Goncharov Electric JET s.r.o.
Štěrboholská 44/1307
PRAHA 10, 10200
IČ: 24772437 DIČ: CZ24772437
Oddíl C, vložka 173077

**APPROVED**
**Chief Designer**
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Group of companies
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"____" "________" 2015

# UNIFIED MODULAR MODULES

## JETD series

Reference specification

**Rev.1**

**APPROVED**

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2015

CONTENT

# 1 GENERAL INFORMATION

1.1 Application area

1.1.1 This reference specification is applied to unified modular JETD series modules (hereinafter referred to as modules) with DC input voltages (12 V, 24 V, 27 V, 48 V), designed for mounting into industrial-purpose equipment.

1.1.2 The modules are produced for temperature ranges from -60 ºC up to +110 ºC with nominal output power from 25 to 400 W and have one galvanically isolated output.

1.1.3 The modules have thermal protection, overvoltage protection, short circuit protection and main channel output current overload protection with automatic self-recovery and return to normal operation mode as soon as case temperature decreases, short circuit or overload is eliminated.

1.2 Classification, conventional symbols, basic parameters and dimensions

1.2.1 Types of modules, their basic characteristics and dimensions (without consideration of outputs' length), weight and service functions are given in Table 1.

1.2.2 Classification and conventional symbols of the modules are given in Picture 1.

1.2.3 The modules are produced in metal heat-conducting cases without flanges (marked as "C") with compound potting.

1.2.4 The modules are non-repairable.

1.2.5 Connection is performed by means of soldering to the outputs. It is allowed to perform tin coating of the outputs with lead-free soldering alloy Sn99,3Cu0,7 with a flux of Fluxplus NC-D500 type at not less than 1 mm distance from the case with its preliminary clearing from oxide layers.

1.2.6 The modules with output power of 200 W and higher have external feedback outputs for load circuits' voltage drop compensation and outputs for parallel connection with even load distribution of several modules.

1.2.7 Nominal values of the modules' output voltage ($U_{nom}$) as per normal climatic conditions are chosen from the range 5, 12, 15, 24, 27, 48 V. In exceptional cases, upon agreement with manufacturer, modules with $U_{nom}$ within a range of 3-60 V may be produced (must be specified upon order placement). Standard modules with 12W, 24W, 27 V input voltage values are manufactured with output voltage up to 15 V.

1.2.8 Increased case temperature for "T" temperature range must not exceed +100 °C.

1.2.9 Insignificant curving of the pinouts, appeared during the modules' placement into antistatic layer, is allowed.

1.2.10 Advertising label can be placed on the surface of the module. It has to be removed before mounting.

1.2.11 On the compound's surface, it is allowed to see-through certain construction elements (electronic components, bundles, etc.), occurrence of single air inclusions (bubbles, holes), not exposing the assembly elements, salient appearance of the elements' forms and bundles.

1.2.12 An example of modules' indication for the order placement and in documentation:

"JETD50-24WS05-UT module"

Table 1 – Types of modules, their basic characteristics and service functions

| Form factor, BRICK | Type of module | Max dimensions (without flanges), without consideration of the outputs, mm | Case type | Max weight, kg | Nominal output power, W | Nominal input voltage denomination | Number of output channels | Remote switch-off | Output voltage adjustment in single-channel modules | "CASE" output | Parallel operation | External feedback | Temperature range | EMC standard National state standard P 51318.22 (EN55022) Class B | Class A | Energy density, W/dm $^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/16 | JETD25 | 33,1x23x10,4 | C | 33 | 25 | 12, 12W, 24, 24W, 27, 48 | 1 | + | + | + | - | - | "T" | with filter TEFD2,5 | + | 3158 |
| 1/8 | JETD50 | 58,5x23x10,15 | | 53 | 50 | | | | | | | | | | | 3792 |
| 1/4 | JETD100 | 58,5x36,9x11,6 | | 97 | 100 | | | | | | | | | with filter TEFD5(12W) TEFD2,5(24W) | | 4011 |
| 1/2 | JETD200 | 61,1x58,5x11,6 | | 187 | 200 | | | | | | + | + | | with filter TEFD10(12W) TEFD5(24W) | | 4824 |
| Full | JETD400 | 116,8x61x13 | | 387 | 400 | 12, 24, 48 | | | | | + | + | | with filter TEFD20(12W) TEFD10(24W) | | 4319 |

Notes:

1. "+" and "-" signs stand for availability/unavailability of service function correspondingly.
2. Standard modules with 12W, 24W, 27 V input values are manufactured with output voltage up to 15 V.

