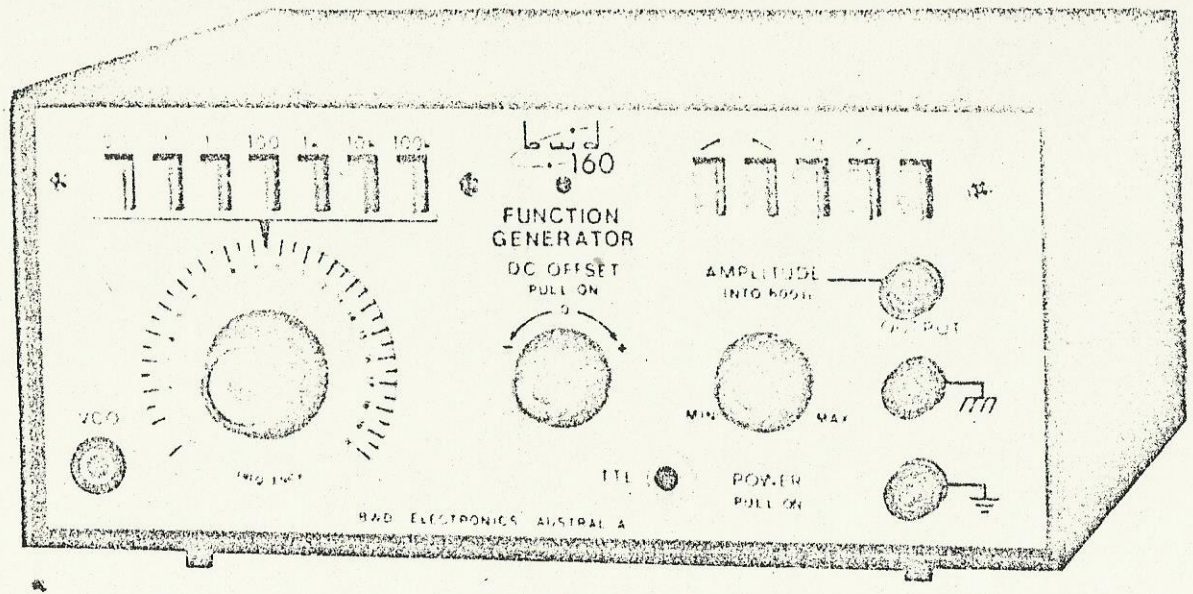
b.w.d

BWD ELECTRONICS

160

FUNCTION GENERATOR

INSTRUCTION MANUAL



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INSTRUMENT HANDBOOK

MODEL bwd 160

1. INTRODUCTION. Model bwd 160 is a small high performance Function Generator providing six simultaneous output signals and a wide variety of waveforms over a frequency range of 0.02Hz to 2MHz.

The three basic waveforms are sine, square and triangle, all of which are available simultaneously as fixed level outputs at the rear panel. The symmetry of all these outputs is normally 1:1, however, by push button selection 20:1 or 1:20 is available from all the fixed outputs. For the phase relationship between the fixed outputs see Section 4.

Any one of the nine possible waveforms can be selected to appear at the main output terminals by push button selection. The main output waveform can be adjusted in both amplitude and D.C. offset to any required value within the specification.

By connecting a voltage source to the V.C.O. input, the frequency of the output can be varied over four decades. A positive voltage increases the frequency producing up to 2 decades of control and a negative voltage decreases the frequency 2 decades. The maximum frequency on any range is that frequency indicated by 20 on the dial.

The auxiliary T.T.L. compatible output is also provided on the front panel, this can be used as a syncronising pulse, pen lift voltage, etc.

All outputs are floating with respect to ground and may be taken to ± 200V above ground.

2. PERFORMANCE.

2.1 FREQUENCY RANGE AND ACCURACY

0.02Hz to 2Hz	± 10% of full scale
0.2Hz to 20Hz	± 10% of full scale
2Hz to 200Hz	± 3% of full scale
20Hz to 2kHz	± 3% of full scale
200Hz to 20kHz	± 3% of full scale
2kHz to 200kHz	± 3% of full scale
20kHz to 2MHz	± 3% of full scale

2.2 FREQUENCY DIAL. Calibrated 1 to 20 with intermediate calibration points 1.0 per division. Also uncalibrated 0.2 point.

2.3 WAVEFORMS. Sine, Square, Triangle, T.T.L. output. Symmetry 1:1, or 20:1 or 1:20.

2.4 OUTPUTS.

(a) Main Outputs (front panel) 0-20V pp O/C 0 -10V pp into 600Ω.

