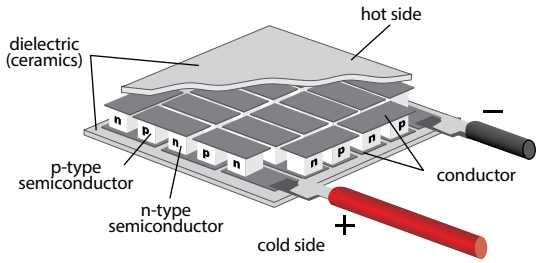
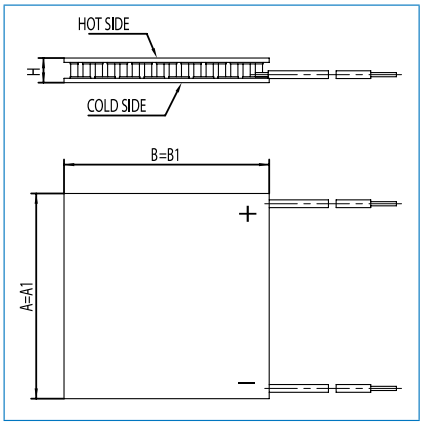
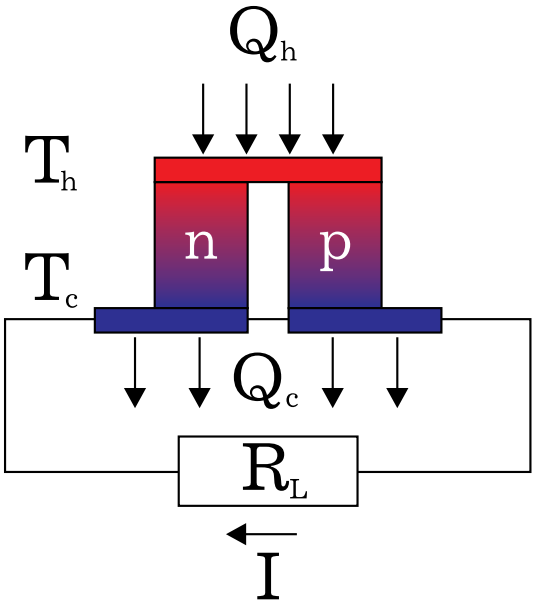
Thermoelectric Generating modules

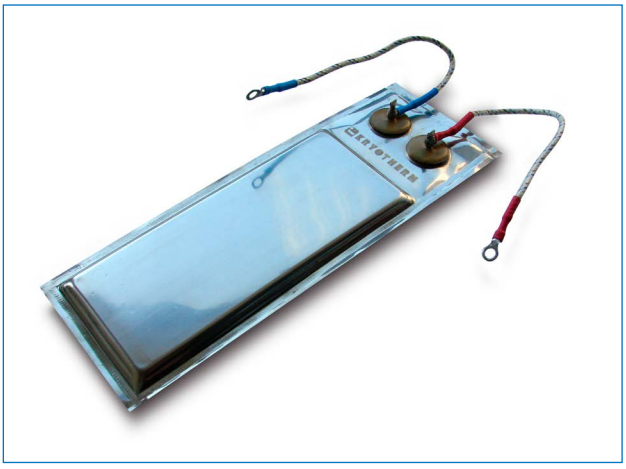
With thermoelectric generating modules (TGM), produced by KRYOTHERM, is possible to get up to several watts DC with voltage up to 6V from one TGM at a temperature difference between it's hot and cold sides of 100°C.

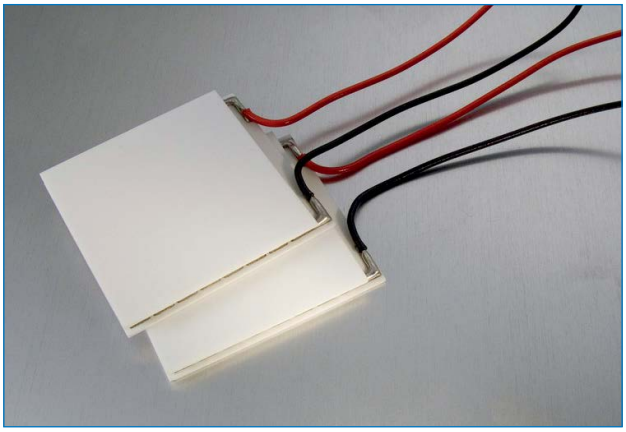


Thermoelectric Generating Module drawing and structure









Applications:

- utilization of waste heat from vehicles (automobiles, ships) engines;
- autonomic supply of energy to operation control devices of water boilers and disposal plants;
- cathodic protection of the oil and gas pipelines;
- conversion of natural heat resources — geothermal waters, etc. into electric energy;
- power supply of stand-alone low-power electronic devices (Energy Harvesting).

