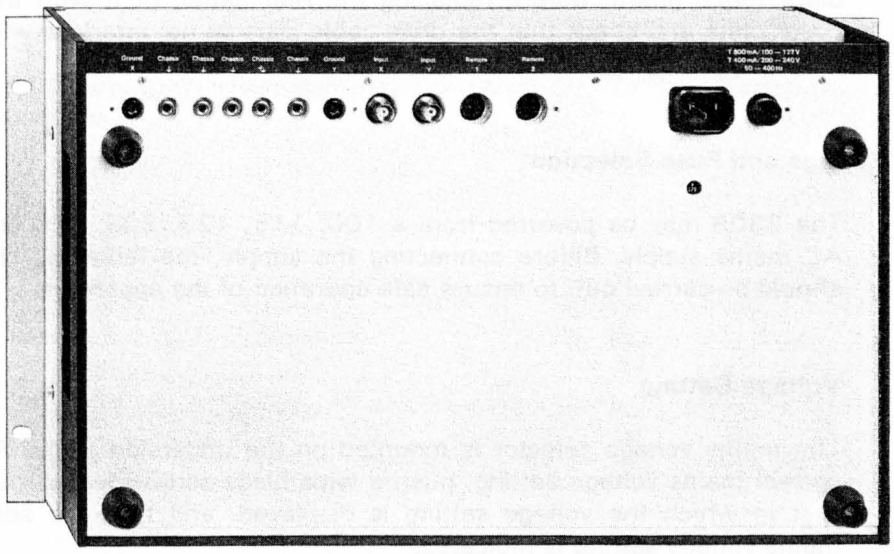


Fig.3.1. The 2308 with Flanges KS 0039 fitted and rear panel sockets mounted on bottom panel for installation in a 19 inch instrumentation rack

For easier connection of cables when the 2308 is mounted in an instrumentation rack, its rear panel sockets may be moved to the bottom panel. To do this stand the Recorder upright on its front panel and using a screwdriver, remove the two screws at the top of the rear panel and the four screws along the rear edge of the bottom panel. Having removed the two panels, carefully pull off the pen carriage drive cable clips from the black metal guard at the rear of the Recorder and remove the four screws fastening the guard to the sides of the Recorder mainframe. Taking care not to damage the drive cable, carefully ease out its plug from the socket on the side of the mainframe and remove the three screws fastening the CHASSIS X-Y (SIGNAL) GROUND, X-Y INPUTS and REMOTE I-II socket assembly, plus the two screws fastening the MAINS INPUT and FUSE assembly. Push both assemblies back into the Recorder and turn them through 90° so that they may be screwed to the socket mounting plate at the bottom of the Recorder.

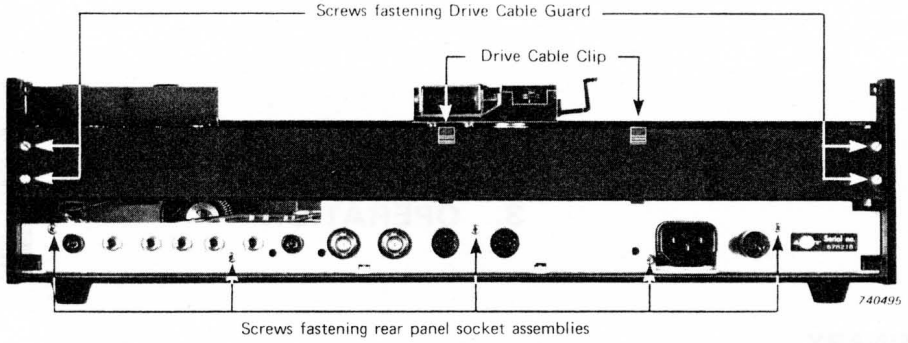


Fig.3.2. The 2308 with rear and bottom panels removed for mounting the rear panel sockets on the bottom panel

For reassembly, fit the drive cable plug in its socket on the side of the Recorder mainframe and pull back the spring steel guard band so it is parallel with the drive cable. Screw the free end of the guard band together with the black metal guard back onto the Recorder and replace the drive cable clips. Pull the drive cable and guard band taut, checking that they are parallel with one another and lay flat against the centre of the black metal guard. Before replacing the rear panel, fit it with the bottom panel socket cover plate and check that the drive cable clips do not interfere with the travel of the pen carriage. Finally replace the bottom panel.

3.1.2. Mains Voltage and Fuse Selection

The 2308 may be powered from a 100, 115, 127, 200, 220 or 240 V (50 to 400 Hz) AC mains supply. Before connecting the supply, the following checks and adjustments should be carried out, to ensure safe operation of the apparatus.

Voltage Setting

The mains voltage selector is mounted on the underside of the Recorder. To select the correct mains voltage setting, push a wide blade screwdriver through the hole just below that in which the voltage setting is displayed, and turn the selector until the correct mains voltage setting is indicated.

Fuse Check and Replacement

The mains fuse is contained in the black knob beside the MAINS INPUT socket on the rear panel. For operation from 100 to 127 V mains supplies, the fuse should be an 800 mA slow blow (B & K No. VF 0050), whilst for 200 to 240 V supplies it should be a 400 mA slow blow (B & K No. VF 0039). Make sure that only fuses with the required rated current and of specified type are used for replacement. The use of mended fuses and of short circuiting of fuse holders is prohibited.

Supply Connections

Once the mains voltage setting and fuse have been checked, the mains supply may be connected to the MAINS INPUT of the Recorder using the Power Cable AN 0010 provided. To fit a suitable plug to the cable see Fig.3.3.

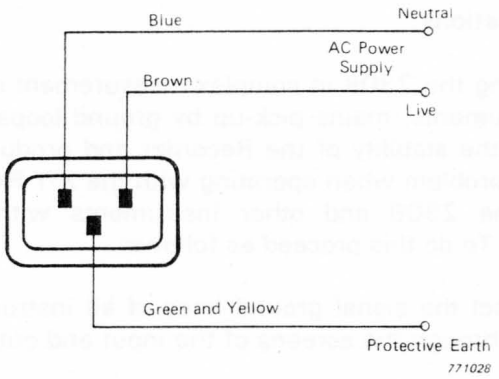


Fig.3.3. Connection of AC mains supply to the MAINS INPUT socket of the 2308

For maximum operating safety it is recommended that the protective (green/yellow) conductor of the power cable be connected to a suitable earth, such as the protective earth contact of a mains socket outlet. The use of an extension cable without protective conductor should be avoided.

3.1.3. Internal Fuses

In addition to the mains fuse, the 2308 also has a number of other slow blow fuses. These help protect the secondary windings of the internal mains transformer and need only be checked when a current overload has occurred with the common and X-Y channel supply lines of the Recorder. As indicated in Fig.3.4 the fuses are located just beside the mains transformer and are accessible on removing the bottom panel. This is fastened by four screws along its rear edge and should be removed only when the Recorder is disconnected from the mains supply. The correct replacement fuses are indicated in Fig.3.4.

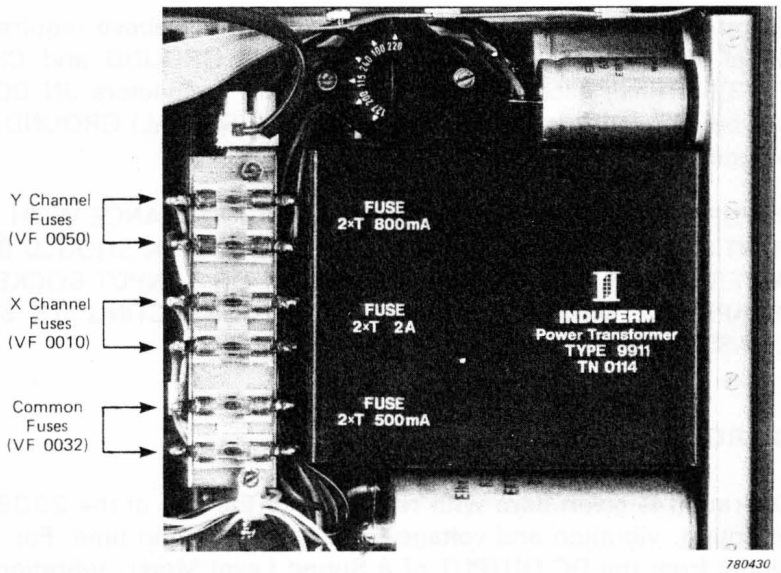


Fig.3.4. The 2308 with bottom panel removed showing internal protection fuses

3.1.4. Grounding Considerations

When using the 2308 in complex measurement set-ups, together with other mains powered instruments, mains pick-up by ground loops may be introduced. To prevent this influencing the stability of the Recorder and producing mains ripple on recordings, which may be a problem when operating with the X-Y RANGE switches set for a high input sensitivity, the 2308 and other instruments with which it is used must be properly grounded. To do this proceed as follows:

1. Connect the signal ground lines of all instruments together. This is done automatically through the screens of the input and output cables.