(b) Auxiliary Outputs (rear panel) Sine, Square, Triangle > IV pp O/C, Zo = 1kΩ.

(c) Vernier control (main output only) > 100:1 range continuously variable.

2.5 D.C. OFFSET (Main Outputs only). 0 ± 10V O/C, 0 ± 5V into 600Ω. Maximum output not to exceed maximum D.C. offset.

2.6 SINE WAVE DISTORTION. <1% 10Hz to 200kHz. <2% 5Hz to 1MHz.

2.7 SQUARE WAVE RISE TIME. < 100n Sec into 600Ω and <15pf.

2.8 TRIANGULAR WAVE LINEARITY. <1% deviation from best straight line 1Hz to 100kHz.

2.9 SYMMETRY (all Outputs). <±2%.

2.10 LEVEL (All main outputs). ± 2% into 600Ω and <15pf 0.02Hz to 2MHz.

2.11 ISOLATED GROUND. Unit normally floating with 1MΩ paralleled with 0.47μF from instrument common to ground. Common may be raised to ± 200V above ground.

2.12 VOLTAGE CONTROL OF FREQUENCY. See Fig. 1.

2.13 T.T.L. OUTPUT RISE TIME. < 50n Sec.

2.14 OPERATING TEMPERATURE. The unit will remain within specification for an ambient temperature of + 10°C to + 35°C. For operation from 0°C to 50°C multiply all tolerances by 2.0.

2.15 POWER REQUIREMENTS. Two versions are available.

2.15 POWER REQUIREMENTS (continued)

100-137V bwd 160/115 200-265V bwd 160/230

2.16 DIMENSIONS, WEIGHT. 21 cm Wide, 9.5 cm High, 21 cm Deep, Weight 1.8Kgm.

3. CONTROLS AND THEIR FUNCTIONS.

3.1 FREQUENCY RANGE SWITCH. Seven decade ranges are available multiplying the dial frequency by 0.1 to 100,000.

3.2 FREQUENCY DIAL. Calibrated from 1 to 20, with an additional uncalibrated point at 0.2.

3.3 WAVEFORM SELECTOR. The three right hand buttons select either square, triangle or sine wave output to appear at the front panel output terminals. The two left hand buttons select the symmetry of the output and alter all outputs simultaneously.

3.4 AMPLITUDE CONTROL AND POWER SWITCH. By pulling the knob outward the power switch is on and rotation of the knob varies the amplitude of the selected waveform appearing at the output terminals.

3.5 D.C. OFFSET CONTROL. A D.C. offset can be applied to the output by pulling the knob outwards and rotating the knob to produce the required D.C. Level. Pushing the knob in de-activates the control.

3.6 POWER INDICATOR. A L.E.D. inserted in one of the low voltage supplies indicates when power is being applied to the circuit. If the fuse blows the indicator will not glow.

3.7 OUTPUT TERMINALS. The 4 mm output terminals supply a 20V p-p signal into an open circuit and 10V p-p into a 600Ω load.

3.8 VOLTAGE CONTROLLED OSCILLATOR INPUT TERMINAL. The frequency of the instrument can be controlled externally by applying a voltage between common and this terminal.

3.9 T.T.L. OUTPUT. A square wave output which is T.T.L. compatible is available at this terminal. NOTE: This output is referred to the COMMON terminal.

3.10 SQUARE WAVE OUTPUT. (Rear Panel)
Provides a 1V pp square wave of identical frequency and phase as the main output.

NOTE: This output is referred to the COMMON terminal on the front panel.

3.11 TRIANGLE WAVE OUTPUT. (Rear Panel)
Provides a 1V pp triangular wave of identical frequency and phase as the main output.

NOTE: This output is referred to the COMMON terminal on the front panel.

3.12 SINE WAVE OUTPUT. (Rear Panel)
Provides a 1V pp sine wave of identical frequency and phase as the main output.

NOTE; This output is referred to the COMMON terminal on the front panel.

3.13 MAINS FUSE. (Rear Panel)
A 100mA Delay fuse connected in series with the primary of the power transformer.

4. OPERATION.

4.1 Check that the instrument is fitted with a transformer suitable for the mains supply. (i.e. 240V or 110V).

4.2 Check that the fuse rating on the rear panel is correct.

4.3 Connect the instrument to the mains supply and switch on. The power on indicator should now light up.

4.4 See figures 2,3,4, 5 and 6 for wave-forms available at the output sockets.

4.5 OPERATION OF V.C.O. Set the controls as follows. Frequency Control to 0.2. Frequency range to x 10kHz. Waveform Selector to sine.