**JET D 50 – 24W S XX – C T**

**Temperature range index:**
**T** – from - 60 ºC up to + 110 ºC

**Case type index:**
**C** – metal case without flanges

**Nominal output voltage, V** (two figures)

**Number of output channels:**
**S** – single

**Nominal input voltage index:**

| | |
|---|---|
| **12** | – 10,5…18 |
| **12W** | – 10,5…36 V |
| **24** | – 18…36 V |
| **24W** | – 18…75 V |
| **27** | – 17…36 V |
| **48** | – 36…75 V |

**Maximum output power, W**

**Power conversion class**
**D - DC/DC low-voltage**

**JET series**

Picture 1 – Classification and conventional symbols of the modules

## 2 SPECIFICATIONS

2.1 Electric parameters requirements

2.1.1 Settled output voltage deviation of the modules under normal climatic conditions and quality of the input electrical energy given in Table 2 does not exceed ±2 %.

Table 2 – Electric power quality norms (DC) at the input

| Nominal input voltage index | Nominal input voltage, V | Range of the set value, V | Transient deviation and its duration, V |
|---|---|---|---|
| 12 | 12 | 9…18 | 9…20 V, duration 1 sec |
| 12W | 12 | 9…36 | 9…40 V, duration 1 sec |
| 24 | 24 | 18…36 | 17…40 V, duration 1 sec |
| 24W | 24 | 18…75 | 17…84 V, duration 1 sec |
| 27 | 27 | 17…36 | 17…80 V, duration 1 sec |
| 48 | 48 | 36…75 | 36…80 V, duration 1 sec |

2.1.2 Output voltage instability at input voltage ($Inst_U$) and output current ($Inst_I$) tapering does not exceed ±2 %.

2.1.3 Thermal instability of the output voltage ($Inst_T$) of modules does not exceed ±3 %.

2.1.4 Transient instability of the output voltage of the modules (It) does not exceed ±0,5 %.

2.1.5 Overall output voltage instability ($Inst_{\Sigma}$) does not exceed ±6 %.

2.1.6 Transient output voltage deviation of the modules ($\delta U_{trans}$) influenced by transient input voltage deviation (within the values from Table 2 with minimal edge time 0,5 ms and along with output current ramp change within the limits from $0{,}3 \cdot I_{nom}$ to $0{,}9 \cdot I_{nom}$ with minimal edge 0,5 ms) does not exceed ±10 %.

2.1.7 Output voltage ripple (peak-to-peak) $U_{ripple}$ does not exceed 2 % of nominal output voltage value.

2.1.8 The modules have output over current and short circuit protection with automatic return to stable functioning after short circuit elimination. Current, consumed by the module during short circuit at the output of any channel, is at least 2,5 times less than current, consumed by the module at nominal values of input voltage and load current.

Overcurrent protection threshold value must be within range from 1,15•Pmax to 1,8•Pmax for modules with power of 10-100 W; and within range from 1,15•Pmax to 1,4•Pmax for modules having 200-1000 W.

2.1.9 The modules have output overvoltage protection and ensure limitation of the output voltage for the first (main) channel at most at $1{,}4 \cdot U_{out}$ nom with automatic return to stable mode after output overvoltage elimination.

2.1.10 The value of full input power of the modules in steady mode must not exceed the following value:

$$P = Pout / \eta , \qquad (2.1)$$

where: Pout – output power;

η - efficiency.

2.1.11 Absolute output voltage value at zero load does not exceed $1{,}1 \cdot U_{nom}$.

2.1.12 Current value, consumed from mains at the moment of cold start-up (Istart), does not exceed values, indicated in Table 3.

Table 3 - Current value, consumed from mains at the moment of cold start-up

| Nominal input voltage index | Current value, consumed from mains at the moment of switching on, A, at $P_{out}$ nom, W | | | | |
|---|---|---|---|---|---|
| | 25 | 50 | 100 | 200 | 400 |
| 12, 12W | 3 | 5,7 | 11,5 | 23,5 | 47 |
| 24, 24W, 27 | 1,6 | 3,4 | 6,8 | 13,6 | 28 |

| Nominal input voltage index | Current value, consumed from mains at the moment of switching on, A, at $P_{out}$ nom, W | | | | |
|---|---|---|---|---|---|
| | 25 | 50 | 100 | 200 | 400 |
| 48 | 0,8 | 1,8 | 3,4 | 6,8 | 14 |

2.1.13 The modules have remote switch-off function, implied through connection of "ON" terminal with "-IN" terminal.

2.1.14 Time, needed for output voltage setting for the first (main) channel of the modules (from the moment of control signal removal from "ON" output) does not exceed 0,1 s.

2.1.15 The modules possess overheat protection function with automatic return to operation mode after overheat elimination. Thermal protection must be activated if case temperature of the module for temperature range "T" is in range from +105 °C to +115 °C.

2.1.16 The modules have terminal for output voltage adjustment, which provides adjustment range ($\Delta U_R$) of not less than ±5 %.

2.1.17 Norms of conductive industrial radio-noises at the input terminals of the modules comply with National Standard Class A (GOST) 51318.22-2006 (EN55022-2006).

