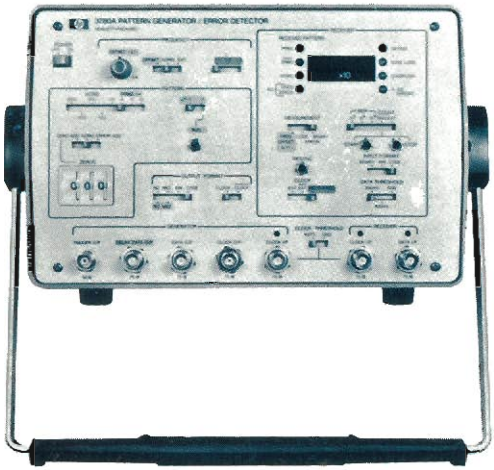
OPERATING MANUAL

PATTERN GENERATOR/ ERROR DETECTOR

3780A



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CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual

HEWLETT PACKARD

OPERATING MANUAL

MODEL 3780A PATTERN GENERATOR/ ERROR DETECTOR

(Including Options 001, 002, 003, 099, 100, 101 and 102)

SERIAL PREFIX

This manual applies directly to Model 3780A Pattern Generator/Error Detectors with serial numbers prefixed 1721U. With changes described in Section 5 this manual also applies to instruments with serial numbers prefixed up to and including 1915U.

03780-90021

PRINTED JULY 1979

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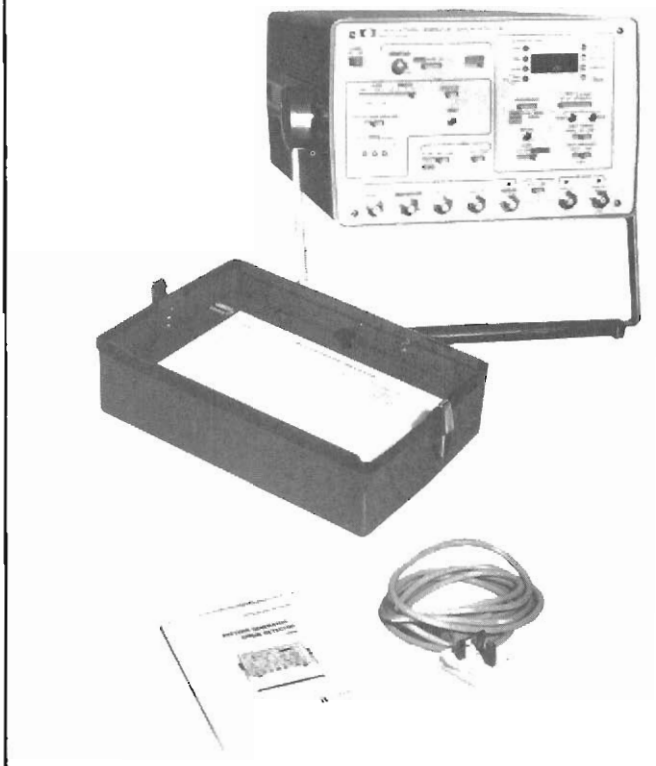


SECTION 1
GENERAL INFORMATION

1-1 INTRODUCTION

This section contains general information relating to the Hewlett-Packard 3780A Pattern Generator/Error Detector. This information includes instrument identification, operating and storage temperatures, initial inspection, installation, instrument description, options, accessories, basic measurement configurations and specifications. Other sections contain information on front and rear panel controls, connectors, and indicators, basic operating procedure, the connection of associated instruments, and backdating information.

1-2 INSTRUMENT IDENTIFICATION

An identification plate is fitted to the rear panel of each instrument. The number on this plate consists of a four digit serial prefix, a reference letter, and a five digit serial number. These details should be quoted in any correspondence with Hewlett Packard relating to the instrument and are particularly important when ordering spare parts or components.

1-3 TEMPERATURE RANGE

The instruments are designed to operate over an ambient temperature range of 0° to 55°C (32° to 131°F) and to be stored at −40° to 75°C (−40° to 167°F).

1-4 INITIAL MECHANICAL INSPECTION

Each instrument is carefully examined both mechanically and electrically prior to shipment. The instruments should be examined as soon as possible after receipt for external damage which may have occurred during shipment such as broken controls or connectors and dents or scratches on the panel surfaces. If any damage is evident refer to Paragraph 1-6 for recommended claim procedure and Paragraph 1-7 for repackaging information.

1-5 INITIAL ELECTRICAL INSPECTION

The Performance Tests in the 3780A service manual provide a method of confirming the specification and may be used as incoming inspection checks. In the event of the instrument not performing within the specifications refer to the claim procedure, Paragraph 1-6 and repackaging information, Paragraph 1-7.

1-6 CLAIMS FOR SHIPPING DAMAGE

If the instrument is physically damaged or fails to meet specifications on receipt, notify the carrier and the nearest Hewlett Packard Sales and Service Office (listed at the back of the service manual). The Sales and Service Office will arrange for repair or replacement without waiting for settlement of a claim with the carrier.

1-7 REPACKAGING FOR SHIPMENT

To protect electronic equipment during storage or shipment always use the best packaging methods available. Hewlett-Packard field offices can provide packing materials used for

original factory packaging at short notice. Two suitable alternative packaging methods are given below:

a. RUBBERISED HAIR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument securely in strong corrugated container (350lb/sq in bursting test) with 2-inch rubberised hair pads placed along all surfaces of the instrument. Insert fillers between pads and container to ensure a snug fit.

b. EXCELSIOR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument in a strong corrugated container (350lb/sq in bursting test) with layer of excelsior about 6-inches thick padded firmly against all surfaces of the instrument.

1-8 POWER REQUIREMENTS

The 3780A Pattern Generator/Error Detector may be operated from a 115 or 230V single phase ac supply. The supply voltage limitations are 115V + 10% to −22% and 230V + 10% to −18%. The supply frequency limitations are 48 to 66Hz and the maximum power consumption is approximately 110VA

1-9 SELECTING 115V or 230V OPERATION

CAUTION

Before connecting the instrument to the supply ensure that the correct voltage range has been selected and that the correct fuse is fitted.

The voltage range is selected with a rear panel switch marked 115V — 230V. Supply voltage ranges are detailed in POWER REQUIREMENTS, Paragraph 1-8.

The fuse is located on the rear panel between the 115 — 230V switch and the POWER input socket. WITH THE POWER CABLE DISCONNECTED unscrew the fuse cover and check that the correct fuse, as detailed on the rear panel, is fitted. Insert the correct fuse for the supply range selected and replace the fuse and cover (see Table 1-1).

Table 1-1 Fuses

Nominal Line Voltage	Fuse Rating	HP Part Number
115V	3A Timed	2110-0381
230V	1.5A Timed	2110-0304

CAUTION

The Replacement of blown fuses should only be performed by a competent service engineer who has first consulted the Power Supply troubleshooting procedure in the Operating and Service Manual. Power Supply Assembly damage can occur if the correct procedure is not carried out.

1-10 SUPPLY CONNECTION

A 3-core power cable is supplied with each instrument using the colour coding given in Table 1-2. It should be ensured that the correct line voltage has been selected before connecting the instrument to the supply. If connection is made via a two pin socket the GREEN/YELLOW CORE OF THE POWER CABLE SHOULD BE CONNECTED TO GROUND for the protection of the operator.

Table 1-2 Power Cable Colour Code

	Line	Neutral	Ground
Europe	Brown	Blue	Green/Yellow
USA	Black	White	Green/Yellow

1-11 COOLING

Forced air cooling is used in the 3780A and the following clearances should be allowed for ventilation.

3 to 4 inches at the rear for air intake.
2 to 3 inches at each side for air exhaust.

The clearances provided by the rubber feet in bench mounting permit adequate ventilation for the top and bottom surfaces. The operating temperature should be maintained within the range 0° to 55°C. Storage temperature limits are −40°C and +75°C.

1-12 AIR FILTER

The instrument has an air intake filter which is fixed to the rear panel with four screws. This filter should be removed and cleaned at intervals of approximately one month, depending on environment. Wash the filter mesh in clean soapy water, rinse thoroughly and dry before refitting.

WARNING

THE INSTRUMENT SHOULD NOT BE OPERATED WITH THE AIR FILTER REMOVED AND THE FAN BLADES EXPOSED.

1-13 SERVICE

A list of Hewlett Packard service offices is given at the rear of this manual. If it is necessary to return an instrument for repair a card should be firmly attached to the instrument giving details of the fault condition or type of service required and the return address. In any correspondence regarding the instrument the full serial number and option information should be given. This information will be found on the rear panel.

1-14 INSTRUMENT DESCRIPTION

Measurement Capability

The 3780A Pattern Generator/Error Detector is a complete error measuring system contained in one portable unit. The instrument measures Binary and Code errors on digital transmission equipment operating at bit rates in the range 1Kb/s – 50Mb/s. Frequency Offset measurements can also be performed at the frequencies installed in the generator.

Binary Errors

The pattern generator transmits a digital test pattern into the system to be tested. Simultaneously, the error detector compares the output of the system under test bit-by-bit with an internally generated pattern. Detected errors can be counted over a chosen gating period and displayed as bit error rate (BER) or total error count (COUNT) on an LED display.

Code Errors

The error detector can be used to monitor interface or line coded information for code errors. These are detected during the decoding process and are counted and displayed in the same way as binary errors. The information need not be a pattern produced by the generator.

The ERROR ADD facility introduces BINARY errors to the data before coding occurs. This facility does not produce code errors and will therefore not show a result in code error measurements.

Note: Differences may occur between measurements of code error rate and binary error rate due to the error extension factor of the 3780A decoder. These result from the fact that one code error does not always result in one binary error. The examples given on page 9 demonstrate how this difference can occur.

Frequency Offset

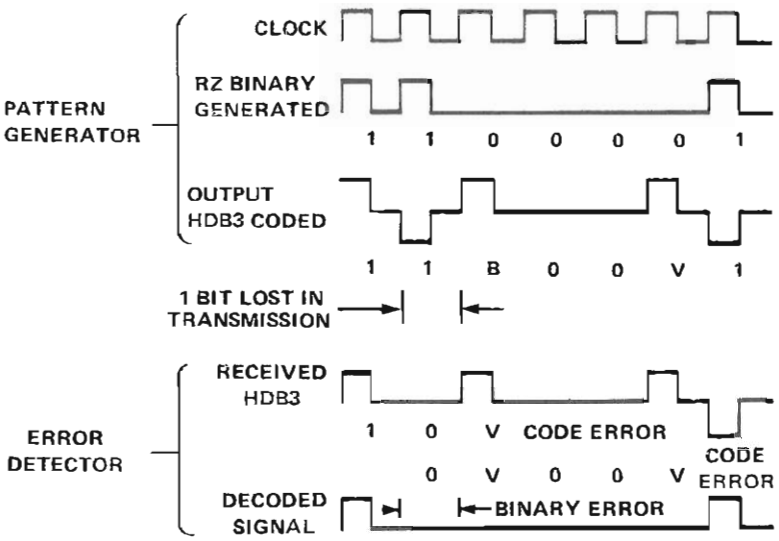
The clock frequency in the pattern generator may be offset and measured in the error detector (receiver). The offset is displayed as a fraction of the nominal crystal centre frequency. The offset of external clock signals applied to the generator can be measured if the frequency is within 25kHz of an installed crystal frequency.

1-15 FACILITIES PROVIDED

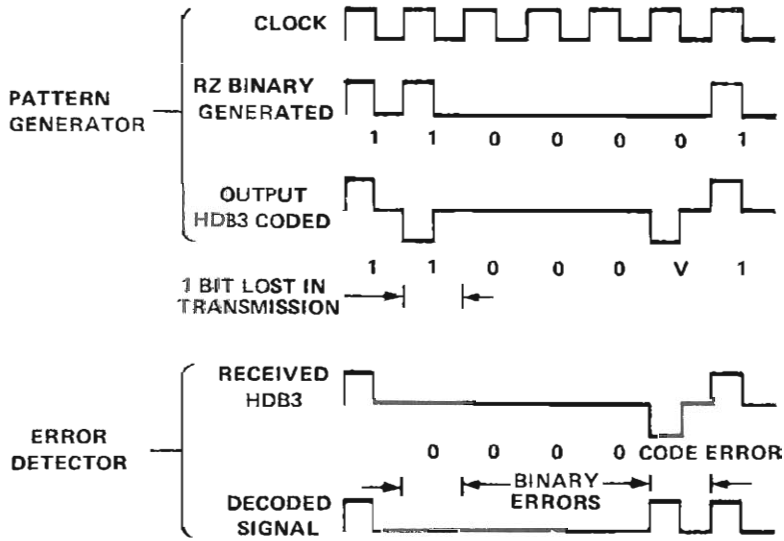
Frequency Control

The generator and receiver may be operated from external clocks in the range 1kHz to 50MHz. The generator has three internal crystal sources in the range 1.5 – 50MHz which may be selected from a number of options. The receiver clock can be recovered from incoming patterns at the frequencies installed in the generator providing that there are two or more transitions in every 20 bits. *Note: this does not occur with the $2^{20} - 1$ PRBS in NRZ format.* The generator internal clocks can be offset by up to at least ±50ppm (except Option 099).

continued on Page 10



EXAMPLE 1 shows how a single bit lost in transmission can result in two code errors and one binary error.



