THYRISTOR DRIVER TD

USER'S MANUAL

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1 PURPOSE AND FUNCTION

Thyristor driver (hereinafter - TD) is intended for high-capacity power thyristors with currents 320÷5000 A. TD is made on base of advanced technology of microelectronics, digital-to-analogue integral circuits using advanced achievements in the sphere of power thyristor control.

The TD performs the following functions:

- afterburning pulse forming with control current rise transconductance and time characteristics, corresponding to turn-on requirements of power transistors at currents up to 5000 A;

- forming of long positive sustaining control current that succeeds afterburning pulse;

- forming of long negative control current when closed thyristor that allows increasing stability to rate of rise of thyristor anode voltage;

- control capability of both standard high capacity thyristors and fast thyristors with switching speed to 20 kHz;

- status signal of current control in thyristor control circuit.

The TD provides control of high-capacity thyristors at currents from 320 to 5000 A. The TD is produced in two embodiments with different control options that allow using TD for control of a big thyristor nomenclature, practically all current nominal and commutation voltage.

2 DRIVER TYPES

TD is produced with different housings, with different control and velocity options, with two types of thyristor control output pulse, for different isolation classes.

TD is produced in two different housings: housing ME is intended for DIN-rail mounting, housing G is intended for panel mounting.

Standard performance of output pulse is a pulse form recommended for producers' control of high-capacity thyristors, having afterburning pulse for accelerated thyristor turn-on and succeeding it long positive sustaining control current. Ruggedized version to du/dt has pulse form with long negative control current during absence of control signal.

Possible control options TD include potential, current control and FOCL control. Potential control is possible from voltage sources of 5 V, current control from current sources of 10 mA.

FOCL control of ME package is carried out using optical receiver of a type HFBR-2522, the version of package G using an optical receiver SFH551/1-1V.

TD are produced with standard velocity (with commutation frequency to 250 Hz), or fast with commutation frequency of 5 and 20 kHz.

Isolation voltage of control circuit and supply source can be 5, 10 or 15 kV. For voltage isolation 15 kV the driver control is performed only by means of fiber optic line.

TD may include a current control circuit in thyristor control circuit. For isolation voltage of 5000 V and maximum commutation frequency 250 kHz and 5 kHz the current control circuit is made with using of optoelectronic coupler, for FOCL driver versions of all insulation voltages the control circuit is made with using of FOCL transmitter of type HFBR-1522 for TD1 and a FOCL transmitter of type SFH756V for TD2.

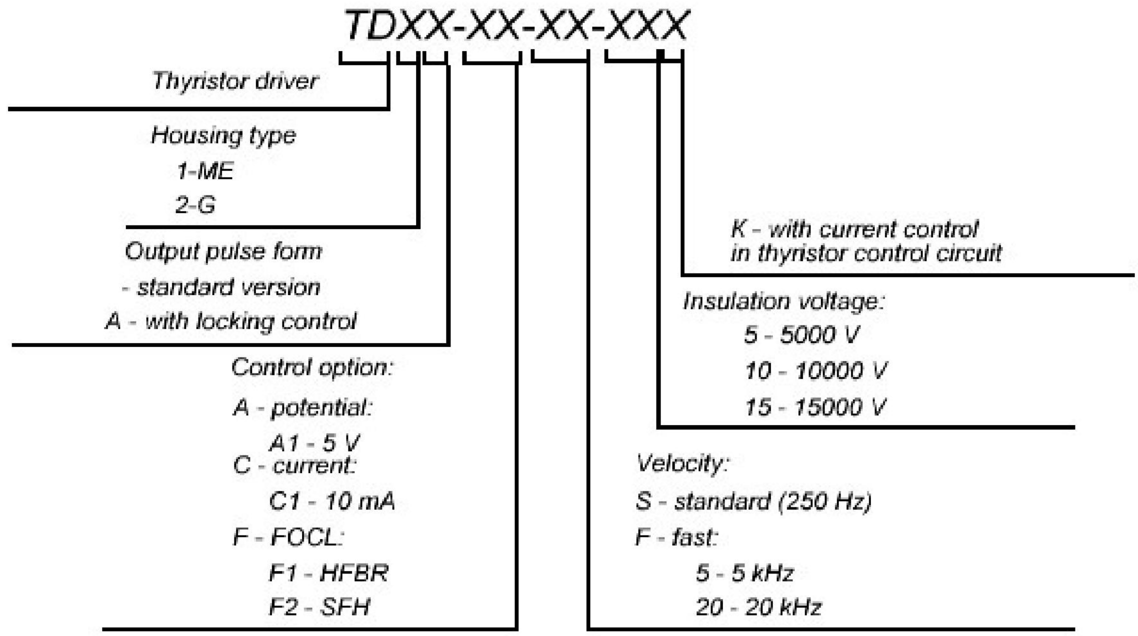


Figure 2.1 – Module name explanation

For example, TD1A-F1-F5-5: thyristor driver in housing ME with capability thyristor blocking control, with current control on input 10 mA, with velocity to 5 kHz, with isolation voltage of control circuit and supply source 5000 V.

Note: instead of the previous versions of the driver TD with control options A2, A3, A4, and also B2 is recommended using the driver version with control B1.

3 GENERAL DESCRIPTIONS

The TD is a printed circuit board with installed elements on it and put in the housing and hermetically sealed with a special compound. The TD structure scheme is shown at Figure 3.1.

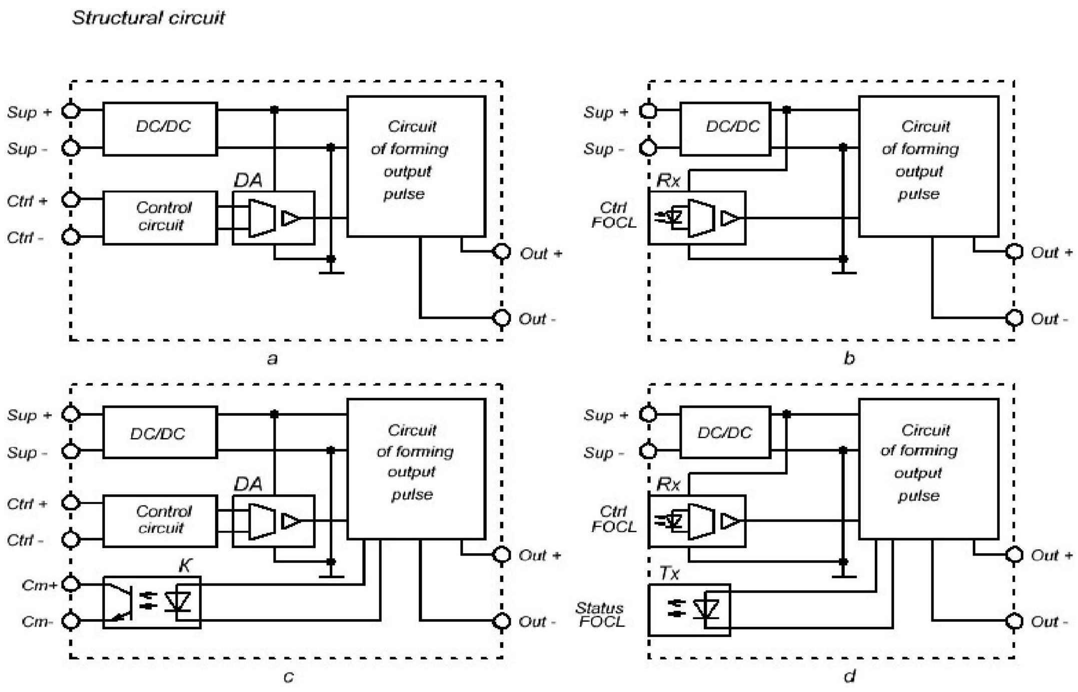


Figure 3.1 – Structure circuit of TD

Figure 3.1 shows structure circuits of the TD:

a – TD with potential or current control;

b – TD with control through fiber optic receiver;

c – TD with potential or current control with current control in thyristor driving circuit with status signal delivery to open optocoupler collector;

d – TD with control through a fiber optic receiver, with current control in thyristor control circuit, with status signal delivery through fiber optic receiver.

