

#### 4. Warranty

All valves manufactured by "Pulsed Technologies Co. Ltd." (The Manufacturer) are guaranteed to be free of defects in workmanship, materials and construction and are designed to give satisfactory service when used under normal operating conditions. The Manufacturer guarantees conformity of thyratrons to the parameters specified in the appropriate clause of the thyratrons' certificate within a period of 12 months from the date of delivery, confirmed by shipping documents, or within a minimum operating time equal to  $5 \times 10^4$  pulses, either within a filament life of 1000 hours whichever comes first. The above conditions should be considered provided the thyratrons are treated in accordance with the technical parameters stated in the appropriate clause of the thyratrons' certificate (p.1.1).

For valves failing before expiration of operating time  $10^4$  pulses, a valve may at the option of Manufacturer be replaced free of charge or credited in full, provided that the filament life guaranteed has not expired. For valves failing with a filament life in excess of the initial period up to operating time  $10^4$  pulses, but less than the total warranty minimum operating life, replacement or credit will be given on pro rata basis determine by the ratio of the unrealised portion of the warranted operating life to the total warranty minimum operating life. The operating life is considered to start when the valve is first put into service, even though it may subsequently be removed and held as a spare.

**Conditions of Warranty.** The warranty is valid only if the following conditions are met :

1. The valve is supplied direct from the Manufacturer or via an agency, representative or other selling medium authorized by Manufacturer.
2. The valve is operated within the published minimum and maximum ratings, provided that safety devices for protection against overcurrent in terms of average current are fitted and operation time counter is used.
3. The valve is not subjected to any negligence in use, storage, transportation or handling.
4. The decision of Manufacturer on the cause of failure and on the value and form of any applicable allowances is accepted by the customer.
5. Right of access to equipment for the purpose of checking operating conditions is granted to any representative of Manufacturer where Manufacturer may so require.
6. Manufacturer is notified within 30 days of the valve failure.
7. The valve is withdrawn from service as soon as possible after the failure is alleged to have occurred.

**5. Claims Information.** In case of a premature failure of a thyatron it should be returned to the Manufacturer within 30 days together with the Certificate stating the following information:

Storage time \_\_\_\_\_  
Date of putting into operation \_\_\_\_\_  
Date of failure \_\_\_\_\_  
Specifications of a mode of operation \_\_\_\_\_

Operating time in the specified mode \_\_\_\_\_ of hours (total switched charge).  
information about operating conditions, cause of failure.

The reasons for removal of a thyatron from operation \_\_\_\_\_  
The items of information are filled \_\_\_\_\_

(Date, signature)

In case of absence of the filled passport the claim is not accepted.

Individual № \_\_\_\_\_, Manufacturing date \_\_\_\_\_

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E-mail: [pulsetech@mail.ru](mailto:pulsetech@mail.ru), [info@pulsetech.ru](mailto:info@pulsetech.ru)

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## TDI3-100k/150 THYRATRON

### Certificate. Certificate of Quality.

TDI3-100k/150 thyatron (Copper Arc Thyatron, Grounded Grid Thyatron) is intended for use as a switch tube in pulse circuits of capacitive storages with sub-microsecond and microsecond pulse duration. The thyatron is manufactured in conformity with technical conditions KBФM.433.212.020TY for use in various installations for domestic as well as export delivery.

#### 1. Basic Technical Data.

Pulse thyatron has a ceramic/metal envelope, six high-voltage sections, filled with hydrogen (deuterium) as buffer gas at  $20 \div 60$  Pa in operational mode only. Semiconductor igniter is used to trigger the switch. Special dielectric coating protects internal surface of the envelope against damage in cases when anode reverse voltage achieves 100% of forward voltage. The tube is environmental-friendly product, has internal shield for minimization of X-Ray emission from the region of anode. The double-ended thyatron TDI3-100k/150D is a bi-directional switch. In TDI3-100k/150D variant the thyatron comprises hollow anode with added igniter and is used, for example, for operation in modes with oscillating current, as well as for triggering both from cathode and anode part.