## 2.2 Reliability parameters

2.2.1 Endurance and life service parameters are given in Table 4.

2.2.2 Mean time between failures (MTBF.) is provided in datasheets for each module.

Table 4 - Endurance and life service parameters

| Reliability parameters | Value |
|---|---|
| Average life ($T_{av.life}$), years | 15 |
| Average shelf life ($T_{shelf\ life}$), years | 15 |
| Gamma-percentile life ($T_r$), case temperature 50 °C and 0,7•$P_{out}$ max, hours | 150 000 (y=0,95) |

## 2.3 Efficiency

2.3.1 Efficiency (η) is given in datasheets for each certain type of module.

## 2.4 Environmental sustainability parameters

2.4.1 The modules must function and maintain their parameters and appearance during and after mechanical and environmental impact, described in Table 5.

Table 5 – Conditions of environmental impact

| Influencing factor, unit of measure | Value of the influencing factor |
|---|---|
| Mechanical impact factors | |
| Sinusoidal vibration:<br>- frequency range, Hz;<br>- acceleration amplitude, m/s$^2$ (g);<br>- vibration displacement amplitude, mm | <br>1 – 2000<br>200 (20)<br>0,3 |
| Single-acting mechanical impact:<br>- impact acceleration peak value, m/s$^2$ (g)<br>- impact acceleration action duration, ms | <br>10000 (1000)<br>0,5 – 2 |

| Influencing factor, unit of measure | Value of the influencing factor |
|---|---|
| Multiple-acting mechanical impact:<br>- impact acceleration peak value, $m/s^2$ (g)<br>- impact acceleration action duration, ms | <br>1500 (150)<br>1 − 5 |
| Acoustic noise:<br>- frequency range, Hz;<br>- noise-pressure level (in relation to $2 \cdot 10^{-5}$ Pa), dB | <br>50 − 10000<br>170 |
| Environmental impact (climatic factors) | |
| Increased ambient temperature, °C | +100 |
| Decreased ambient temperature, °C | − 60 |
| Temperature cycling, °C | from – 60 to +125 |
| Increased air humidity, %:<br>- relative humidity at ambient temperature +35 °C | <br>100 |
| Low atmospheric pressure, Pa (mm of mercury) | $0,67x10^3$ (5) |
| High atmospheric pressure, Pa (mm of mercury) | $2,92x10^5$ (2207) |
| Pressure variation:<br>- pressure variation range, Pa (mm of mercury)<br>- speed of pressure variation, Pa/s | <br>$2,92 \cdot 10^5$-$0,67 \cdot 10^3$ (2207-5)<br>40 |
| Atmospheric condensed water (frost and dew):<br>- minimum value during operation, °C | <br>−20 |

2.5 Exterior view requirements

2.5.1 On the surface of each module, there must be placed a relevant mark from QC department, name label, marking of the first (base) pin, serial number and date of production (pre-last pair of figures stand for a month, last pair of figures stand for a year).

2.6 Safety parameters

2.6.1 In modules galvanic isolation is present between input and output, input and case, output and case, and output channels. The insulation resistance of electric circuits, galvanically isolated from each other or the module's case, measured at testing DC voltage of 500 V, must be:

| | |
|---|---|
| - in normal climatic conditions | - not less than 20 MOhm |
| - in conditions of increased air humidity | - not less than 1 MOhm |
| - in conditions of increased (decreased) operating temperature | - not less than 5 MOhm |

2.6.2 Insulation strength of electric circuits, galvanically isolated from each other or the module's case, should ensure the absence of breakdown and surface flashovers when exposed to the continuous voltage:

a) between In-Out, In-Case terminals:
  1) in normal climatic conditions - 1500 V;
  2) at increased humidity, increased (decreased) ambient temperature - 500 V;

b) between Out-Case terminals:
  1) in normal climatic conditions - 1000 V;
  2) at increased humidity, increased (decreased) ambient temperature - 500 V.

2.7 Design requirements

2.7.1 Overall, mounting and installation dimensions are given in datasheets for each module.

2.7.2 The design of modules must guarantee their steady functioning in any position and absence of mechanical resonance when influenced by sinusoidal vibration within frequency range from 5 to 50 Hz with vibration displacement amplitude 0,3 mm.

2.7.3 The output terminals of modules withstand exposure to stretching force without mechanical damage of not more than:

- for terminals 0,8 mm in diameter - 10 N;
- for terminals 1,0 mm in diameter - 20 N;
- for terminals 1,5 mm in diameter - 40 N.

2.7.4 Terminals' coating ensures solderability without any additional maintenance during 12 months and allows triple resoldering without connectors crippling and module's electrical characteristics impairment.

2.7.5 The weight of modules must not exceed the values given in Table 1.

2.8 Completion

2.8.1 Each separately delivered module must be provided with warranty list as per policy of the manufacturing company.

2.8.2 As an option, each shipped batch of modules may be supplied with heat-conducting paste. It has to be specified upon order placement.