The TD of all modifications includes: DC/DC converter; opto decoupling circuit DA on base of FOCL for transmission of control signal that forms the output pulse; output pulse forming circuit generating pulse with current source of necessary form on controlling thyristor electrode. In TD modifications with potential or current control there is a control circuit converting input potential or current control signal into signal for giving to optoelectronic decoupling circuit DA.

In TD modifications with FOCL control, controlling signal for driver version in housing ME is given to FOCL receiver of type HFBR2522, for driver version in housing G the control signal is given to FOCL receiver SFH551/1-1V. In modifications with current control in controlling thyristor electrode output pulse forming circuit gives status signal about current availability in thyristor drive circuit by means of K transmitter that is optically isolated from control and supply circuits.

For isolation voltage of supply circuits and control circuits equ1led 5 kV as a transmitter is used an optocoupler with output of status signal on open collector of the optocoupler. In the modification TD of all insulation voltages as a transmitter for the version of the driver ME is used FOCL-transmitter HFBR1522, and for driver version in housing G a FOCL transmitter SFH756V is used.

Connection to the TD in housing of type ME is carried out with screw terminal blocks, to the TD in housing G -with spring terminal blocks of type DG142V. Outputs application is shown in Table 3.1.

Table 3.1 – Outputs application

Symbol	Function
Sup +	Supply plus
Sup -	Supply minus
Ctrl +	Control plus
Ctrl -	Control minus
FOCL cont	FOCL receiver HFBR2522 for driver TD1X-XX-XX-XXX
	FOCL receiver SFH551/1-1V for driver TD2X-XX-XX-XXX
Out +	Output signal plus
Out -	Output signal minus
FOCL status	Control signal of current availability in thyristor control circuit (FOCL transmitter HFBR1522 for driver TD1X-XX-XX-XXX)
	Control signal of current availability in thyristor control circuit (FOCL transmitter SFH756V for driver TD2X-XX-XX-XXX)
St+	Control signal plus of current availability in thyristor control circuit (optocoupler transistor collector)
St-	Control signal minus of current availability in thyristor control circuit (optocoupler transistor emitter)

4 BASIC CHARACTERISTICS

Basic electric characteristics and maximum permissible electric TD characteristic at temperature 25 °C are shown in Table 4.1.

Table 4.1 – Basic and maximum permissible electric characteristics

Name	Unit	Rate			Note
		min	type	max	
Supply characteristics					
Supply voltage	V	15		30	

Current consumption (at $U_{ctrl} = 0$)	mA	40		60	TD1-XX-XX-XXX
		50		85	TD1A-XX-XX-XXX
Control circuit characteristics					
Potential control:					
Control signal voltage	V		5		TDXX-A1-XX-XXX
Input current	mA			10	
Current control:					
Control signal current	mA	8	10	12	TDXX-C1-XX-XXX
Voltage	V	5		36	
FOCL:		FOCL-receiver HFBR2522			TD1X-F1-XX-XXX
Wave length	nm		660		
Effective diameter	mm		1		
		FOCL-receiver SFH551/1-1V			TD2X-F2-XX-XXX

Continuation of Table 4.1

Name	Unit	Rate			Note
		min	type	max	
Wave length	nm		660		
Diameter of optical fiber	mm		2.2		
Frequency of controlled signal	kHz			0.25	TDXX-XX-S-XXX
				5	TDXX-XX-F5-XXX
				20	TDXX-XX-F20-XXX
Duty factor		2			
Status signal characteristics					
FOCL:		FOCL-transmitter HFBR1522			
Wave length	nm		660		
Effective diameter	mm		1		
		FOCL-transmitter SFH756V			
Wave length			660		
Diameter of optical fiber			2.2		
Optocoupler:					U_{isol} is equal to 5kV $f_{com} \leq 5$ kHz
Collector-emitter voltage	V			55	
Collector current	mA			50	
Output characteristics					
Amplitude of afterburning pulse I_{gm}	A	4		5.5	Rn = 1 Ω
Amplitude of continuous positive sustaining current Igon	A	0.8	1		Rn = 1 Ω
Amplitude of continuous negative current Igoff	A	0.15	0.25		Rn = 1 Ω
Time characteristics					
Turn-on delay td(on)	μs			1	
Turn-off delay td(off)	μs			5	
Rise time duration of afterburning pulse tr	μs		0.4	1	Rn = 1 Ω
Fall time duration of afterburning pulse t_f	μs			4	
Afterburning pulse duration of level 50% $t_p(I_{gm})$	μs	20		25	TDXX-XX-S-XXX
		15		18	TDXX-XX-F5-XXX
		8		10	TDXX-XX-F20-XXX
Pulse fall time t_{off}	μs			1	
Isolation characteristics					
Insulation voltage of power supply and control circuit U_{isol}	V	5000			DC, during 1 minute
		10000			
		15000			

The full product list of the drivers' series TD is shown in Table 4.2-4.6

Table 4.2 — Line of drivers' series TD1X-XX-XXX for isolation 5 kV

Isolation	Housing type	Control	Status	Speed	Driver
5 kV	TD1 (housing ME)	5 V, 10 mA	-	250 Hz	TD1X-A1-S-5
		5-36 V, 10 mA			TD1X-C1-S-5
		HFBR2522			TD1X-F1-S-5
		5 V, 10 mA	-	5 kHz	TD1X-A1-F5-5
		5-36 V, 10 mA			TD1X-C1-F5-5
		HFBR2522			TD1X-F1-F5-5
		5 V, 10 mA	-	20 kHz	TD1X-A1-F20-5
		5-36 V, 10 mA			TD1X-C1-F20-5
		HFBR2522			TD1X-F1-F20-5
		5 V, 10 mA	Open collector of optocoupler	250 Hz	TD1X-A1-S-5K
		5-36 V, 10 mA			TD1X-C1-S-5K
		HFBR2522	HFBR1522		TD1X-F1-S-5K
		5 V, 10 mA	Open collector of optocoupler	5 kHz	TD1X-A1-F5-5K
		5-36 V, 10 mA			TD1X-C1-F5-5K
		HFBR2522	HFBR1522		TD1X-F1-F5-5K
		HFBR2522	HFBR1522	20 kHz	TD1X-F1-F20-5K

Table 4.3 — Line of drivers' series TD2X-XX-XXX for isolation 5 kV

Isolation	Housing type	Control	Status	Speed	Driver
5 kV	TD2 (housing G)	5 V, 10 mA	-	250 Hz	TD2X-A1-S-5
		5-36 V, 10 mA			TD2X-C1-S-5
		SFH551/1-1V			TD2X-F2-S-5
		5 V, 10 mA	-	5 kHz	TD2X-A1-F5-5
		5-36 V, 10 mA			TD2X-C1-F5-5
		SFH551/1-1V			TD2X-F2-F5-5
		5 V, 10 mA	-	20 kHz	TD2X-A1-F20-5
		5-36 V, 10 mA			TD2X-C1-F20-5
		SFH551/1-1V			TD2X-F2-F20-5
		5 V, 10 mA	Open collector of optocoupler	250 Hz	TD2X-A1-S-5K
		5-36 V, 10 mA			TD2X-C1-S-5K
		SFH551/1-1V	SFH756V		TD2X-F2-S-5K
		5 V, 10 mA	Open collector of optocoupler	5 kHz	TD2X-A1-F5-5K
		5-36 V, 10 mA			TD2X-C1-F5-5K
		SFH551/1-1V	SFH756V		TD2X-F2-F5-5K
		SFH551/1-1V	SFH756V	20 kHz	TD2X-F2-F20-5K