2. Connect the signal ground line of one of the instruments in the X channel chain and one in the Y channel chain to chassis, and then connect the chassis of both instruments to the protective earth contact of a mains socket outlet. It is essential that this is done on only one instrument in each chain, preferably that nearest the measurement source. If the X and Y signals are derived from the same source then only the X channel signal ground line or only the Y channel signal ground line (not both) should be connected to chassis.

3. Make the necessary adjustments such that the chassis of each of the other instruments in the measurement and recording set-up, is connected to one and only one of the following points a) the protective earth contact of a mains socket outlet, b) signal ground and c) chassis ground of another instrument which must eventually be connected to mains ground.

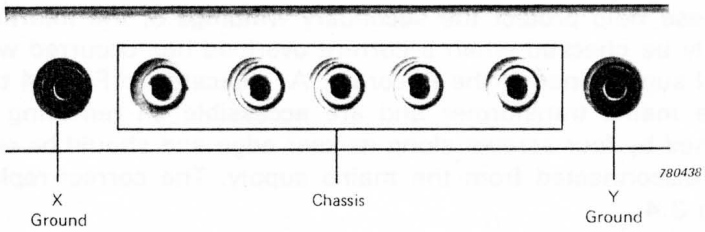


Fig.3.5. X-Y (SIGNAL) GROUND and CHASSIS sockets on rear panel of the 2308

For grounding the 2308 in accordance with the above requirements, its rear (or bottom) panel is equipped with the X-Y (SIGNAL) GROUND and CHASSIS sockets shown in Fig.3.5. These accept the pair of dual pin connectors JN 0005 provided, which when not being used to connect the X and/or Y (SIGNAL) GROUND sockets to chassis may be plugged into the CHASSIS sockets for storage.

IMPORTANT: FOR SAFE OPERATION IN ACCORDANCE WITH IEC 348, THE INPUT CURRENT OF INPUT SIGNALS GREATER THAN 50 V PK SHOULD BE LIMITED TO 0,7 mA PK. ALTERNATIVELY THE SCREEN OF THE X OR Y INPUT SOCKET TO WHICH THE SIGNAL IS APPLIED, MUST BE GROUNDED BY CONNECTING ITS SIGNAL GROUND LINE TO CHASSIS AS DESCRIBED ABOVE.

3.2. RECORDING PROCEDURE

Operation is given here with reference to the use of the 2308 for making cartesian plots of sound, vibration and voltage levels as a function time. For this purpose the measured signal from the DC OUTPUT of a Sound Level Meter, Vibration Meter, Electronic Voltmeter or some other measuring instrument, is used to control the Y (vertical) deflection of the pen, whilst the internal sweep generator of the Recorder is used to control the X

(horizontal) deflection of the pen carriage. With the X-RANGE switch set to its "41,7 mV/mm Cal." setting, nine calibrated sweep rates from 0,2 to 100 mm/s may be selected with the internal sweep generator, which for zero to full scale X deflection over a 240 mm paper length, enable record times of 20 minutes down to 2,4 seconds to be obtained.

The recording procedure is as follows:

1. Carry out the preliminary adjustments necessary. See section 3.1.

2. Set the FUNCTION SELECTOR to its "Standby" mode. The red power "On" LED just above the switch should light indicating that mains power is connected.

3. Move the pen carriage by hand to the extreme right of its travel and fit the pen holder with one of the fibre pens provided.

4. Place a sheet of preprinted graph paper on the paper platten and carefully align it, preferably with its bottom and left hand edges flush with the bottom and left hand edges of the platten. Almost any kind of paper up to A4 DIN (8,3 by 11,7 in) size may be used, but not paper which is bent or crumpled.

5. Turn the FUNCTION SELECTOR one position clockwise to actuate the electrostatic paper hold, and smooth the paper flat against the platten, taking care not to alter its alignment. If the platten fails to grip the paper properly, it should be cleaned as in section 3.3.1.

6. For a horizontal pen deflection, directed by the internal sweep generator, set the X channel controls as follows:

   SWEEP: "Int."
   POLARITY: "Norm."
   GAIN: "Cal." click-stop position
   RANGE: "41,7" mV/mm — Cal. setting

7. Set the internal sweep generator SWEEP mode switch to "Hold" and select a SWEEP RATE setting giving a record time appropriate for the measurement about to be recorded. See Table 3.1.

Sweep Rate (mm/s)	0,2	0,5	1	2	5	10	20	50	100
Sweep Time	20m	8m	4m	2m	48s	24s	12s	4,8s	2,4s

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Table 3.1. Sweep times for 240 mm — zero to full scale — X sweep as a function of SWEEP RATE setting. Valid with "41,7 mV/mm — Cal." setting of X RANGE switch only

8. Set the FUNCTION SELECTOR switch to "Servo On" and press the SWEEP RESET button to return the pen carriage to the start of its travel.

9. Adjust the zero deflection of the pen on the X axis, so that it rests at a convenient starting point on the paper. To do this adjust X ZERO-SET potentiometer. The potentiometer is a multiturn type and therefore may have to be given several turns before its influence on the position of the pen is noticable.

10. For a vertical pen deflection directed by the measuring instrument employed in the recording arrangement, set the Y channel controls as follows:

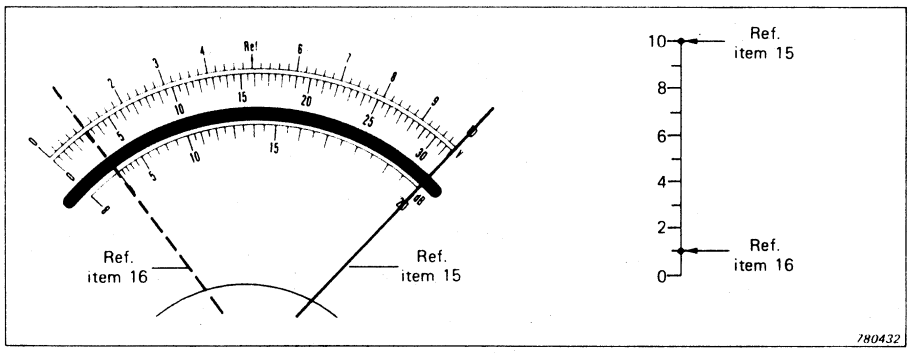

Fig.3.6. Calibration of X-Y Recorder pen deflection (Y axis only) when reference deflections of full scale and 20 dB below full scale are produced on the measuring instrument's meter for recording from its DC LIN OUTPUT

SWEEP: "Ext."
POLARITY: "Norm." for positive input signal
"Inv." for negative input signal
GAIN: "Cal." click-stop position
RANGE: "1000" mV/mm

11. Adjust the zero deflection of the pen on the Y axis so that it rests at a convenient point on the paper. To do this, adjust the Y channel ZERO-SET potentiometer, whilst at the same time keeping its ZERO-CHECK button pressed. The ZERO-SET potentiometer is a multi-turn type and therefore may have to be given several turns before its influence on the position of the pen is noticeable.

12. Connect the Y channel INPUT socket with the DC LIN or LOG OUTPUT socket of the measuring instrument, supplying the signal to be recorded.

13. Connect the measuring instrument with a sound, vibration or voltage reference source, whichever is appropriate for the measurement about to be recorded, and calibrate the instrument so that its meter indicates the correct reference level. See Instruction Manual for measuring instrument concerned.

14. Mark off the vertical axis of the recording paper with the appropriate scale (linear scale for DC LIN. OUTPUT signals — logarithmic scale or linear dB scale for DC LOG. OUTPUT signals) corresponding with the meter scale of the measuring instrument.

15. Leaving the reference source connected and keeping the same control settings used for calibration of the measuring instrument, adjust the Y channel RANGE switch and GAIN potentiometer to move the pen to the level graduation on the paper corresponding with the reference level indicated by the measuring instrument. See Fig.3.6 and 3.7.

16. Set the RANGE ATTENUATOR knobs or push-buttons of the measuring instrument for a sensitivity 10 times lower than that used for calibration. As indicated in Fig.3.6 and 3.7 the pen should move to a level graduation a factor of 10 (20 dB) below its previous level. If not, adjust the Y channel ZERO-SET potentiometer until the correct deflection is obtained.