2.8.3 As an option, each shipped batch of modules may be supplied with attachment for output ripple measurement. It has to be specified upon order placement.

2.9 Packing and marking

2.9.1 There is a relevant marking on the surface of each module.

2.9.2 Marking is resistant to clearing solvents' impact (alcohol-gasoline blend).

2.9.3 Packaging fully complies with transportation and storage requirements.

2.10 Transportation and storage requirements

2.10.1 Packaging and design of the modules allow their transportation at any distance by means of auto, railway, sea and air transport vehicles.

2.10.2 The modules can be stored in primary packaging in non-heated storages.

# 3 SAFETY REQUIREMENTS

3.1 Safety of the modules is provided by design of equipment, into which they are installed.

3.2 Any operation with the modules must be carried out in strict adherence to the existing safety rules and documentation requirements.

3.3 Only skilled personnel with special training and practical experience of work with electric equipment are allowed to work with the modules.

3.4 It is strictly forbidden to connect and disconnect connection wires during module's operation.

# 4 TRANSPORTATION AND STORAGE

4.1 The modules are transported in mechanical impact-proof and direct atmospheric-fallout-proof packaging by transport vehicles of all types.

4.2 The modules are stored in primary packaging or mounted into the equipment in any storage areas except for outdoor areas.

# 5 OPERATION GUIDELINES

5.1 ESD protection

5.1.1 Modules must be used with consideration of ESD protection requirements.

5.2 Installation and attachment of modules in the equipment

5.2.1 Installation of modules and their mounting in the equipment must be carried out with consideration of mechanical loads, with which the equipment operates, and heat dissipation.

5.2.2 Modules with flanges may be fastened onto the PCB and heat sink with screws.

5.2.3 Recommended tightening torques for modules' mounting into the equipment must not exceed 0,4 N.m – for M2,5 screw, and 0,7 N.m – for M3 screw.

5.2.4 It is necessary to consider peculiarities of modules' design during their installation into equipment. The basis is PCB with elements for external surface assembly, which is potted with compound and placed in thin-wall or reinforced metal case from the outputs' side. With regard to this, application of mechanical force for mounting module with a clamp, strip, heat sink, etc., to compound and to module's case, is unacceptable.

5.2.5 When attaching modules into the equipment, it is allowed:

- to cut input terminals ("Input", "IN") and output voltage terminals ("Output", "OUT") at not less than 3 mm from the case surface;
- to cut other outputs flush with the case surface, if it does not affect mechanical mounting of module in the equipment;
- a single curve of the outputs at 90º level, at not less than 2 mm from the case surface with curve radius of not less than 0,5 mm.

5.2.6 When cutting, curving and forming outputs, it is necessary to apply special stencils and to ensure immobility of the outputs between the curving point and the case. Twisting of the outputs around an axis is not allowed.

5.2.7 Under conditions of severe mechanical impact, it is recommended to attach modules to PCB by means of damper glues.

5.2.8 The module's mounting by means of soldering with low-temperature brazes is allowed, provided that period of continuous soldering does not exceed 5 seconds, and case temperature does not exceed 125 °C.

5.3 Thermal mode and thermal characteristics of the modules

5.3.1 Modules, as a rule, require installation on a heat sink with firm adherence of their surface through the thermal paste (for example, silicone thermal paste-8, Dow Corning 4490). Special attention must be paid to the surface area and evenness of surfaces contacting between module and heat sink, equal distribution of the thermal paste and its minimum thickness.

5.3.2 Modules with the output power of 200 W and more may be used without a heat sink, but only upon condition if they are bonded (with a thermal conductive paste) to a heat-conducting base plate, whose length and width match the module's case dimensions with thickness not less than 2,0 mm for JETD200 and 2,5 mm for JETD400.

5.3.3 A more preferable position for the modules is a vertical one, when its long side is placed horizontally.

5.3.4 Installation of modules on heat sinks of any design, providing stipulated case temperature accomplishment, including use of forced air-cooling, is allowed.

5.3.5 To choose the right heat sink or to define possibilities for the module's operation without a heat sink, it is necessary to calculate two parameters:

- thermal losses, appearing during module's operation;
- thermal resistance of a heat sink in relation to the environment, providing heat dissipation into the atmosphere for prevention of module's overheating.

Thermal losses are defined in the following way:

$$Pdis = Pout \cdot (1 - \eta) / \eta \qquad (5.1)$$

where: Pdis – thermal losses (dissipated power);
Pout – output power;
η – efficiency.

Necessary (maximum) thermal resistance is defined in the following way:

$$Rt = (Tc - Ta) / Pdis \quad (5.2)$$

where: Tc – heat sink's temperature;
Ta – ambient temperature;
Rt – thermal resistance heat sink – environmental air.

