e2v technologies

CX2412A, CX2412AX
Air-Cooled, Deuterium-Filled, Two-Gap Thyratrons

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

ABRIDGED DATA

The CX2412A and CX2412AX are air-cooled, deuterium-filled, two-gap thyratrons with 6-inch diameter metal/ceramic envelopes, incorporating dispenser cathodes and high capacity reservoirs to provide extended operational life.

The CX2412AX must be used with e2v technologies resistor box MA942A; this permits a larger variation in internal hydrogen pressure than in the CX2412A.

Pulse Modulator Service

Peak forward voltage	50	kV max
Peak forward current	15	kA max
Average anode current	15	A max
Pulse repetition rate	5000	pps max

Single-Shot and Fault Conditions

Peak anode current	40	kA
Conducted charge:		
capacitor discharge	0.5	C
power supply follow-on	18	C
Repetition frequency	1 pulse per 10 s max	

GENERAL

Electrical

Cathode	impregnated tungsten matrix dispenser type	
Cathode heater voltage	6.3 ± 0.3	V
Cathode heater current	130	A
Reservoir heater voltage (see note 1)	6.3 ± 0.3	V
Reservoir heater current	7	A
Cathode and reservoir heater configuration	see schematic and notes 1 and 2	
Tube heating time	15	min

Mechanical

Seated height	395 mm (15.551 inches) max
Clearance required below mounting flange	76.2 mm (3.000 inches) min
Overall diameter (mounting flange)	257 mm (10.118 inches) nom
Net weight	25 kg (55 pounds)
Mounting position	see note 3
Tube connections	see note 4 and outline

Accessories

470 pF, 40 kV high voltage capacitor	MA2414B
25 MΩ, 30 kV high voltage divider resistor	MA2457A
Trigger system	MA2709A

Cooling

The tubes must be cooled by forced-air. A fan must be mounted below the tube and forced-air directed axially at the tube base. The forced-air must be ducted past the cathode flange and directed by a suitable electrically insulating cowling past the grids and anode cooling ring. The fan should have a capacity in excess of 7.1 m^3/min (250 ft^3/min). The maximum envelope temperature is 150 °C.

For average currents of around 10 A and above, using the CX2412 or CX2412X with oil cooling may be more practical and effective.

e2v technologies limited, Waterhouse Lane, Chelmsford, Essex CM1 2QU England Telephone: +44 (0)1245 493493 Facsimile: +44 (0)1245 492492
e-mail: enquiries@e2vtechnologies.com Internet: www.e2vtechnologies.com Holding Company: e2v holdings limited

e2v technologies inc. 4 Westchester Plaza, PO Box 1482, Elmsford, NY10523-1482 USA Telephone: (914) 592-6050 Facsimile: (914) 592-5148
e-mail: enquiries@e2vtechnologies.us

PULSE MODULATOR SERVICE
MAXIMUM AND MINIMUM RATINGS

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

	Min	Typical	Max	
Anode (Pulse Modulator Service)				
Peak forward voltage	–	–	50	kV
Peak inverse voltage	–	–	see note 5	kV
Peak forward current	–	–	15	kA
Average current	–	–	15	A
Pulse repetition rate	–	300	–	pps
Anode (Single-Shot and Fault Conditions)				
Peak forward anode voltage	–	50	–	kV
Peak forward anode current	–	40	–	kA
Total conducted charge (see note 6):				
capacitor discharge	–	0.5	–	C
power supply follow-on	–	18	–	C
Repetition frequency			1 pulse per 10 s max	
Triggering (See schematic, page 5)				
For maximum life these thyratrons must be triggered with a pre-pulse on grid 1.				
Grid 2 – Pulsed				
Unloaded grid 2 drive pulse voltage (see notes 7 and 8)	500	2000	2500	V
Grid 2 pulse duration	0.5	1.0	2.0	µs
Rate of rise of grid 2 pulse (see note 9)	1.0	5.0	–	kV/µs
Grid 2 pulse delay (see schematic diagram)	0.5	1.0	5.0	µs
Peak inverse grid 2 voltage	–	–	−450	V
Loaded grid 2 bias voltage (see note 10)	0	−150	−180	V
Impedance of grid 2 drive circuit (see note 11)	25	50	200	Ω
Grid 1 – Pulsed				
Unloaded grid 1 drive pulse voltage	500	–	2000	V
Grid 1 pulse duration	1.0	–	–	µs
Peak inverse grid 1 voltage	–	–	450	V
Peak grid 1 drive current (see note 10)	40	–	90	A

