CX1937, CX1937X
Oil Cooled, Deuterium Filled, Three-Gap Metal/Ceramic Thyratron

The data to be read in conjunction with the Hydrogen Thyratron Preamble.

ABRIDGED DATA

Deuterium-filled, solid anode, three-gap thyratrons with metal/ ceramic envelope, suitable for switching high peak and average power at high pulse repetition rates.

The CX1937X, which must be used in conjunction with TE2V resistor box MA942A, permits a larger variation in internal deuterium pressure than the CX1937.

Resistor box settings and/or reservoir heater voltage can be adjusted within the specified limits to obtain the maximum thyratron gas pressure consistent with the required voltage hold-off

Peak forward anode voltage	-	80 kV max
Peak forward anode current	-	10 kA max
Peak reverse anode current	-	10 kA max
Average anode current	-	10 A max
Operating frequency	-	5 kHz max

GENERAL DATA

Electrical

Cathode	-	Barium aluminate impregnated tungsten
Cathode heater voltage (see note 1)	-	6.3 ± 5%
Cathode heater current	-	90 A
Reservoir heater voltage (see notes 1 and 2)	-	6.3 ± 5%
Reservoir heater current	-	7.0 A
Tube heating time (minimum)	-	10 min
Anode to upper gradient grid capacitance	-	50 pF
Lower gradient grid to grid 2 capacitance	-	40 pF
Upper to lower gradient grid capacitance		60 pF

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Mechanical

Seated height	-	348 mm max
Clearance required below mounting flange	-	75 mm min
Overall diameter (excluding		6.000 inches max
Net weight	-	27.6 pounds approx.
Mounting position	-	See note 3
Tube connections	-	See outline

Cooling

The tube must be cooled by total liquid immersion, for example in force-circulated transformer oil (see E2V Technologies Technical Reprint No. 108 'The cooling of oil-filled electrical equipment, with special reference to high power line-type pulse generators' by G. Scoles). Care must be taken to ensure that air is not trapped inside the tube end cover.In addition to 600 W of heater power, the tube dissipates several hundred watts per ampere of average current, and this must be taken into account when determining cooling requirements.

PULSE MODULATOR SERVICE

MAXIMUM AND MINIMUM RATINGS

These ratings cannot necessarily be used simultaneously, and no individual rating must be exceeded.

Anode		**Min**	**Max**	
Peak forward voltage (see note 4)	.	-	80	kV
Peak inverse anode voltage	.	See note 5		
Peak forward anode current	.	-	10	kA
Average anode current	.	-	10	A
Rate of rise of anode current	.	See notes 6 and 7		

Triggering

For maximum life and minimum grid spike, these thyratrons should be triggered with a pre-pulse on grid 1.

Grid 2		**Min**	**Max**	
Unloaded grid 2 drive pulse voltage (see note 8)	.	1000	2000	V
Grid 2 pulse duration	.	1.0	-	µs
Rate of rise of grid 2 pulse (see notes 6 and 9)	.	10	-	kV/µs
Grid 2 pulse delay (see note 10)	.	0.5	3.0	µs
Peak inverse grid 2 voltage	.	-	450	V
Loaded grid 2 bias voltage (see note 11)	.	-50	-200	V
Peak trigger pulse drive current	.	5	40	A

Grid 1 – Pulsed		**Min**	**Max**	
Unloaded grid 1 drive pulse voltage	.	600	2000	V
Grid 1 pulse duration	.	2.0	-	µs
Rate of rise of grid 1 pulse	.	1.0	-	kV/µs
Peak inverse grid 1 voltage	.	-	450	V
Loaded grid 1 bias voltage	.	See note 12		
Peak grid 1 drive current (see note 13)	.	5.0	100	A

Grid 1 – DC Primed		**Min**	**Max**	
DC grid 1 unloaded priming voltage	.	75	450	
DC grid 1 priming current	.	0.50	2.0	A

Cathode		**Min**	**Max**	
Heater voltage	.	6.3 ± 5%		V
Heating time	.	10	-	min

Reservoir		**Min**	**Max**	
Heater voltage (see note 1)	.	6.3 ± 5%		V
Heating time	.	10	-	min

Environmental		**Min**	**Max**	
Ambient air temperature	.	0	+40	°C

CHARACTERISTICS

	Min	Typ	Max	
Critical DC anode voltage for conduction .	-	2.0	5.0	kV
Anode delay time .	-	200	250	ns
Anode delay drift time (see note 14) .	-	15	25	ns
Time jitter (see note 15) .	-	5.0	15.0	ns
Recovery time .		See note 16		
Cathode heater current (at 6.3 V) .	80	90	100	A
Reservoir heater current (at 6.3 V) .	6.0	7.0	8.0	A

NOTES

It is recommended that the cathode heater and the reservoir heater are supplied from independent power supplies. The common connection for these two supplies is the pair of yellow sleeved leads, not the cathode flange.