17. Repeat items 15 and 16 once or twice. This will cancel out any interaction in the adjustment of the Y channel RANGE and ZERO-SET controls, improving the accuracy of the calibration. Once correctly calibrated, full scale pen deflection will correspond

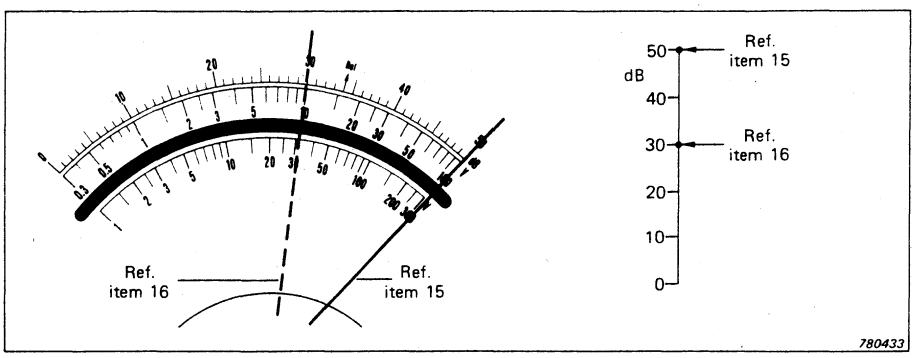

Fig.3.7. Calibration of X-Y Recorder pen deflection (Y axis only) when reference deflections of full scale and 20 dB below full scale are produced on the measuring instrument's meter for recording from its DC LOG OUTPUT

to full scale pointer deflection on the meter, whatever measurement range is selected on the measuring instrument.

18. Disconnect the reference source and apply the signal to be recorded to the measuring instrument.

19. Set the RANGE ATTENUATOR knobs or push-buttons of the measuring instrument to obtain a suitable pointer deflection on the meter and pen deflection on the Recorder, that does not exceed full scale. Avoid further adjustment of RANGE, GAIN and ZERO-SET controls of the Recorder, or calibration will be lost.

20. To commence recording, set the FUNCTION SELECTOR switch to "Pen Down" and the SWEEP mode switch to "Normal". The pen and pen carriage will move across the paper, automatically plotting out the signal. On completion of the recording the movement of the pen carriage will stop automatically, at which point the FUNCTION SELECTOR switch should be switched back by hand to its "Servo On" position to lift the pen from the paper.

    To make a new recording, set the FUNCTION SELECTOR back to its "Standby" position and insert a fresh sheet of graph paper as in item 4. With the FUNCTION SELECTOR set to "Servo On" and the SWEEP mode switch set to "Hold", press the SWEEP-RESET button to return the pen carriage back to the start of the sweep, ready to commence recording as in item 20.

3.3. CARE AND MAINTENANCE

The 2308 is a robust instrument which is designed to provide the user with many years of trouble free operation. However, to maintain the Recorder in peak operating condition at all times, regular cleaning is necessary. This is especially important when the Recorder is subjected to continuous daily use and may be performed as outlined in the following sections.

3.3.1. Paper Platten

The effectiveness of the electrostatic paper hold function of the 2308 is dependent on the cleanliness of its paper platten. To remove grease, dirt and other foreign matter, dip a soft cloth in luke warm water to which some mild soap has been added, wring it out and wipe it over the surface of the platten. Having deposited enough solution to lightly

damp, but not wet the platten, thoroughly rinse the cloth in fresh water, wring it out till it is almost dry and wipe it over the platten, removing the remaining grease and dirt. If ink stains are present, rub the contaminated areas with a soft cloth, dampened with ethyl alcohol. To finish, rub with a clean, dry cloth, making sure that the platten is absolutely dry before commencing operation.

WARNING! TO PREVENT RISK OF ELECTRIC SHOCK AND DAMAGE TO THE RECORDER, DISCONNECT IT FROM THE MAINS SUPPLY BEFORE CLEANING. ALSO AVOID USE OF SOLVENTS AND CLEANING AGENTS OTHER THAN THOSE MENTIONED, AS THEY MAY DAMAGE THE PLATTEN.

3.3.2. Guide Runners and Potentiometers

These should be inspected and cleaned at 3 to 6 month intervals, or whenever the pen or pen carriage show signs of irregular or erratic movement.

Disassembly

For access to the guide runners and potentiometers of the Recorder, disconnect it from the mains supply and using a small screwdriver, remove the two screws fastening its rear panel. Carefully pull off the pen carriage drive cable clips from the black metal guard behind the rear panel and remove the four screws fastening the guard to the sides of the Recorder mainframe. Taking care not to damage the drive cable, carefully ease its plug out of the socket on the side of the mainframe and remove the two screws at the rear and front of the pen carriage arm (see Figs.3.8 and 3.9 respectively). Finally lift off the pen carriage arm from the Recorder, ready for cleaning.

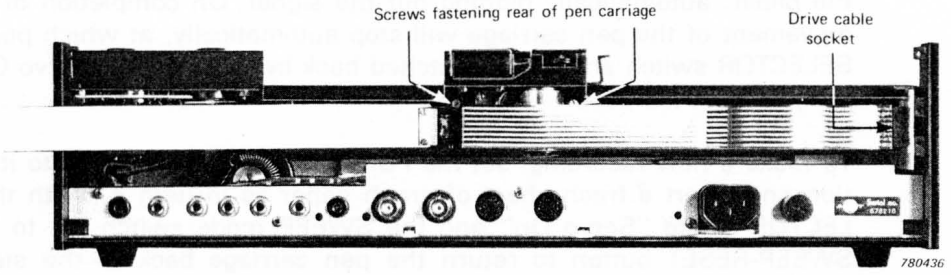

Fig.3.8. The 2308 with rear panel and drive cable guard removed

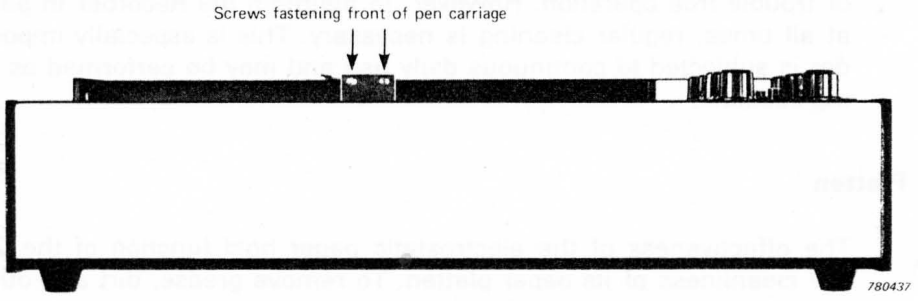

Fig.3.9. Front view of the 2308

Cleaning

To remove grease and dirt embedded on the pen carriage guide runner and rollers, wipe with a soft cloth dampened with ethyl alcohol. Avoid flooding the rollers with alcohol as this will remove the lubrication of their bearings.

Ethyl alcohol may also be used for cleaning the X-Y potentiometers of the Recorder. The X potentiometer is located just behind the pen carriage guide rod shown in Fig.3.7, whilst the Y potentiometer is on the underside of the pen carriage arm. Alcohol should be applied using the soft cotton swab at the end of a Q tip, which should be wiped along the entire length of the two gold platted contact strips as well as the black conductive strip of each potentiometer. Take care that the cotton swab does not get caught under the potentiometer contact wipers, as this will bend them out of alignement. Repeat cleaning, using fresh swabs, until these are no longer blackened.

Before reassembly, wipe a clean cloth along the pen holder guides on the underside of the pen carriage arm and lightly lubricate the spring steel drive cable guard, where it makes contact with the pen carriage guide rod. Do not lubricate the guide rod or the pen holder guides.

Reassembly

For reassembly, follow the disassembly instructions in reverse. However, before screwing the right hand end of the black metal guard to the Recorder, make sure that the free end of the spring steel guard band is correctly positioned underneath it. Having replaced, but not tightened the screws, fit the clips fastening the drive cable and pull it taut, making sure that it is parallel with the guard band and rests flat against the centre of the black metal guard. Finally move the pen carriage arm to check that the drive cable clips do not interfere with its travel.

4. USE WITH OTHER INSTRUMENTS

4.1. GENERAL

The X-Y Recorder Type 2308 is a versatile instrument which must be used with other instrumentation if its full potential is to be exploited. The range of B & K measuring, analyzing and generating instrumentation with which it may be used is shown in Fig.2 of Chapter 1.

Also indicated in Fig.2 are the appropriate remote control cables for synchronous operation of the 2308 with the instrumentation shown. These are available on separate order and are for connection to the REMOTE I and REMOTE II control sockets on the rear panel of the Recorder. REMOTE I accepts external DC voltage ramps for control of the X deflection of the pen, whilst REMOTE II provides DC voltage ramps for remote voltage controlled tuning of external instrumentation. Both control sockets accept the standard 8 pin DIN plug (B & K no. JP 0802) provided, and for automatic recording of frequency responses and analyses etc., may be used as discussed in the following sections.

4.2. REMOTE I SYNC.

B & K Signal Generators and Frequency Analyzers that are equipped with a FREQUENCY CONTROL or SYNC. VOLTAGE OUTPUT, produce a 0 to 10 V DC control ramp proportional to their frequency or sweep period. By applying the ramp to the auxiliary ramp input line of the REMOTE I control socket of the Recorder shown in Fig.4.1, it may be used to control the X deflection of the pen, thus permitting synchronous recordings of frequency responses and analyses etc. to be made using the Recorder.