EXAMPLE 2 shows how a single bit lost in transmission can result in one code error and two binary errors

1-15 continued from Page 8.

Pattern Selection

Three maximal length pseudo random binary sequences (PRBS) of length 511, 32767 and 1048575 bits and five four-bit repetitive word patterns are produced by the generator. The PRBS generator may also be used to generate random repetitive word patterns of length 9, 15 or 20 bits.

Option 001 provides a front panel programmable, 16 bit word in place of the five four-bit and random repetitive word patterns. This can also provide two 8 bit words alternated by an external signal applied via the rear panel.

Up to 999 zeros can be added once per sequence to all of the selectable patterns.

When the PRBS/WORD switch of the receiving instrument is set to one of the PRBS positions, or when the internal SYSTEMATIC ERROR DETECTION switch A37 S2 is set to OFF, the error detector automatically recognises and reproduces a synchronous error free version of any PRBS or WORD pattern produced by the generator. This includes $\overline{\text{PRBS}}$ but excludes any pattern containing added zeros or alternating words (Options 001 or 003).

Instruments are supplied with the internal SYSTEMATIC ERROR DETECTION switch, A37 S2, set to the ON position. In this mode the reference WORD of the receiving instrument can be preset to one of the fixed 4 bit words, or with Options 001 or 003 to the 16 bit word. This is achieved by setting the PRBS/WORD switch of the receiving instrument to the appropriate 4 bit word, or with Options 001 or 003 by setting the PRBS/WORD switch to 16 and selecting the appropriate word with the WORD SELECT switches. Systematic errors on the 4 or 16 bit words will then result in sync loss at the receiving instrument.

A typical example of the use of systematic error detection in an end-to-end measurement is given below:

If the transmitted word **1100** is repeatedly received as **1000** as the result of a systematic fault, then the following results will be obtained with the receiving instrument.

PRBS/WORD switch setting (receiving instrument)	**RESULT**	
9, 15 or 20	NO ERRORS	WORD
1000	NO ERRORS	WORD
1100	ERRORS	SYNC LOSS

An indication of receive pattern lock is given by LED lamps. A manual override on the automatic sync is provided which forces a sync loss; when released the instrument reverts to automatic synchronisation.

Data and Clock Format

The generator test pattern may be produced in binary RZ or NRZ, or ternary, HDB3 or HDB2 formats. When operating in binary format a second binary output is available which is 6 bits advanced on the main data output. The receiver data input format selection is independent of the generator controls.

CLOCK or $\overline{\text{CLOCK}}$ may be selected independently on generator output and receiver input.

A choice of trigger threshold is provided on clock and data inputs allowing continuous or burst mode operation. Indication of signal triggering is given by LED lamps.

Error Counter Control and Display

Control of error counter timebase may be internal over 10^6, 10^8 or 10^{10} clock periods, manual via start/stop push buttons or external via the printer output connector. Internal error counts are displayed as a scaled BER reading in the form X.Y x 10^{-n}. Error counts over a manually or externally controlled timebase are displayed as a scaled COUNT reading in the form X.Y x 10^{+n}. Frequency offset is displayed as a fraction of the nominal centre frequency in the form XY x 10^{-n} where n = 6 usually. The display uses seven segment LED characters.

Flags

Indications of measurement gating, sync loss and count overflow are provided by LED lamps. An indication is also given if the last measurement result is based on less than 100 errors.

Note: Sync loss applies to binary measurements only. Sync loss does not apply to code error and frequency offset measurements and the sync loss flag is therefore inhibited in these measurement modes.

Self Check

A fixed binary error rate of 10^{-2} may be injected into the test pattern in order to check the error detector functions. This facility is mutually exclusive with zero add and also does not apply to code error and frequency offset measurements.

Trigger Outputs

A trigger output, giving one transition per sequence, is available from a front panel socket on the generator. The output is modified during zero add to allow examination of the zero block or the pattern immediately following it on an oscilloscope.

The receiver section also provides a trigger output, (for PRBS only) giving one pulse per sequence, from a rear panel socket.

Error Detector Outputs

In addition to receiver trigger and clock outputs, there are three outputs which can be used to evaluate error distribution. These are an error output giving one pulse per error, a BCD printer output and a pen recorder output.

1-16 OPTIONS

Option 001 provides front panel programmable 16 bit or two 8 bit words as described in Section 2-11.

Option 002 provides small Siemens connectors on all external 75 ohms interfaces in place of BNC connectors.

Option 003 is a combination of options 001 and 002.

Option 099 deletes frequency offset generation.

Options 100-102 provide different crystal frequencies to those fitted in the standard instrument as follows:-

STANDARD	2048, 8448 and 1536kHz
OPTION 100	2048, 8448 and 34368kHz
OPTION 101	1544, 6312 and 44736kHz
OPTION 102	1544, 6312 and 3152kHz

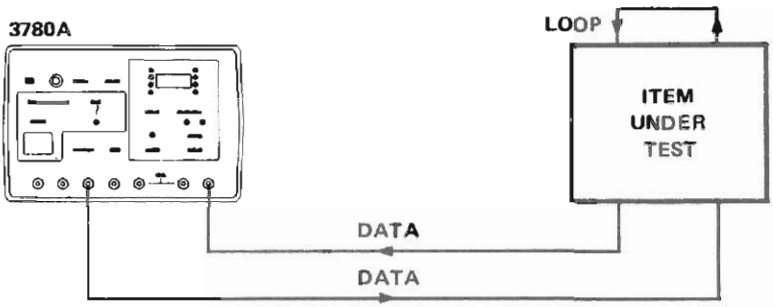
In the case of options 101 and 102, the HDB3/HDB2 codec is replaced by a B6ZS/B3ZS codec.

1-17 MEASUREMENT CONFIGURATIONS

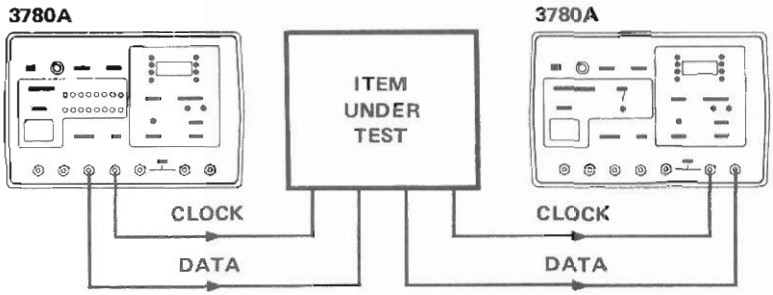
There are two basic measurement configurations for the 3780A Pattern Generator/Error Detector, these are "loop back" and "end to end". With loop back measurements the same instrument is used for both signal generation and measurement. With end to end measurements two instruments are used one to transmit the test pattern through a channel under test and another at the remote terminal to make measurements. The item under test may be a complete transmission system or individual system components.

Note: When the end to end configuration is used the MEASUREMENT switch of the sending instrument should not be set to FREQ OFFSET as this could introduce jitter on the transmitted signal.

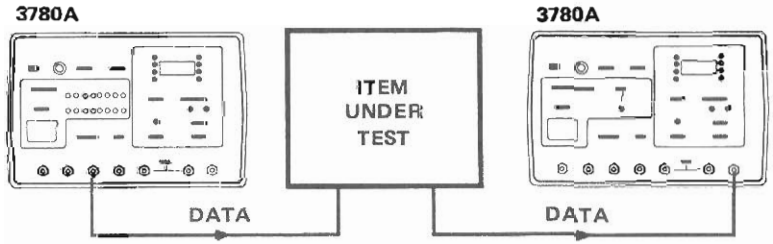
TYPICAL CONFIGURATIONS



LOOP BACK CONFIGURATION
(USING RECOVERED CLOCK)



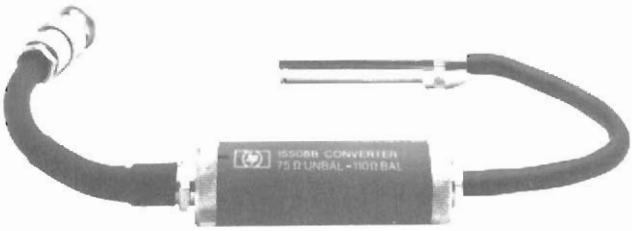
END TO END CONFIGURATION



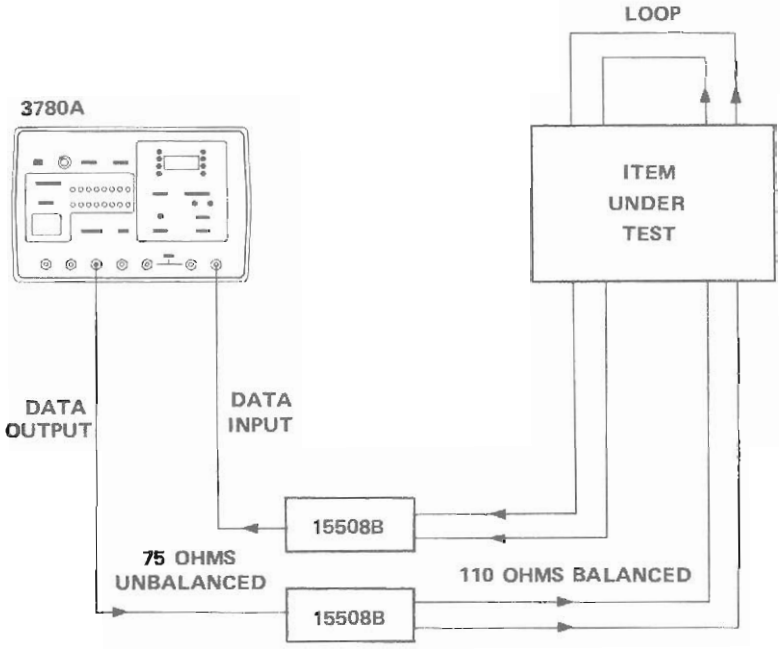
END TO END CONFIGURATION
(USING RECOVERED CLOCK)

1-18
ACCESSORIES

Unbalanced/Balanced converters, Model 15508B



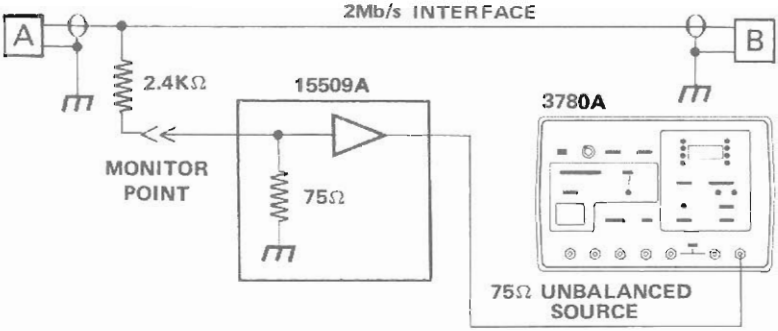
The model 15508B is a 75Ω unbalanced to 110Ω balanced impedance converter having a frequency range 1 — 10MHz. The following example shows a typical application of the converter for making loop back measurements on a 110Ω balanced test item.



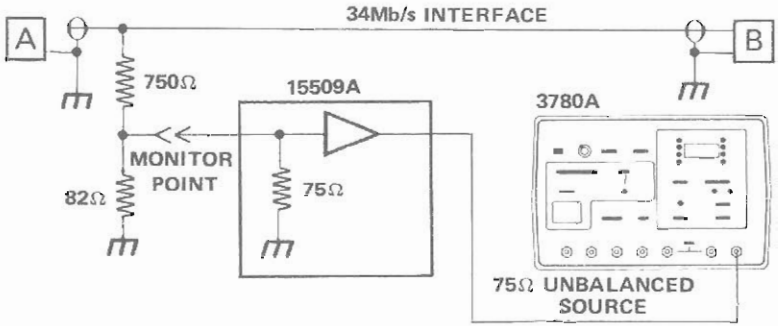
MEASUREMENTS ON A 110 OHM BALANCED TEST ITEM

Cable preamplifier Model 15509A.

The model 15509A is a cable preamplifier with 75Ω input and 25dB gain, designed to provide an interface between a monitor output point and the 3780A Pattern Generator/ Error Detector. The power supply for the preamplifier is available from front panel sockets on the model 3780A. The following examples show typical applications of the cable preamplifier.