N.B. The tube will suffer irreversible damage if the cathode flange is connected as the common point.

The cathode heater supply must be connected between the cathode flange and the cathode heater leads (yellow sleeves), the reservoir heater supply must be connected between the cathode heater leads (yellow sleeves) and the reservoir heater lead (red sleeve), see Figs. 1 and 2. In order to meet the jitter specification, it may be necessary in some circumstances that the cathode heater be supplied from a DC source.

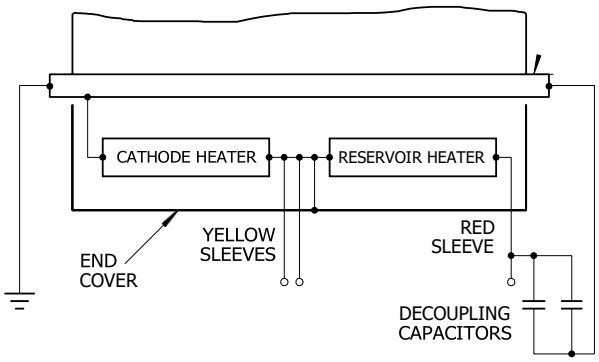


Fig. 1 CX1937 base connections

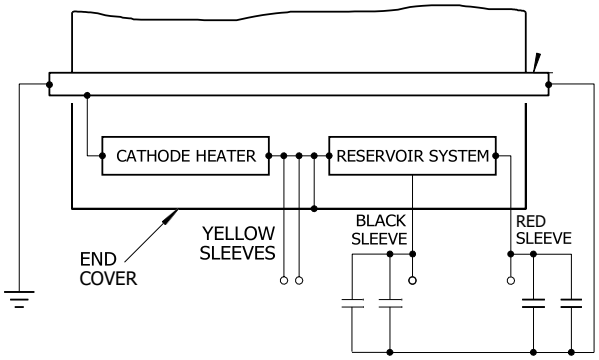


Fig. 2 CX1937X base connections

Care should be taken to ensure that excessive voltages are not applied to the reservoir heater circuit from the cathode heater supply because of high impedance cathode heater connections. For example, in the worst case, an open circuit heater lead will impress almost double voltage on the reservoir heater, especially on switch-on, when the cathode heater impedance is minimal. This situation can be avoided by ensuring that the two supplies are in anti-phase. The reservoir heater circuit must be decoupled with suitable capacitors, for example, a 1 µF capacitor in parallel with a low inductance 1000 pF capacitor.
The heater supply systems should be connected directly between the cathode flange and the heater leads. This avoids the possibility of injecting voltages into the cathode and reservoir heaters. At high rates of rise of anode current, the cathode potential may rise significantly at the beginning of the pulse, depending on the cathode lead inductance, which must be minimised at all times. If a single transformer is used to supply both the cathode heater and the reservoir heater, then the reservoir heater lead (red sleeve) must be connected to the mounting flange

1. CX1937X gas pressure may be altered using Teledyne e2v resistor box type MA942A. The CX1937X **must** be used in conjunction with the MA942A. The resistor box must be connected between the reservoir gas pressure control lead (black sleeve) and the cathode heater lead (yellow sleeve). Gas pressure may be increased by increasing the resistor box settings from their initial recommended values which are marked on the gas pressure control lead. The gas pressure may be increased to a value consistent with the required forward hold-off voltage. Additional variations in gas pressure can be achieved by altering the reservoir power supply voltage within the specified range.

2. The tube must be fitted using its mounting flange. The preferred orientation is with the tube axis vertical and anode uppermost; mounting the tube with its axis horizontal is permissible. The tube should not be mounted with its axis vertical and cathode uppermost.

3. The maximum permissible peak forward voltage for instantaneous starting is 80 kV and there must be no overshoot.

4. The peak inverse voltage including spike must not exceed 10 kV for the first 25 ms after the anode pulse. Amplitude and rate of rise of inverse voltage contribute greatly to tube dissipation and electrode damage; if these are not minimised in the circuit, tube life will be shortened considerably. The aim should be for an inverse voltage of 3–5 kV peak with rise time of 0.5 ms.