Unless otherwise indicated in Fig.2, the appropriate remote control cable for connection of the DC control voltage ramp of B & K instruments to the Recorder is the standard 8 pin remote control cable AQ 0034. With non B & K instruments a DC ramp may be applied to the REMOTE I socket of the Recorder as indicated in Fig.4.1. The auxiliary ramp input has an input impedance of approximately 1 MΩ and can withstand ramp voltages as high as 300 V pk without damaging the Recorder. However, for safe operation in accordance with IEC 348, the input current of control voltage ramps exceeding 50 V pk should be restricted to 0,7 mA. The maximum voltage excursion of the ramp for zero to full scale X deflection covering 240 mm on the paper, depends on the setting of the X-RANGE switch of the Recorder and is specified in Table 5.1.

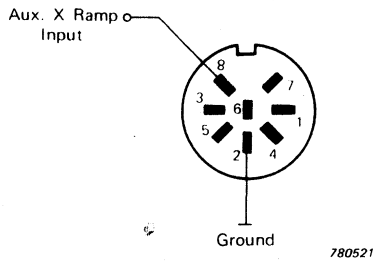

Fig.4.1. External view of the REMOTE I control socket of the 2308 with auxiliary X ramp input indicated

The setting up procedure for control of the X deflection of the 2308 using an external DC ramp is given below. This is suitable for semi-automatic recording of frequency responses and analyses and explains how to synchronize the X deflection of the pen with the frequency sweep of manually tuned types of signal generator and analyzer with DC ramp output. With other instruments, a similar procedure may be used.

1. Taking a sheet of graph paper, graduate up to 160 mm (6,3 in) of its vertical axis and up to 240 mm (9,4 in) of its horizontal axis, with the appropriate amplitude and frequency scales for the response or analysis. For recording over a 3 decade, logarithmic frequency scale corresponding with B & K Generators and Analyzers, use of the preprinted Recording Paper QP 1000 will be found convenient. See Chapter 1.
2. Place the graph paper on the paper platten of the Recorder and carefully align it, preferably with its bottom and left hand edges flush with the corresponding edges of the platten.
3. Set the FUNCTION SELECTOR switch to its "Paper Hold" mode and taking care not to alter the alignment of the paper, smooth it flat against the paper platten, to help ensure a firm paper grip.
4. For horizontal pen deflection directed by the DC voltage ramp produced by the Generator or Analyzer to be used in the recording set-up, set the X channel controls of the Recorder as follows:

   SWEEP: "Ext."
   POLARITY: "Norm."
   GAIN: "Cal." click-stop position
   RANGE: "41,7" mV/mm — Cal. setting

5. Using the appropriate remote control cable (AQ 0034 unless otherwise specified in Fig.2), connect the REMOTE I control socket of the Recorder with the FREQ. CONTROL VOLTAGE OUTPUT socket of the Generator or Analyzer. Check that the X (SIGNAL) GROUND-CHASSIS sockets on the rear of the Recorder are interconnected.
6. On the Generator or Analyzer, set the SWEEP CONTROL switch to "Manual" and adjust the FREQUENCY TUNING knob so that the FREQUENCY DISPLAY LEDs of the instrument display the lower frequency limit of the frequency range selected for the response or analysis.
7. On the Recorder set the FUNCTION SELECTOR switch to "Servo On" and using the X-ZERO SET control, adjust the horizontal deflection of the pen until the pen is immediately over the frequency graduation corresponding with the lower frequency limit selected in item 6.
8. On the Generator or Analyzer adjust the FREQUENCY TUNING knob so that the instrument displays the upper frequency limit required for the response or analysis. The pen carriage will start to move, automatically following the frequency sweep of the Generator or Analyzer.
9. Check that the pen is immediately over the frequency graduation on the paper corresponding with the upper frequency limit selected in item 8. If not, adjust the X-GAIN potentiometer to move the pen to the appropriate graduation.
10. Using the FREQUENCY TUNING knob, tune the Generator or Analyzer back to the lower frequency limit and using the Y channel controls of the Recorder, calibrate the vertical pen deflection in accordance with the meter of the measuring or analyzing instrument. To do this, select the linear frequency response mode of the measuring or analyzing instrument and proceed as in items 10 to 19 of section 3.2.

The 2308 is now correctly synchronized with the Generator or Analyzer. To commence recording, select the appropriate measurement bandwidth for the response or analysis and with the FUNCTION SELECTOR set to "Pen Down", very slowly turn the FREQUENCY TUNING knob of the Generator or Analyzer. The Recorder pen will now follow the frequency sweep of the Generator or Analyzer, automatically plotting out the response or analysis.

On reaching the required upper frequency limit, raise the pen by setting the FUNCTION SELECTOR back to "Stand-by". To repeat or make another recording, place a fresh sheet of graph paper on the paper platten and set the FUNCTION SELECTOR back to its "Servo On" position. Having turned the FREQUENCY TUNING knob of the Generator or Analyzer back to the required start frequency, check that the pen is over the appropriate frequency graduation on the paper, before setting the FUNCTION SELECTOR to "Pen Down".

Using the X RANGE switch to increase the sensitivity of X deflection of the pen, it is possible to expand the frequency scale of the recorded response or analysis. However, for maximum expansion, the start of the sweep must correspond with the lower frequency limit of the sweep range selected on the Generator or Analyzer, where its control ramp is at zero. For expansion of any part of a Generator's or Analyzer's sweep range, the use of the auxiliary ramp output available at pin 7 of the REMOTE II socket of the 2308 is recommended. See section 4.3.

4.3. REMOTE II SYNC.

For remote voltage controlled frequency tuning of Signal Generators and Frequency Analyzers, the 2308 has two auxiliary ramp voltage output lines. These are available at the REMOTE II control socket of the Recorder which has the pin identities shown in Fig.4.2.

Both auxiliary ramp output lines produce a 0 to 10 V DC voltage ramp and have a minimum load impedance of 10 kΩ. The ramp available at pin 8 is derived directly from the internal sweep generator of the Recorder, whilst that available at pin 7 is generally more useful, as it summed with a fixed DC offset voltage which may be adjusted between —10 and + 10 V using the RAMP SET control of the Recorder. This permits independent adjustment of the start frequency of a Generator's or Analyzer's frequency sweep, enabling any part of its sweep range to be selected for recording with expanded frequency scale that fills the entire paper width. The rate at which the Generator or Analyzer frequency is swept by the ramps is a function of the SWEEP RATE setting of the Recorder and may be determined as in section 5.3.

For remote voltage controlled tuning of B & K Generators and Analyzers, which are furnished with a FREQUENCY CONTROL VOLTAGE INPUT socket, the ramp available at pin 7 of the REMOTE II control socket is used. As indicated in Fig.2 of Chapter 1 this may

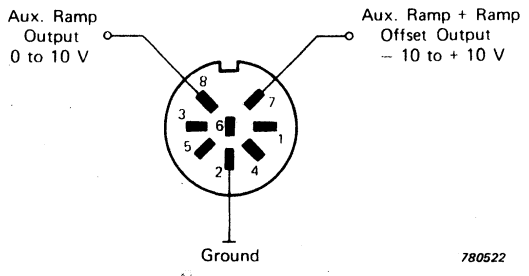

Fig.4.2. External view of the REMOTE II control socket of the 2308 with internal sweep generator auxiliary ramp voltage outputs indicated

be applied to the instruments using the standard 8 pin remote control cable AQ 0034, which is available on separate order. However, with instruments accepting control cables marked by a double asteris in Fig.2, the leads to pins 1, 3, 4, 5, 6 and 8 of one of the control cable plugs must be disconnected. This is necessary to prevent instrument control lines not specifically designed for use with the 2308 inhibiting its operation.

The setting up procedure for remote voltage controlled tuning of a Generator or Analyzer using the auxiliary control voltage ramp available at pin 7 of the REMOTE II control socket of the Recorder, is given below. This is suitable for fully automatic recording of frequency responses and analyses and explains how to synchronize the frequency sweep of a Generator or Analyzer with the X deflection of the Recorder pen. For operation with non B & K, voltage controlled, Generators and Analyzers, a similar procedure may be used.

1. Taking a sheet of graph paper, graduate up to 160 mm (6,3 in) of its vertical axis and up to 240 mm (9,4 in) of its horizontal axis with the appropriate amplitude and frequency scales for the response or analysis. These should match part or the entire range of the measuring and generating and/or analyzing instrumentation to be used in the recording arrangement. For recording over a 3 decade, logarithmic, frequency scale corresponding with B & K Generators and Analyzers, the use of the preprinted Recording paper QP 1000 is convenient. See Chapter 1.