MEASUREMENTS AT A MONITOR POINT ON A 2Mb/s INTERFACE



MEASUREMENTS AT A MONITOR POINT ON A 34Mb/s INTERFACE

1-19 SPECIFICATIONS

Note: All transition times relate to 10 – 90% of pulse height. All pulse widths specified at 50% pulse height.

GENERATOR

Internal Clock	Frequency:	Three crystal clocks 1536, 2048 and 8448kHz.
	Accuracy:	Better than ± 3ppm at ambient.
	Stability:	Typically better than ± 12ppm 0°C to 55°C. Typically better than ± 5ppm/year ageing.
	Format:	Square wave, 50 ± 6% duty cycle.
	Jitter:	Less than (0.5% of period + 150 ps) pk-pk;
Clock Offset	Range:	Continuously variable up to at least ± 50ppm about installed crystal frequencies; offset can be displayed in receiver.
External Clock	Frequency:	1kHz – 50MHz.
	Impedance:	75 ohms nominal to ground.
	Triggering:	Automatic or ground threshold switch, min. pulse width (30% of period + 2 ns).
	Sensitivity:	Better than 500mV pk-pk.
	Amplitude:	5V pk-pk max. limits ± 5V.
	Indicator:	LED illuminated if clock transitions present.
Clock Output	Polarity:	CLOCK or $\overline{\text{CLOCK}}$ switch.
	Impedance:	75 ohms nominal to ground.
	Amplitude:	3V ± 0.3V pk-pk.
	DC Offset:	Space 0V, mark 3V.
	Transition Times:	Less than 4ns.
	Overshoot:	Less than 10% of pulse amplitude.
	Protection:	Open/short circuit protected, max. voltage ± 6V short term.
Patterns	PRBS:	Maximal length 2^9-1, $2^{15}-1$, $2^{20}-1$ randomly selectable 9, 15, 20 bit sequence.
	WORD:	0000, 1000, 1010, 1100, 1111 fixed words.
	Zero Add:	1-999 zeros, variable in unit steps, may be added once per sequence to any pattern; zero block occurs before longest run of zeros in maximal length PRBS.
	Error Add:	10^{-2} binary error rate may be added to any pattern (10 consecutive errors added every 1000 clock periods),

Data Format	Binary:	NRZ or RZ (50 ± 6% width on internal clock).
	Ternary:	RZ AMI or coded (50 ± 6% width on internal clock).
	Codes:	HDB3 or HDB2 (rear panel switch).
Data Output	Impedance:	75 ohms nominal to ground.
	Amplitude:	Binary 3V ± 0.3V pk-pk. Ternary 4.74V ± 0.47V pk-pk.
	DC Offset:	Binary space 0V, mark 3V. Ternary space 0V, mark ± 2.37V. Ratio of +ve to −ve pulse amplitude 1.0 ± 0.05.
	Transition Times:	Less than 4ns.
	Overshoot:	Less than 10% of pulse amplitude.
	Protection:	Open/short circuit protected, max. voltage ± 6V short term.
Delay Data Output	Format:	Binary only.
	Relative Delay:	6 bits advanced on main data output
	DC Offset:	Binary space 0V ± 0.3V, mark 3V ± 0.3V.
	Other specifications as for main data output.	
Clock/Data Phasing	NRZ Data:	Rising edge of clock nominally in middle of data.
	RZ Data:	Clock and data nominally coincide.
Trigger Output	Format:	Square wave with one transition per word or sequence.
	Position:	Transitions nominally coincident with start of word or before first zero of longest zero block on PRBS.
	Width:	Equal to word or sequence length, but output held at zero during zero add
	Impedance:	50 ohms nominal to ground.
	Amplitude:	1V min. pk-pk.
	Transition Times:	Less than 5ns.
	Overshoot:	Less than 10% of pulse amplitude.
	Protection:	Open/short circuit protected, max. voltage ± 5V short term.

RECEIVER

Data Input	Rate:	1Kb/s – 50Mb/s
	Impedance:	75 ohms nominal to ground
	Triggering:	Choice of nominal threshold 200mV, 600mV, or ground; min. pulse width (30% of period + 2ns).
	Sensitivity:	Better than 500mV pk-pk.
	Amplitude:	5V pk-pk max. limits ± 5V.
	Indicator:	LED illuminated if data transitions present.

Data Format	Binary:	NRZ or RZ
	Ternary:	RZ AMI or coded.
	Codes:	HDB3 or HDB2 (rear panel switch common with generator).
Clock Recovery	Frequency:	At the three internal rates of generator (selection switch common with generator).
	Mode:	Operates on any data input provided there are two or more transitions every 20 bits (data loss inhibits clock recovery circuit).
External Clock	Frequency:	1kHz – 50MHz
	Polarity:	CLOCK or $\overline{\text{CLOCK}}$ switch.
	Impedance:	75 ohms nominal to ground.
	Triggering:	Automatic or ground threshold switch (common with generator), min. pulse width (30% of period + 2ns).
	Sensitivity:	Better than 500mV pk-pk.
	Amplitude:	5V pk-pk max. limits ± 5V.
	Indicator:	LED illuminated if clock transitions present.
Clock/Data Phasing	Recovered Clock:	Automatic phasing.
	External Clock:	Rising edge of clock should be nominally in middle of data pulse (typically 3ns internal delay of clock relative to data between inputs and sampling point).
Patterns	PRBS and WORD:	All patterns produced by generator excluding added zeros and alternating words; receiver also recognises $\overline{\text{PRBS}}$.
	Indicators:	LED indication of pattern lock for PRBS, $\overline{\text{PRBS}}$, WORD and ALL ONES/ZEROS (indicators inhibited during sync loss and code error or frequency offset measurements).
Synchronisation	Mode:	Automatic with manual override.
	Sync Loss:	Greater than approx. 20,000 errors in 500,000 clock periods.
	Manual:	Sync override via push button forcing a sync loss.
	Resync Time:	Typically less than 500 bits.
Measurements	Modes:	Binary errors, code errors, frequency offset.
	BINARY ERRORS:	Closed loop bit-by-bit detection on any pattern produced by generator excluding added zeros and alternating words.

		CODE ERRORS:	Detected on any pattern according to the following rules where 0 = space 1 = mark V = bipolar violation.
		AMI:	Bipolar violations are code errors.
		HDB3:	01V, 10V, 11V, 0000 and 0100V are code errors.
		HDB2/B3ZS:	1V, 000 and 010V are code errors.
		B6ZS:	0V0, 1V0, 1V1, 00V1 and 000000 are code errors (see options) (000000V1 and 000000V0 produce a single code error).
		FREQUENCY OFFSET:	Measurement of fractional offset of generator clock output from installed crystal rates.
Display	**BER**	Method:	Totalises errors over selected gating period and automatically scales the answer.
		Gating:	10^6, 10^8 or 10^{10} clock periods, repetitive.
		Format:	X.Y x 10^{-n} LED
		Range:	0.0 x 10^{-9} → 4.0 x 10^{-2} (binary errors). 0.0 x 10^{-9} → 9.9 x 10^{-2} (code errors over 10^{10} clocks). 0.0 x 10^{-7} → 1.0 x 10^{-0} (code errors over 10^8 clocks). 0.0 x 10^{-5} → 1.0 x 10^{-0} (code errors over 10^6 clocks).
		Accuracy:	Indication given if measurement result based on less than 100 errors.
	COUNT	Method:	Totalises errors over selected gating period.
		Gating:	Manual start/stop push button switches. External control via printer output.
		Format:	X.Y x 10^{+n} LED with automatic round-up.
		Range:	0.0 x 10^1 → 9.9 x 10^8
	FREQ. OFFSET	Method:	Counts deviation frequency over 10^6 clock periods of internal standard crystal rate.
		Gating:	Automatic.
		Format:	XY x 10^{-n} with automatic round-up
		Range:	Up to 25kHz deviation from nominal crystal rate.
		Accuracy:	± 1 count relative to the internal standard clocks.

STROBING	BER & FREQ OFFSET:	Display strobed at end of gating interval; maximum refreshment rate 2 Hz.
	COUNT:	Display continuously updated with round-up when measurement ends.
Flags (LED's)	Gating:	Indicates measurement in progress, will extinguish for at least 500ms between measurements.
	Sync Loss:	Indicates local pattern reference has lost sync, display blanks and measurement is terminated (BER) or halted (COUNT); flag remains lit for at least 500ms (BER) or held (COUNT) until measurement is terminated. (Sync loss inhibited during code error and frequency offset measurements).
	Overflow:	Indicates internal error or frequency count $\geqslant 10^9$, display blanks and measurement is terminated (BER) or halted (COUNT); flag remains lit for at least 500ms (BER) or held (COUNT) until measurement is terminated.
	$<$100 Errors:	Indicates less than 100 errors counted during last error measurement (inhibited during frequency offset measurements).
Printer Output (rear panel)	Format:	8421 BCD 10 columns BER F * X * Y * 10 – N COUNT F * X * Y * 10 + N
	Flags:	F = V for $<$100 errors F = 1 for overflow F = 2 for sync loss F = 3 for clock loss F = 4 for data loss
	Print Modes:	BER – print command given on termination of measurement. COUNT MAN – print command given on STOP command from front panel COUNT EXT – print command given on STOP command from printer.
	Print Command:	TTL pulse, min. print cycle time 500ms.

Recorder Output (rear panel)

Format:	Current source with 500ms minimum response.		
Impedance:	Greater than 50K ohms.		
Range:	1mA variation over 16 levels into 10K ohms max.		
BER:	Eleven level signal		
	FSD = level	15	BER $< 10^{-8}$
		14	$< 10^{-7}$
		13	$< 10^{-6}$
		12	$< 10^{-5}$
		11	$< 10^{-4}$
		10	$< 10^{-3}$
		9	$< 10^{-2}$
		8	$< 10^{-1}$
		7	$\geqslant 10^{-1}$
		4	sync loss
		0	signal loss
COUNT:	Four level signal		
	FSD = level	15	signal no errors
		7	signal plus errors
		4	sync loss
		0	signal loss

Note: when using recovered clock, signal loss = data loss
when using external clock, signal loss = clock loss

Calibration:	Two rear panel push buttons giving FSD and Zero. Internal adjustment of range 1mA ± 0.2mA and centering 0mA→0.5mA.

Error Output (rear panel)

Format:	One pulse per error (inhibited during sync loss).
Impedance:	50 ohms nominal to ground.
Amplitude:	1V min. pk-pk.
Transition Times:	Less than 5ns.
Overshoot:	Less than 10% of pulse amplitude.
Protection:	Open/short circuit protected, max. voltage ± 5V short term.

Trigger Output (rear panel)

Format:	One pulse per sequence (PRBS only)
Position	Near the start of the longest zero block in PRBS).
Width:	Nominally one clock period.
Impedance:	50 ohms nominal to ground.
Amplitude:	1V min. pk-pk.
Transition Times:	Less than 5ns.
Overshoot:	Less than 10% of pulse amplitude.
Protection:	Open/short circuit protected, max. voltage ± 5V short term.

Clock Output (rear panel)

Format:	Detector clock available as a monitor
Width:	Nominal 50% duty cycle for recovered clock.
Impedance:	50 ohms nominal to ground.
Amplitude:	1 V min pk-pk.
Transition Times:	Less than 5ns.
Overshoot:	Less than 10% of pulse amplitude.
Protection:	Open/short circuit protected, max. voltage ± 5V short term.

GENERAL

Power Supply

115V $^{+10\%}_{-22\%}$ or 230V $^{+10\%}_{-18\%}$ AC 48 – 66Hz, max
consumption approx 110VA

Probe Power

External fused supplies of +5V, 200mA and –5V, 200mA for HP logic probes.

Connectors

All signal connectors are BNC (except options 002, 003).
Printer output via 50 pin Amphenol connector.
Recorder output via two binding posts.

Dimensions

195 x 335 x 475mm (H x W x L).
7 3/4 x 13 3/16 x 18 5/8 in

Weight

12.5kg 27½lb

Environment

Operating temperature range 0 to +55°C.
Storage temperature range –40 to +75°C.

Accessories Available

75 ohms unbalanced to 110 ohms balanced impedance passive converters having frequency range 1 – 10MHz.

Cable preamplifier for monitor output points on digital interface.

OPTIONS

001

All words replaced by 16 bit front panel programmable word. This can also provide two 8 bit words alternated by an external signal applied via the rear panel. Changeover is synchronous with end of words. Zero add then operates on individual 8 bit words, and trigger output is 8 bits wide.

External input sensitivity:	250mV pk-pk squarewave DC-100kHz 0.5V pk-pk sine or triangular wave 200Hz – 100kHz
Max. input voltage:	15V rms
Impedance:	nominally 1000 ohms

002

Siemens 1.6mm connectors replace all external 75 ohm BNC connectors.