CHARACTERISTICS

Critical DC anode voltage for conduction	–	0.5	2.0	kV
Anode delay time (see note 12)	–	0.1	0.3	µs
Anode delay time drift (see note 13)	–	15	25	ns
Time jitter (see note 14)	–	5.0	15	ns
Recovery time (see note 10)	–	15	–	µs
Cathode heater current (at 6.3 V)	115	130	145	A
Reservoir heater current (at 6.3 V)	5	7	10	A

NOTES

1. The heater and reservoir supplies must be connected to the tube as follows (see schematic and outline):

   Lead 'H' is identified by a yellow sleeve; lead 'R' is identified by a red sleeve; lead 'HR' is identified by a yellow and red sleeve.

   The cathode heater supply must be connected between leads 'H' and 'HR'.

   The reservoir heater supply must be connected between leads 'HR' and 'R'.

   Care must be taken to ensure that the reservoir heater is not subjected to voltages higher than specified. This can happen, for example, if the cathode heater supply connection to the lead 'HR' is a poor, high impedance, connection; the reservoir would then have almost all of the cathode and reservoir supply voltage applied to it.

   It is important that the reservoir and cathode heater supplies are connected in anti-phase so that this situation can be avoided. This can be checked before the tube heater leads are connected by measuring the voltage between the terminals to which the leads 'H' and 'R' are to be connected. If the supplies are in anti-phase, a voltage close to zero will be measured. Either two AC or two DC supplies may be used.

   The reservoir leads, 'R' and 'HR', and gas pressure lead 'GP' on CX2412AX, should be decoupled with capacitors as indicated in the schematic. This provides a low impedance shunt for any fast transient voltages which may appear across the reservoir supply terminals during operation of the tube.

   If a single transformer is used to supply both the heater and reservoir, then 'H' and 'R' must be connected to one end of the transformer and 'HR' to the other.

2. In applications where the internal gas pressure needs to be increased and optimised, CX2412AX should be used with e2v technologies resistor box MA942A.

   The resistor box must be connected between the gas pressure control lead 'GP' (black sleeve) and the heater/reservoir common lead 'HR' (yellow/red sleeve). Gas pressure may be increased by increasing the resistor box settings from their initial recommended values which accompany each delivered CX2412AX. The gas pressure may be increased to a value consistent with the required forward hold-off voltage. Additional small variations in gas pressure can be achieved by altering the reservoir heater supply voltage within the specified range.

3. The preferred mounting position is vertical, anode uppermost, although the tube may be operated with its axis horizontal. The tube should not be operated vertically with its cathode uppermost. The tube must be fitted using its mounting flange.

4. For low to moderate rms currents, the anode can be connected by the central screw only. At high rms currents, the central screw should be removed and the anode connection made using the other four anode screws (see outline).

5. The peak inverse voltage including spike must not exceed 7 kV for the first 25 μs after the anode pulse. Amplitude and rate of rise of inverse voltage contribute greatly to anode dissipation and electrode damage; if these are not minimised in the circuit, tube life will be shortened considerably. The aim should be for a maximum inverse voltage of 3 - 5 kV peak with a rise time of >0.5 μs.

6. Under fault conditions, most of the coulombs are often in the power supply follow-on current rather than the storage capacitor discharge. Equipment manufacturers must minimise the fault coulombs. For high power equipments, where these ratings may be exceeded, a power supply crowbar may be needed.

7. The term 'unloaded' means that the measurement is made at the tube grid with the cathode and reservoir heaters cold, i.e. not energised.