2. Place the graph paper on the paper platten of the Recorder and carefully align it, preferably with its bottom and left hand edges flush with the corresponding edges of the platten.

3. Set the FUNCTION SELECTOR switch to its "Paper Hold" mode and taking care not to alter the alignment of the paper, smooth it flat against the paper platten, to help ensure a firm paper grip.

4. For horizontal pen deflection directed by the internal sweep generator of the Recorder, set the X channel controls as follows:

   SWEEP: "Int."
   POLARITY: "Norm."
   GAIN: "Cal." click-stop position
   RANGE: "41,7" mV/mm — Cal. setting

5. Set the SWEEP CONTROL switch of the Generator or Analyzer to "Ext. Volt" and connect its REMOTE FREQUENCY CONTROL VOLTAGE-IN socket to the REMOTE II socket of the Recorder, using the appropriate remote control cable (AQ 0034 unless otherwise specified in Fig.2).

6. Set the internal sweep generator SWEEP mode switch of the Recorder to "Hold" and select a SWEEP RATE setting appropriate for the response or analysis. See Sweep Rate Considerations — sections 5.3 and 5.4.

7. Set the FUNCTION SELECTOR to "Servo On", press the SWEEP-RESET button and adjust the X-ZERO SET potentiometer until the pen rests over the frequency graduation on the paper, corresponding with the required lower frequency limit for the response or analysis.

8. Adjust the RAMP SET potentiometer of the Recorder until the FREQUENCY DISPLAY LEDs of the Generator or Analyzer indicate the same lower frequency limit as the pen on the paper.

Note: To activate the FREQUENCY DISPLAY LEDs of the Generator or Analyzer, it may be necessary to turn its FREQUENCY ADJUSTMENT knob, so that its frequency pointer is on scale.

9. Set the SWEEP MODE switch to "Normal". The auxiliary control voltage ramp of the Recorder should now move the pen carriage across the paper, automatically tuning the Generator or Analyzer frequency. When the FREQUENCY DISPLAY LEDs of the Generator or Analyzer indicate the required upper frequency limit for the response or analysis, stop the sweep by setting the SWEEP mode switch back to "Hold".

   If the required frequency limit is exceeded, set the SWEEP mode switch to "Reverse" and then back to "Hold" when the correct frequency indication is obtained.

10. The pen should now be immediately over the frequency graduation on the paper corresponding with the upper frequency limit selected in item 9. If not, adjust the X-GAIN potentiometer and possibly the X-RANGE switch to move the pen to the appropriate graduation.

11. Press the SWEEP-RESET button to return the pen carriage and Generator or Analyzer back to the start of the sweep. The Generator or Analyzer should now indicate the required lower frequency limit with the pen immediately over the corresponding frequency graduation on the paper. If not repeat items 7 to 11.

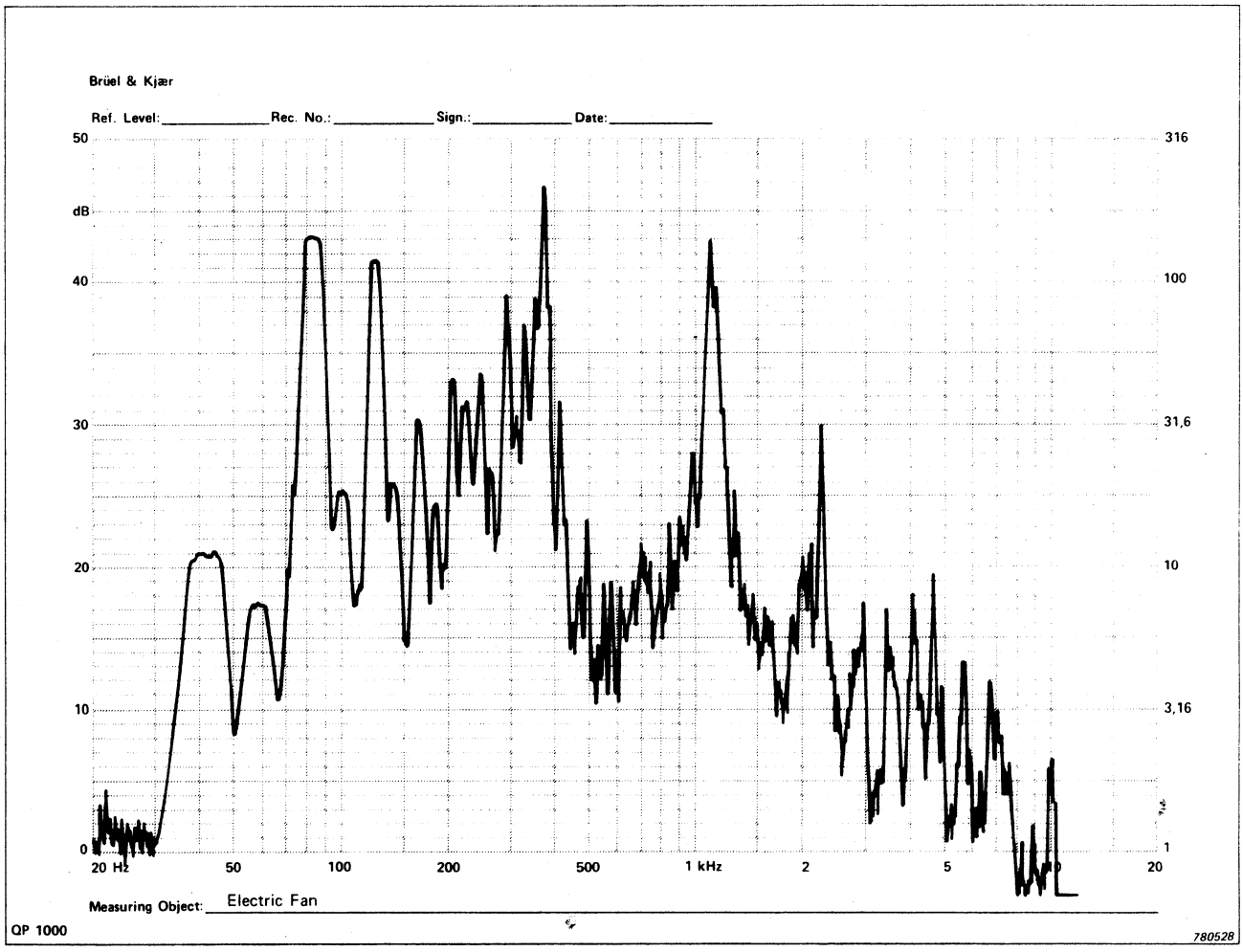

Fig.4.3. Example of narrow band analysis recorded with a 3 decade frequency scale

12. Using the Y channel controls of the Recorder, calibrate the vertical deflection of the pen in accordance with the meter of the measuring or analyzing instrument employed in the recording arrangement. To do this, select the linear frequency response mode of the measuring or analyzing instrument and proceed as in items 10 to 19 of section 3.2.

The 2308 is now correctly synchronized with the Generator or Analyzer. To commence recording select the appropriate measurement bandwidth for the response or analysis and with the FUNCTION SELECTOR of the Recorder set to "Pen Down", set the SWEEP mode switch to "Normal". The Recorder will now automatically sweep the Generator or Analyzer frequency and the pen plot out the response or analysis.

On completion of the recording, the movement of the pen carriage will stop automatically. To raise the pen and reset the pen carriage back to the start of its travel, set the FUNCTION SELECTOR and SWEEP mode switches back to their "Servo On" and "Hold" positions and press the SWEEP-RESET button. At the same time this will automatically reset the Generator or Analyzer back to the start frequency.

To repeat or make another recording, set the FUNCTION SELECTOR to "Standby" and place a fresh sheet of graph paper on the paper platten, remembering to check that the pen is immediately over the appropriate start frequency graduation on the paper before setting the FUNCTION SELECTOR to its "Pen Down" position.