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Thermoelectric Generating modules

Abbreviations and definitions	
TGM	Thermoelectric generating module
Rac	Electric resistance of TGM, for specified temperature range at 1 kHz AC
Rac at 22°C	Electric resistance of TGM, measured at 295K (22°C) at 1 kHz AC
Rt	Thermal resistance of TGM for specified temperature range
Ri	Value of internal electric resistance of TGM at working temperature
I	Value of output current with load resistance R_L =Ri
U	Value of output voltage with load resistance R_L =Ri
P	Value of output electrical power with load resistor R_L =Ri
η	Efficiency of TGM with load resistand R_L =Ri (show TGM performance)

Note: TGM's indicated parameters include temperature losses in the ceramic plates and the 30 microns layer of heat conductive silicon oil at hot and cold sides.

Medium temperature Generating modules Mars series

Type	Overall dimensions, mm			Fitting dimensions, mm			Tcold side=75°C Thot side=500°C		
	A	B	C	A1	B1	C1	Ri*, Ohm	P, W	Performance, %
Mars-40	259	92	12,4	171	68	12,4	0,7	42	6,7

R_i* – module's internal resistance at R_i=R_L , where R_L – electrical resistance load.
The compression force is 10 tons.
Warranty period under the working temperature Thot side=500°C – 10 years.

Thermoelectric generating modules										
Type	Dimensions, mm			Rac, Ohm	Rac at 22°C, Ohm	Rt, K/W	U	I	P	η
	A	B	H				Volts	Amps	Watts	%
Tcold side = 30°C; T hot side = 200°C (maximum working temperature)										
TGM-127-1,0-0,8	30	30	3,1	1,84	1,29	1,69	3,00	1,66	5,1	4,7
TGM-127-1,0-1,3	30	30	3,6	3,00	2,1	2,7	3,4	1,12	3,8	5,1
TGM-127-1,0-2,5	30	30	4,8	5,8	4,0	5,0	3,7	0,63	2,3	5,4
TGM-127-1,4-0,8	40	40	3,1	0,95	0,66	0,87	3,00	3,1	9,4	4,6
TGM-127-1,4-1,2	40	40	3,5	1,42	0,49	1,28	3,3	2,3	7,5	4,9
TGM-127-1,4-1,5	40	40	3,9	1,89	1,31	1,69	3,4	1,81	6,2	5,1
TGM-127-1,4-2,0	40	40	4,3	2,4	1,64	2,1	3,5	1,5	5,3	5,3
TGM-127-1,4-2,5	40	40	4,8	3,0	2,0	2,6	3,6	1,23	4,5	5,4
TGM-127-2,0-1,3	48	48	3,6	0,75	0,53	0,69	3,1	4,1	12,6	4,7
TGM-199-1,4-0,8	40	40	3,2	1,46	1,03	0,57	4,1	2,8	11,4	4,1
TGM-199-1,4-1,15	40	40	3,6	2,1	1,48	0,81	4,6	2,2	10,0	4,6
TGM-199-1,4-1,2	40	40	3,7	2,2	1,54	0,84	4,6	2,1	9,8	4,6
TGM-199-1,4-1,5	40	40	4,1	2,9	2,0	1,12	5,0	1,69	8,4	4,9
TGM-199-1,4-2,0	40	40	4,4	3,7	2,6	1,39	5,2	1,41	7,3	5,1
TGM-199-1,4-2,5	40	40	4,9	4,6	3,2	1,72	5,4	1,17	6,3	5,2
TGM-199-1,4-3,5	40	40	6,0	6,5	4,5	2,4	5,6	0,87	4,9	5,4
TGM-253-1,4-1,5R	d 61	-	3,9	3,8	2,6	0,85	6,8	1,8	12,2	5,1
TGM-254-1,0-1,3	40	40	3,6	6,0	4,2	1,36	6,6	1,1	7,3	5,0
TGM-287-1,0-1,3	40	40	3,6	6,7	4,7	1,21	7,3	1,08	7,9	4,9
TGM-287-1,0-1,5	40	40	3,8	7,8	5,4	1,39	7,5	0,96	7,2	5,0
TGM-287-1,0-2,5	40	40	4,8	13,0	9,0	2,3	8,1	0,62	5,0	5,3