5. The ultimate value which can be attained depends to a large extent upon the external circuit. The rate of rise of current can be well in excess of 100 kA/µs.

6. This rate of rise refers to that part of the leading edge of the pulse between 25% and 75% of the pulse amplitude.

7. Measured with respect to cathode.

8. A lower rate of rise may be used, but this may result in the anode delay time, delay time drift and jitter exceeding the limits quoted.

9. The last 0.25 µs of the top of the grid 1 pulse must overlap the corresponding first 0.25 µs of the top of the delayed grid 2 pulse.

10. Negative bias must be applied to grid 2 to ensure anode voltage hold-off.

11. DC negative bias voltages must not be applied to grid 1. Grid 1 is pulse driven and the potential of grid 1 may vary between -10 V and +5 V with respect to cathode potential during the period between the completion of recovery and the commencement of the succeeding grid pulse.

12. The optimum grid 1 pulse current is the maximum value which can be applied without causing premature commutation. This value is variable depending on gas pressure, maximum forward anode voltage, grid 2 negative bias voltage, peak current and repetition rate.

13. Measured between the second minute after the application of HT and 30 minutes later

14. A time jitter of less than 1 ns can be obtained if the cathode heater voltage is supplied from a DC source, by adopting double-pulsing, and by applying a grid 2 pulse with a rate of rise of voltage (unloaded) in excess of 20 kV/ms.

15. The amount of time available for thyratron recovery must be maximised by circuit design, and reliable operation may necessitate the use of command charging techniques. The amount of time required for recovery is affected by gas pressure, peak current, pulse duration and load mismatch which keeps the thyratron in a conducting state.

HEALTH AND SAFETY HAZARDS

TE2V hydrogen thyratrons are safe to handle and operate, provided that the relevant precautions stated herein are observed. TE2V does not accept responsibility for damage or injury resulting from the use of electronic devices it produces. Equipment manufacturers and users must ensure that adequate precautions are taken. Appropriate warning labels and notices must be provided on equipments incorporating TE2V devices and in operating manuals

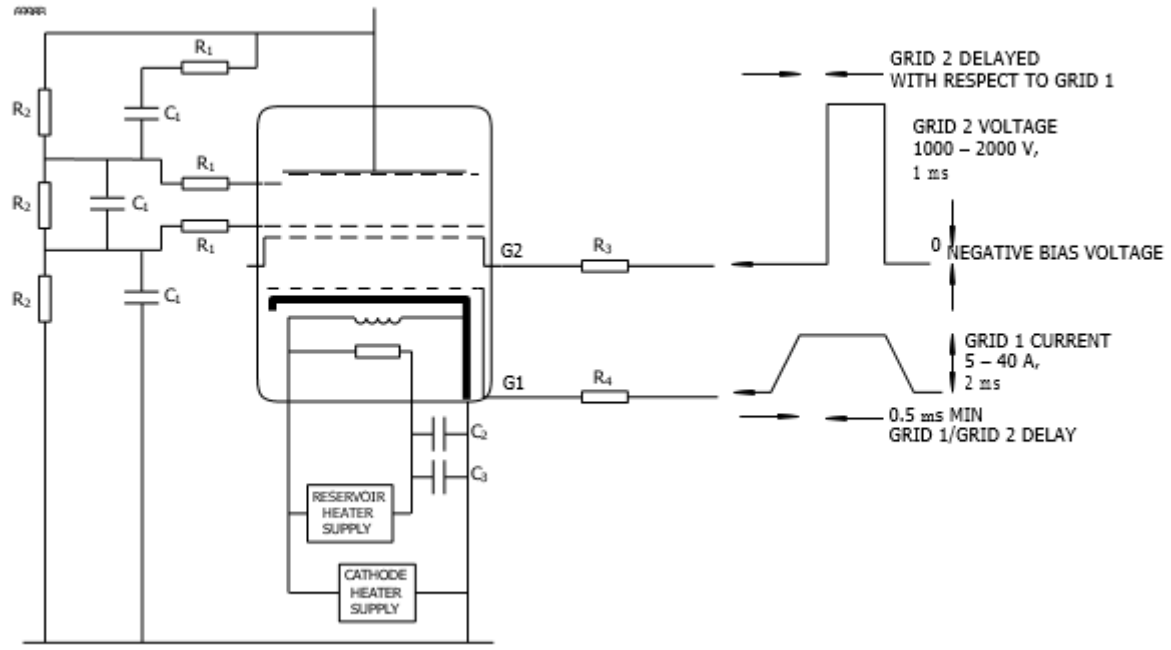
High Voltage

Equipment must be designed so that personnel cannot come into contact with high voltage circuits. All high voltage circuits and terminals must be enclosed and fail-safe interlock switches must be fitted to disconnect the primary power supply and discharge all high voltage capacitors and other stored charges before allowing access. Interlock switches must not be bypassed to allow operation with access doors open.