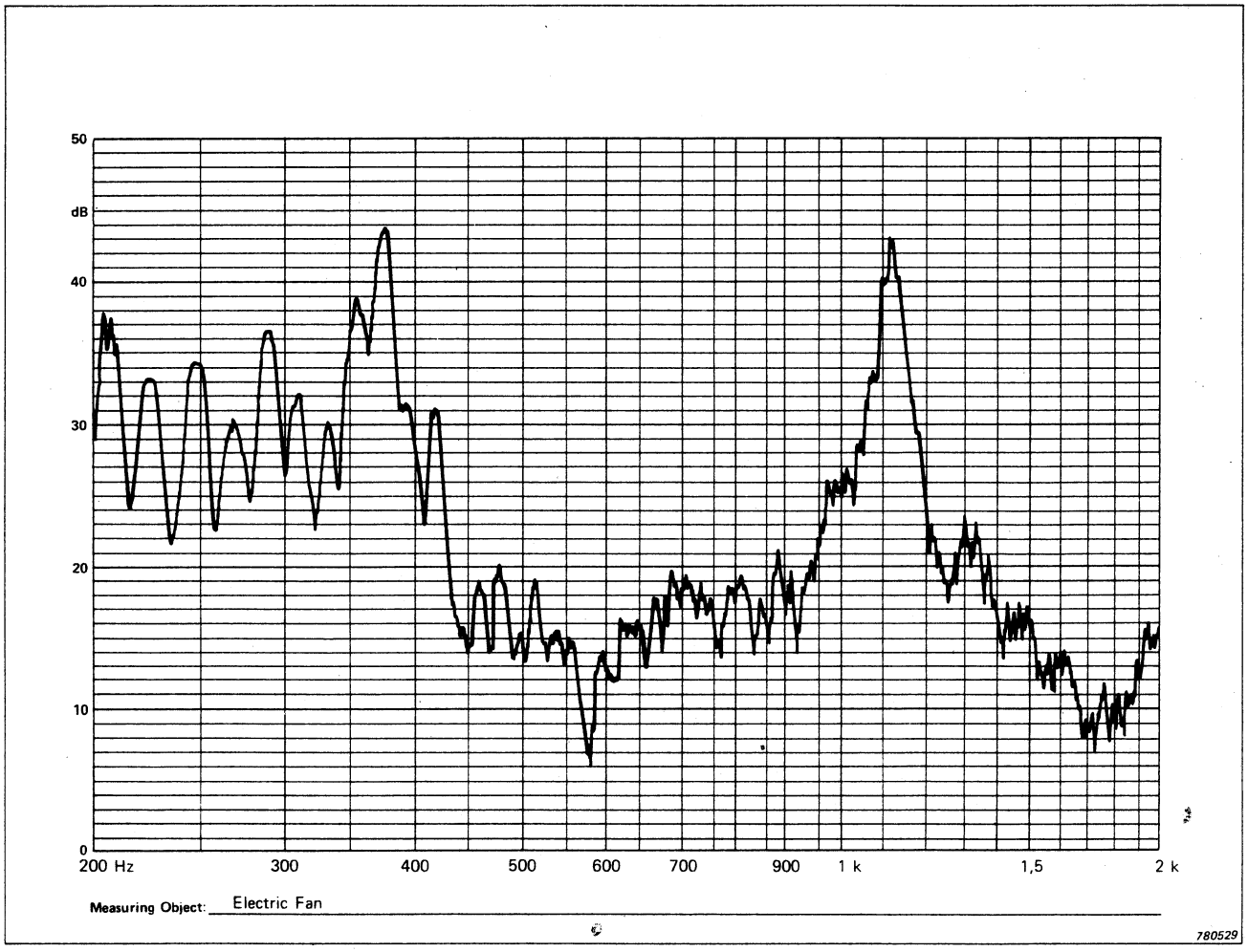

Fig.4.4. Detail of narrow band analysis shown in Fig.4.3, recorded with "expanded" single decade frequency scale

For recording a response or analysis with "expanded" frequency scale, covering any part of the total sweep range of the Generator or Analyzer, exactly the same procedure as outlined in items 1 to 12 above, may be used. However, in this case the X-RANGE and X-GAIN controls must be used to increase the sensitivity of the X deflection of the Recorder. Examples of narrow band spectra, recorded with a 3 decade and "expanded" single decade frequency scale are shown in Figs.4.3 and 4.4 respectively.

For further information on the use of B & K measuring, analyzing and generating instrumentation with the 2308, the Instruction Manuals for the relevant instruments should be consulted.

5. MEASUREMENT AND ANALYSIS CONSIDERATIONS

5.1. MAXIMUM INPUT VOLTAGE RATING

The X-Y channel inputs of the 2308 are protected against voltage overload and can withstand input levels as high as 300 V pk without breakdown of the Recorder. However, for safe operation in accordance with IEC 348, the input current of voltage levels exceeding 50 V Peak must be restricted to 0,7 mA pk. Alternatively the screen of the X or Y INPUT socket to which the voltage is applied must be connected to chassis as specified in section 3.1.4.

5.2. INPUT LEVEL VERSUS X AND Y PEN DEFLECTION

The input voltage level required to produce a particular X or Y pen deflection on the 2308, depends on the setting of the RANGE and GAIN controls of the Recorder. With the GAIN controls set to "Cal." the exact level can be determined using the relation:

$$V = \text{length of deflection (mm)} \times \text{RANGE switch setting (mV/mm)} \qquad \text{—(5.1}$$

which for full scale X deflection of 240 mm and full scale Y deflection of 160 mm, gives the values specified in Table 5.1. With the GAIN controls set to a position other than "Cal.", the input level required is greater.

	RANGE (mV/mm)setting															
	0,02	0,05	0,1	0,2	0,5	1	2	5	10	20	50	100	200	500	Y 1000	X cal 41,7
Input Voltage for 160 mm Y deflection	3,2	8	16	32	80	160	320	800	1,6	3,2	8	16	32	80	160	
Input for 240 mm X deflection	4,8	12	24	48	120	240	480	1200	2,4	4,8	12	24	48	120		10
	mV								V							

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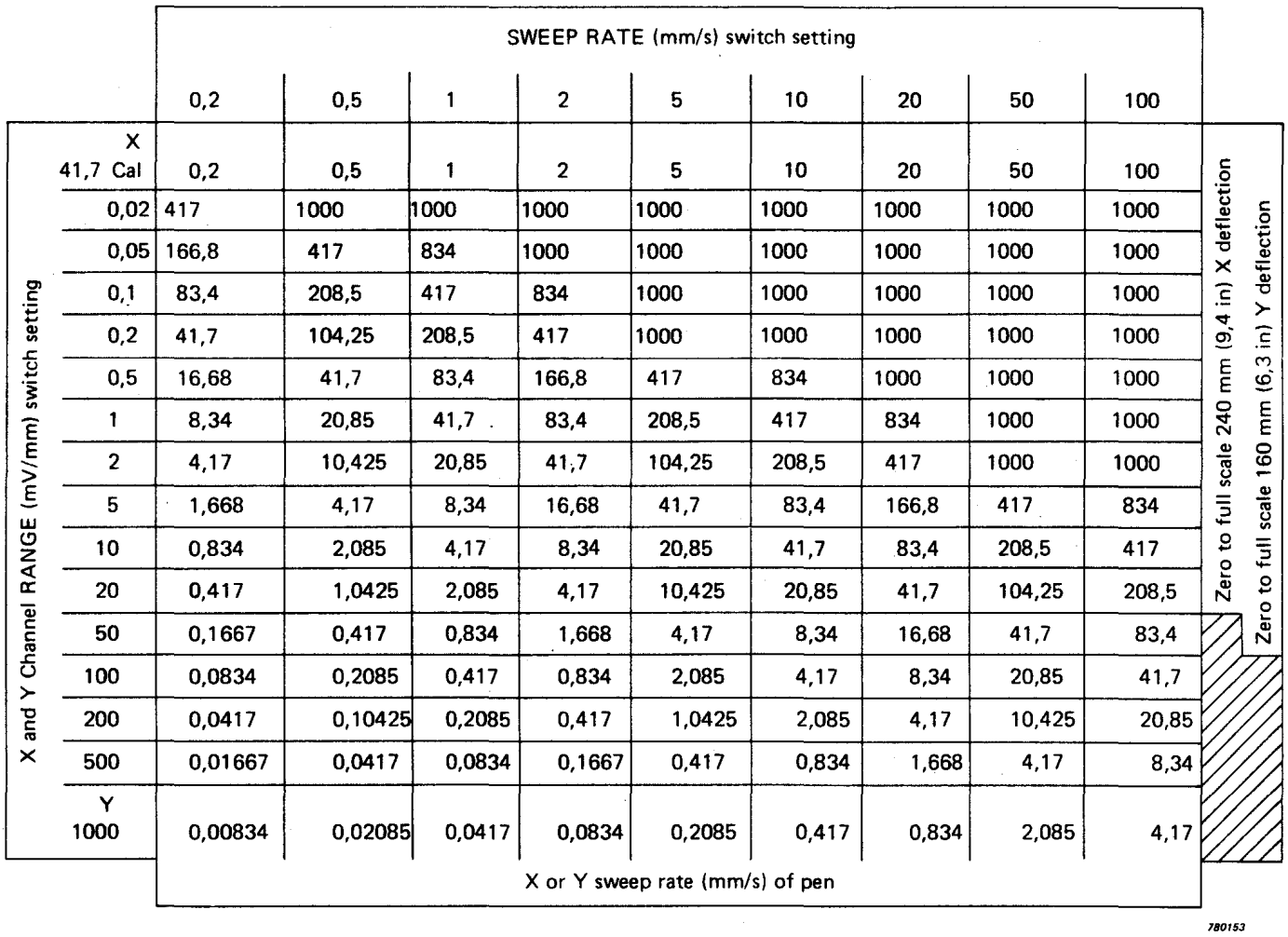
Table 5.1. Input voltage for full scale X and Y pen deflection on the 2308, as a function of RANGE switch setting with GAIN controls set to "Cal."