8. Measured with respect to cathode.

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

10. The tubes have a short recovery time for their size, and may be operated satisfactorily in some applications with zero negative bias applied to the control grid (grid 2). However, applying negative bias as specified to grid 2 is recommended to give a faster recovery time after forward conduction and a higher protection against spurious triggering. A reasonable negative bias level ($\geqslant$100 V) is needed to allow grid 1 to be pre-pulsed at a reasonable level, which is necessary for maximum cathode life.

11. The grid 1 and grid 2 pulse drive circuits must be connected to their respective grids with suitable series resistors which will cope with any grid spike. It is recommended that these series resistors are mounted as close to their respective grids as possible and are 12 W vitreous enamelled wirewound types.

12. The time interval between the instant at which the rising unloaded grid 2 pulse passes cathode potential and the instant when anode conduction takes place.

13. Measured between the second minute after the application of high voltage and thirty minutes later.

14. Lowest jitter is obtained with the highest rate of rise of applied grid 2 voltage pulse, and when the cathode heater is supplied from a DC source.

HEALTH AND SAFETY HAZARDS

e2v technologies hydrogen thyratrons are safe to handle and operate, provided that the relevant precautions stated herein are observed. e2v technologies 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 e2v technologies 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

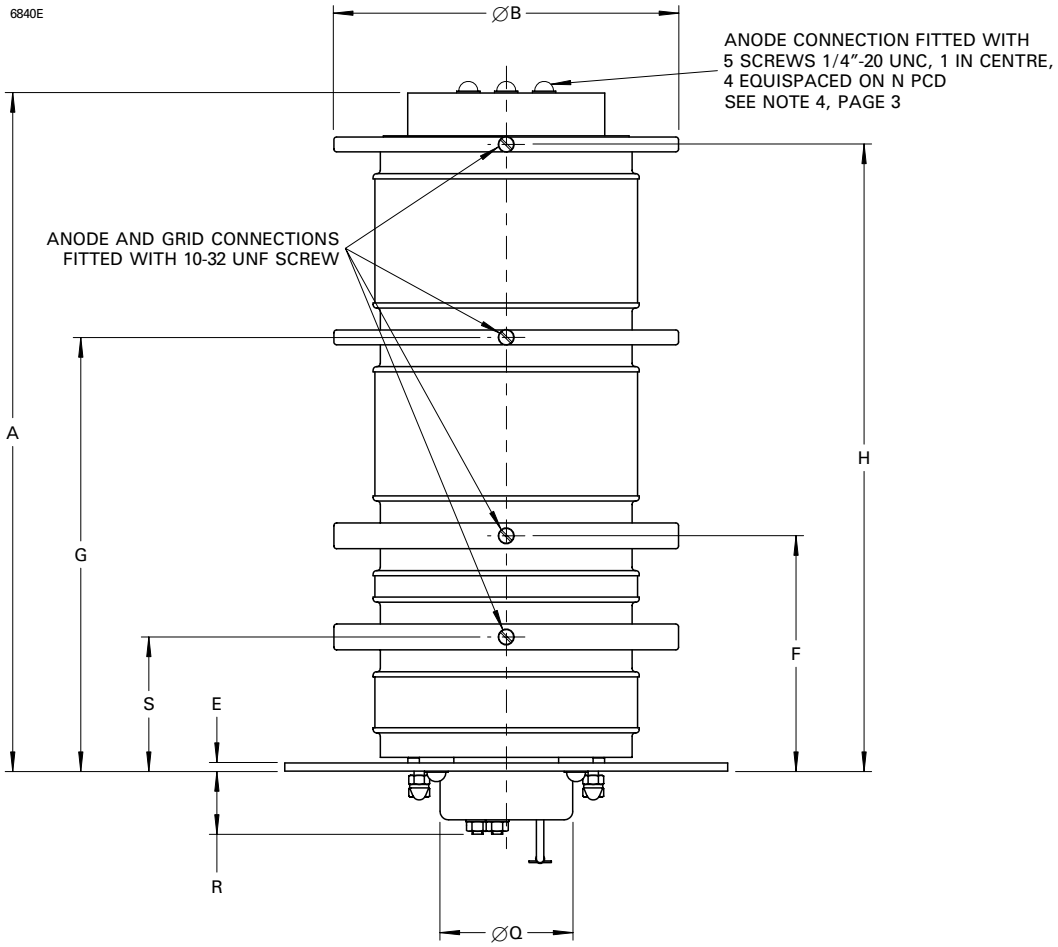
All high voltage devices produce X-rays during operation and may require shielding. The X-ray radiation from hydrogen thyratrons is usually reduced to a safe level by enclosing the equipment or shielding the thyratron with at least 1.6 mm ($^1/_{16}$ inch) thick steel panels.