Design of the thyatron is covered by Russian Federation patents № 1807798, 2300157, 2418339, International Patents PCT/RU2005/000298, PCT/RU2011/000038 and US Patents No.7,825,595 B2 and US8,735,866 B2.

#### 1.1. Electrical Parameters in Optimum Operation Mode

Parameter	Value	Fact. value
Forward anode voltage, $kV$	25÷120	
Peak forward anode current, $kA$	20	
Anode current 1st half-wave width, $\mu s$	5.0	
Pulse repetition rate, $Hz$	0.5	
Heater R voltage, $V$ , (not less/not more)	3.0/7.0	
Heater G voltage, $V$ , (not less/not more)	5.5/6.5	
Heater R current (at nominal $U_{HR} = \quad V$ ), $A$	2.5	
Heater G current (at nominal $U_{HG} = \quad V$ ), $A$	2.5	
Peak open circuit trigger voltage, $kV$ , (not less/not more)	4.0/10.0	
Peak trigger current, $A$ , (not less/not more)	80/200	
Trigger current pulse duration, $\mu s$	2÷4	
Tube warm-up time, minutes	5.0	

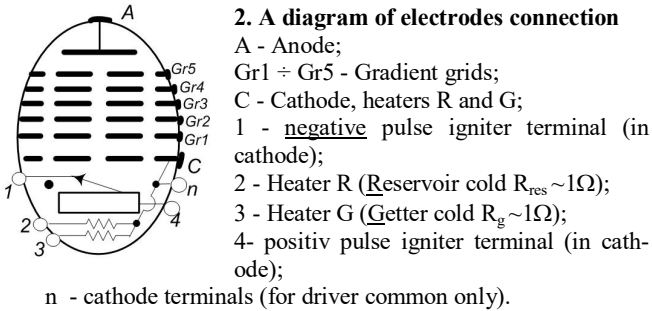
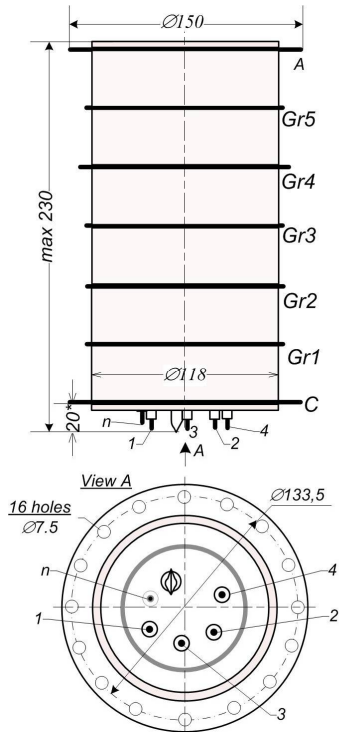
#### 1.2. Absolute ratings (maximus, nonsimultaneous)\*

Parameter	Value
Peak forward anode voltage, $kV$ (Notes 1, 2,3)	10÷150
Peak reverse anode voltage, $kV$ (Notes 3)	50
Peak forward anode current, $Ib$ , $kA$	100
Peak reverse anode current, $Ibx$ , $kA$ (Note 4)	up to 95% of $Ib$
Maximum anode current rise rate, $A/s$ (Note 5)	$5 \cdot 10^{11}$
Anode current pulse duration, $\mu s$	0.1÷100.0
Pulse repetition rate, $f$ , $Hz$ (Note 6)	300
Switched energy per shot, $J$	20 000
Anode Dissipation Factor ( $Pb = V \times A \times pps$ ) (Note 6)	$70 \cdot 10^9$
Root mean square current, $RMS = \sqrt{Ib \times ib}$ ( $ib = C \cdot U \cdot f$ ) (Note 6)	700
Peak open circuit trigger voltage, $kV$ , (not less/not more)	4.0/10.0
Peak trigger current, $A$ , (not less/not more)	80/250
Rate of rise of ignition voltage pulse, $kV/\mu s$ , not less (Note 7)	5.0
Time Jitter, $ns$	5

**Notes** \*Operation of the thyatron when two or more parameters listed in p.1.1 are exceeded simultaneously may be permitted only upon agreement with the Manufacturer.