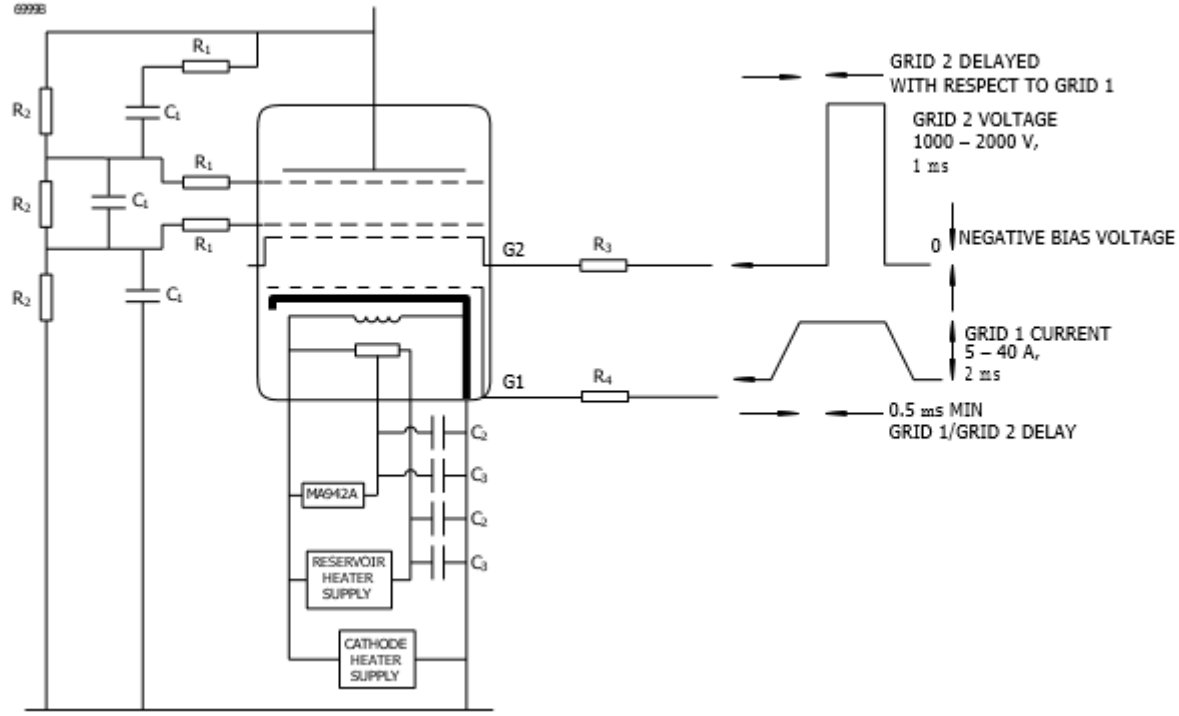
X-Ray Radiation

All high voltage devices produce X-rays during operation and may require shielding. The X-ray radiation from hydrogen thyratrons is usually reduced to a safe level by enclosing the equipment or shielding the thyratron with at least 1.6 mm (1/16 inch) thick steel panels.
Users and equipment manufacturers must check the radiation level under their maximum operating conditions.

CX1937 SCHEMATIC DIAGRAM



CX1937X SCHEMATIC DIAGRAM



Recommended Values (both diagrams)

R_1 = 470 O 2.5 W vitreous enameled wirewound resistors.

R_2 = 5 to 20 MO high voltage resistors with a power rating consistent with forward anode voltage.

R_3 = Grid 2 series resistor. 12 W vitreous enameled wirewound is recommended, of an impedance to match the grid 2 drive pulse Recommended Values (both diagrams)

R_4 = Grid 1 series resistor. 12 W vitreous enameled wirewound is recommended, of a total impedance to match the grid 1 drive pulse circuit.

C_1 = 500 pF capacitors with a voltage rating equal to the peak forward voltage (C1 is needed to share the anode voltage equally between the high voltage gaps on fast charging rates. When the charging time is greater than approx. 5 ms, C1 may be omitted).