Ambient temperature Ta is the maximum value for working conditions. Heat sink temperature Tc must be set at the value not higher than the maximum acceptable level of case temperature of the module. For modules with "T" index maximum case temperature is 100 °C, but it is not the operating temperature, it is the case temperature, after which thermal protection switches on. For modules with "T" index, it is recommended to set the case operating temperature at the level of not higher than 95 °C, when choosing a heat sink. Given that, it is necessary to consider that with each 10 °C of operating temperature increase, reliability (MTBF) decreases by 1,5-2 times.

5.3.6 After defining required thermal resistance of a heat sink Rt in accordance with formulas (5.1), (5.2), it is necessary to compare this value with the thermal resistance of the case without any additional heat sink. Thermal resistance values for "Case-Environment" without heat sink are given in datasheets. These values are valid for natural convection cooling conditions provided that the module is placed vertically, as it is described in p.5.3.3. If calculated value of Rt is higher than thermal resistance "Case-Environment" of a module, then there is no necessity to use a heat sink.

As an example, let us calculate Rt for JETD100, provided that it is operating at 80 W, at maximum ambient temperature of 30 °C, efficiency (as per datasheet) is 91 %. The marginal case temperature will be set at the level of 95 °C.

Therefore, in accordance with (5.1): Pdis = 80•0,09/0,91 = 7,9 W;
in accordance with (5.2): Rt = (95 – 30) / 7,9 = 8,2 °C/W.

As per datasheet, thermal resistance "Case-Environment" values without heat sink for JETD100 module makes up 7,7 °C/W. As this value is less than the calculated value, it means that for stipulated conditions usage of additional heat sink is not required.

5.3.7 If calculated value of Rt is less than thermal resistance "Case-Environment" of a module, then it is necessary to choose a heat sink with thermal resistance value not exceeding the calculated value. Rt values are presented in datasheets for heat sinks (heat sink profiles), or can be provided by manufacturer upon request.

5.3.8 Relevant recommendations on heat sink calculation are given in "Documentation" section on our web site.

5.3.9 Efficiency of the module is included into thermal losses calculations, whereas efficiency value at 100 % load is presented in datasheets. In real-life application conditions load can dramatically differ from the maximum value. It is necessary to take into account that maximum efficiency usually conforms to 70–75 % of the output power. At 100 % of the output power, efficiency decreases by 1–3%, whereas at 30 % of the output power, efficiency decreases by 3–6 %.

5.3.10 Dependence of the ultimate output power on the ambient temperature and thermal resistance of a heat sink with consideration of the maximum case temperature and its efficiency is defined with expressions (5.1), (5.2). Typical graphs for this dependence are provided in datasheets.

5.3.11 During thermal tests and thermal resistance examination, it is necessary to control the case temperature of modules thoroughly, so as not to allow surpassing maximum values. Temperature sensor must be placed 1 – 3 mm high above the heat sink housing in the center of the long side, side for measurements is the right one (when looking at the module from the input side, when its terminals are directed upwards). Along with that, it is necessary to use heat-conducting thermal paste for thermal resistance reduction between sensor and metal base; measurement part of the sensor (10-mm) must go through a controllable area and must be completely submerged into the heat-conducting paste.

5.3.12 Modules' cases are performed in thin-wall design (thickness of the wall is from 0,8 to 1,0 mm), wherefore, in JETD200, JETD400 hot spots appear. Those are local areas, placed directly under power components with a higher temperature than the average case temperature. Case temperature of the module in thermal spots areas is by 10 °C (ΔT) higher than the temperature at the side surface of the module at the juncture of the module and heat sink. Which is why when measuring temperature at the side of module's case, maximum temperature must not exceed 95 °C (for temperature range "T").

5.4 Connecting modules to input power

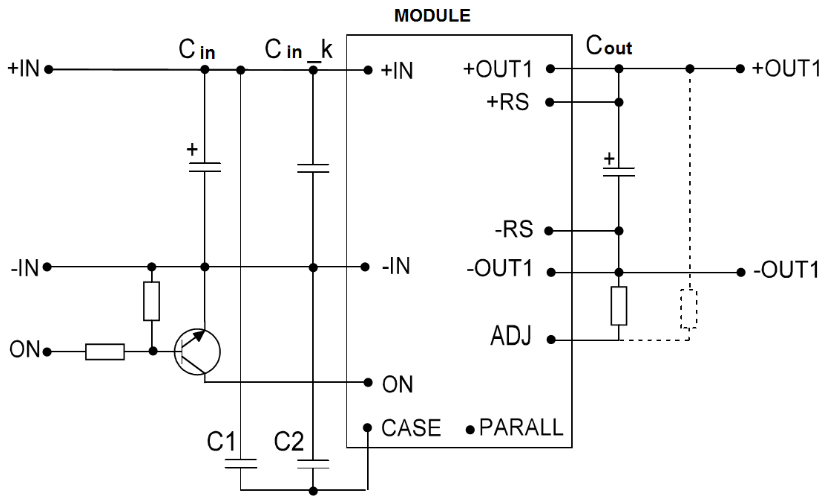
5.4.1 Soldering of the modules' output channels is recommended to perform with electrical soldering device with maximum power of 60 W at a maximum temperature of 300 °C for not more than 5 seconds per output. Soldering is allowed not more than three times at a distance of at least 1 mm from the edge of potting. Bending the pins when soldering is unacceptable.