- 1) Immerse the tube into SF<sub>6</sub>, N<sub>2</sub> or oil when operating at voltage over 45 kV.
- 2) The dwell time at the peak anode voltage should be minimized in order to minimize pre-firing. For operation at the rated peak forward anode current, the dwell time must be less than 0.5 of pulse period, but must not exceed 1 millisecond.
- 3) After the thyatron anode current ceases and before voltage is reapplied to anode, the anode voltage must be kept between minus (100 -5000) Volts for at least 100 μs for working gas deionization.
- 4) For hollow anode variants TD13-100k/150H and TD13-100k/150D. For TD13-100k/75 reverse current <10% of I<sub>b</sub>.
- 5) The ultimate value depends on the external circuit parameters.
- 6) Pb > 3·10<sup>6</sup> and RMS > 80 can be achieved in burst mode only (i<sub>b</sub> = CU<sub>af</sub> – average current, C – switching capacitance). Burst and pause durations must be agreed with the Manufacturer.
- 7) High-rate of rise of trigger voltage pulse trigger system by a cable pulse generator (fig.2).

1.3. Maximum overall dimensions (∅<sub>cathode flange</sub> × H<sub>max</sub>), mm - 152 × 230. Weight - not more than 7.8 kg.  
 1.4. Lifetime expectancy specified in item 1.1 - 10<sup>6</sup> Coulomb.



**2. A diagram of electrodes connection**  
 A - Anode;  
 Gr1 ÷ Gr5 - Gradient grids;  
 C - Cathode, heaters R and G;  
 1 - negative pulse igniter terminal (in cathode);  
 2 - Heater R (Reservoir cold R<sub>res</sub> ~ 1Ω);  
 3 - Heater G (Getter cold R<sub>g</sub> ~ 1Ω);  
 4 - positiv pulse igniter terminal (in cathode);  
 n - cathode terminals (for driver common only).

**ATTENTION!** It is required in all circuits to carefully observe polarity of ignition voltage applied to the appropriate leads of the ignitor and to provide symmetry of current pick-off from cathode and anode flanges relative to the axis of the device: (J.Slough, C.Pihl, V.D.Bochkov, et al, «Prospective Pulsed Power Applications Of Pseudospark Switches», 17th IEEE International Pulsed Power Conference, 2009, Washington, DC).  
 The thyratrons must be handled carefully in order to prevent mechanical effect on the leads 1, 2 exceeding 3 kgs in an axial direction and 1kgs in direction perpendicular to the axes. It is strictly forbidden to hit the valve tails.

**3. Operation Guidelines**  
 3.1. Trigger negative signal must be applied to the tail 1 of the thyatron. Resistance of igniter within warranty period is 5kΩ ÷ 200 MΩ.

- 3.2. For reliable operation of the thyratrons use the pulse driver PB-3D providing powering of auxiliary electrodes in conformity with rated parameters. The driver is designed and manufactured by Pulsed Technologies Co. Ltd.
- 3.3. Switching sequence: a) apply heater voltage to the appropriate tail; b) allow the heater to warm up for not less than 5 min; c) apply pulsed ignition voltage to the igniter, apply anode voltage (30-50% of maximum level), smoothly raise the anode voltage to the operating level. It is permitted to simultaneously switch on heater and trigger voltages.
- 3.4. The maximum-allowed temperature of cathode, anode and grid flanges is +100°C. If exceeded, a forced air or liquid (oil) cooling must be used. Air flow rate is to be not less than 2.5 m<sup>3</sup>/min at 25°C ± 10°C of thermofoir.
- 3.5. When switching off voltages first switch off anode voltage, then all the rest voltages. It is permitted to switch off all voltages simultaneously.