With the DC input equal to zero, the output frequency will be approximately 2KHz. Increasing the D.C. input to + 10V will increase the output frequency to approx. 200kHz. Decreasing the D.C. input to 0.1V will decrease the output frequency to approx. 20 Hz. For the graph of frequency versus D.C. input see Fig. 1.

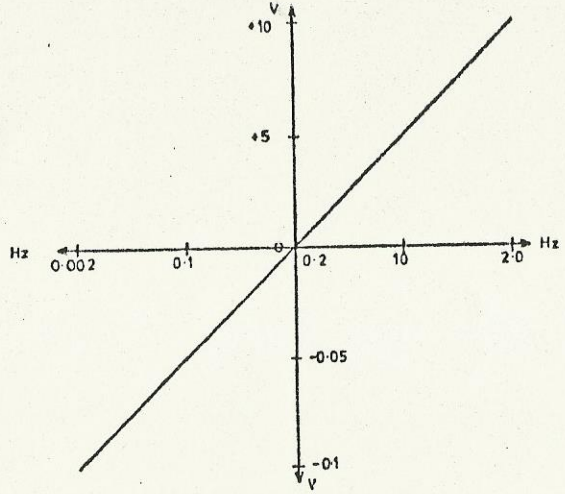


FIG. 1 VCO CHARACTERISTIC

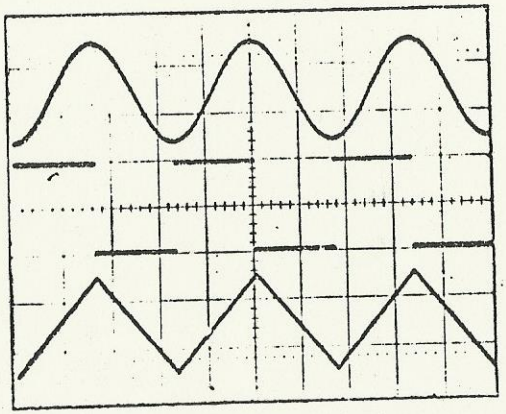


FIG. 2 WAVE FORM PHASE RELATIONSHIPS

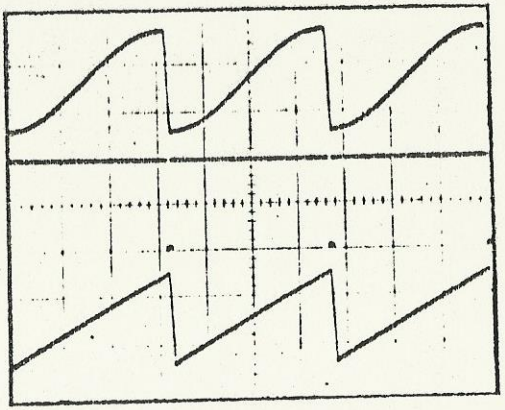
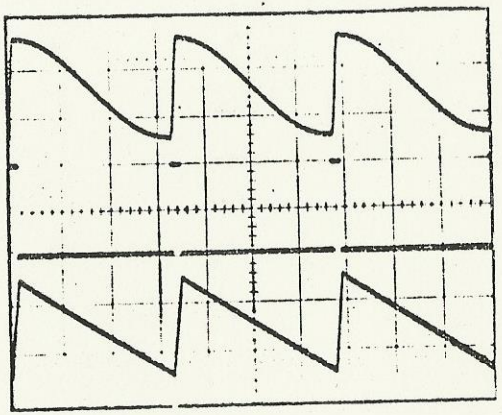


FIG. 3 WAVE FORMS WITH 20:1 SYMMETRY.

FIG. 4 WAVE FORMS WITH 1:20 SYMMETRY.



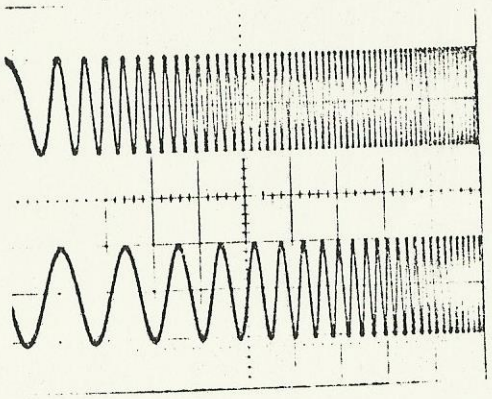
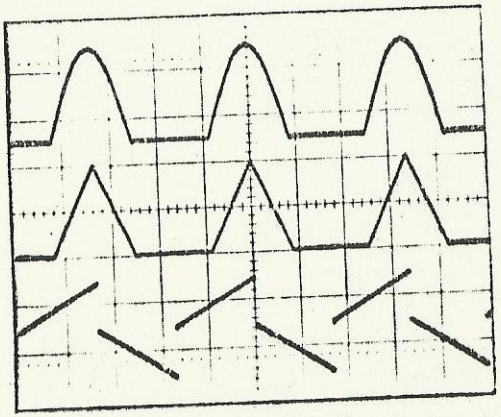