Table 4.4- Line of drivers' series TD1X-XX-XXX for isolation 10 kV

Isolation	Housing type	Control	Status	Speed	Driver
10 kV	TD1 (housing ME)	5 V, 10 mA	-	250 Hz	TD1X-A1-S-10
		5-36 V, 10 mA			TD1X-C1-S-10
		HFBR2522			TD1X-F1-S-10
		5 V, 10 mA	-	5 kHz	TD1X-A1-F5-10
		5-36 V, 10 mA			TD1X-C1-F5-10
		HFBR2522			TD1X-F1-F5-10
		5 V, 10 mA	-	20 kHz	TD1X-A1-F20-10
		5-36 V, 10 mA			TD1X-C1-F20-10
		HFBR2522			TD1X-F1-F20-10
		HFBR2522	HFBR1522	250 kHz	TD1X-F1-S-10K
		HFBR2522	HFBR1522	5 kHz	TD1X-F1-F5-10K
		HFBR2522	HFBR1522	20 kHz	TD1X-F1-F20-10K

Table 4.5- Line of drivers' series TD2X-XX-XXX for isolation 10 kV

Isolation	Housing type	Control	Status	Speed	Driver
10 kV	TD 2 (housing G)	5 V, 10 mA	-	250 Hz	TD2X-A1-S-10
		5-36 V, 10 mA			TD1X-C1-S-10
		SFH551/1-1V			TD1X-F2-S-10
		5 V, 10 mA	-	5 kHz	TD2X-A1-F5-10
		5-36 V, 10 mA			TD1X-C1-F5-10
		SFH551/1-1V			TD1X-F2-F5-10
		5 V, 10 mA	-	20 kHz	TD2X-A1-F20-10
		5-36 V, 10 mA			TD1X-C1-F20-10
		SFH551/1-1V			TD1X-F2-F20-10
		SFH551/1-1V	SFH756V	250 kHz	TD2X-F2-S-10K
		SFH551/1-1V	SFH756V	5 kHz	TD2X-F2-F5-10K
		SFH551/1-1V	SFH756V	20 kHz	TD2X-F2-F20-10K

Table 4.6 — Line of drivers' series TD1X-XX-XXX and TD2X-XX-XXX for isolation 15 kV

Isolation	Housing type	Control	Status	Speed	Driver
15 kV	TD1 (housing ME)	HFBR2522	-	250 Hz	TD1X-F1-S-15
		HFBR2522	-	5 kHz	TD1X-F1-F5-15
		HFBR2522	-	20 kHz	TD1X-F1-F20-15
		HFBR2522	HFBR2522	250 Hz	TD1X-F1-S-15K
		HFBR2522	HFBR2522	5 kHz	TD1X-F1-F5-15K
		HFBR2522	HFBR2522	20 kHz	TD1X-F1-F20-15K
	TD2 (housing G)	SFH551/1-1V	-	250 Hz	TD2X-F2-S-15
		SFH551/1-1V	-	5 kHz	TD2X-F2-F5-15
		SFH551/1-1V	-	20 kHz	TD2X-F2-F20-15
		SFH551/1-1V	SFH756V	250 Hz	TD2X-F2-S-15K
		SFH551/1-1V	SFH756V	5 kHz	TD2X-F2-F5-15K
		SFH551/1-1V	SFH756V	20 kHz	TD2X-F2-F20-15K

5 DRIVER CONTROL

The main task of TD (pulse generator of thyristor control) is generation of current pulse in the thyristor control circuit in the present point of time with the required amplitude values and length.

Thyristor is a bipolar semiconductor element that is controlled by current, therefore driver block should be a current source of the required form and that is delivered to circuit: control electrode – thyristor cathode.

In this case the voltage between control electrode and cathode is a function of input full resistance of control circuit.

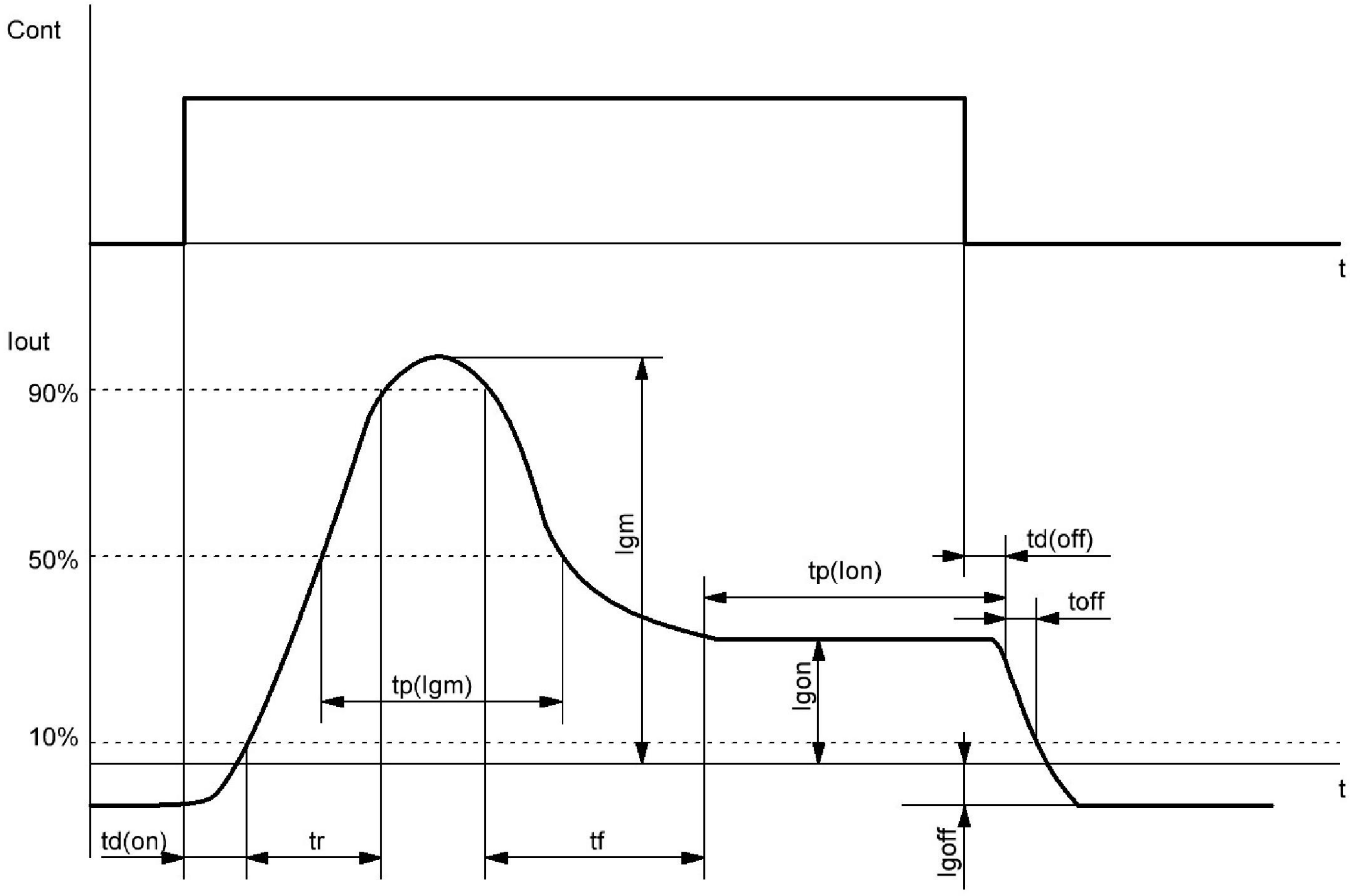


Figure 5.1 – Functional diagram

Figure 5.1 represents a standard current form, which is recommended for power thyristor control. The main requirements that presented to the driver that control the thyristor, are caused by thyristor switching characteristics, control circuit parameters and converter load.