5.4.2 It is forbidden to switch on the modules during tests by means of contact devices with short contact breaks (bouncing).

5.4.3 It is forbidden to install and connect modules to electrical circuits under voltage.

5.5 Typical connection schemes for the modules

5.5.1 Typical connection schemes are shown in Pictures 5.1 and 5.2. To improve the quality of power supplied to the equipment, it is necessary to bridge input and output circuits of the modules with Cin, Cout capacitors with low total resistance of a corresponding voltage. Capacity and recommended types of input and output capacitors for single-channel modules given for C1…C2, Cin, Cin_k are presented in Table 6, for Cout – in Table 7. Table 8 demonstrates maximum total values of Cout capacitors, at which start-up is possible.




Picture 5.1 - Typical connection scheme for a single-channel module

Table 6 – Recommended capacity values of isolation and input capacitors for the typical connection scheme

| Nominal output power, W | C1, C2, nF | Cin | Cin_k |
|---|---|---|---|
| Nominal input voltage 12 V ("12", "12 W") | | | |
| 25 | 1500pF 2000V X7R (LD06GC152KAB1A AVX) | 33uF 50V | 10uF 50V (CGA6P3X7S1H106K TDK) |
| 50 | | 68uF 50V | 2 x 10uF 50V (CGA6P3X7S1H106K TDK) |
| 100 | | 120uF 50V | 2 x 10uF 50V (CGA6P3X7S1H106K TDK) |
| 200 | | 220uF 50V | 3 x 10uF 50V (CGA6P3X7S1H106K TDK) |
| 400 | | 470uF 50V | 4 x 10uF 50V (CGA6P3X7S1H106K TDK) |
| Nominal input voltage 24 V, 27 V ("24 ", "24 W", 27) | | | |
| 25 | | 22uF 100V | 4.7uF 100V (CGA6M3X7S2A475K TDK) |

| Nominal output power, W | C1, C2, nF | Cin | Cin_k |
|---|---|---|---|
| 50 | 500pF 2000V X7R LD06GC152KAB1A AVX) | 47uF 100V | 2 x 4.7uF 100V (CGA6M3X7S2A475K TDK) |
| 100 | | 68uF 100V | 3 x 4.7uF 100V (CGA6M3X7S2A475K TDK) |
| 200 | | 100uF 100V | 3 x 4.7uF 100V (CGA6M3X7S2A475K TDK) |
| 400 | | 220uF 100V | 4 x 4.7uF 100V (CGA6M3X7S2A475K TDK) |
| Nominal input voltage 48 V ("48") | | | |
| 25 | 1500pF 2000V X7R LD06GC152KAB1A AVX) | 10uF 100V | 2,2uF 100V (CGA6M3X7S2A225K TDK) |
| 50 | | 22uF 100V | 4.7uF 100V (CGA6M3X7S2A475K TDK) |
| 100 | | 47uF 100V | 6,8uF 100V (CGA6M3X7S2A475K TDK) |
| 200 | | 68uF 100V | 6,8uF 100V (CGA6M3X7S2A475K TDK) |
| 400 | | 100uF 100V | 2 x 4.7uF 100V (CGA6M3X7S2A475K TDK) |

Table 7 – Recommended values of capacity of output capacitors Cout for the typical connection scheme

| Output power, W | Output voltage, V | | | |
|---|---|---|---|---|
| | more than 3 V up to 6 V incl. | more than 6 V up to 15 V incl. | more than 15 V up to 32 V incl. | more than 32 V up to 80 V incl. |
| 25 | 47UF 10V (TPSB476M010R0650 AVX) | 15UF 25V (TPSC156K025R0300 AVX) | 6,8UF 50V (T495D685M050ATE300 Kemet) | 5,6uF 100V (ELXV101ELL5R6MEB5D Nippon Chemi-Con) |
| 50 | 220UF 10V (T495D227M010ATE100 Kemet) | 68UF 25V (T495D686K025ATE200 Kemet) | 2 x 10UF 50V (T494D106K050AT Kemet) | 12uF 100V (ELXV101ELL120MFB5D Nippon Chemi-Con) |
| 100 | 2 x 150UF 10V (T495D157M010ATE050 Kemet) | 2 x 68UF 25V (T495D686K025ATE200 Kemet) | 2 x 10UF 50V (T494D106K050AT Kemet) and 39UF 50V (ELXV500ELL390MFB5D Nippon Chemi-Con) | 33uF 100V (ELXV101ELL330MH15D Nippon Chemi-Con) |
| 200 | 2 x 220UF 10V (T495D227M010ATE100 Kemet) | 3 x 68UF 25V (T495D686K025ATE200 Kemet) | 3 x 10UF 50V (T494D106K050AT Kemet) and 68uF 50V (ELXV500ELL680MH12D Nippon Chemi-Con) | 68uF 100V (ELXV101ELL680MJ25S Nippon Chemi-Con) |
| 400 | no | no | 6 x 10UF 50V (T494D106K050AT Kemet) and 1000uF 50V (ELXV500ELL102ML30S Nippon Chemi-Con) | 470uF 100V ELXV101ELL471ML40S Nippon Chemi-Con) |