FIG. 5 FREQUENCY SWEEP WITH LINEAR & LOG RAMPS

FIG. 6 MISCELLANEOUS WAVE FORMS - SINE & TRIANGLE WITH DC OFFSET - TRIANGLE & SQUARE SELECTED SIMULTANEOUSLY.



4.6 If a negative going ramp is required to control the frequency, set the desired maximum frequency by the frequency control dial and a negative going ramp will decrease the frequency. A 10V ramp will sweep the frequency from the maximum as set on the dial to two decades lower. Examples of linear and logarithmic sweep are shown in Fig. 5.

5. CIRCUIT DESCRIPTION.

5.1 TRIANGLE AND SQUARE WAVE GENERATOR.

The frequency control voltage from RV2 is taken via U1 and U2 to appear as two equal but opposite voltages to drive the current sources Q1 - Q4. Q3, Q4 and R13 are connected to form a negative current source which always has twice the magnitude of the positive current source. D1 and D2 form a switch which allows the negative current to either be passed to the timing capacitors C 1 to C7 or absorbed by the switch. The timing capacitors see either + 1 or + 1 + (- 2 1) = - 1.

5.1 TRIANGLE AND SQUARE WAVE GENERATOR. (continued)

The waveform at the timing capacitors is taken via buffer amplifier Q5 and Q6 to the comparator U3 which directly drives the current switch D1 and D2. A Triangular waveform is present at the output of Q5 and Q6 and a square wave at the output of U3.

The T.T.L. output is also taken from U3.

5.2 SINE WAVE CONVERTOR. U4 takes the triangular wave and converts it to a sine wave whose D.C. level, amplitude and distortion can be adjusted by RV5, 6, 7 and 8.

5.3 BUFFER AMPLIFIERS. Each of the three waveforms ggenerated are passed through unity gain amplifiers to enable loading changes to take place without altering frequency or the waveshape of the waveforms. An output is taken from each of the buffer amplifiers via a 1000Ω resistor providing all three basic waveforms simultaneously at the rear panel.

5.4 OUTPUT AMPLIFIER. The triangle, square and sine wave outputs of the buffer amplifiers are selected by S4 waveform selector switch and the output amplitude is set by RV10.

Q13 and Q14 differential amplifier and Q15, Q16 output stage form a fixed gain wideband amplifier. DC offset is applied to Q14 base from RV15 and R78.

5.5 POWER SUPPLIES. The secondary of the power transformer is rectified and filtered to provide ± 25V unregulated. These voltages are used to supply the output amplifier and the regulated supplies.

U5 dual tracking regulator is used to provide the ± 15V regulated rails.

Zener diode D13 and transistor Q18 provide + 6V and D12, Q17 provide - 6V.

6. ALIGNMENT.

WARNING

DANGEROUS VOLTAGES EXIST AT SEVERAL POINTS THROUGHOUT THIS INSTRUMENT. WHEN OPERATING WITH THE COVERS REMOVED DO NOT TOUCH EXPOSED CONNECTIONS OR COMPONENTS. ALWAYS DISCONNECT THE INSTRUMENT FROM THE POWER OUTLET BEFORE CLEANING, SOLDERING AND REPLACING PARTS.

6.1 TEST INSTRUMENTS REQUIRED.

Multimeter	D.C. Voltage to > 20V
Oscilloscope	"Y" Bandwidth DC to > 5MHz
	"Y" Sensitivity at least 1V/cm
Digital Frequency Meter	1Hz to > 2MHz
Distortion Analyser	Frequency Range 5Hz-1MHz.

6.2 COVER REMOVAL.

The top cover is removed by first removing the screws on each side of the instrument and then lifting the cover vertically away from the instrument. The bottom cover is removed by removing the two screws in the bottom cover and then lifting away from the instrument. Fitting of the covers is the reverse of the above procedure.

6.3 D.C. VOLTAGE RAILS.

Before attempting any adjustments the following D.C. Voltages must be checked.

+ 15V ± 1V -15V ±1V +6V -1 +0.5V

-6V - 1 + 0.5V

Should any one of these voltages be incorrect the appropriate regulator section should be investigated for faults.