Thermoelectric Generating modules

Thermoelectric generating modules										
Type	Dimensions, mm			Rac, Ohm	Rac at 22°C, Ohm	Rt, K/W	U	I	P	η
	A	B	H				Volts	Amps	Watts	%
Tcold side = 50°C; T hot side = 150°C (maximum working temperature)										
TGM-127-1,0-0,8	30	30	3,1	1,76	1,29	1,72	1,83	1,04	1,9	3,0
TGM-127-1,0-1,3	30	30	3,6	2,9	2,1	2,8	2,0	0,7	1,41	3,2
TGM-127-1,0-2,5	30	30	4,8	5,5	4,0	5,2	2,2	0,4	0,86	3,4
TGM-127-1,4-0,8	40	40	3,1	0,91	0,66	0,88	1,79	1,97	3,5	2,9
TGM-127-1,4-1,2	40	40	3,5	1,35	0,99	1,31	1,95	1,44	2,8	3,1
TGM-127-1,4-1,5	40	40	3,9	1,8	1,31	1,73	2,0	1,13	2,3	3,3
TGM-127-1,4-2,0	40	40	4,3	2,2	1,64	2,2	2,1	0,94	1,96	3,4
TGM-127-1,4-2,5	40	40	4,8	2,8	2,0	2,7	2,1	0,77	1,65	3,4
TGM-127-2,0-1,3	48	48	3,6	0,72	0,53	0,71	1,85	2,6	4,7	3,0
TGM-199-1,4-0,8	40	40	3,2	1,41	1,03	0,57	2,5	1,75	4,3	2,6
TGM-199-1,4-1,15	40	40	3,6	2,0	1,48	0,82	2,7	1,36	3,7	2,9
TGM-199-1,4-1,2	40	40	3,7	2,1	1,54	0,86	2,8	1,32	3,7	2,9
TGM-199-1,4-1,5	40	40	4,1	2,8	2,0	1,14	3,0	1,06	3,1	3,1
TGM-199-1,4-2,0	40	40	4,4	3,5	2,6	1,41	3,1	0,88	2,7	3,2
TGM-199-1,4-2,5	40	40	4,9	4,4	3,2	1,76	3,2	0,73	2,3	3,3
TGM-199-1,4-3,5	40	40	6,0	6,1	4,5	2,5	3,3	0,54	1,82	3,5
TGM-253-1,4-1,5R	d 61	-	3,9	3,6	2,6	0,87	4,0	1,13	4,5	3,3
TGM-254-1,0-1,3	40	40	3,6	5,7	4,2	1,39	3,9	0,69	2,7	3,2
TGM-287-1,0-1,3	40	40	3,6	6,4	4,7	1,24	4,3	0,68	2,9	3,1
TGM-287-1,0-1,5	40	40	3,8	7,4	5,4	1,42	4,5	0,6	2,7	3,2
TGM-287-1,0-2,5	40	40	4,8	12,4	9,0	2,3	4,8	0,39	1,85	3,4
Tcold side= 50°C; T hot side= 280°C (maximum working temperature)*										
TGM-31-2,8-2,0	40	40	4,5	0,15	0,08	2,0	0,8	5,2	4,2	4,1
TGM-49-2,8-2,0	40	40	4,5	0,24	0,12	1,3	1,12	4,6	5,2	3,7
TGM-31-2,8-3,5	40	40	6,0	0,27	0,13	3,5	0,89	3,3	2,9	4,5
TGM-49-2,8-3,5	40	40	6,0	0,43	0,21	2,2	1,3	3,0	4,0	4,2
TGM-31-2,8-5,0	40	40	7,5	0,39	0,19	5,0	0,93	2,4	2,2	4,7
TGM-49-2,8-5,0	40	40	7,5	0,61	0,30	3,2	1,38	2,3	3,1	4,4

*- Important! This type of TGM does not satisfy ROHS requirements.