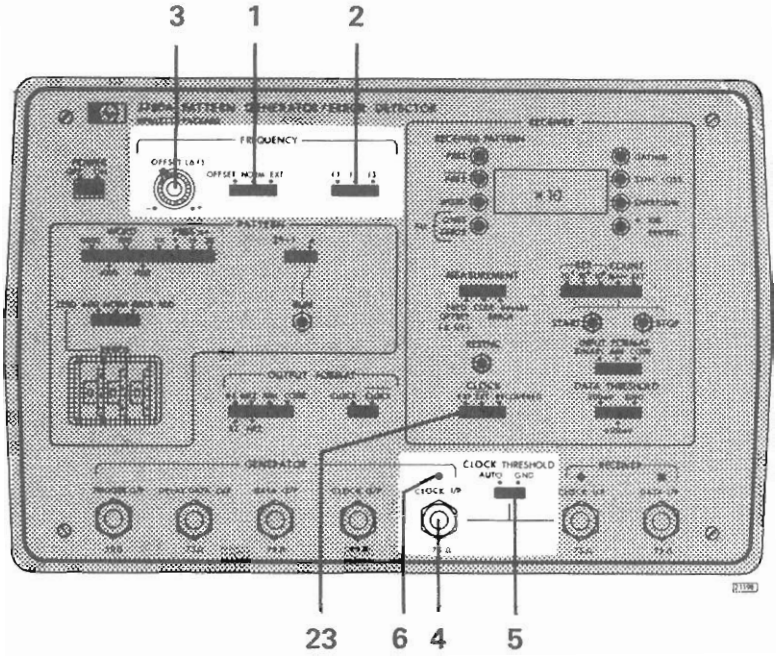
003	Combination of options 001 and 002.
100	Internal clock frequencies of 2048, 8448 and 34368kHz.
101	Internal clock frequencies of 1544, 6312 and 44736kHz HDB3/HDB2 codec replaced by B6ZS/B3ZS codec.
102	Internal clock frequencies of 1544, 6312 and 3152kHz HDB3/HDB2 codec replaced by B6ZS/B3ZS codec.
099	Clock frequency offset generation deleted.

SECTION 2

CONTROLS, CONNECTORS AND INDICATORS

2-1 INTRODUCTION The front and rear panel controls connectors and indicators are described in the order normally used to set up the instrument. This order is as follows:

2-2 GENERATOR FREQUENCY CONTROLS



GENERATOR FREQUENCY CONTROLS

Determine generator clock frequency.

(1) The CLOCK SELECTION switch selects the generator clock source:

In the EXT position the generator is clocked with an external input in the range 0.5 to 5V pk-pk applied to the CLOCK I/P connector (4). In the NORM position the generator is clocked with one of the crystal clock frequencies selected with the frequency switch (2). In the OFFSET position the generator is clocked with a frequency offset from that selected with the FREQUENCY switch (2) by an amount up to ± 50ppm. The amount of offset is selected with the OFFSET (Δf) control (3).

(2) The FREQUENCY switch selects one of three internal crystal oscillators as a clock source for the generator section. This switch also selects the appropriate clock recovery circuit in the receiver when the RECOVERED position of the receiver CLOCK switch (23)

is selected. The frequencies indicated by f_1 f_2 and f_3 are listed on the rear panel of the instrument. The frequencies available are as follows:

	f_1kHz	f_2kHz	f_3kHz
Standard	2048	8448	1536
Option 100	2048	8448	34368
Option 101	1544	6312	44736
Option 102	1544	6312	3152

(3) The OFFSET (Δf) control can be used to vary the generator clocking frequency from the fixed values f_1 f_2 or f_3, selected with the FREQUENCY switch (2), by up to ±50ppm. This control is only operative when the CLOCK SELECTION switch (1) is in the OFFSET position.

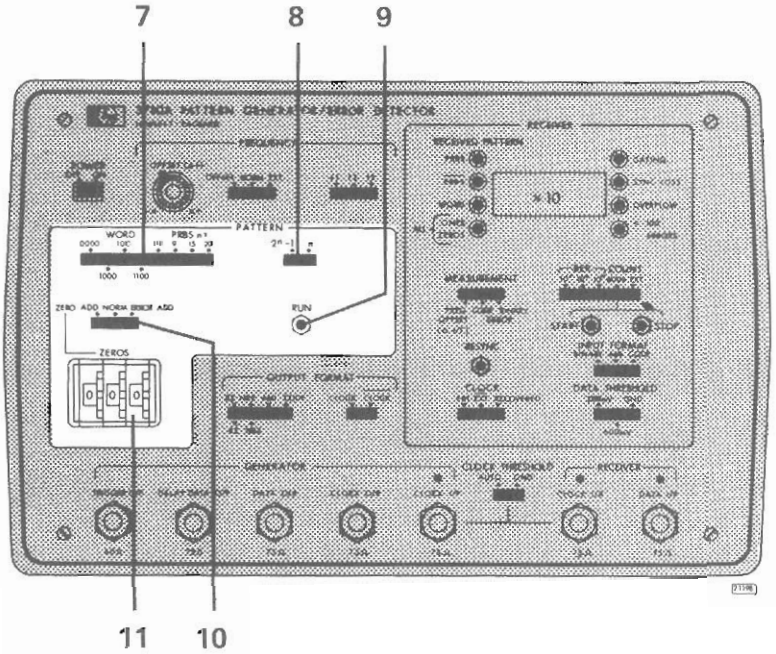
(4) The CLOCK I/P connector accepts an external clock input for the generator in the range 1kHz to 50MHz the input sensitivity is 0.5V pk-pk and the maximum amplitude is 5V pk-pk within the limits ±5V. This input is enabled by selection of the EXT position of the CLOCK SELECTION switch (1), it is an unbalanced input with an impedance of 75 ohms.

(5) The CLOCK THRESHOLD switch selects the triggering threshold for external clock signals applied to both Generator and Receiver sections of the instrument via the CLOCK I/P connectors (4) and (24). In the AUTO position the triggering is automatic at the mean signal level. In the GND position the triggering is at the instrument ground level.

(6) The GENERATOR EXTERNAL CLOCK TRIGGER indicator lamp is 'on' when an external clock input at CLOCK I/P connector (4) is correctly triggered. The lamp will be 'off' if clock transistions are absent for more than 150ms.

OPTION 099 The OFFSET (Δf) control and the OFFSET position of the clock selection switch are deleted. All references to these in (1) and (3) above do not apply.

2-3 GENERATOR PATTERN CONTROLS



GENERATOR PATTERN CONTROLS

Determine the sequence generated.

(7) The PRBS/WORD switch selects the pattern to be generated from fixed four bit words: 0000, 1000, 1010, 1100, 1111 or the value of n: 9, 15, 20. The value of n selected may be used to produce an n bit word or a $2^n - 1$ bit PRBS as selected with the $2^n - 1/n$ switch (8).

The PRBS/WORD switch is also used to preset a reference 4 bit word on a receiving instrument (16 bit word with options 001 or 003) in order to detect systematic errors.

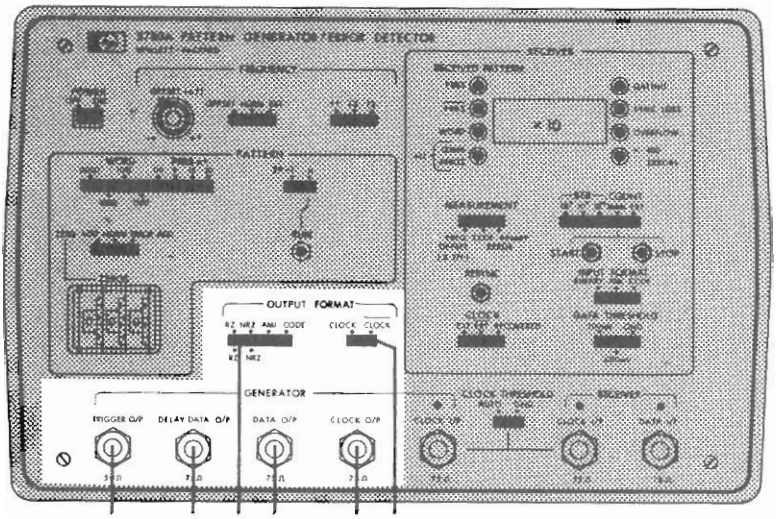
(8) When the PATTERN SELECTION switch (7) is in one of the n=9, 15 or 20 positions the $2^n - 1/n$ switch either selects a $2^n - 1$ bit maximal length PRBS or an n bit word. The n bit word is selected at random as any consecutive n bits of the $2^n - 1$ PRBS continuously recycled. The content of the n bit word may be changed with the RUN switch (9).

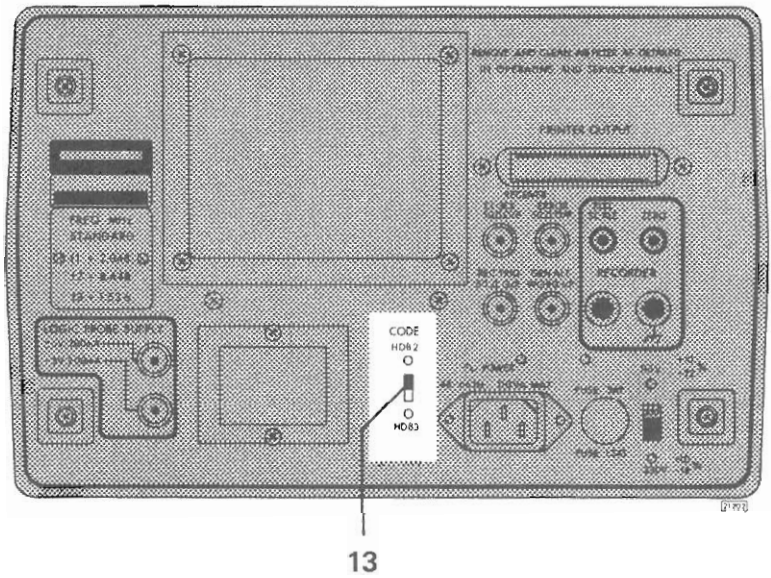
(9) The RUN switch selects the content of the n bit word by allowing the 2^n-1 bit PRBS to run normally when the switch is pressed and to return to continuous recycling of the current n bits when the switch is released.

(10) The ZERO ADD/NORM/ERROR ADD switch selects data modification. In the ZERO ADD position the number of zeros, up to 999, selected with the ZEROS switch (9) are added between words or before the longest run of zeros in the PRBS. In the NORM (normal) position the generator produces repetitive WORD or PRBS patterns. The data is not modified and the sequence is determined by controls (7) (8) and (9) only. In the ERROR ADD position a fixed binary error rate of 10^{-2} is introduced into the generator sequence by producing 10 consecutive errors in every 1000 clock periods.

(11) The ZEROS switch selects the number of zeros added to any pattern when the ZERO ADD position of the ZERO ADD/NORM/ERROR ADD switch (10) is selected.

2-4 GENERATOR FORMAT CONTROLS AND OUTPUT CONNECTORS





GENERATOR FORMAT CONTROLS AND OUTPUT CONNECTORS

Determine generator output format.

(12) The DATA FORMAT switch selects between binary and ternary data output formats. The binary data formats, RZ, return to zero, and NRZ, non return to zero are available at both DATA O/P (14) and DELAY DATA O/P (15) connectors. The ternary data formats, AMI, alternate mark inversion, and CODE, HDB3 or HDB2 (options 101 and 102 B6ZS or B3ZS), selected with the rear panel CODE switch are available at the DATA O/P connector (14) only.

(13) The CODE switch on the rear panel selects HDB3 or HDB2 code formats (options 101 and 102 B6ZS or B3ZS) when the CODE position of the DATA FORMAT switch (12) is selected.

(14) The DATA O/P connector provides a 75 ohm unbalanced data output as selected with the PATTERN and FORMAT controls. The output amplitude of the mark in binary formats is 3V and in ternary formats ±2.37V. The space in both formats is 0V. The connector has open and short circuit protection and will withstand an input of up to ± 6V for short periods.

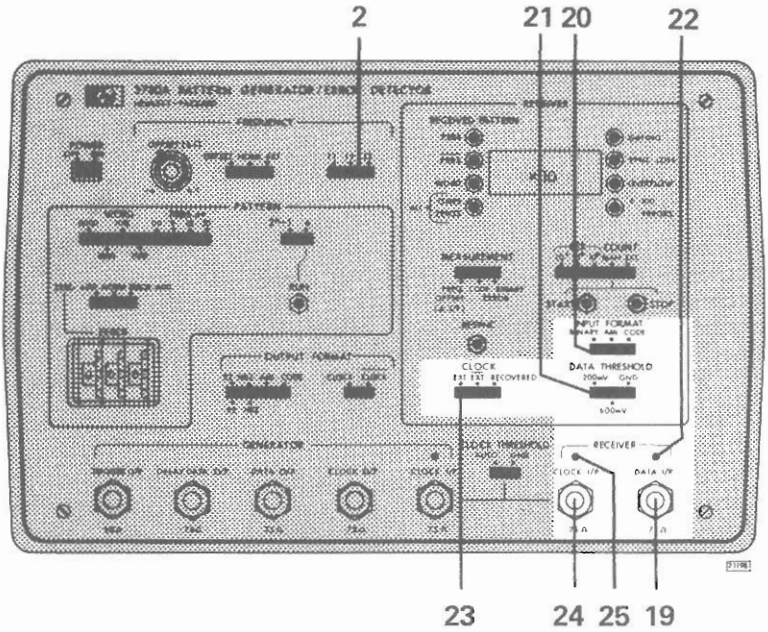
(15) The DELAY DATA O/P connector provides a data output of the binary formats RZ and NRZ, delayed by 6 bits less than a complete sequence i.e. 6 bits advanced on the data at DATA O/P (14). In all other respects this output is identical to the normal data output.