6.4 MECHANICAL SETTING OF THE DIAL.

Turn the dial to the max. clockwise position. Loosen the grub screw knob and set the dial so that the 0.2 calibration mark is ajacent to the arrow on the front panel.

6.4 MECHANICAL SETTING OF THE DIAL (continued)

Tighten the grub screw.

When the dial is turned to the maximum counter clockwise position the 20 calibration point should be 1cm ±0.5cm to the left of the arrow.

6.5 FREQUENCY CALIBRATION. (a) Set dial to 20. (b) Note the frequency on each of the ranges x10, x100, x1 kHz and x10kHz (c) Using the range which appears to have an average frequency, set RV1 for the correct frequency with dial still at 20. (d) Using the same range as in (c) set RV 3 for correct frequency with the dial at 1. Repeat (c) and (d) as necessary for correct calibration. (e) Adjust RV4 for equal symmetry on the triangular waveform.

Select x100kHz dial to 20 and adjust CV1 to 2MHz ± 1.5% Adjust RV16 for zero volts offset at the output terminals, with output amplitude control set to zero.

6.6 SINE WAVE DISTORTION ADJUSTMENT. (a) Set the waveform selector to ∿ and the amplitude to maximum. Place a 600Ω load across the terminals and connect the distortion analyser across the 600Ω load. (b) Set the frequency range to x10kHz and the dial to 10, i.e. a frequency of 100kHz. (c) Adjust RV7 so that the output signal swings equally about the common voltage (d) Adjust RV8 to give approx. 10V pp output. (e) Since RV5 and RV6, distortion presents, interact with one another, first one and then the other must be set to give minimum distortion, the procedure being repeated until no further improvement can be gained.

6.7 OUTPUT LEVEL PRESETS. (a) Set the frequency range to x100Hz and the dial to 10. Select ∿ and set the output amplitude control to maximum clockwise. (b) adjust RV9 to produce 21 to 22V pp output into an open circuit or 10.5 to 11V pp into 600Ω when measured at the output terminal. (c) Select ⏦ and set RV8 for the same level as RV9.

NOTE: Use an oscilloscope to set these output levels.

MAINTENANCE

7. REPLACEMENT PARTS. Spares are normally available from the manufacturer B.W.D. Electronics Pty. Ltd. When ordering it is necessary to indicate the model and serial number of the instrument. If exact replacements are not to hand locally available alternatives may be used provided they possess a specification not less than, or physical size not greater than the original components.

Several semi-conductors in Model bwd 160 have been factory selected for the particular position they occupy. It is most important that the handbook parts list, Section B be consulted before replacing any semi-conductors since selected or matched devices can ONLY be obtained from the manufacturer B.W.D. Electronics Pty. Ltd.

As the policy of B.W.D. Electronics Pty. Ltd., is one of continuing research and development, the Company reserves the right to supply the latest equipment and make amendments to circuits and parts without notice.

160 PARTS LIST

DESCRIPTION					PART NO.	SUPPLIER
C1	220µF	3.15V	10%	TANT	Type TAD	Soanar
C2	22µF	16V	10%	TANT	Type TAD	Soanar
C3a	1µF	200V	10%	PYE	Type N	Soanar
C3b	1µF	200V	10%	PYE	Type N	Soanar
C3c	200nF	100V	10%	PYE	Type N	Soanar
C4	220nF	100V	10%	PYE	Type N	Soanar
C5	22nF	100V	10%	PYE	Type N	Soanar
C6	2µ2	100V	10%	PYE	Type N	Soanar
C7	150pF	630V	10%	PYS		Allied
C8	100nF	63V		CDS		
C9	100nF	63V		CDS		
C10	100nF	63V		CDS		
C11	100nF	63V		CDS		
C12	1000µF	25V		Elec.	Type RB	Soanar
C13	1000µF	25V		Elec.	Type RB	Soanar
C14	10nF	100V	10%	PYE	Type N	Soanar
C15	10nF	100V	10%	PYE	Type N	Soanar
C16	10µF	16V	10%	Ta	Type TAD	Soanar
C17	10µF	16V	10%	Ta	Type TAD	Soanar