5.3. SWEEP RATE

5.3.1. Recorder Pen

The 0,2 to 100 mm/s sweep rate settings marked around the SWEEP RATE switch of the 2308, are applicable when using the internal sweep generator for control of the X



X and Y Channel RANGE (mV/mm) switch setting	SWEEP RATE (mm/s) switch setting								
	0,2	0,5	1	2	5	10	20	50	100
X 41,7 Cal	0,2	0,5	1	2	5	10	20	50	100
0,02	417	1000	1000	1000	1000	1000	1000	1000	1000
0,05	166,8	417	834	1000	1000	1000	1000	1000	1000
0,1	83,4	208,5	417	834	1000	1000	1000	1000	1000
0,2	41,7	104,25	208,5	417	1000	1000	1000	1000	1000
0,5	16,68	41,7	83,4	166,8	417	834	1000	1000	1000
1	8,34	20,85	41,7	83,4	208,5	417	834	1000	1000
2	4,17	10,425	20,85	41,7	104,25	208,5	417	1000	1000
5	1,668	4,17	8,34	16,68	41,7	83,4	166,8	417	834
10	0,834	2,085	4,17	8,34	20,85	41,7	83,4	208,5	417
20	0,417	1,0425	2,085	4,17	10,425	20,85	41,7	104,25	208,5
50	0,1667	0,417	0,834	1,668	4,17	8,34	16,68	41,7	83,4
100	0,0834	0,2085	0,417	0,834	2,085	4,17	8,34	20,85	41,7
200	0,0417	0,10425	0,2085	0,417	1,0425	2,085	4,17	10,425	20,85
500	0,01667	0,0417	0,0834	0,1667	0,417	0,834	1,668	4,17	8,34
Y 1000	0,00834	0,02085	0,0417	0,0834	0,2085	0,417	0,834	2,085	4,17

Table 5.2. X-Y sweep rates of pen as a function of SWEEP RATE and RANGE switch settings with GAIN controls set to "Cal."

deflection of the Recorder, with its X channel RANGE and GAIN controls set to "41,7" mV/mm and "Cal." respectively. They are not applicable when other RANGE and GAIN control settings are employed, or when using the internal sweep generator to control the Y deflection. In these circumstances the actual sweep rate of the pen is as specified in Table 5.2 and can be determined using the relation:

$$\text{Sweep Rate of Pen (mm/s)} = \frac{\text{SWEEP RATE switch setting (mm/s)}}{\text{RANGE switch setting (mV/mm)}} \times 41{,}7 \text{ mV/mm} \quad \text{—(5.2}$$

5.3.2. External Generator or Analyzer

With regard to determining the sweep rate of external Frequency Generators and Analyzers when tuned using the auxiliary control voltage ramp of the internal sweep generator (see section 4.3), the relationship between ramp voltage level V and frequency f is of importance. This depends on the type of frequency sweep.

For Generators and Analyzers having a linear frequency sweep:

$$V = \frac{1}{A_s} f \quad \text{—(5.3}$$

where A_s is the sweep sensitivity of the Generator or Analyzer in Hz/V and f is the frequency in Hz to which the Generator or Analyzer is tuned by the ramp voltage V.

Differentiating eqt. 5.3 with respect to time, gives:

$$\frac{dv}{dt} = \frac{1}{A_s} \frac{df}{dt} \qquad \text{—(5.4}$$

where dv/dt is the slope S_v of the voltage ramp in V/s and df/dt is the sweep rate S_A of the Generator or Analyzer frequency in Hz/s

$$S_v = \frac{1}{A_s} S_A \qquad \text{—(5.5}$$

With the 2308 the slope S_v of the auxiliary control voltage ramp may be related to the SWEEP RATE setting S_r of the Recorder using

$$S_v = 41{,}7 \ 10^{-3} \ S_r \qquad \text{—(5.6}$$

Substituting eqt. 5.6 into eqt. 5.5, we obtain

$$S_r = \frac{1}{41{,}7 \ 10^{-3}} \frac{S_A}{A_s} \qquad \text{—(5.7}$$

which rearranging, gives:

$$S_A = 41{,}7 \ 10^{-3} \ S_r \ A_s \qquad \text{—(5.8}$$

Therefore knowing the sweep sensitivity As of the Generator or Analyzer, its sweep rate S_A in Hz/s may be calculated for any particular SWEEP RATE setting S_r on the 2308. With B & K types of remote voltage tuned Generator and Analyzer having "× 0,1 Lin" (2 Hz to 2 kHz), "× 1 Lin" (20 Hz to 20 kHz) and "× 10 Lin" (200 Hz to 200 kHz) sweep ranges, the sweep sensitivity is 0,2 kHz/V, 2 kHz/V and 20 kHz/V respectively. Substituting these values into eqt. 5.8, gives the sweep rates specificied in Table 5.3.

X-Y Recorder SWEEP RATE	0,2	0,5	1	2	5	10	20	50	100	mm/s
"X 0,1 Lin" (0,2 kHz/V)	0,00167	0,00417	0,0083	0,0167	0,0417	0,0834	0,167	0,417	0,834	
"X 1 Lin" (2 kHz/V)	0,0167	0,0417	0,083	0,167	0,417	0,834	1,67	4,17	8,34	kHz/s
"X 10 Lin" (20 kHz/V)	0,167	0,417	0,83	1,67	4,17	8,34	16,7	41,7	83,4	
"X 0,1 Log" (0,3 dec/V)										
"X 1 Log" (0,3 dec/V)	0,0025	0,00625	0,0125	0,025	0,0625	0,125	0,25	0,625	1,25	dec/s
"X 10 Log" (0,3 dec/V)										

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Table 5.3. Sweep rates of B & K Generators and Analyzers as a function of SWEEP RATE setting of the 2308

Table 5.3 also gives sweep rates for B & K Generators and Analyzers having a logarithmic frequency sweep. These were calculated using eqt. 5.8, which may also be used for determining logarithmic sweep rates provided that these are expressed in terms of frequency decades/s and not Hz/s. This requires that the sweep sensitivity A_s is given in frequency decades/V. With the "× 0,1 Log" (2 Hz to 2 kHz), "× 1 Log" (20 Hz to 20 kHz) and "× 10 Log" (200 Hz to 200 kHz) sweep ranges of B & K Generators and Analyzers, A_s = 0,3 dec/V.

For determining the logarithmic sweep rates in Hz/s, the relationship between ramp voltage level and frequency is:

$$V = \frac{1}{A_S} \log_{10} \frac{f}{f_L} \qquad \text{—(5.9}$$

where A_s is the sweep sensitivity of the Generator or Analyzer in decades/V, f is the frequency in Hz to which the Generator or Analyzer is tuned by the ramp voltage V, and f_L is the lower frequency limit of the sweep range in Hz

Differentiating eqt. 5.9 with respect to time, gives:

$$\frac{dv}{dt} = \frac{0{,}43429}{A_s\ f} \frac{df}{dt} \qquad \text{—(5.10}$$

where dv/dt is the slope S_v of the voltage ramp in V/s and df/dt is the sweep rate of the Generator or Analyzer frequency in Hz/s

$$S_v = \frac{0{,}43429}{A_s\ f} S_A \qquad \text{—(5.11}$$

Substituting eqt. 5.6 for S_v into eqt. 5.11, gives:

$$S_r = 10{,}4 \frac{S_A}{A_s\ f} \qquad \text{—(5.12}$$

which rearranging, gives

$$S_A = 96\ \ 10^{-3}\ \ A_s\ S_r\ f \qquad \text{—(5.13}$$

From which the sweep rate S_A in Hz/s of Generators and Analyzers having a logarithmic frequency sweep can be obtained.

Selection of a suitable sweep rate for analysis, depends on a number of factors and is discussed in the following sections.

5.4. RANDOM SIGNAL ANALYSIS

5.4.1. General

Selection of a suitable sweep rate for random signal analysis is based on the averaging time selected for measurement of true RMS levels.

The RMS value (ψ) of a random signal $x(\tau)$ is defined by

$$\psi^2 = \lim_{T\to\infty} \frac{1}{T} \int_0^T x^2\ (\tau)\ d\tau \qquad \text{—(5.14}$$

where T is the analysis averaging time, which for 100% accuracy must tend to infinity. In practice this is impossible, and T must be restricted to a finite value. This restriction leads to an error in the RMS measurement. A commonly used expression for the normalized standard deviation (or error) $\pm\ \epsilon$ of an RMS measurement is

$$\epsilon = \frac{1}{2\sqrt{BT}} \text{for } BT > 5 \qquad \text{—(5.15}$$

where B is the analysis bandwidth in Hz and T is the averaging time of the analysis in

seconds. A common parameter in analyses of this type is the number of statistical degrees of freedom k, which is given by

$$k = 2\,BT \qquad \text{—(5.16}$$

It is common practice to work with a value of 50 for k, this being an efficient analysis value.