Table 8 - Maximum total capacity of output capacitors $C_{out}$ for the typical connection scheme

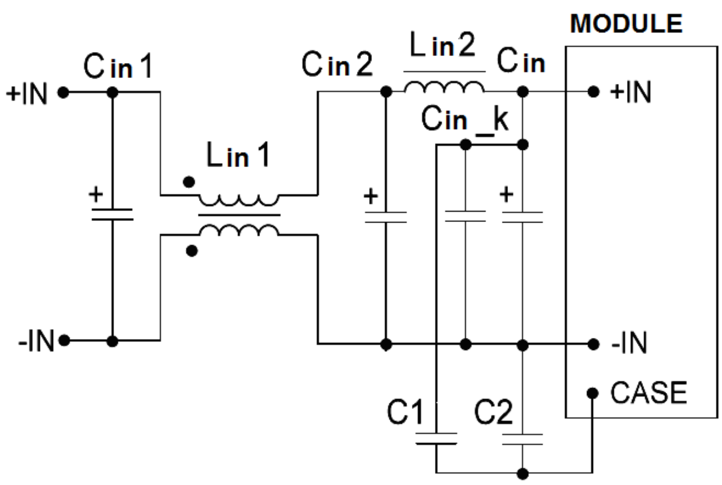
| Nominal output power, W | Maximum total capacity of output capacitors $C_{out}$, uF | | | | | |
|---|---|---|---|---|---|---|
| | 5 | 12 | 15 | 24 | 27 | 48 |
| JETD25 | 4 500 | 780 | 500 | 200 | 150 | 50 |
| JETD50 | 13 000 | 2 200 | 1400 | 550 | 450 | 150 |
| JETD100 | 21 000 | 3 600 | 2 300 | 900 | 700 | 220 |
| JETD200 | 40 000 | 7 000 | 4 400 | 1 700 | 1 400 | 400 |
| JETD400 | - | 12 000 | 7 700 | 3 000 | 2 400 | 800 |

Notes for Table 8:

1. The maximum total capacity of the output capacitors $C_{out}$ is given for 50 % load at nominal input voltage.
2. For non-standard output voltages, other than those specified in Table 8, the maximum total output capacity is calculated on the basis of $Cout\ max*Uout^2$ being a constant value.

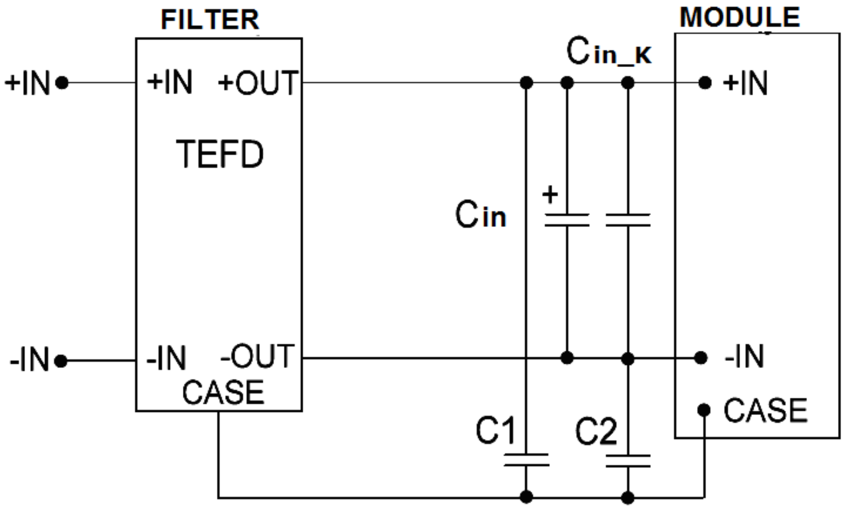
5.5.2 Capacitors must be placed in close proximity to the output terminals of the module at distance of not more than 10 mm from the case. Capacitors C1, C2 are ceramic chip-capacitors from X7R temperature group with the maximum voltage that complies with required insulation strength voltage «input-case», «output-case».

5.5.3 In a case when certain EMC requirements are specified for the equipment, connection schemes with external filter are applied for the modules in accordance with Pictures 5.2, 5.3 and Table 1.