The basis characteristics describing control wave front (I_{gm}, dig/dt, tr and tp(I_{gm}), determine the following thyristor characteristics:

- Turn-on delay time;
- Fall time of forward voltage when connection;
- Turn-on energy;
- Permitted value of anode rise current when connection (di/dt).

1 di_G/dt

 High-capacity pulse with sharp leading edge guarantees turn-on simultaneity both the main thyristor and integrated with it amplifier. The weak pulse creates local areas hazard of anode current passing. This can lead to destruction of device structure beside of local overheats.

- When series thyristor connection. When connecting it is very important to ensure simultaneous connection of all series-connected thyristors to avoid overvoltage at more slowly connected device. With a view to compensating thyristor turn-on delay time spread of one group you should give a rather high-powered control pulse with sharp leading edge. Consequences of small unbalance in turn-on time, caused by technological spread in chips temperature, may be eliminated using damping RC-circuits («snubber»), which are connected to each of the thyristors. This snubber is usually used to avoid overvoltage that arise when thyristor disconnecting.

- When parallel thyristor connection. The difference in descriptions of connected conducting thyristors may be decreased by means of control pulses' current. This is also a main factor of even current distribution between parallel-connected thyristors at the initial interval of turn-on process, which is in dynamic mode.

- When thyristor operation under high level conditions of electromagnetic disturbances. In this case you should turn-on filter between cathode and controlling thyristor electrode which at the same time will weaken control pulse.

For all thyristors current value I_{gm} should be about 10 A. For value di_G/dt there are no recommended extra limitations. The practical limitations for this characteristic are self-inductance of thyristor control circuit and voltage value of control circuit U_{GM}. Current burst time on leading edge of a pulse $t_p(I_{gm})$ should be in the following range: 10 µs at $di_G/dt \geq 20$ A/ µs and 30 µs при $di_G/dt \leq 5$ A/ µs.

2 I_{gon}

In many thyristor devices the moment when thyristor voltage becomes positive, and it should take load current, can not be synchronized with driver pulse. In this case connection may be carried out by control current, formed in the early emergence of positive voltage. As the current, that then arises, has low value di/dt, it is sufficient that current value Igon should exceed to a little degree control current level with regard to minimum value of junction temperature, mentioned for specific service conditions.

Current I_{gon} should be given in control circuit as well in the cases when anode current can change and decrease unexpectedly to hold current value or become even negative. In this case availability of current I_{gon} guarantees the preservation of thyristor on state at all intervals, where thyristor conducting state is needed.

Current effect I_{gon} at thyristor on state voltage is insignificantly until anode current is very small, that is like hold current. It is recommended to support current $I_{gon} \geq I_{GT}$, where I_{GT} – minimal control DC, required for thyristor connection with regard to possible minimum chip temperature.

3 tp(I_{gon})

Current Igon should be also delivered to control circuit in those cases when anode current can be changed unexpectedly and decreased to hold current value or even can be negative. In this case current availability I_{gon} guarantees the retention of thyristor on state in all ranges where the conducting state is required.

4 I_{goff}

As known thyristors have low stability to rate of change of anode voltage. The manufacturer of high-capacity thyristors take special measures when carrying out the mechanical process to increase dU/dt but this parameter can not be increased over 400÷600 V/µs. Availability of long negative current Igoff on controlling thyristor electrode, at the moments, when thyristor should be closed, will increase thyristor stability to rate of change of anode voltage.

TD functions in such a way to form signal of necessary form on controlling thyristor electrode. Driver supply is performed from DC source with supply voltage of 15÷30 V. Input voltage is transformed with built-in DC/DC converter and comes to output signal forming circuit. TD control is carried out from current or potential signal that is optically isolated from supply and output circuit, characteristics thereof are shown in Table 4.1, as well with FO control.

Controlling signals come to output pulse forming circuit that is an amplifier-former that forms output pulse with necessary time characteristics by the instrumentality of built-in current source. For TD options which include current control in thyristor control circuit, the forming circuit of output pulse defines current passing in thyristor control circuit, and gives status signal about its availability. For isolation voltage of 5 kV status signal forms by the instrumentality of optocoupler, and for isolation voltage of 10 and 15 kV status signal forms by the instrumentality of FO control.

Control signals are delivered to output pulse-shaping circuit that is an amplifier-former that forms input pulse with the required time characteristics by means of built-in current source. The variants of TD that include current control in thyristor control circuit, output pulse-sharing circuit determines current flowing in thyristor control circuit and gives status signal about its availability. If the insulation voltage is 5 kV then the status signal is formed by means of optocoupler, and if the insulation voltage is 10 and 15 kV then the status signal is formed by means of FOCL transmitter.