Standard and additional options of TGMs		
Description	Notation	Note
Parallelism and flatness of mounting surfaces		
Flatness 0,02 mm; Parallelism 0,03 mm	**L1**	Standard performance. Height tolerance ± 0,05mm
Flatness 0,015 mm; Parallelism 0,02 mm	**L2**	Height tolerance ± 0,025mm
Flatness 0,01 mm; Parallelism 0,01 mm	**L3**	Height tolerance ± 0,015mm
Other standard and additional options		
Tolerance of Rac value		± 10%
Tolerance of length (dimensions A) and width (dimensions B)		+0,5 / –0,2mm
Tolerance of height		± 0,35mm (standart performance)
Type and length of lead wires	-	By customer's requirements

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Application recommendations:

For optimum performance of TGM it is important to follow several key points.

1. The surface on which TGM is to be mounted should be as flat as possible. Flatness of the surface should be not over 20 microns while 5 - 10 microns are recommended.
2. The module has to be properly pressed between the heat source and the heat sink. To yield the best results the load should be not less than 1,0 kN per one TGM of 40x40mm in dimensions. To optimize loading it is better to use a spring together with bolting.

Thermal expansion of TGM in the simple bolted construction could damage TGM in case of excessive screw torque or as a results of quick pressure loss. To compensate the thermal expansion of TGM in a wide temperature range and stabilize the compression force the bolting construction should be provided with compression springs.

3. The temperature of the hot side of the TGM should not exceed the given in the specification temperature.
4. The edge of the heat source should extend at least 10 or 5 mm beyond the edge of the module.
5. The temperature of the face of the module should be uniform at every point.
6. Mounting bolts should be as thin as possible, preferably made of materials with low thermal conductivity (e.g. stainless steel).
7. For better contact and thermal conductivity across the interface thermal transfer compound should be used, but not too much in order to avoid preventing solid to solid contact between the two surfaces.

Mounting of TGM by compressive load
Construction of thermoelectric generator (TEG) should guarantee that the compression force does not exceed 1,5kN (per one 40x40mm TGM) in the whole temperature range.

Attention! During the exploitation of TGM with the decrease of electric load an increase of the hot junction temperature up to 5 % of the difference between hot and cold sides of the module can follow.

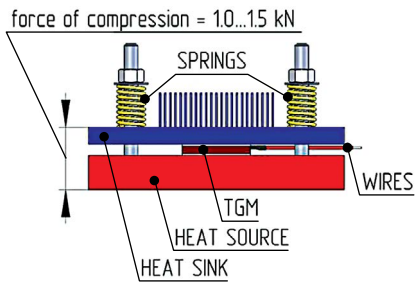
For maximum power generation of the TEG the TGM should be chosen taking into account features of other elements of construction including the heat-sinks and thermal interface materials.
Heat resistance of TGM is one of the most important parameters. Heat resistance of heat-sinks on the cold and hot sides is determined by the following ratio:

$$Rt \sim k \cdot (Rc + Rh),$$

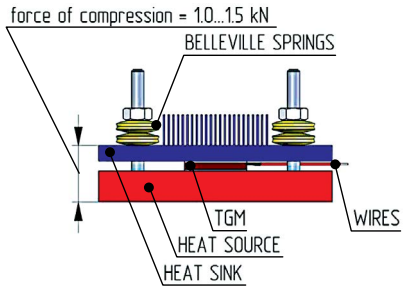
were:

- **k** – numerical coefficient equal to 1,0…1,5;
- **Rc** – heat resistance between the cold side of TGM and the ambient (the heat resistance of the heat-sink and thermal transfer compound interface);
- **Rh** – heat resistance between the hot side of TGM and the heat-source with specified temperature.

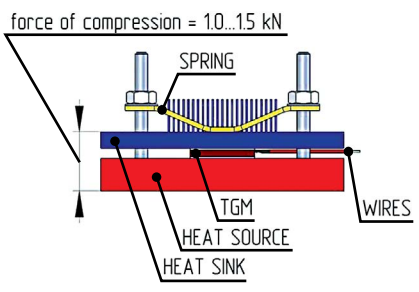
Examples of most common mounting constructions with compressive load (compression value for 40x40 mm TGM)



Coil spring compression



Disk (Belleville) spring compression



Leaf spring compression