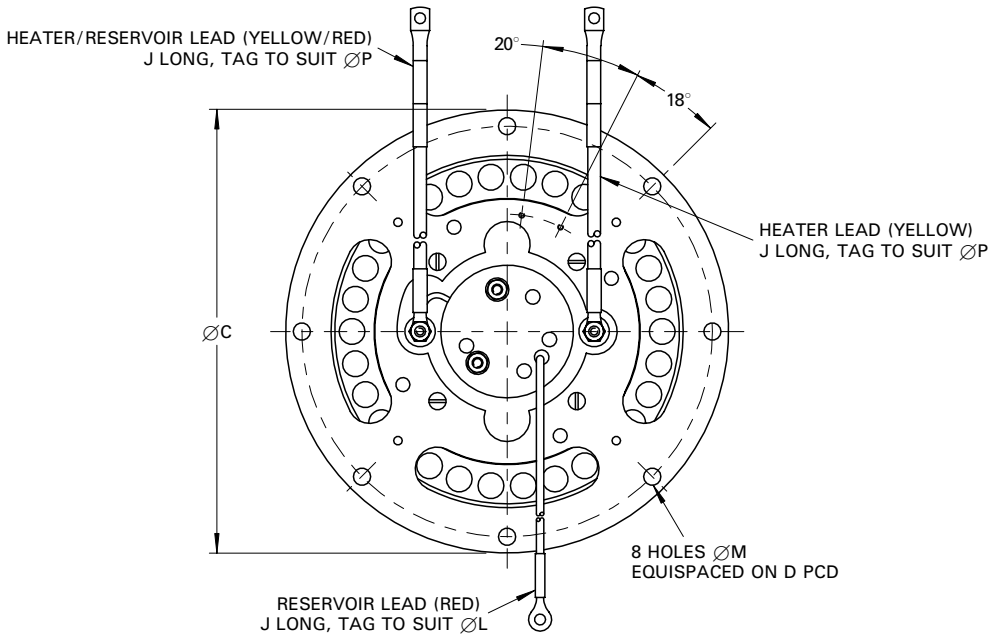
Users and equipment manufacturers must check the radiation level under their maximum operating conditions.

OUTLINE OF CX2412A

(All dimensions without limits are nominal)

CX2412AX outline is identical, except that it has a gas pressure control lead (black).