6 GRAPHS EXPLAINING CIRCUIT OPERATION

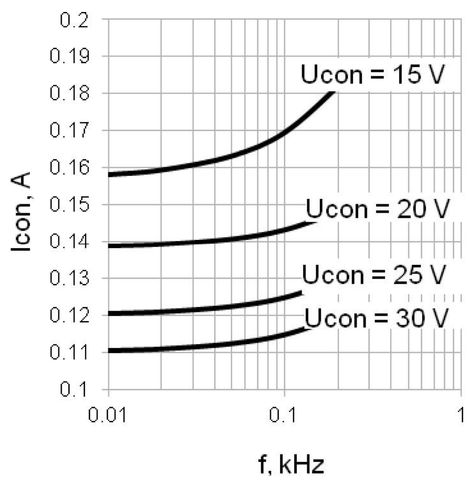


Figure 6.1 – Current consumption versus switching frequency TDXX-XX-S-XXX

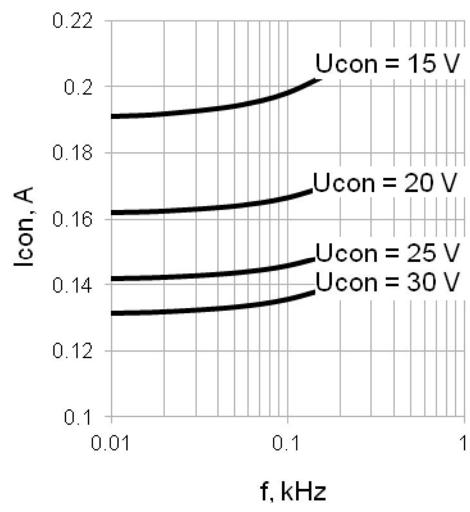


Figure 6.2 – Current consumption versus switching frequency TDXA-XX-S-XXX

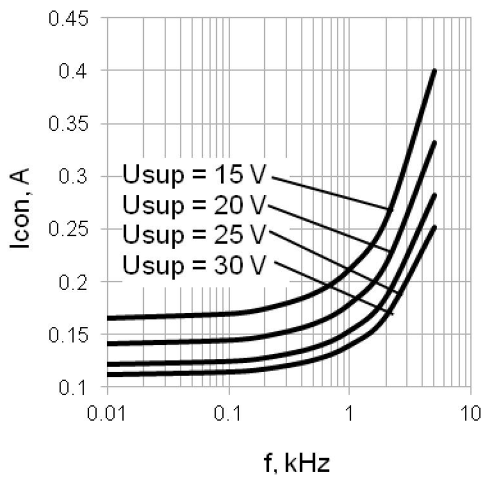


Figure 6.3 – Current consumption versus switching frequency TDXX-XX-F5-XXX

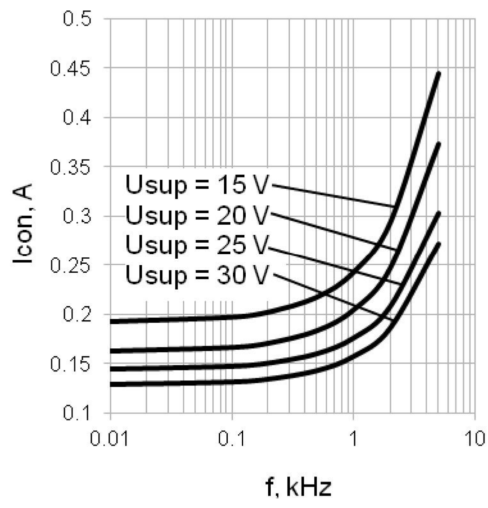


Figure 6.4 – Current consumption versus switching frequency TDXA-XX-F5-XXX

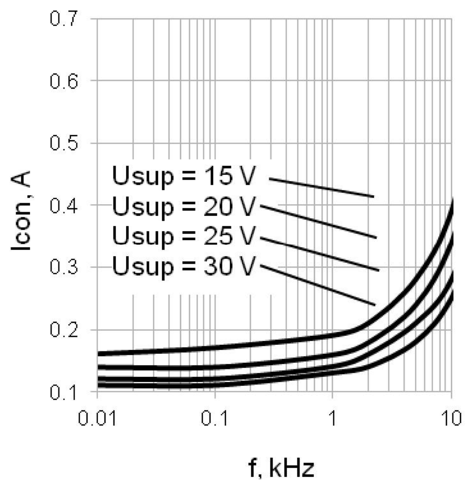


Figure 6.5 – Current consumption versus switching frequency TDX-XX-F20-XXX

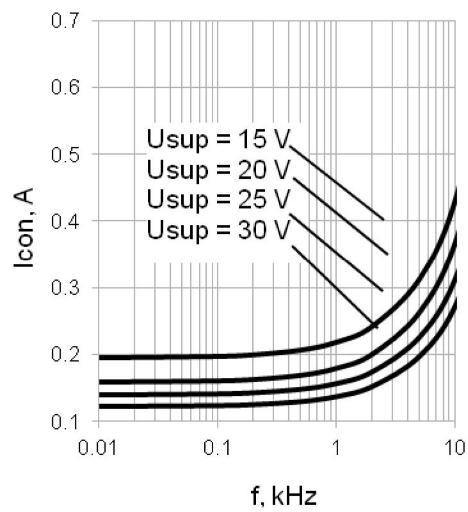


Figure 6.6 – Current consumption versus switching frequency TDX**A**-XX-F20-XXX

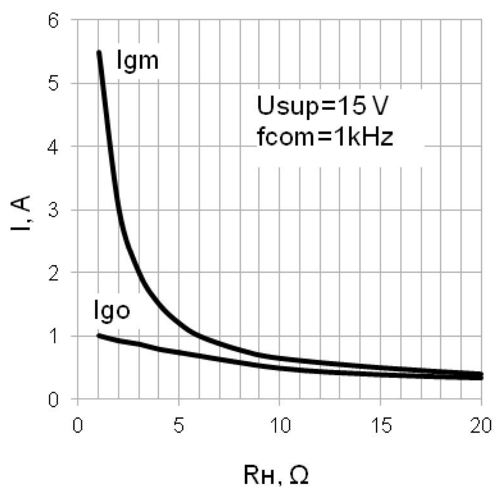


Figure 6.7 – Dependence graph of afterburner pulse amplitude and continuous positive current versus load resistance

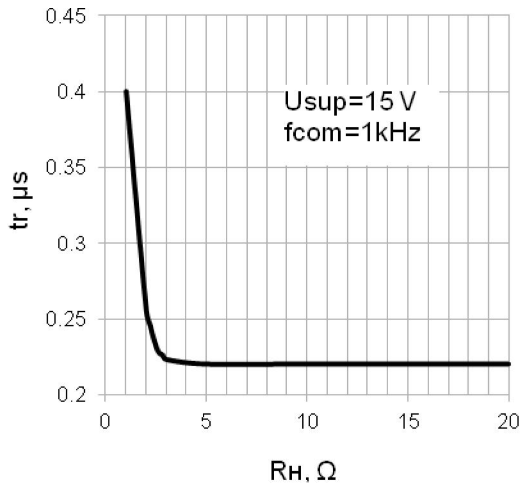


Figure 6.8 – Dependence graph of afterburner pulse front versus load resistance

7 SERVICE RECOMMENDATIONS

Connection to the driver

Connection to the driver in housing ME is carried out by means of screw terminal blocks, in housing G it is connected by means of press terminal blocks series DG142V. FOCL control connection and status signal connection is performed by means of LED.

Driver adjustment

The driver in housing ME is installed to the standard DIN-rail 35 mm, in housing G it is installed to the panel by means of screws M4.

The driver should be settled in such a way that to provide it from additional heating from the neighboring elements.

Service requirements

The module should only be used in exposure to mechanical loads in accordance with Table 7.1.

Table 7.1 – Mechanical loads impacts

External exposure factor	External exposure factor value
Sinusoidal vibration: - frequency range, Hz - acceleration amplitude, m/s^2 (g)	 0.5 – 100 150 (15)
Mechanical shock of single action : - peak impact acceleration , m/s^2 (g); - duration of impact acceleration, ms	 40 (4) 50

The module should be used under the influence of climate stresses in accordance with Table 7.2.

Table 7.2 – Impact of climate impacts

Climatic factor	Value of climatic factor
Low temperature of environment: - operating, °C; - absolute, °C	 - 40 - 45
High temperature of environment: - operating, °C; - absolute, °C	 + 85 + 100
Relative humidity at a temperature 35 °C without condensation %, max	98

Safety requirements

1. Be careful when the device operating.
2. All connections should be performed only when the power is off.
3. Connect measuring devices only after deenergizing.
4. Never alter the device. If disassemble and modernization of device is necessary, please contact the manufacturer.
5. Do not expose the driver to water and other liquids.