C_2, C_3 : Reservoir protection capacitors with a voltage rating 5500 V;

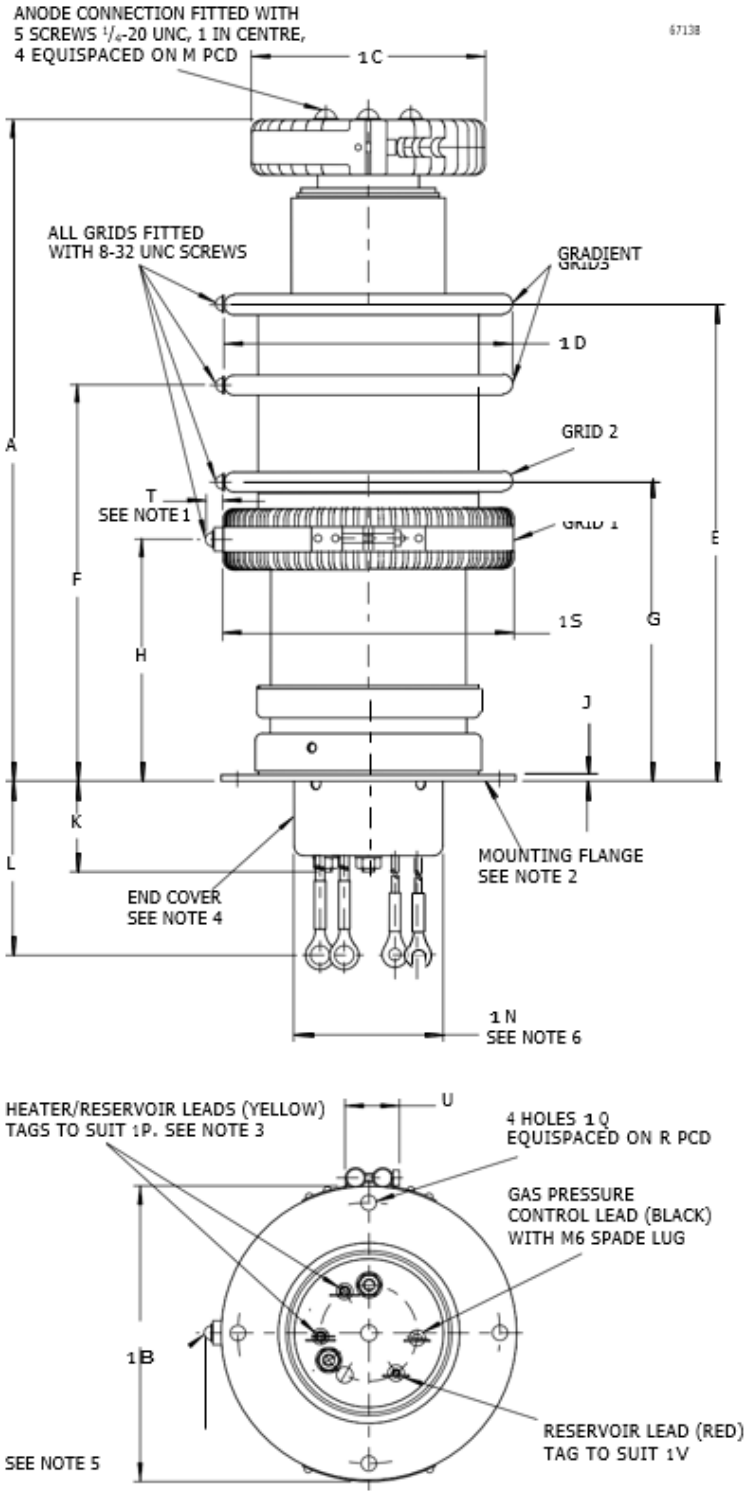
C_2 = 1000 pF low inductance (e.g. ceramic),

C_3 = 1 mF (e.g. polycarbonate or polypropylene).

Components R3, R4, C2 and C3 should be mounted as close to the tube as possible.