DESCRIPTION					PART NO.	SUPPLIER
C18						
C19						
C20	10µF	16V	10%	Ta	Type TAD	Soanar
C21	10µF	16V	10%	Ta	Type TAD	Soanar
C22	10µF	16V	10%	Ta	Type TAD	Soanar
C23	100µF	63V		CDS		
C24	470nF	630V	10%	PYE	Type N	
CV1	10-40pF	Variable		CER	10S-06	Stetner
CV2	4-20pF	Variable		CER	10S-06	Stetner
RV1	5K	Preset			PT10V	PIHER
RV2	10K	2W w/w Variable			-	AGN
RV3	5K	Preset			PT10V	PIHER
RV4	100	Preset			PT10V	PIHER
RV5	1K	Preset			PT10V	PIHER
RV6	5K	Preset			PT10V	PIHER
RV7	220	Preset			PT10V	PIHER
RV8	4K7	Preset			PT10V	PIHER
RV9	470	Preset			PT10V	PIHER
RV10	1K	Variable cw DPST pp sw				PIHER
RV11	20K	Preset			PT10V	PIHER

PARTS LIST - 160 (continued)

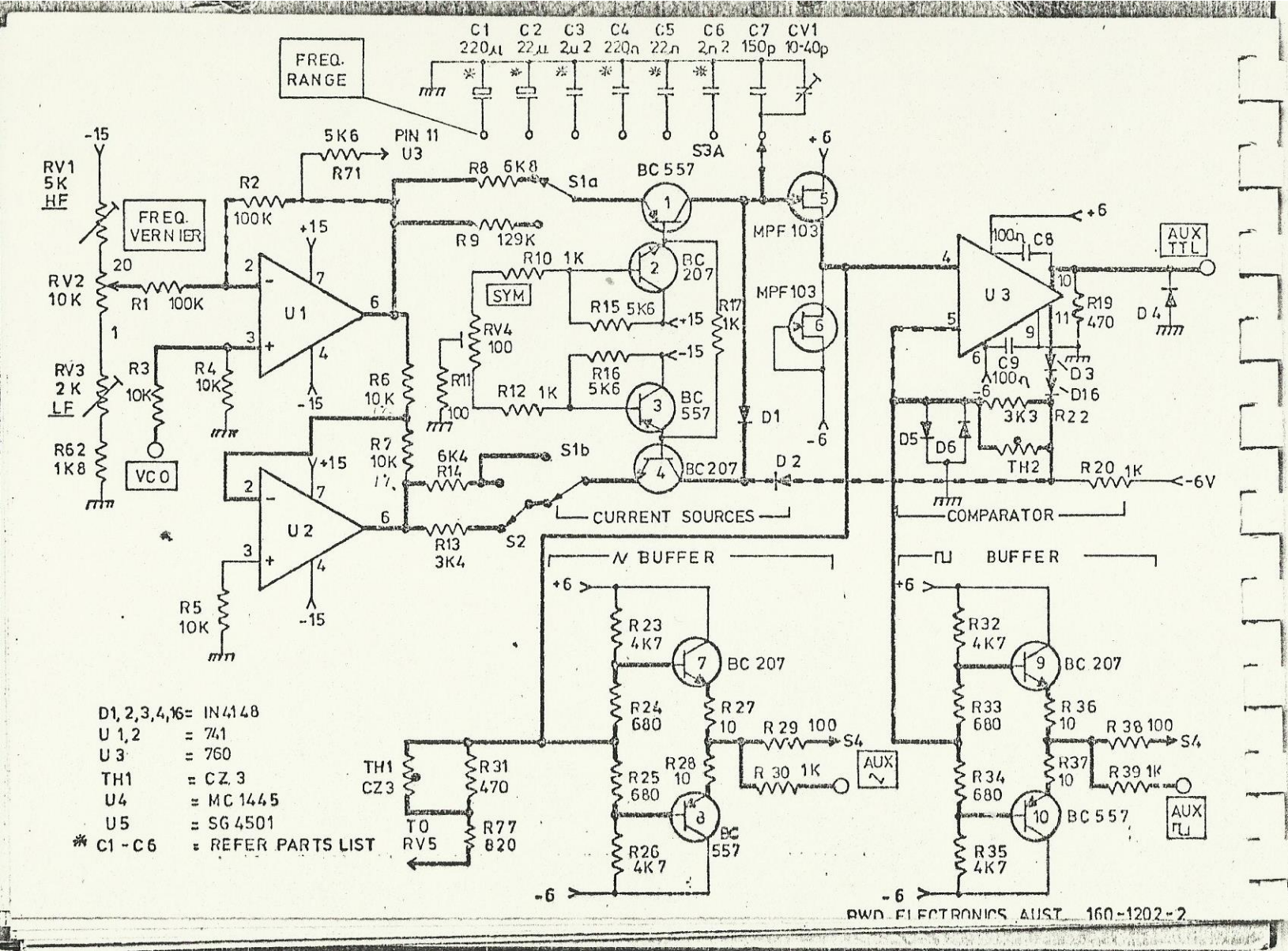
DESCRIPTION				PART NO.	SUPPLIER
RV12	20K	Preset		PT10V	PIHER
RV13	20K	Preset		PT10V	PIHER
RV14	20K	Preset		PT10V	PIHER
RV15	10K	Variable cw DPST pp sw			ELNA
RV16	22K	Preset		PT15H	PIHER
S1) S2) S4)	5 BANK	ISOSTAT		SR 121	bwd
S3	7 BANK	ISOSTAT		SR 82	bwd
S5	On Rear of RV15				
S101	On Rear of RV10				
T1	Power Transformer			T144A	bwd
TH1	Thermistor			CZ3	STC
TH2	Thermistor			CZ3	STC
F100	FUSE	100mA	Delay	3Ag	