(16) The CLOCK/$\overline{\text{CLOCK}}$ switch selects normal or inverted generator clock output at the CLOCK O/P connector (17).

(17) The CLOCK O/P connector provides a 75 ohm unbalanced generator clock output. The output can be normal or inverted as selected with the CLOCK/$\overline{\text{CLOCK}}$ switch (16) and the output frequency may be either an internal or external clock source. The output mark amplitude is 3V and the space is 0V. The connector has both open and short circuit protection and will withstand an input of up to ± 6V for short periods.

(18) The TRIGGER O/P connector provides one transition per word or sequence coincident with the start of the word and before the longest block of zeros of a PRBS. The amplitude of the trigger output is 1V and it is a 50 ohm unbalanced signal. The output has both open and short circuit protection and will withstand an input of up to ±5V for short periods.

2-5 RECEIVER INPUT CONTROLS AND CONNECTORS



RECEIVER INPUT CONTROLS AND CONNECTORS Set receiver clock and data input conditions.

(19) The DATA I/P connector is a 75 ohm unbalanced input which accepts the data input for the receiver. The data input frequency range is 1Kb/s to 50Mb/s and the input sensitivity is 0.5V pk-pk. The maximum input amplitude is 5V pk-pk within the limits ± 5V. The data triggering threshold can be selected with the DATA THRESHOLD switch (21).

(20) The DATA FORMAT switch selects the appropriate binary or ternary receiver operation for incoming data at the DATA I/P connector (19). In the code position a choice of HDB3 or HDB2 code (options 101 and 102 B6ZS or B3ZS code) is provided with the rear panel CODE switch (13) which is common with the generator.

(21) The DATA THRESHOLD switch selects the receiver data triggering level. Trigger level should be chosen to fall within 10% and 90% of data amplitude. Binary

triggering levels of GND (ground), 200mV or 600mV may be selected. Ternary triggering levels of ± 200mV or ± 600mV may be selected.

Note: In recovered clock mode the data threshold level should be set closest to 50% of maximum input data amplitude to allow the rising edge of the clock, after a fixed delay, to coincide with the centre of the data pulse.

(22) The DATA INPUT TRIGGER indicator lamp is 'on' when data applied to the DATA I/P connector (19) is correctly triggered. The lamp will be 'off' if data transitions are absent for more than 150ms.

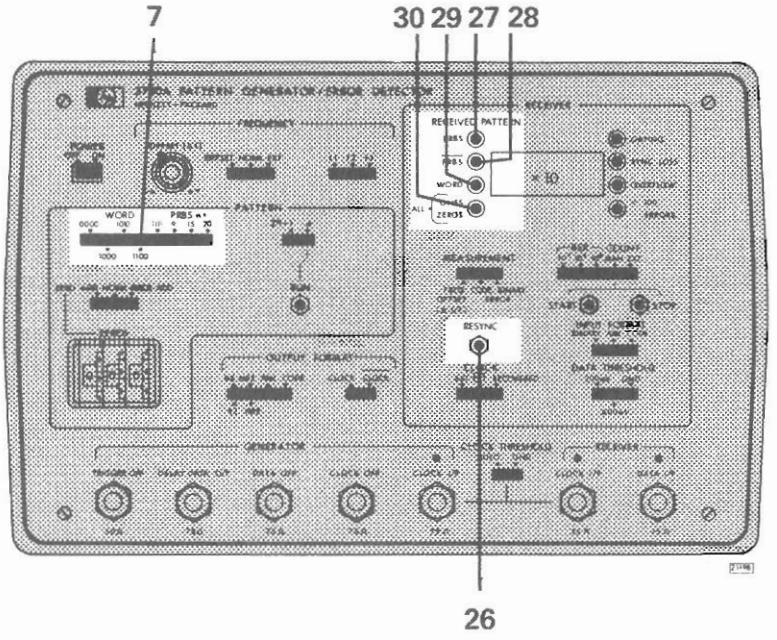
(23) The CLOCK switch selects the receiver clock source. In the EXT and $\overline{\text{EXT}}$ positions the receiver is clocked with a normal or inverted input applied to the RECEIVER CLOCK I/P connector (24). In the RECOVERED position the receiver is clocked with a signal recovered from the data at the DATA I/P connector (19). The appropriate clock recovery frequency is selected with the FREQUENCY switch (2).

Note: for clock recovery there must be two or more transitions in every 20 bits. This does not occur in the $2^{20} - 1$ PRBS when in NRZ format.

(24) The CLOCK I/P connector is an unbalanced 75 ohm input for a receiver external clock in the frequency range 1kHz to 50MHz. The input sensitivity is 0.5V pk-pk and the maximum input amplitude is 5V pk-pk within the limits ± 5V. The clock triggering threshold can either be ground or automatic [mean level of clock input as selected with the CLOCK THRESHOLD switch (5)] . The CLOCK THRESHOLD switch is common with the generator.

(25) The RECEIVER CLOCK INPUT TRIGGER indicator lamp is 'on' when a clock signal applied to the CLOCK I/P connector (24) is correctly triggered. The lamp will be 'off' if clock transitions are absent for 150ms.

2-6 RECEIVER SYNCHRONISATION AND SYNC INDICATORS



SYNC AND SYNC INDICATORS Automatic synchronisation with manual override and received pattern indication.

(26) The RESYNC switch is a manual override on the automatic synchronisation system. When the RESYNC switch is pressed a search for synchronism is initiated. The incoming pattern is examined for parity with each of the possible incoming patterns until less than 4 errors occur in 100 clock periods. Synchronisation is then regained, and the type of pattern indicated by one of the synchronisation indicators (27) to (30).

(27) PRBS The normal 2^9-1, $2^{15}-1$ or $2^{20}-1$ bit PRBS produced by the generator.

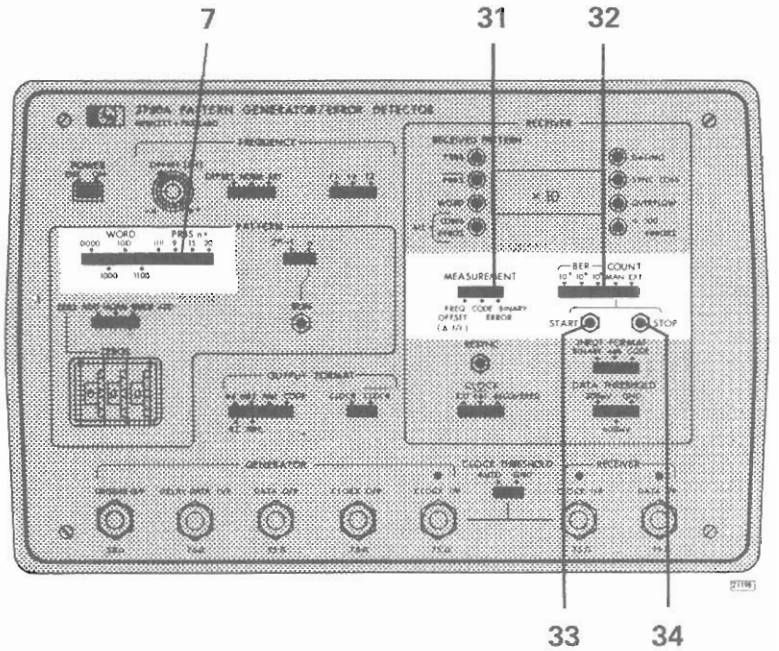
(28) $\overline{\text{PRBS}}$ The inverse of the 2^9-1, $2^{15}-1$ or $2^{20}-1$ bit PRBS produced by the generator.

(29) WORD When the PRBS/WORD switch (7), of the receiving instrument, is set to 9, 15 or 20 the WORD lamp indicates synchronisation to any word which is repetitive in blocks of 9, 12, 15, 16 or 20 bits.

When the PRBS/WORD switch (7), of the receiving instrument, is set to the fixed 4 bit words 1000, 1010, or 1100, or with options 001 or 003 when the PRBS/WORD switch is set to 16 and a word selected the WORD SELECT switches which is not all 1's or all 0's; the WORD lamp indicates synchronisation to that word.

(30) ALL ONES, ALL ZEROS Any word sequence with less than 4 zeros in 100 clock periods or less than 4 ones in 100 clock periods.

2-7 RECEIVER MEASUREMENT CONTROLS



MEASUREMENT CONTROLS Select, measurements to be made, display format, and time-base.

(31) The MEASUREMENT switch selects the measurement to be performed.

In the FREQUENCY OFFSET ($\Delta f/f$) position the fractional difference between the standard and offset frequencies *of the generator section* is measured. With the CLOCK SELECTION switch (1) set to OFFSET, the fractional frequency difference measured is the offset selected with the OFFSET Δf control (3) divided by the frequency f selected with the FREQUENCY switch (2).

In the CODE ERRORS position the receiver monitors the input data at DATA I/P (19) for violations of the coding laws. The coding law is selected with the receiver DATA FORMAT switch (20) as either AMI or CODE and in the CODE position the type of code HDB3, HDB2 (option 101 and 102 B6ZS, B3ZS) is selected with the rear panel CODE switch (13) which is common with the generator. The result may either be

displayed as a bit error rate or error count as selected with the TIMEBASE switch (32). The measurement range is 0.0×10^{-9} to 9.9×10^{-2} in BER 10^{10}, 0.0×10^{-7} to 1.0×10^{0} in BER 10^{6} or 10^{8} and 0.0×10^{1} to 9.9×10^{8} in COUNT.

In the BINARY ERRORS position the receiver measures the binary errors on a binary or a coded input applied to the DATA I/P connector (19). The binary errors are measured on a bit by bit basis using a reference pattern generated in the receiver. The result may either be displayed as a bit error rate or error count as selected with the TIMEBASE switch (32). The measurement range is 0.0×10^{-9} to 4.0×10^{-2} in BER and 0.0×10^{1} to 9.9×10^{8} in COUNT.

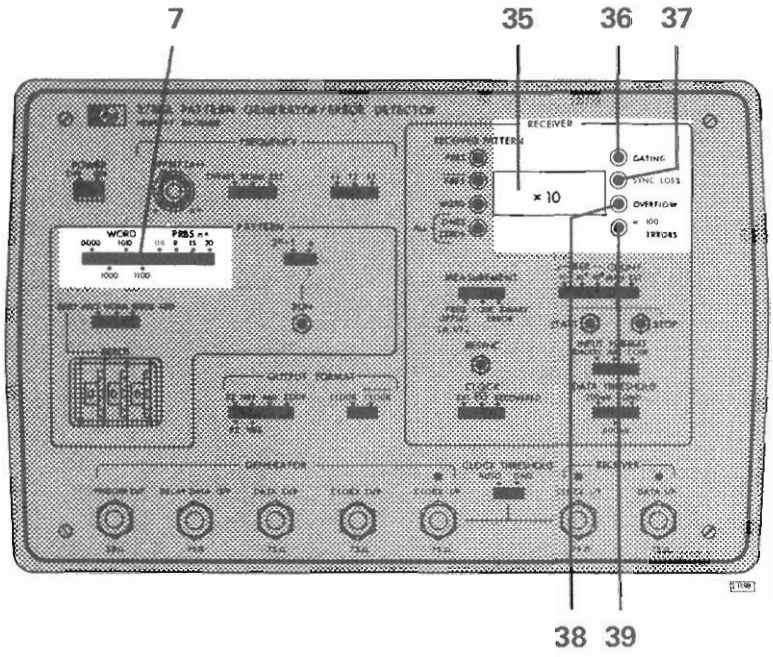
If the test signal being received is one of the fixed 4 bit words, or with options 001 or 003 a 16 bit word, two methods of operation are available depending on the setting of the PRBS/WORD switch (7). With the PRBS/WORD switch set to 9, 15 or 20, the receiving instrument will synchronise to the incoming pattern irrespective of systematic errors. With the PRBS/WORD switch set to the relevant word, the error detector will only synchronise to that word.