8 RELIABILITY SPECIFICATIONS

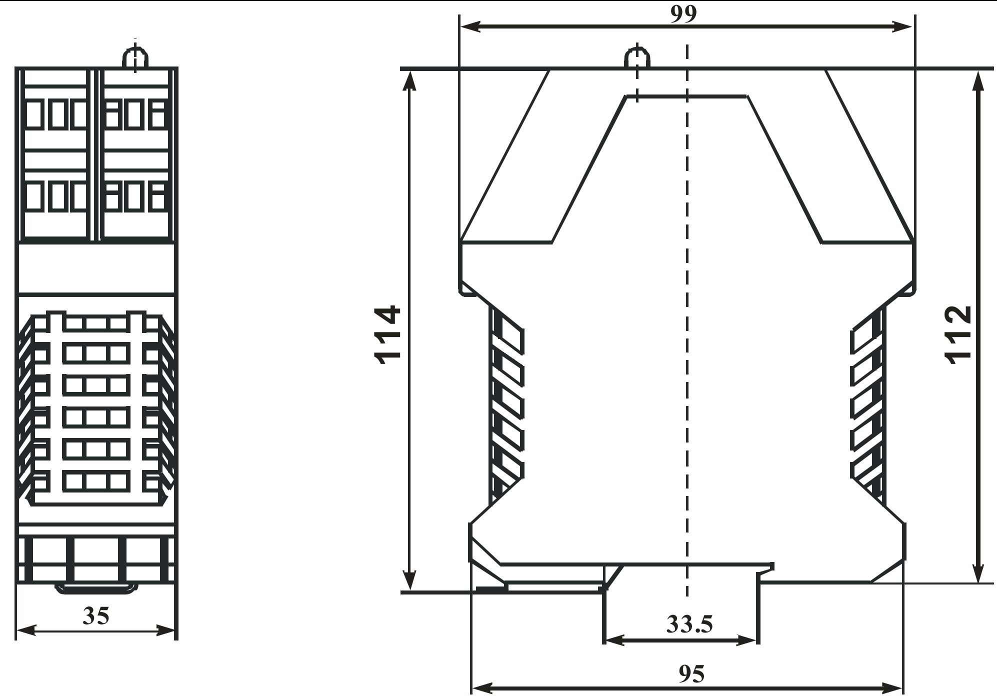
Reliability probability of the module for 25000 hours must be at least 0.95.

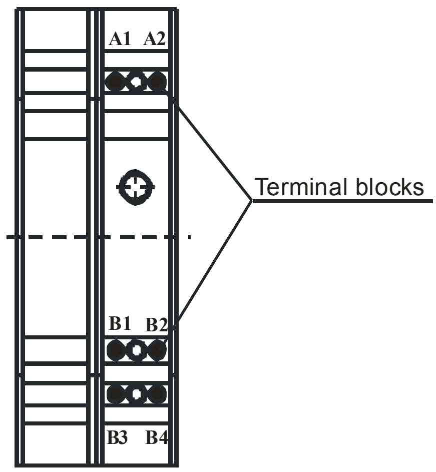
Gamma-percent life must be no less than 50000 hours by γ = 90 %.

Gamma-percent service life of the modules, subject to cumulative operating time is not more than gamma-percent life, not less than10 years, at γ = 90 %.

Gamma-percent storageability time of the modules, at γ = 90 % and storing – 10 years.

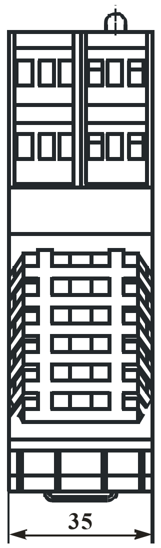
9 OVERALL AND CONNECTING DIMENSIONS

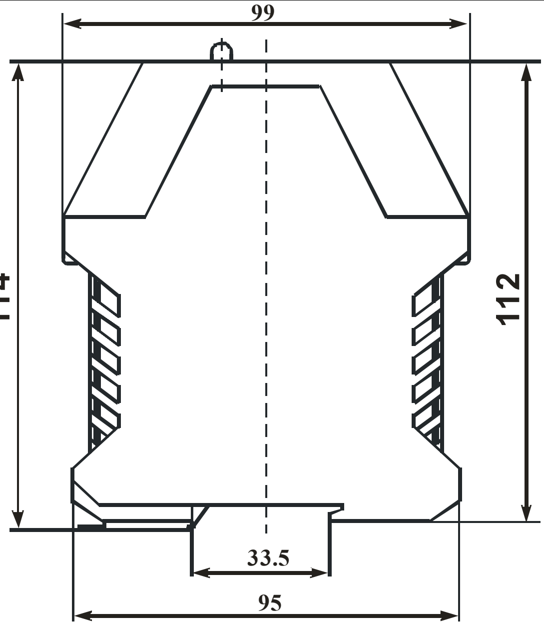


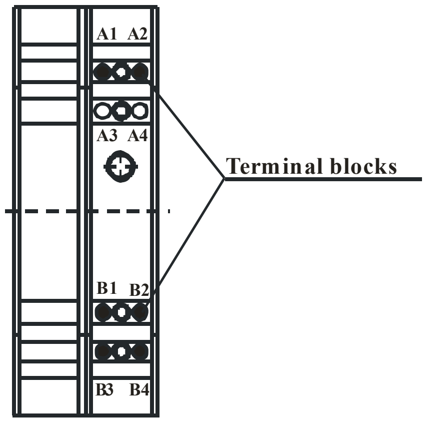


Outputs	Function
A1	+ out
A2	- out
B1	- sup
B2	+ sup
B3	- cont
B4	+ cont

TD1(A)-A1(C1)-S(F5,F20)-5(10) – with current and potential control without status

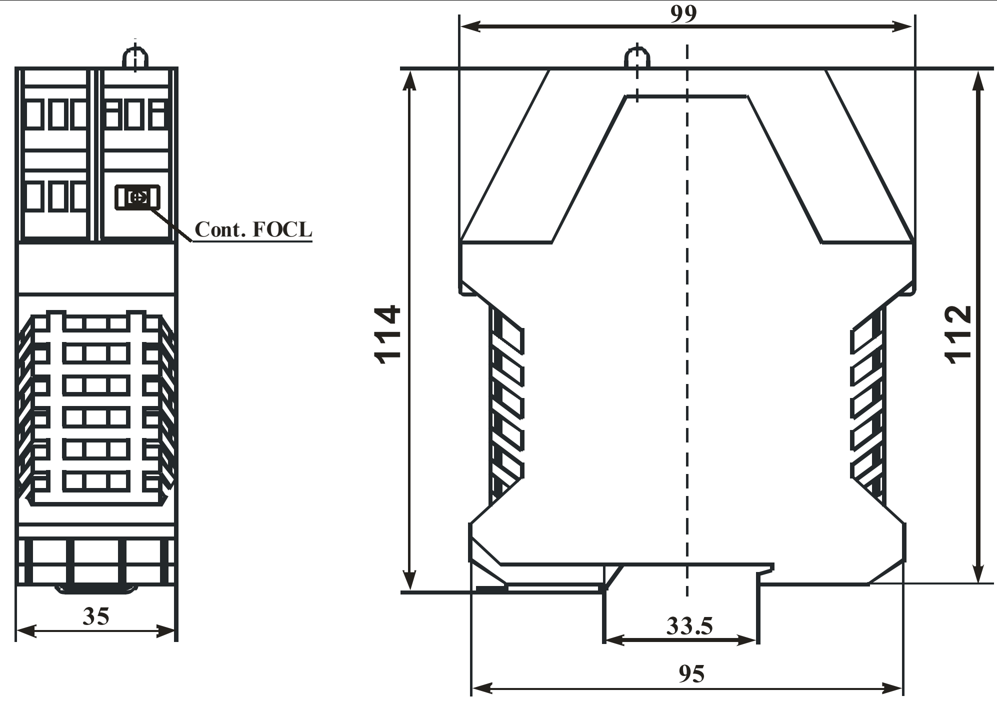


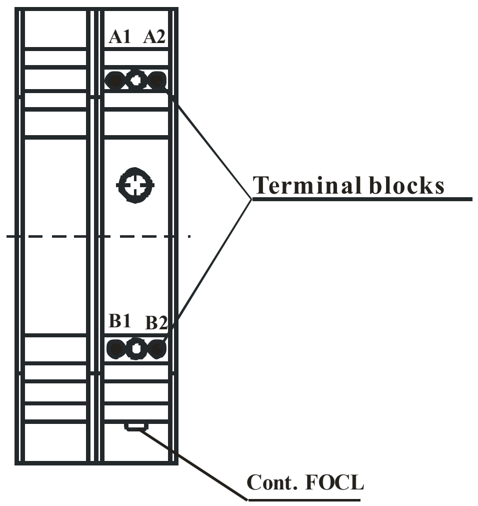




Outputs	Function
A1	+ out
A2	- out
A3	+ st
A4	- st
B1	- s
B2	+ s
B3	- cont
B4	+ cont