All Resistors are 1/4 WATT 5%
Unless otherwise indicated.

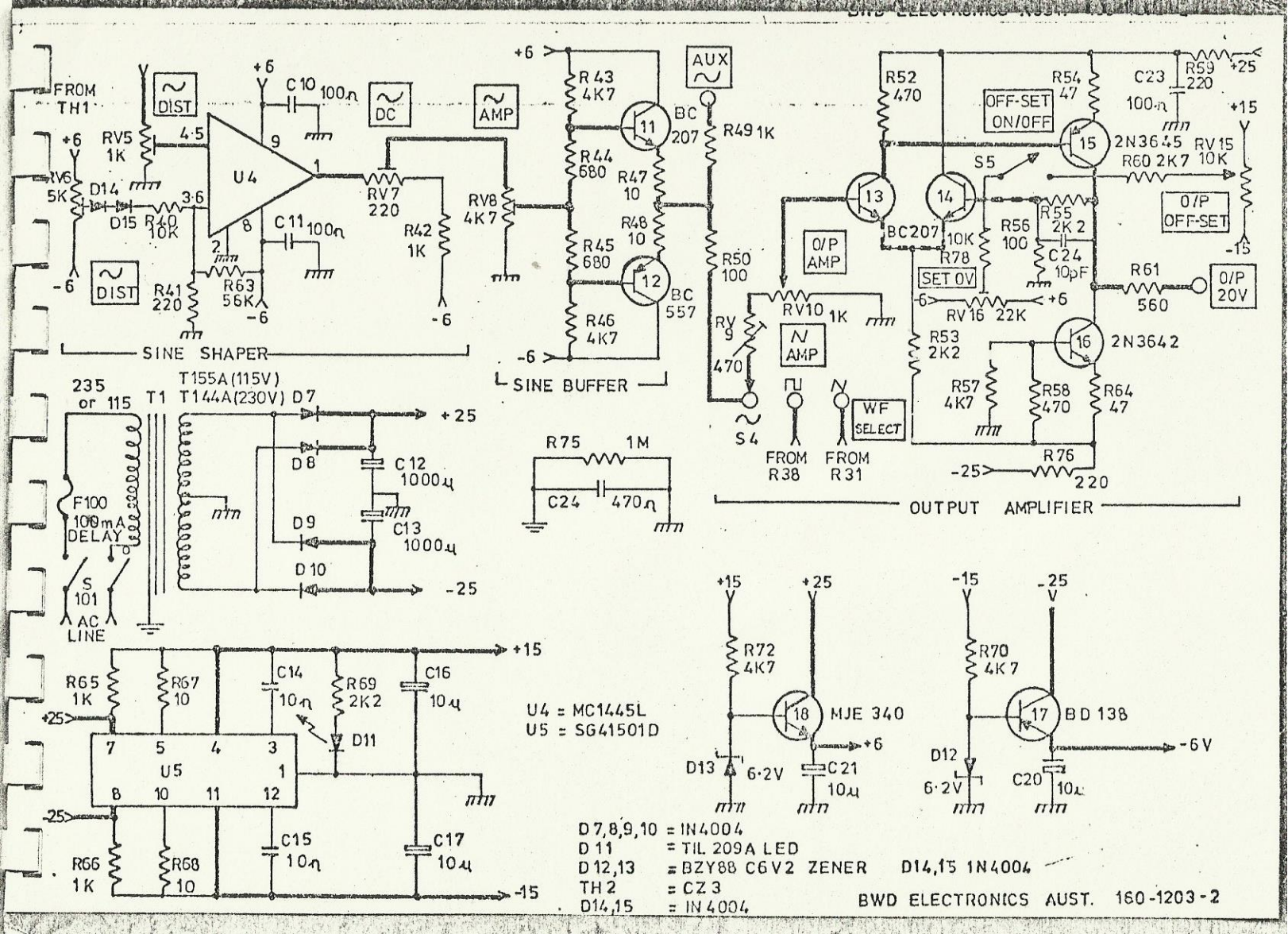
R1	100K		R17	1K		R36	10		R55	2K2	
R2	100K		R18	100		R37	10		R56	100	
R3	10K		R19	470		R38	100		R57	4K7	
R4	10K		R20	100		R39	1K		R58	470	
R5	10K		R21	470		R40	10K		R59	220	
R6	10K		R22	470		R41	100		R60	2K7	
R7	10K	1%	R23	4K7		R42	1K		R61	560	
R8	6K8	1%	R24	680		R43	4K7		R62		
R9A	12K	1%	R25	680		R44	680		R63		
R9B	8K2	1%	R26	4K7		R45	680		R64	47	
R10	1K		R27	10		R46	4K7		R65	1K	
R11	100		R28	10		R47	10		R66	1K	
R12	1K		R29	100		R48	10		R67	10	
R13A	6K8	1%	R30	1K		R49	1K		R68	10	
R13B	6K8	1%	R31	1K		R50	100		R69	2K2	
R14A	6K8	1%	R32	4K7		R51	1K		R70	4K7	
R14B	120K	1%	R33	680		R52	470		R72	4K7	
R15	5K6		R34	680		R53	2K2		R74	100	
R16	5K6		R35	4K7		R54	47		R75	1M	
									R76	220	
									R77	470	