(32) The TIMEBASE switch selects the counter timebase interval over which errors are counted. The BER positions give a choice of 10^{6}, 10^{8} or 10^{10} clock periods for measurement gating. The measurement result is automatically scaled and presented in the form X. Y x 10^{-n} with an indication if this result is computed from less than 100 errors (39). In the COUNT position errors are counted over a period either selected manually with the START and STOP switches (33) and (34) or externally by a command from an external printer. In this mode a positive going TTL pulse at pin 47 of the PRINTER OUTPUT connector (40) stops the counter and produces a print command. The counter normally restarts 400ms after the stop command however it is possible, with the change of an internal link, to hold the restart until the pulse at PRINTER OUTPUT pin 47 goes "low".

(33) The START switch controls the start of the manual measurement gating period when the TIMEBASE switch (32) is in the COUNT MAN position. The count is initiated by the switch being depressed. This switch can also be used to restart a measurement when counting errors over 10^{6}, 10^{8} or 10^{10} clock periods.

(34) The STOP switch stops the measurement when counting over a manually controlled timebase. The count is stopped by the switch being depressed.

2-8 RECEIVER DISPLAY AND FLAG INDICATORS



DISPLAY AND FLAG INDICATORS

Present the result and indicate state of measurement.

(35) The DISPLAY shows the measurement result. Frequency offset measurements are displayed in the form XY x 10^{-n}. Code error and binary error measurements are displayed as BER in the form X.Y x 10^{-n} or as COUNT in the form X. Y x 10^{+n}.

(36) The GATING flag indicates that a measurement is in progress. The indicator will be 'off' for at least 500ms between measurements.

(37) The SYNC LOSS flag indicates loss of receiver pattern synchronisation. The indicator is inhibited during code error and frequency offset measurement.

Sync loss will also be indicated when the PRBS/WORD switch (7) is in one of the fixed 4 bit word positions which is different to the word being received. With options 001 and 003 sync loss will be indicated when the PRBS/WORD switch is set to 16 and the word

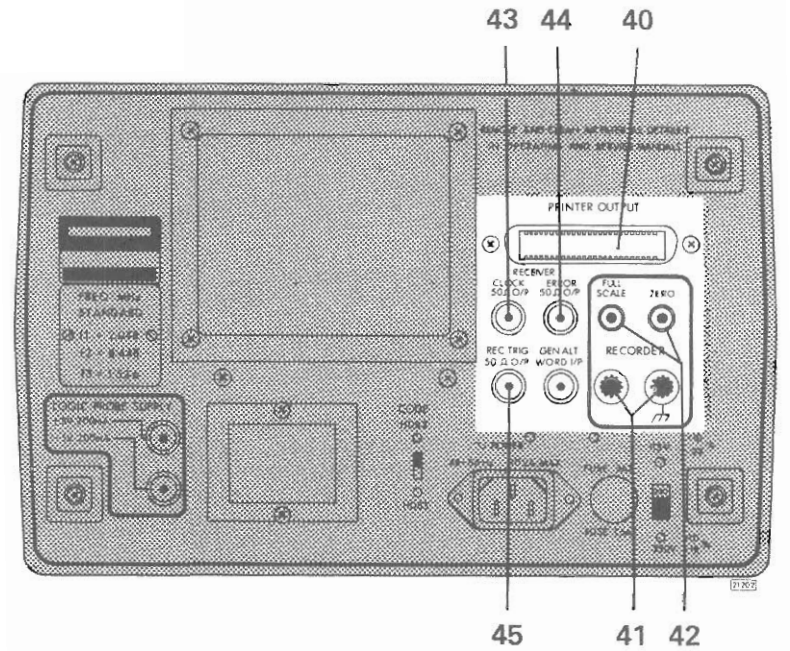
selected with the WORD SELECT switches is different to the word being received.

Note: This does not apply if the PRBS/WORD switch is set to one of the PRBS positions, 9, 15 or 20, or if the internal SYSTEMATIC ERROR DETECTION switch A37S2 is set to OFF, as the error detector will then synchronise to any repetitive 9, 12, 15, 16 or 20 bit word.

(38) The OVERFLOW flag indicates that the internal error or frequency count has reached or exceeded 10^9.

(39) The <100 ERRORS flag indicates that less than 100 errors were counted during the last error measurement. The indicator is inhibited during frequency offset measurements.

2-9 RECEIVER OUTPUTS



RECEIVER OUTPUTS

(40) The PRINTER OUTPUT connector provides an 8421 BCD output of the measurement result and current flag signal. In the BER and COUNT MAN positions of the TIMEBASE switch (32) the print command is at the termination of the measurement and in the COUNT EXT position the print command is initiated by the printer providing a positive going TTL pulse at pin 47 of this connector. The Counter normally restarts 400ms after the stop command, however it is possible, with the change of an internal link, to hold the restart until the pulse at the PRINTER OUTPUT socket, pin 47, goes "low". Further details of the printer output are given on page 51.

(41) The RECORDER OUTPUT connectors provide a high impedance current source output suitable for connection to a chart recorder. The output comprises 16 current levels with a total variation of 1mA into an impedance of 10K ohms max. There is an eleven level

indication of BER and a four level indication of count and the response time is 500ms minimum. Further details of the recorder output are given on page 52.

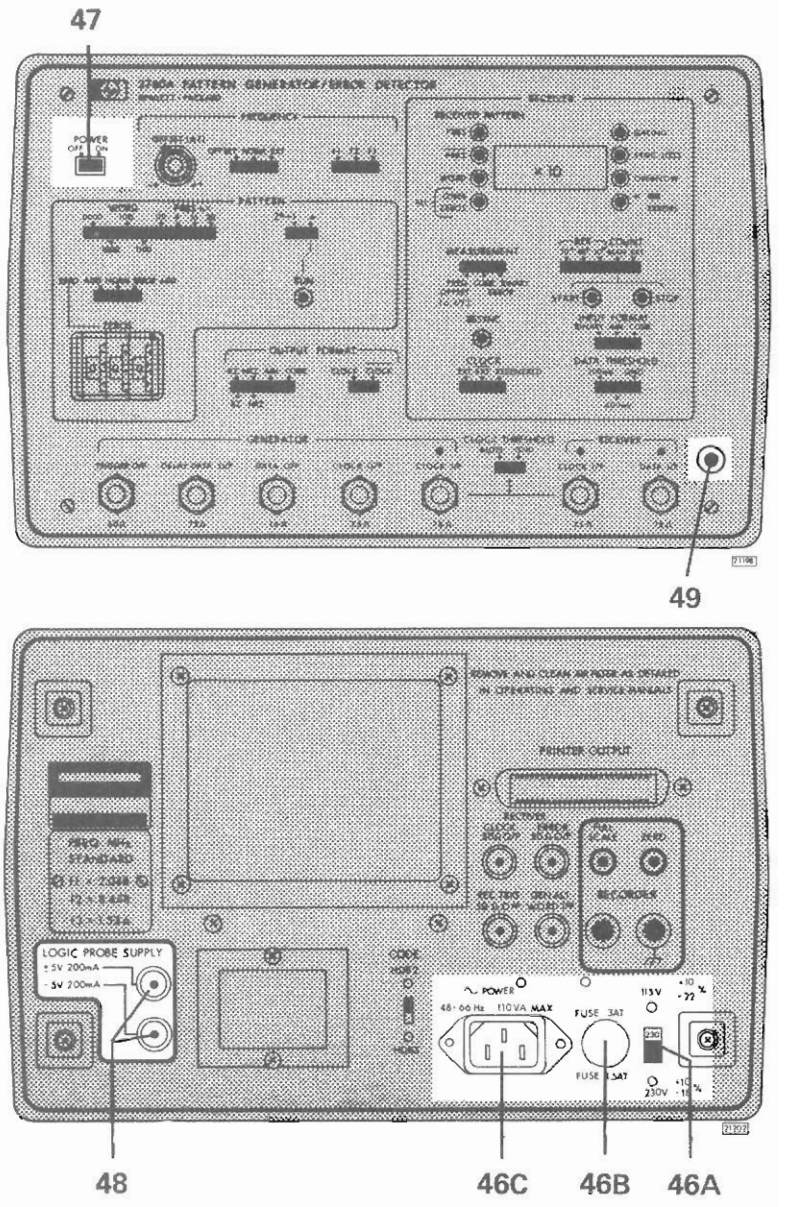
(42) The RECORDER CALIBRATION switches provide 1mA for FULL SCALE and 0mA for ZERO calibration of a chart recorder connected to the RECORDER OUTPUT connectors (41).

(43) The RECEIVER CLOCK output provides an output of the receiver clock signal for recovered or ext clock. The output amplitude is 1V min pk-pk and the pulse width is nominally the same as the clock with a 50% duty cycle for recovered clock. The connector has both open and short circuit protection and will withstand an input of up to ± 5V for short periods. The output impedance is 50 ohms.

(44) The ERROR output connector provides one pulse per error. The output pulse amplitude is 1V min pk-pk and the pulse width is nominally the same as the clock mark. The connector has both open and short circuit protection and will withstand an input of up to ± 5V for short periods. The impedance of this output is 50 ohms and the output is inhibited during sync loss.

(45) The RECEIVER TRIGGER output provides one pulse per received PRBS sequence near the start of the longest zero block. The output pulse amplitude is 1V min pk-pk and the pulse width is nominally one clock period. The connector has both open and short circuit protection and will withstand an input of up to ± 5V for short periods. The output impedance is 50 ohms.

2-10 POWER CONTROLS AND CONNECTORS



(46) The POWER INPUT module comprises a supply voltage selection switch (46A), the supply fuse (46B) and a socket for the power supply cable (46C). Details of setting the supply voltage switch and fuse selection are given on page 6 Paragraph 1-9.

WARNING

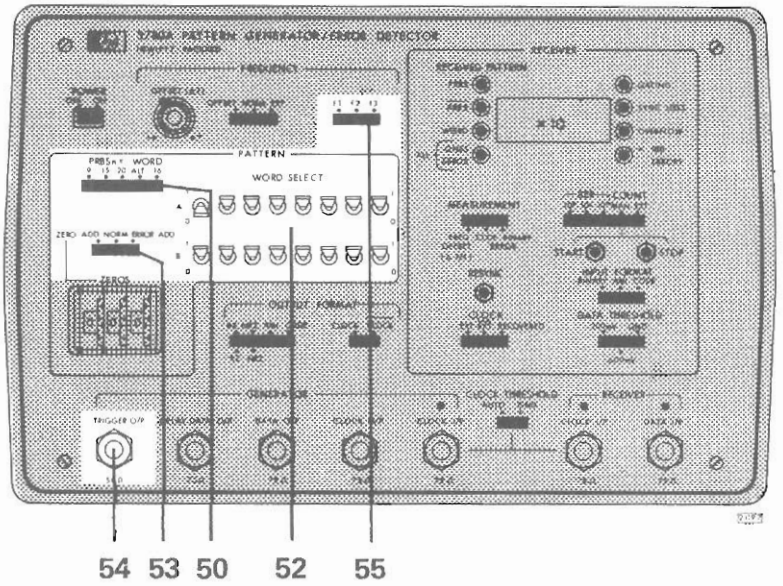
BEFORE CONNECTING THE INSTRUMENT TO THE SUPPLY ENSURE THAT THE VOLTAGE SELECTOR IS IN THE CORRECT POSITION AND THAT A FUSE OF THE CORRECT RATING IS FITTED.

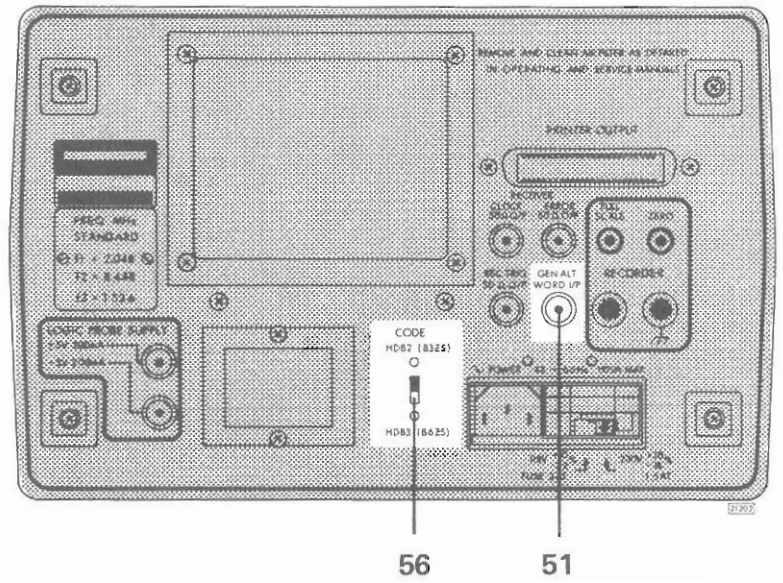
(47) The POWER switch controls the ac power input to the instrument.

(48) The LOGIC PROBE SUPPLY connectors provide power for a logic probe which may be required for the service or repair of the instrument. Both + and −5 volts are available and both supplies are internally fused at 200mA.