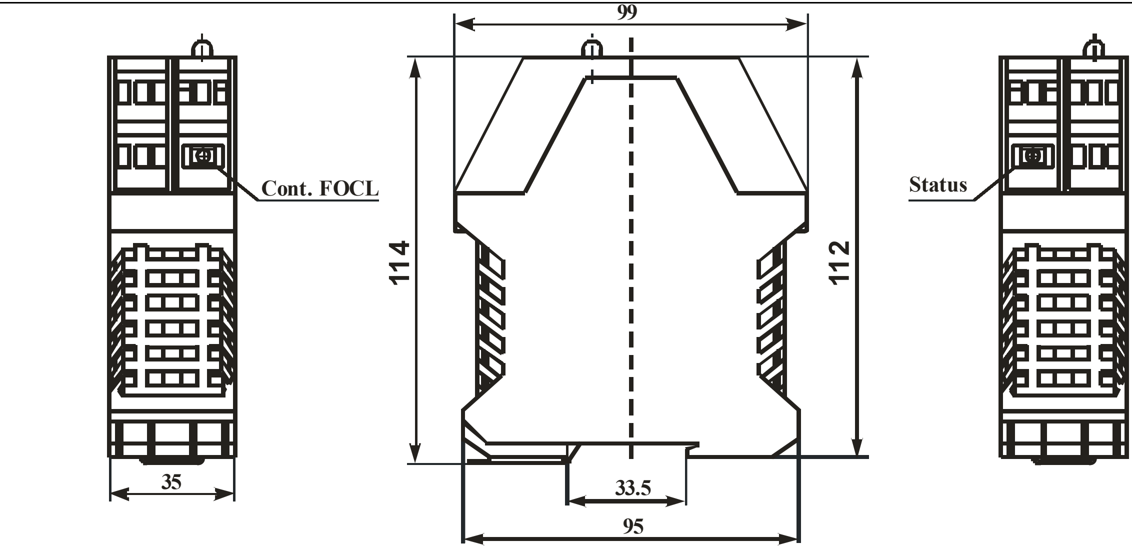
TD1(A)-A1(C1)-S(F5,F20)-5K – with current and potential control with status

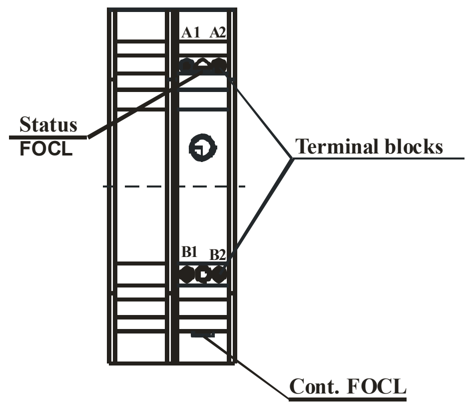




Outputs	Function
A1	+ out
A2	- out
B1	- sup
B2	+ sup

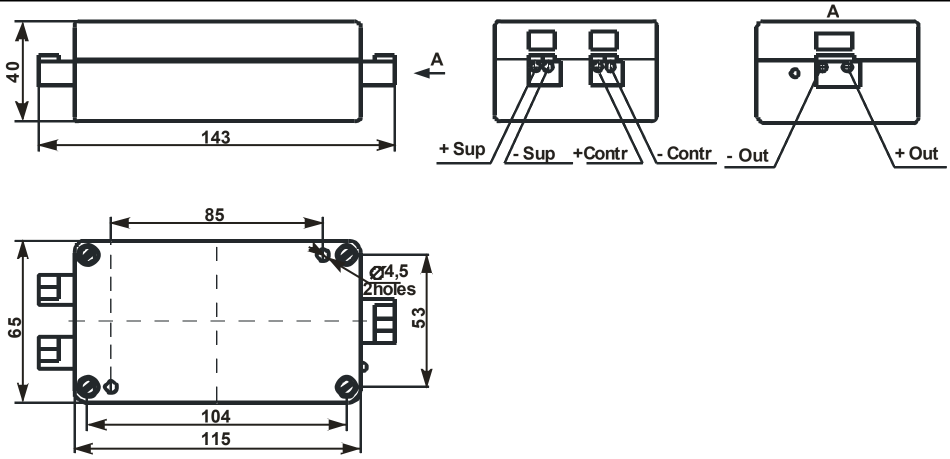
TD1(A)-F1-S(F5,F20)-5(10,15) – with FOCL control without status