OUTLINE OF CX1937X (All dimensions without limits are nominal)

CX1937 outline is identical, except that it has no gas pressure control lead



Ref	Millimetres	Inches
A	342.0 + 6.0	13.465 + 0.236
B	152.40 + 0.25	6.000 + 0.010
C	120.65 max	4.750 max
D	150.0 + 3.0	5.906 + 0.118
E	246.5 + 6.0	9.705 + 0.236
F	205.0 + 6.0	8.071 + 0.236
G	154.7 + 6.0	6.090 + 0.236
H	125.3 + 6.0	4.933 + 0.236
J	4.35 max	0.171 max
K	60.0 max	2.362 max
L	343.00 + 6.35	13.504 + 0.250
M	44.0	1.732
N	78.0 max	3.071 max
P	9.5	0.374
Q	8.0	0.315
R	135.74	5.344
S	152.4 + 3.0	6.000 + 0.118
T	15.0 max	0.591 max
U	36.0 max	1.417 max
V	6.0	0.236

Inch dimensions have been derived from millimetres

Outline Notes

1. This dimension also applies to the clamping screws and lugs.
2. The mounting flange is the connection for the cathode and cathode heater return.
3. These two leads must be connected in parallel to the same terminal of the heater transformer
4. The end cover is at heater potential and must not be grounded.
5. The terminal screws are in line with the hole in the mounting flange to within ±6.35 mm.
6. The recommended mounting hole is 93.5 mm (3.861 inches) diameter

MA942A RESISTOR BOX

'X' type thyratrons have an additional lead on the base which enables the user to adjust the gas pressure inside the tube to a greater degree than is possible by changing the reservoir voltage. This allows the gas pressure to be optimised for a particular set of operating conditions, reducing the power dissipation in the thyratron to a minimum and maximising its switching speed. The maximum gas pressure allowable is dependent on the voltage hold off required; the higher the gas pressure, the more likely the thyratron is to break down spontaneously. Optimisation is achieved by increasing the gas pressure until the thyratron will no longer reliably hold off the required anode voltage, and then reducing it again only until the tube will operate reliably without spontaneous anode voltage breakdowns.

The gas pressure of E2V Technologies metal envelope thyratrons is normally set during manufacture to allow reliable operation at the maximum rated anode voltage, by resistors inside the base cap of the tube. In 'X' type tubes, these resistors are omitted and replaced by two parallel variable resistors mounted in the MA942A resistor box which is connected to the thyratron as shown in the schematic diagram. Increasing the value of this parallel combination will increase the pressure in the thyratron.

'X' type thyratrons are supplied with a recommended minimum combination of values. Do not use a lower combined value of resistors as this would result in the tube being operated with an unacceptably low gas pressure and may lead to tube damage and reduced tube life.

Ten resistor values can be selected by each rotary switch (3.3 O, 4.7 O, 6.8 O, 8.2 O, 10 O, 15 O, 18 O, 22 O, 33 O, O/C), giving the range of possible values shown in the table.

Paralleled Value (O)	Control Box Settings (O)		Paralleled Value (O)	Control Box Settings (O)	
1.65	3.3	3.3	5.19	6.8	22.0
1.94	3.3	4.7	5.30	8.2	15.0
2.22	3.3	6.8	5.63	8.2	18.0
2.35	4.7	4.7	5.64	6.8	33.0
2.35	3.3	8.2	5.97	8.2	22.0
2.48	3.3	10.0	6.00	10.0	15.0
2.70	3.3	15.0	6.43	10.0	18.0
2.78	4.7	6.8	6.57	8.2	33.0
2.79	3.3	18.0	see note	6.8	O/C
2.87	3.3	22.0	6.87	10.0	22.0
2.99	4.7	8.2	7.50	15.0	15.0
3.00	3.3	33.0	7.67	10.0	33.0
3.20	4.7	10.0	8.18	15.0	18.0
see note	3.3	O/C	see note	8.2	O/C
3.40	6.8	6.8	8.92	15.0	22.0
3.58	4.7	15.0	9.00	18.0	18.0
3.72	6.8	8.2	9.90	18.0	22.0
3.73	4.7	18.0	see note	10.0	O/C
3.87	4.7	22.0	10.31	15.0	33.0
4.05	6.8	10.0	11.0	22.0	22.0
4.10	8.2	8.2	11.65	18.0	33.0
4.11	4.7	33.0	13.2	22.0	33.0
4.51	8.2	10.0	15.0	15.0	O/C
4.68	6.8	15.0	16.5	33.0	33.0
see note	4.7	O/C	18.0	18.0	O/C
4.94	6.8	18.0	22.0	22.0	O/C
5.00	10.0	10.0	33.0	33.0	O/C
			O/C	O/C	O/C

Note Do not set parallel resistors to these values, as this may cause the power rating of the resistor to be exceeded.

Outline

(All dimensions without limits are nominal)

Ref	Millimetres	Inches
AA	125.0	4.921
AB	80.0	3.150
AC	57.0	2.244
AD	85.0 max	3.346 max

Inch dimensions have been derived from millimetres.