(49) The cable preamplifier power supply provides, −12.6V, +15V and ground, as a power source for the Model 15509A cable preamplifier accessory. This accessory provides an interface between monitor output points and the model 3780A.

2-11 OPTION CONTROLS AND CONNECTORS





OPTION 001/003 Option 001 is the 16 bit word option and option 003 is the 16 bit word option with small Siemens connectors.

(50) The PRBS/WORD switch selects the pattern to be generated. In the n = 9, 15 and 20 positions a maximal length PRBS of $2^n - 1$ is produced as for the standard instrument. In the n = 16 position the generator produces a repetitive 16 bit word whose content is selected with the WORD SELECT switches (52). In the ALT position the generator produces two 8 bit repetitive words A and B alternated by an external signal applied to the GEN ALT WORD I/P connector (51) on the rear panel. The word 'A' is selected by a positive going transition of the input signal and the word 'B' by a negative going transition.

The PRBS/WORD switch in conjunction with the WORD SELECT switches (52) is used to preset a reference 16 bit word on a receiving instrument in order to detect systematic errors.

(51) The GEN ALT WORD I/P connector accepts a signal to switch between words A and B as selected with the WORD SELECT switches (52). The input sensitivity is 250mV pk-pk for a dc to 100kHz square wave or 0.5V for a 200Hz to 100kHz sine or triangular wave. The input impedance is nominally 1K ohm and the maximum voltage is 15V rms.

(52) The WORD SELECT switches select the content of the 16 bit or two 8 bit words produced by the generator.

(10)/(53) The ZERO ADD/NORM/ERROR ADD switch performs the same function as in the standard instrument as described on page 28. Zeros are added once per sequence to the 16 bit word between words or individually to the 8 bit words.

(18)/(54) The TRIGGER output socket provides a trigger output of one transition per word or sequence as for the standard instrument described on page 31. With the 16 bit word the transition occurs before each word and in the alternate mode the transition occurs before each 8 bit word A or B.
All other controls, connectors and indicators are the same as the standard instrument.

OPTION 002 Option 002 instruments have small Siemens connectors in place of the 75 ohm BNC connectors.
All other controls, connectors and indicators are the same as in the standard instrument.

OPTION 100 (2)/(55) The internal crystal frequencies selected with the FREQUENCY switch are as follows:
f_1 2,048kHz f_2 8,448kHz f_3 34,368kHz.
These frequencies are listed on the rear panel of the instrument.
All other controls, connectors and indicators are the same as in the standard instrument.

OPTION 101 (2)/(55) The internal crystal frequencies selected with the FREQUENCY switch are as follows:
f_1 1,554kHz f_2 6,312kHz f_3 44,736kHz
These frequencies are listed on the rear panel of the instrument.

(13)/(56) The rear panel CODE switch selects B3ZS and B6ZS code formats in the generator and receiver.
All other controls, connectors and indicators are the same as in the standard instrument.

OPTION 102 (2)/(55) The internal crystal frequencies selected with the FREQUENCY switch are as follows:
f_1 1,554kHz f_2 6,312kHz f_3 3,152kHz
These frequencies are listed on the rear panel of the instrument.

(13)/(56) The rear panel CODE switch selects B3ZS and B6ZS code formats in the generator and receiver.
All other controls, connectors and indicators are the same as in the standard instrument.

OPTION 099 (1)/(3) The frequency OFFSET (Δf) control and the OFFSET position of the clock selection switch are deleted.
All other controls, connectors and indicators are the same as in the standard instrument.

SECTION 3
OPERATING PROCEDURE

3-1 INTRODUCTION

The 3780A PATTERN GENERATOR/ERROR DETECTOR measures binary errors, code errors, and frequency offset. The measurements may be local using a loop back method or through a channel under test to a remote error detector.

3-2 BINARY OR CODE ERROR MEASUREMENTS

To make Binary Error or Code Error measurements proceed as follows:

Generator

1. Select the generator FREQUENCY either internal (NORM) f_1 f_2 f_3 or external (EXT) from the CLOCK I/P.
2. Select the generator pattern 2^n-1 PRBS, n bit word or one of the fixed words.
3. Select the generator output format, RZ or NRZ for binary outputs AMI or CODE including rear panel CODE format for code outputs.
4. Connect the generator DATA O/P to the item under test.
5. If not using recovered clock connect the generator CLOCK O/P to item under test.

Receiver

6. Connect data from item under test to receiver DATA I/P.
7. If not using recovered clock connect clock from item under test to CLOCK I/P.
8. Select DATA THRESHOLD 200mV, 600mV or GND.
9. Select receiver CLOCK drive EXT, $\overline{\text{EXT}}$ OR RECOVERED.
10. Select INPUT FORMAT BINARY (RZ or NRZ), AMI or CODE.

    Note: The code will be the code selected with the rear panel CODE switch of the receiving instrument.

11. Select MEASUREMENT to be made CODE ERRORS or BINARY ERRORS.
12. If the generator pattern selected in step 2 was one of the fixed words and systematic error detection is required, select the same fixed word with the PRBS/WORD switch of the receiving instrument. If systematic error detection is not required, select one of the PRBS (9, 15 or 20) positions of the PRBS/WORD switch on the receiving instrument.

13. For Binary Errors ensure that synchronism has been achieved by observation of the RECEIVED PATTERN indicators.

14. Select TIMEBASE and DISPLAY MODE, BER over 10^6 10^8 or 10^{10} clock periods or COUNT, MANUAL or EXTERNAL.

    Note: In BER the measurement starts automatically, in COUNT MANUAL the measurement is initiated with the START switch, and in COUNT EXTERNAL the measurement is initiated from an external printer.

15. Ensure that the receiver is operating correctly by observing the GATING indicator.

    Note: Differences may occur between measurements of binary error rate and code error rate due to the error extension factor of the decoder. This is fully described in paragraph 1-14..

3-3 FREQUENCY OFFSET MEASUREMENT

To set a required generator offset proceed as follows:

1. Select the generator FREQUENCY f_1 f_2 or f_3.
2. Select the OFFSET position of the generator CLOCK SELECTION switch.
3. Set the receiver MEASUREMENT to FREQUENCY OFFSET.
4. Ensure correct operation by observing the display and GATING indicator.
5. Adjust the generator OFFSET control to give a display of the required offset.

To measure the offset of an external data input proceed as follows:

1. Connect the external data input to the receiver DATA I/P connector.
2. Select the RECOVERED position of the receiver CLOCK format switch.
3. Connect the receiver CLOCK output on the rear panel to the generator CLOCK I/P.
4. Set the generator CLOCK SELECTION to EXT.
5. Select the comparison frequency with the generator FREQUENCY switch f_1 f_2 or f_3.
6. Set the receiver MEASUREMENT to FREQUENCY OFFSET.

7. Ensure correct operation by observing the display and GATING indicator.

To measure the offset of an external clock input connect the external clock input to the generator CLOCK I/P and proceed as in steps 4 to 7 above.

SECTION 4
CONNECTION OF ASSOCIATED INSTRUMENTS

4-1 INTRODUCTION

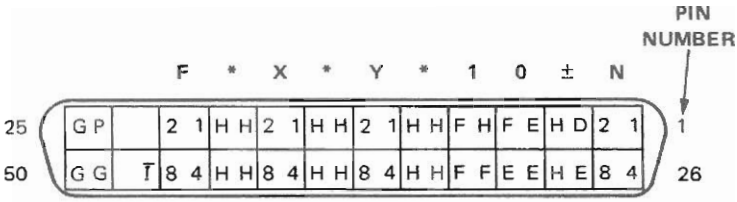
The outputs provided for external recording or display of the measurement results are described in this section. The outputs covered are for a printer, a chart recorder and a counter.

4-2 PRINTER

The printer output is designed for direct use with a Hewlett-Packard 5055A 50508 or 5150A printer. The information from flag signals and display is presented for a 10 column print out in the form:

F * X * Y * 10 ± N

Where F represent the flag information and the remaining digits represent a BER or COUNT display in the form X.Y x 10 ± n. The output information is in 8421 BCD form and print information between the error detector and printer is carried on two lines. The error detector Printer output socket connections are as follows:



PRINTER OUTPUT SOCKET AS VIEWED ON REAR PANEL

KEY

1, 2, 4, 8	BCD WEIGHTING
D	HIGH FOR + LOW FOR –
E	LOW EXCEPT DURING SYNC LOSS OR OVERFLOW FLAGS
F	LOW EXCEPT DURING SYNC LOSS OR OVERFLOW FLAGS
G	GROUND
H	PERMANENT HIGH
$\overline{T}$	$\overline{\text{INHIBIT}}$ 3780A COUNT CONTROL FROM PRINTER
P	PRINT COMMAND FROM 3780A TO PRINTER

The flag signal information is coded as follows:

PRINT OUT	FLAG
1	OVERFLOW
2	SYNC LOSS
3	CLOCK LOSS
4	DATA LOSS
V	LESS THAN 100 ERRORS

Note: On standard Hewlett-Packard 5055A and 5050B printers V is produced for decimal 13 or binary 1101 print commands.

The print command in the BER mode of operation is given at the termination of each measurement. The print command in COUNT MANUAL is given when the STOP switch is pressed and in COUNT EXTERNAL on receipt of a stop command from the printer. The print command is a TTL pulse and the minimum print cycle time is 500ms.

The counter normally restarts 400ms after the stop command however it is possible, with the change of an internal link, to hold the restart until the pulse at the PRINTER OUTPUT socket, pin 47, goes "low" ie the printer then controls both stop and start of the measurement.

4-3 RECORDER

The recorder output provides a high impedance current source output suitable for connection to a chart recorder. The output comprises 16 current levels with a total variation of 1mA into an impedance of 10K ohms max. Two pushbutton switches give Full scale and Zero outputs for setting up the recorder and there are internal adjustments for range 1mA ± 0.2mA and centre 0 to 0.5mA. The minimum response time is 500ms. The output levels are as follows:

Level 15 = FSD

BER operation	LEVEL	BER
	15	$<10^{-8}$
	14	$<10^{-7}$
	13	$<10^{-6}$
	12	$<10^{-5}$
	11	$<10^{-4}$
	10	$<10^{-3}$
	9	$<10^{-2}$
	8	$<10^{-1}$
	7	$\geqslant 10^{-1}$
	4	SYNC LOSS
	0	SIGNAL LOSS

COUNT operation	LEVEL	Information
	15	Signal without errors
	7	Signal with errors
	4	Sync Loss
	0	Signal Loss

Signal loss indicates clock loss when using an external clock and data loss when using recovered clock.

4-4 COUNTER

To make large error counts with greater resolution than is possible on the 3780A display an external counter may be connected to the rear panel ERROR output socket.
The output is one pulse per error, the pulse amplitude being 1V pk-pk minimum.
The output is inhibited during sync loss.

SECTION 5
MANUAL CHANGES

5-1 INTRODUCTION

Changes have been made to the model 3780A Pattern Generator/Error Detector which affect these operating instructions. Note the Serial Number Prefix of the instrument and make the changes specified in the following table:

Serial Prefix or Number	make change	Paragraphs
Below 1610U	1,2,3	5-2,5-3,5-4
1610U	2,3	5-3,5-4
1620U	3	5-4
1721U	NONE	
1739U-00436	4	5-5
1810U-00561	4,5	5-5,5-6
1901U	4,5,6	5-5,5-6,5-7
1915U-00946	4,5,6,7	5-5,5-6,5-7,5-8
1915U-00976	4,5,6,7,8	5-5,5-6,5-7,5-8,5-9

5-2 CHANGE 1

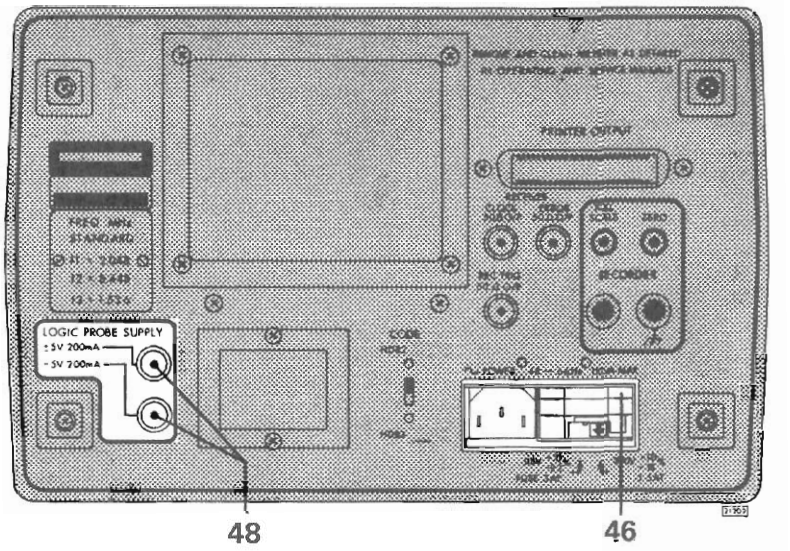
Power Input Module

Replace paragraph 1-6 page 6 with the following:

Before connecting to the supply check that the correct voltage range has been selected and that the correct fuse is fitted. The voltage range is selected with a lever in the rear panel input connector. To select the voltage range, slide the shutter over the connecting pins and expose the fuse compartment. Remove the line fuse by pulling the lever marked FUSE PULL. Set the voltage selector to the required range as indicated by the arrow on the selection lever and the ranges marked on the rear panel. Insert the correct fuse for the supply range selected as indicated on the rear panel. Slide the shutter over the fuse compartment to expose the connecting pins. The instrument is now ready for connection to the supply.