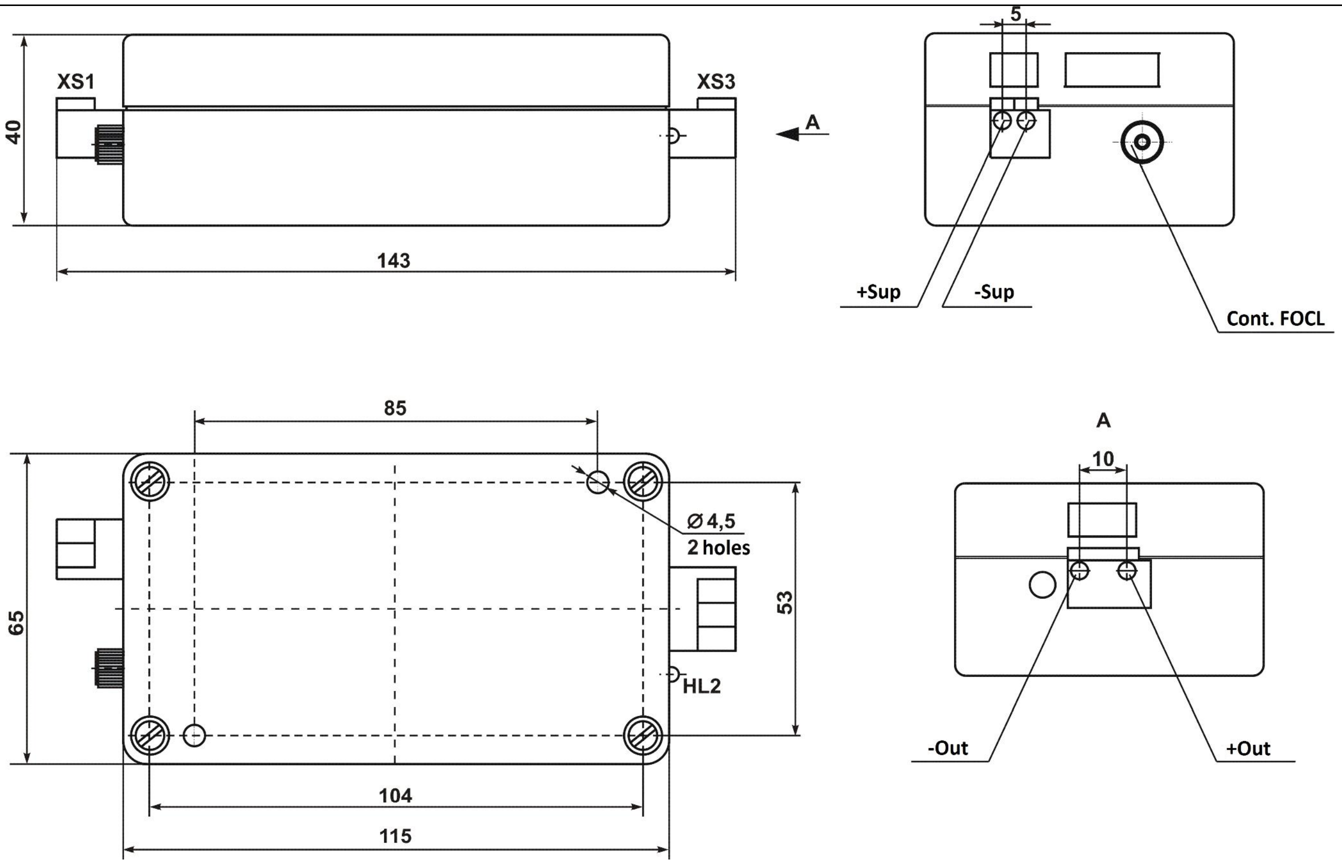


Outputs	Function
A1	+ out
A2	- out
B1	- sup
B2	+ sup

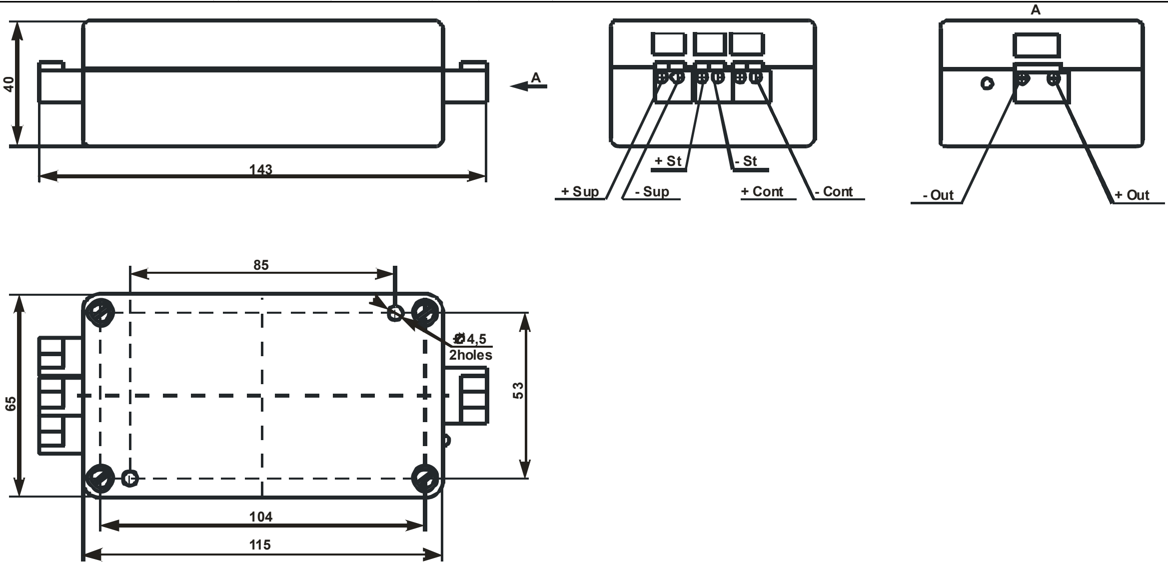
TD1(A)-F1-S(F5,F20)-5(10,15)K –with FOCL control with FOCL status



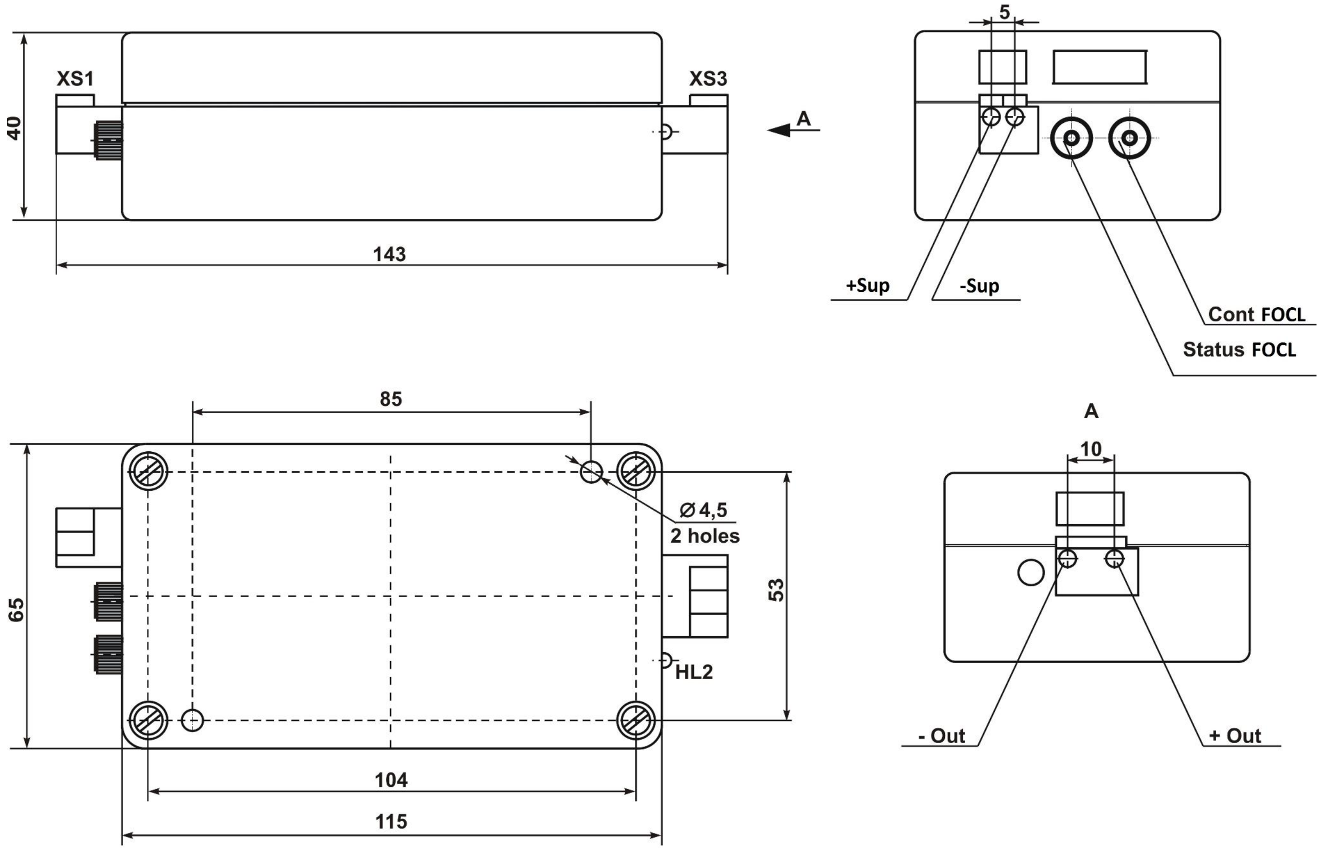
TD2(A)-A1(C1)-S(F5,F20)-5(10) – with current and potential control without status



TD2(A)-F2-S(F5, F20)-5(10,15) – with FOCL control without status



TD2(A)-A1(C1)-S(F5,F20)-5K – with current and potential control with status



TD2(A)-F2-S(F5, F20)-5(10,15)K – with FOCL control with FOCL status

Precious metals are not contained.

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