Thus if $2\,BT = 50$

$BT = 25$

Substituting back for BT in eqt.5.15, gives

$$\epsilon = \pm\ 10\% \text{ for } BT = 25$$

The value of BT will be taken as 25 in the following analysis.

With constant bandwidth analysis, B assumes a constant value, but for constant percentage bandwidth analysis, B increases linearly with frequency according to the relationship.

$$B = \frac{rf}{100} \qquad \text{—(5.17}$$

where r is the percentage bandwidth. The minimum analysis averaging time T_A can be calculated for a BT product of 25 as

$$T_A \geqslant \frac{25}{B} \text{ for } \epsilon < \pm\ 10\% \qquad \text{—(5.18}$$

The sweep rate S_A may be connected with the calculated averaging time, by specifying that one bandwidth must never be scanned in less than two averaging times — one averaging time being allowed for full response of the RC averaging circuit of the Frequency Analyzer or Measuring Amplifier and a further averaging time for settling of the Recorder pen to the correct level.

$$S_A = \frac{B}{2\,T_A} \qquad \text{—(5.19}$$

or in terms of filter dwell time

$$S_A = \frac{B}{T_D} \qquad \text{—(5.20}$$

where $T_D \geqslant 2\,T_A$

5.4.2. Constant Bandwidth

For constant bandwidth analysis with a linear or logarithmic frequency sweep, the averaging time T_A remains constant at all frequencies in the sweep range. The choice of correct averaging time may be determined using eqt. 5.18 where

$$T_A > \frac{25}{B} \quad \text{for } \epsilon < \pm\ 10\%$$

which for the 3,16 Hz, 10 Hz, 31,6 Hz, 100 Hz, 316 Hz and 1000 Hz bandwidths available with B & K types of constant bandwidth frequency analyzer, gives the averaging time settings specified in Table 5.4.

Bandwidth (Hz)	3,16	10	31,6	100	316	1000
Averaging Time (s)	10	3	1	0,3	0,1	0,1

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Table 5.4. Averaging time settings for constant bandwidth analysis of random signals

The choice of appropriate sweep rate depends on the type of frequency sweep. With a linear frequency sweep the sweep rate remains constant at all frequencies in the sweep range. This is shown by eqt. 5.8 where

$$S_A = 41{,}7\ 10^{-3}\ S_r\ A_s$$

which substituting eqt. 5.19 for S_A and rearranging, gives

$$S_r = \frac{B}{83{,}4\ 10^{-3}\ T_A\ A_s} \qquad \text{—(5.21}$$

With the "× 1 Lin" (20 Hz to 20 kHz) sweep range of B & K types of remote voltage tuned Analyzer

$$As = 2\ \text{kHz/V}$$

$$S_r = \frac{B}{83{,}4\ 10^{-3}\ 2\ 10^{3}\ T_A}$$

$$S_r = 6\ 10^{-3}\ \frac{B}{T_A} \qquad \text{—(5.22}$$

From which the Recorder SWEEP RATE settings giving the required analysis sweep rates with B & K Analyzers can be calculated. Substituting the averaging times and bandwidths given in Table 5.4 into eqt. 5.22 gives the Recorder SWEEP RATE settings specified in Table 5.5.

Bandwidth (Hz)	3,16	10	31,6	100	316	1000
SWEEP RATE (mm/s)	–	–	0,2	2	20	50

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Table 5.5. X-Y Recorder SWEEP RATE settings for constant bandwidth analysis of random signals with the "× 1 Lin" (20 Hz to 20 kHz) sweep range of B & K Frequency Analyzers. With the "× 0,1 Lin" (2 Hz to 2 kHz) range multiply by 10 to obtain the correct SWEEP RATE setting, whilst with the "× 10 Lin" (200 Hz to 200 kHz) range multiply by 0,1

For constant bandwidth analysis with a logarithmic frequency sweep, the sweep rate depends on frequency. This is shown by eqt.5.13 where

$$S_A = 96\ 10^{-3}\ A_s\ S_r\ f$$

which substituting eqt. 5.19 for S_A and rearranging gives

$$S_r = \frac{5.2}{A_s}\ \frac{B}{f\ T_A} \qquad \text{—(5.23}$$

With B & K Generators and Analyzers having a logarithmic frequency sweep

$$A_s = 0{,}3 \text{ dec/V}$$

$$S_r = 17{,}36 \frac{B}{f\, T_A} \quad \text{mm/s} \qquad \text{—(5.24}$$

As one bandwidth is scanned most quickly at the maximum analysis frequency, this frequency must be substituted into eqt. 5.23 to give the required Recorder SWEEP RATE setting. These settings are given in Table 5.6.

Bandwidth (Hz)	Maximum Analysis Frequency (Hz)				
	20	200	2k	20k	200k
3,16	0,2	–	–	–	–
10	2	0,2	–	–	–
31,6	20	2	0,2	–	–
100	100	20	2	0,2	–
316	100	100	20	2	0,2
1000	100	100	50	5	5

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Table 5.6. X-Y Recorder SWEEP RATE settings (mm/s) for constant bandwidth analysis of random signals with the "× 0,1 Log" (2 Hz to 2 kHz), "× 1 Log" (20 Hz to 20 kHz) and "× 10 Log" (200 Hz to 200 kHz) sweep ranges of B & K Frequency Analyzers

5.4.3. Constant Percentage Bandwidth

With constant percentage bandwidth analysis, the analysis bandwidth B increases with frequency. This is shown by eqt. 5.17

$$B = \frac{rf}{100}$$

where r is the percentage bandwidth.

Substituting for B in eqt. 5.18 gives:

$$T_A \geqslant \frac{2500}{rf} \qquad \text{—(5.25}$$

from which it can be seen that the longest averaging time is required at the start frequency of the analysis where the bandwidth is the narrowest. For the 1%, 3%, 6%, 12%, 23% (1/3 octave) and 70,7% (1/1 octave) constant percentage bandwidths in most common use, eqt. 5.25 gives the preferred averaging time settings specified in Table. 5.7.

With constant percentage bandwidth analysis, a logarithmic rather than a linear frequency sweep is used. The sweep rate therefore increases with frequency as shown by eqt. 5.13 where

$$S_A = 96\ 10^{-3}\ A_s\ S_r\ f$$

Bandwidth (%)	Averaging Time (s)				
1%	–	100	10	1	0,1
3%	–	100	10	1	0,1
6%	300	30	3	0,3	0,1
12%	100	10	1	0,1	0,1
1/3 oct 23%	100	10	1	0,1	0,1
1/1 Oct 70,7%	30	3	0,3	0,1	0,1
Minimum Analysis Frequency (Hz)	2	20	200	2k	20k

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Table 5.7. Averaging time settings for constant percentage bandwidth analysis of random signals

Substituting eqt. 5.19 for S_A, and rearranging, gives:

$$S_r = 5{,}2 \frac{B}{A_s T_A f}$$

Substituting eqt. 5.17 for B, gives

$$S_r = 0{,}05 \frac{r}{A_s T_A} \qquad \text{—(5.26}$$

from which the X-Y Recorder SWEEP RATE settings, giving the required analyzer sweep rates for constant percentage bandwidth analysis, can be calculated. The settings specified in Table 5.8 are for Analyzers with a sweep sensitivity of 0,3 dec/V.

For further information on frequency analysis, the handbook "Application of B & K Equipment to Frequency Analysis", is available on request.

Bandwidth (%)	SWEEP RATE (mm/s)				
1%	–	–	–	0,2	1
3%	–	–	–	0,5	5
6%	–	–	0,2	2	10
12%	–	0,2	2	20	20
1/3 oct 23%	–	0,2	2	20	20
1/1 oct 70,7%	0,2	2	20	100	100
Minimum Analysis Frequency (Hz)	2	20	200	2k	20k

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Table 5.8. X-Y Recorder SWEEP RATE settings for constant percentage bandwidth analysis of random signals using a remote voltage tuned Frequency Analyzer with sweep sensitivity of 0,3 dec/V

6. SERVICE AND REPAIR

The 2308 is designed and constructed to provide the user with many years of safe, reliable operation. However, should a fault occur which impairs its correct function and operating safety, then it should be immediately disconnected at the mains source and be secured against unintended operation. For repair consult the separate Service Instruction Manual available for the 2308 or contact your local B & K service representative. Under no circumstances should repair be attempted by persons not qualified in the service of electronic instrumentation.