Replace the power controls and connectors (rear panel) diagram, Paragraph 2-10, page 42 and their description (46) page 43 with the following:

(46) The POWER INPUT module comprises a supply voltage selection switch, the supply fuse and a socket for the power supply cable. Details of setting the supply voltage switch and fuse selection are given on page 6 Paragraph 1-9.



5-3
CHANGE 2
Systematic
Error
Detection

Replace the Pattern Selection part of paragraph 1-15, page 10 with the following:

Pattern Selection

Three maximal length pseudo random binary sequences (PRBS) or length 511, 32767 and 1048575 bits and five four-bit repetitive word patterns are produced by the generator. The PRBS generator may also be used to generate random repetitive word patterns of length 9, 15 or 20 bits.

Option 001 provides a front panel programmable, 16 bit word in place of the five four-bit and random repetitive word patterns. This can also provide two 8 bit words alternated by an external signal applied via the rear panel.

Up to 999 zeros can be added once per sequence to all of the selectable patterns.

The error detector automatically recognises and reproduces a synchronous error-free version of any PRBS or WORD pattern produced by the generator, including $\overline{\text{PRBS}}$ but excluding those patterns containing added zeros or alternating words (option 001). An indication of receive pattern lock is given by LED lamps. A manual override on the automatic sync is provided which forces a Sync Loss; when released the instrument reverts to automatic synchronisation.

Replace item (7) of the Generator Pattern Controls 2-3, page 28 with the following:

(7) The PATTERN SELECTION switch selects the pattern to be generated from fixed four bit words:

0000, 1000, 1010, 1100, 1111 or the value of n: 9, 15, 20. The value of n selected may be used to produce an n bit word or a $2^n - 1$ bit PRBS as selected with the $2^n - 1/n$ switch (8).

Replace item (29) of the Receiver Synchronisation and Sync Indicators 2-6, page 35 with the following:

(29) WORD Any word which is repetitive in blocks of 9, 12, 15, 16 or 20 bits.

Delete the final paragraph of item (31) Receiver Measurement Controls 2-7, page 37.

Replace item (37) Receiver Display and Flag Indicators 2-8, page 38 with the following:

(37) The SYNC LOSS flag indicates loss of receiver pattern synchronisation. The indicator is inhibited during code error and frequency offset measurement.

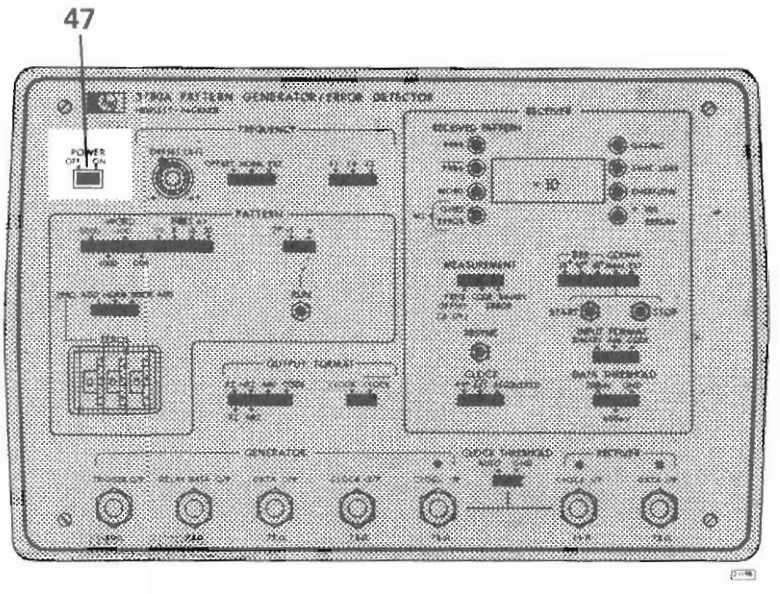
Replace item (50) Option Controls and Connectors 2-11, page 45 with the following:

(50) The PRBS/WORD switch selects the pattern to be generated. In the n = 9, 15 and 20 positions a maximal length PRBS of $2^n - 1$ is produced as for the standard instrument. In the n = 16 position the generator produces a repetitive 16 bit word whose content is selected with the WORD SELECT switches (52). In the ALT position the generator produces two 8 bit repetitive words A and B alternated by an external signal applied to the GEN ALT WORD I/P connector (51) on the rear panel. The word 'A' is selected by a positive going transition of the input signal and the word 'B' by a negative going transition.

Delete step (12) Binary or Code Error Measurements 3-2, page 47.

5-4
CHANGE 3
Power Supply for Line Amplifier 15509A

Replace the Power Controls and Connectors (front panel) diagram, paragraph 2-10, page 42 with the following:



Delete item (49), page 43

5-5
CHANGE 4

Receiver Specifications, Page 19.
Add to the CODE ERRORS specification the following:

HDB3/HDB2: Violations of Violations selectable with an internal switch.

Page 36, RECEIVER MEASUREMENT CONTROLS, Paragraph (31).
Add the following to the paragraph beginning, "In the CODE ERRORS position":
As an alternative to violations of the coding laws, it is possible with HDB2/HDB3 to measure violations of violations, where an error is registered for each bipolar violation which has the same polarity as the previous inserted violation.

An internal switch A34S1 selects between measurements of the coding law errors (VOCAB = vocabulary) and measurements of violations of violations (VIOL = violation of violations).

Page 47, BINARY OR CODE ERROR MEASUREMENTS.
Add the following to Paragraph (11):

(11a) For HDB2/HDB3 code errors, select vocabulary errors (VOCAB) or violation of violations (VIOL) with internal switch A34S1.

5-6 CHANGE 5 Options

Page 12, Paragraph 1-16 OPTIONS.
Add the following paragraph:-

Option 100 provides an equaliser and attenuator, operational at 34.368Mb/s when ternary coded data HDB2 or HDB3 is selected. The equaliser compensates for characteristic losses in interstation cable in the data path. $\sqrt{F}$ characteristic equalisation is introduced in the Receiver to compensate for up to 12dB cable losses at 17.184Mb/s from a 1V pk source. The attenuator is included in the Generator and provides the 1V pk source.

Page 23 OPTIONS and Page 46 OPTION 100.
Add the following to Option 100 specification:

OPTION 100: When the 3780A is used at F3 = 34.368Mb/s with a ternary coded output and input format, the following parameters apply.

DATA OUTPUT

Impedance;	nominal 75Ω to ground.
Amplitude;	± 1V ± 0.1V.
Zero Level;	0V ± 0.1V.
Transition Times;	< 4ns.
Overshoot;	< 10% pulse amplitude.

DATA INPUT

Rate;	nominal 34.368Mb/s.
Impedance;	nominal 75Ω to ground.
Equalisation,	Automatic $\sqrt{F}$ equalisation for cable losses up to 12dB at Fc/2 from a 1V pk source
Format;	Ternary coded HDB2 or HDB3.
Amplitude;	3V pk maximum.
Indicator;	LED illuminated if data transitions present.

Page 32/33, Paragraph (21).
Add the following:
If on instruments fitted with Option 100 (F3 equaliser and attenuator) FREQUENCY F3 and CODE are selected, the DATA THRESHOLD switch should be set to "200mV".

5-7
CHANGE 6
Sync Loss:

Page 18, Synchronisation specification.
Add the following to the "Sync Loss" paragraph.
Greater than approx. 20,000 errors in 500,000 clock periods with switch selectable override. Automatic sync loss can be disabled by internal manual SYNC LOSS switch A37S3.

Page 20.
Add the following to the "Sync Loss" specification.
Sync loss mechanism may be overridden by internal manual SYNC LOSS switch A37S3.

Page 34, Paragraph 26.
Add the following paragraph:
(26a) Synchronisation will be maintained until greater than 20,000 errors are accumulated in 500,000. clock periods. This criteria can be overridden by internal manual SYNC LOSS switch A37S3 set to ON, so that up to 100% errors may be accumulated. During instrument normal operation A37S3 is set to OFF.

5-8
CHANGE 7

Page 18, Receiver "Patterns" specification:
Change reference to "ALL ONES ZEROS" indicator to "AIS".

Page 20, Printer Output (rear panel) specification:
Include the following additional value for "Flags":

F = A for AIS

Page 21, Recorder Output (rear panel) specification:
Delete the specifications for BER and COUNT.
Add the following specifications for BER and COUNT.

BER:

Thirteen level signal

FSD = level 15	BER $<10^{-8}$
14	$<10^{-7}$
13	$<10^{-6}$
12	$<10^{-5}$
11	$<10^{-4}$
10	$<10^{-3}$
9	$<10^{-2}$

8	$<10^{-1}$
7	$<10^{-0}$
6	$= 10^{0}$
4	SYNC LOSS
2	AIS
0	SIGNAL LOSS

COUNT: Five level signal

Levels		Reference	
FSD =	15	Signal no errors	} except AIS
	7	Signal plus errors	}
	4	SYNC LOSS	
	2	AIS	
	0	SIGNAL LOSS	

Page 34/35 SYNC AND SYNC INDICATORS.
Delete paragraphs (29) and (30).
Add new paragraphs (29) and (30) as follows:

(29) WORD Any word which is repetitive in blocks of 9, 12, 15, 16, 20 bits including ALL ZEROS (any word with less than 4 ones in 100 clock periods).

(30) AIS ALARM INDICATION SIGNAL, being all ones (any word sequence with less than 4 zeros in 100 clock periods).

Page 52, Printer Flag signal information.
Include the additional value for "Flags":

F = A for AIS

Page 52, Paragraph 4-3, RECORDER.
Delete the specification for BER and COUNT operation.
Add new specification for BER and COUNT operation as follows:
BER Thirteen level signal.

BER Operation	Levels	BER
FSD	15	$<10^{-8}$
	14	$<10^{-7}$
	13	$<10^{-6}$
	12	$<10^{-5}$
	11	$<10^{-4}$
	10	$<10^{-3}$
	9	$<10^{-2}$
	8	$<10^{-1}$

7	$<10^{-0}$
6	$= 10^{0}$
4	SYNC LOSS
2	AIS
0	SIGNAL LOSS

COUNT Five level signal.

COUNT

Operation	Levels	Reference	
FSD	15	Signal no errors	except AIS
	7	Signal plus errors	except AIS
	4	SYNC LOSS	
	2	AIS	
	0	SIGNAL LOSS	

5-9 Page 12, Paragraph 1-16.

CHANGE 8 Add the following paragraph to Option 101 description only.

OPTION 101 Option 101 provides an equaliser and line build out network, operational at 44.736Mb/s when ternary coded data (B6ZS or B3ZS) is selected. The equaliser compensates for characteristic losses in interstation cable in the data path. $\sqrt{F}$ characteristic equalisation is introduced in the Receiver to compensate for up to 12dB cable losses at 22.368Mb/s (Fc/2) from a 0.909V pk source. The line build out network provides at the Generator DATA O/P a shaped output pulse which conforms to CCITT pulse mask (Rec. G.703.4). The shape of the data output waveform is equivalent to a 0.909V pk ternary coded data waveform transmitted through 450ft of 75Ω cable.

Page 23, OPTIONS/Page 46, OPTION 101.

Add the following to Option 101 specifications:

OPT 101 If the 3780A FREQUENCY is set to F3 and the Generator OUTPUT FORMAT and Receiver INPUT FORMAT set to CODE the following specifications apply.

Data Output (F3 coded)	Amplitude:	580mV ± 10%
	Shape:	Conforms with CCITT pulse width for co-axial pair interface at 44.736 Mb/s, (Rec. G.703.4).
	Impedance	Nominally 75Ω unbalanced
Receiver Data Input	Equalisation:	Automatic $\sqrt{F}$ equalisation for cable losses up to 12dB at Fc/2 (FC = 44.736) from a 0.909V pk source.

Rate.	44.736Mb/s nominal.
Impedance:	Nominally 75Ωunbalanced

Pages 32/33, Paragraph (21);
Add the following:
If on an instrument fitted with either Option 100 or 101 the FREQUENCY is set to F3, and the INPUT/OUTPUT FORMAT to CODE the DATA THRESHOLD switch should be set to "200mV".

HEWLETT PACKARD

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PRINTED IN U.K.