PARTS LIST - 160 (continued)

D1	IN4148
D2	IN4148
D3	IN4148
D4	IN4148
D5	IN4148
D6	IN4148
D7	IN4004
D8	IN4004
D9	IN4004
D10	IN4004
D11	TIL 209A LED
D12	BZY88/C6V2 Zener
D13	BZY88/C6V2 Zener
D14	IN4004
D15	IN4004
Q1	BC557
Q2	BC207
Q3	BC557
Q4	BC207
Q5	MPF 103) matched
Q6	MPF 103) pair
Q7	BC 207
Q8	BC 557
Q9	BC 207
Q10	BC 557
Q11	BC 207
Q12	BC 557
Q13	BC 207
Q14	BC 207
Q15	2N3645
Q16	2N3642
Q17	BD138
Q18	MJE 340
U1	741
U2	741
U3	760
U4	MC1445L
U5	SG41501D



D1, 2, 3, 4, 16= IN4148
U 1, 2 = 741
U 3 = 760
TH1 = CZ. 3
U4 = MC 1445
U5 = SG 4501
* C1 - C6 = REFER PARTS LIST


FROM TH1
DIST
+6
C10 100n
DC
AMP
RV5 1K
RV6 5K
D14
D15
R40 10K
U4
4·5
9
1
3·6
8
2
C11 100n
RV7 220
R42 1K
RV8 4K7
R41 220
R63 56K
-6
DIST
SINE SHAPER
R43 4K7
R44 680
R45 680
R46 4K7
R47 10
R48 10
11
12
BC 207
BC 557
SINE BUFFER
AUX
R49 1K
R50 100
RV9 470
RV10 1K
N AMP
O/P AMP
S4
FROM R38
FROM R31
WF SELECT
R52 470
R54 47
C23 100n
R59 220
+25
+15
OFF-SET ON/OFF
15
2N3645
RV15 10K
R60 2K7
S5
13
14
BC207
R55 2K2
R56 100
10K
R78
SET 0V
RV16 22K
C24 10pF
O/P OFF-SET
R61 560
O/P 20V
16
2N3642
R53 2K2
R57 4K7
R58 470
R64 47
R76 220
OUTPUT AMPLIFIER
235 or 115
T1
T155A(115V)
T144A(230V)
D7
D8
D9
D10
C12 1000µ
C13 1000µ
F100 100mA DELAY
S 101
AC LINE
R75 1M
C24 470n
R65 1K
R67 10
C14 10n
R69 2K2
C16 10µ
D11
U5
C15 10n
C17 10µ
R66 1K
R68 10
U4 = MC1445L
U5 = SG41501D
R72 4K7
18
MJE 340
D13 6·2V
C21 10µ
R70 4K7
17
BD 138
D12 6·2V
C20 10µ
D7,8,9,10 = IN4004
D 11 = TIL 209A LED
D 12,13 = BZY88 C6V2 ZENER
TH2 = CZ 3
D14,15 = IN4004
D14,15 1N4004
BWD ELECTRONICS AUST. 160-1203-2