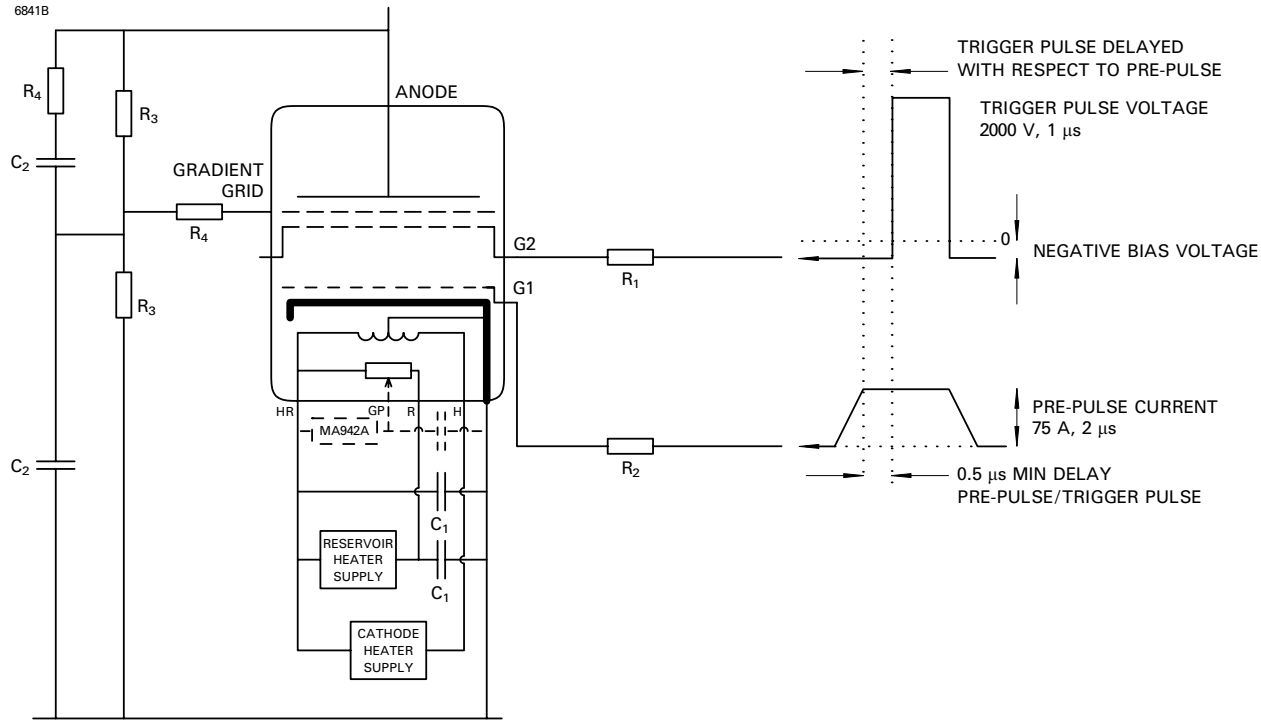


Ref	Millimetres	Inches
A	395.0 max	15.551 max
B	203.2 max	8.000 max
C	257.0	10.118
D	238.25	9.380
E	4.75	0.187
F	136.6	5.378
G	251.75	9.911
H	363.75	14.321
J	266.7 ± 12.7	10.500 ± 0.500
L	6.35	0.250
M	10.0	0.394
N	77.9	3.067
P	8.0	0.315
Q	78.0 max	3.071 max
R	40.0 max	1.575 max
S	76.4	3.008

Inch dimensions have been derived from millimetres.

SCHEMATIC DIAGRAM

Recommended connections.



R_1 = 25 - 200 Ω vitreous enamelled wirewound resistor to match the drive circuit.

R_2 = 12 W vitreous enamelled wirewound resistor to set the grid 1 drive current.

The gradient grid must be connected to the mid-point of the voltage divider chain formed by R_3 and C_2 (if used).

R_3 = 10 to 25 MΩ high voltage resistors with a power rating consistent with the forward voltage.

R_4 = 470 Ω 2.5 W vitreous enamelled wirewound resistors.

C_2 = 300 - 500 pF with a voltage rating equal to the peak forward voltage. These capacitors may be needed to divide the charging voltage properly when charging times are less than 5 ms.

The reservoir heater leads 'R' and 'HR', and 'GP' if MA942A is used, should be decoupled with pulse rated capacitors, e.g. polypropylene, as indicated above. C_1 = 100 nF @ 1000 V.

Cathode and reservoir heater connections, see notes 1 and 2.

Resistor box MA942A is required with CX2412X only.

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 Ω, 4.7 Ω, 6.8 Ω, 8.2 Ω, 10 Ω, 15 Ω, 18 Ω, 22 Ω, 33 Ω, O/C), giving the range of possible values shown in the table.

Paralleled Value (Ω)	Control Box Settings (Ω)		Paralleled Value (Ω)	Control Box Settings (Ω)	
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.