3.6. For ensuring warranty period of operation in modes different from those specified in p.1.1 it is necessary to select voltage of the heater subject to certain mode of thyatron operation. For this purpose (with nominal load) increase hydrogen reservoir (R) heater voltage in increments of 0.1 ÷ 0.3 V from the value specified in the certificate staying at each value for 2 ÷ 3 minutes before appearance of signs of unstable operation (transition to higher frequency or to continuous discharge). In appearance of the signs switch off anode voltage, reduce heater R voltage 0.1 ÷ 0.2 V and within a minute switch on anode voltage and maintain it for 5-10 minutes. At steady operation fix the given heater voltage. Further it is desirable to repeat this procedure after every total 10<sup>4</sup> C of operation.

3.7. After transportation or a long period of storage regulated seasoning at operation conditions within not less than 30 minutes is required. When aging the thyatron, anode voltage must be raised gradually by steps of 3 ÷ 5 kV from minimum peak voltage of 10 ÷ 15 kV up to peak forward anode voltage. The criteria of successful seasoning at each step will be an absence of misfires within 3-5 minutes.

Recommended Circuit for Ignition Pulse Generator

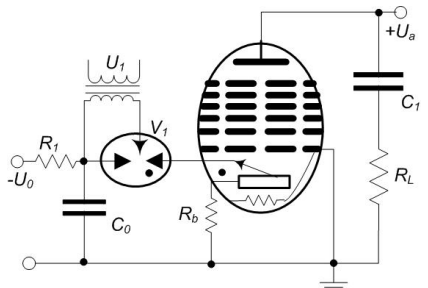


Fig.1. The electrical schematic of a triggered spark gap based ignition pulse generator.  
 V<sub>1</sub>- RU83-6 Trigger Spark Gap.  
 R<sub>1</sub>=10kΩ, R<sub>b</sub>=(10÷50)Ω,  
 C<sub>0</sub>=(0.01÷0.2) μF,

Version of Ignition Pulse Generators

Fig.2. The electrical schematic of low-jitter (<5 ns), low-energy, trigger system cable pulse generator. (V.A.Gribkov, M.Scholz, V.D.Bochkov, et al, Pseudosparks in nanosecond range of its operation: firing, jitter, and disconnection, Journal of Physics D: Appl. Phys. 37, 2004, p.2107–2111.) U<sub>0</sub>=8 ÷ 12 kV, C<sub>1</sub>=(0.01 ÷ 0.2) μF  
 V<sub>1</sub>- spark gap; cable length ~ 6 m;

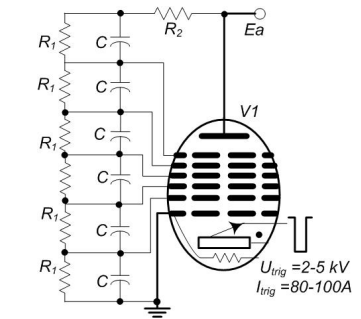
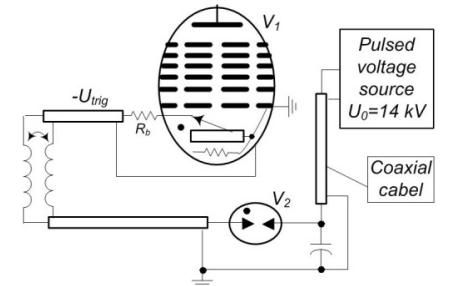


Fig. 3. Principal circuit of gradient grid feed.  
 C=(0.3÷0.5) nF, R1=(5÷20)MΩ,  
 R2=470Ω

length cable (stray inductance L<sub>s</sub> → 0).  
 C<sub>1</sub>, C<sub>2</sub>: Reservoir protection capacitors with a voltage rating > 500 V;  
 C<sub>1</sub> = 1000 pF low inductance (e.g. ceramic), C<sub>2</sub> = 1μF (e.g. polycarbonate).  
 Components C<sub>1</sub>, C<sub>2</sub> should be mounted as close to the tube as possible.

Fig.4. Please make sure that voltage jumps (stray voltage) U<sub>s</sub>=L<sub>s</sub>·di/dt in ground circuit should be minimized. For that heating voltage cable must be connected to the thyatron connectors directly. Also load circuit must be connected right to the thyatron cathode and equipment case directly. Cathode of the tube must be connected with equipment case by a minimum