Lin1 – 70 µH, 80A (C-36A29-06, CWS Coil Winding);
Lin2 – 1 µH, 85A (IHLP8787MZER1R0M5A, Vishay);
Cin1, Cin2 –33 µF, 100 V (ELXV101ELL330MH15D, NIPPON CHEMI-CON);
Cin, Cin_k, C1, C2 – as per Table10

Picture 5.2 – Typical connection scheme for JETD200, JETD400 with external filter for conductive industrial interference elimination

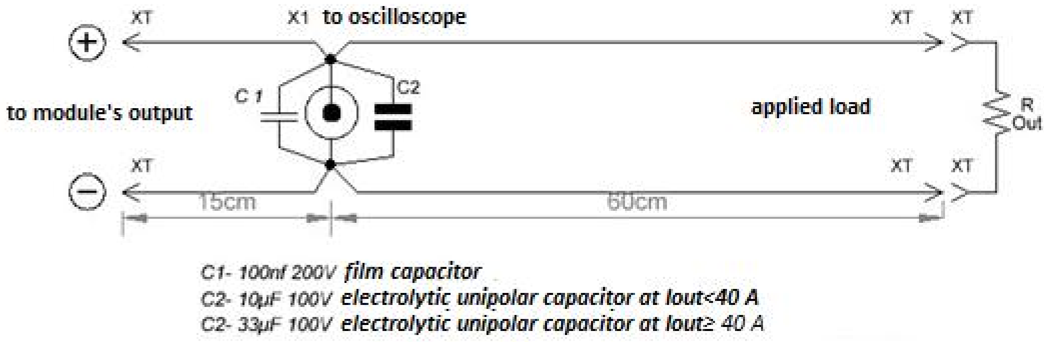



Cin, Cin_k, C1, C2 – in accordance with Table 11
Picture 5.3 Connection scheme for JETD25…JETD200 series with external filter (TEFD series) for conductive industrial interference elimination

5.5.4 Inductors Lin1 and Lin2 may be made on toroidal nanocrystal cores with high value of magnetic conductivity, for example, PMEC 403/V (Nanocrystalline core R201205 PMEC). Inductor’s windings must be winded in one layer for even coverage of core halves, number of turns in windings must be the same. Each winding must be placed in its own sector of the core.

5.5.5 Choice of a form factor of a core and inductivity depends on required noise elimination level, dimensions, etc. Cross-section of the coil’s wires is chosen depending on maximum input current value and allowed value of voltage drop at the filter's elements.

5.5.6 To measure the output voltage ripple, it is necessary to use a special ripple measurement attachment. Attachment scheme with values of the used elements is given below. The design should provide direct output current flow through the pins of elements C1, C2. On the left, the wires laid in a twisted pair (the length of about 15 cm) are coming from the output terminals of the module. On the right, the load wires are also arranged in a twisted pair. Wires for output current up to 40 A are at least 2,5 mm$^2$, for output current from 40 A are at least 3,5 mm$^2$ in cross-sectional area. Standard oscillograph probe is connected to the BNC terminal X1, which is structurally located directly at C1, C2. The attachment for output ripple measuring is available and can be ordered.



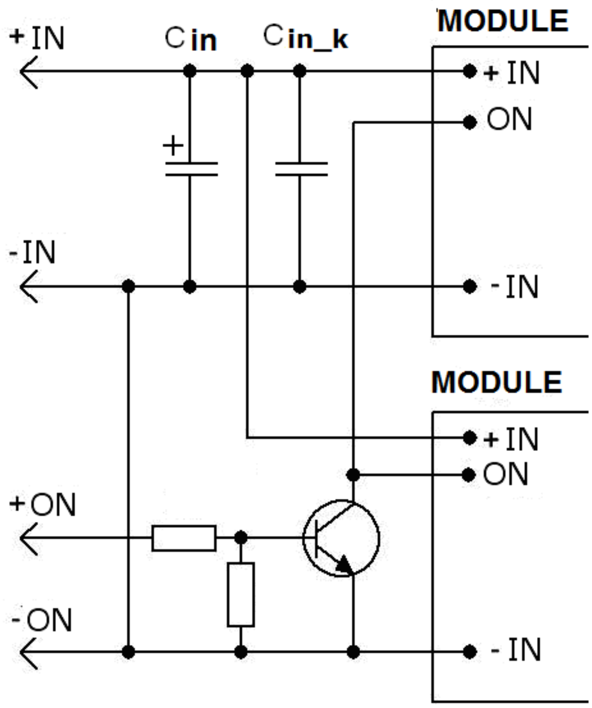

Picture 5.4 – Attachment for output voltage ripple measurement

5.5.7 Using standard oscillograph probe with a relatively long ground terminal (about 15 cm) as a device for ripple measurement leads to a large high-frequency noise induction on the measured signal. The reason is the "loop", created by the ground output, on which noise, emitted by the PSU, is induced.

5.6 Remote on/off function

5.6.1 Remote on/off may be carried out by means of mechanical contact of relay or electric switch of open collector type. Turning off the module must be performed by connection of "ON" output with "-IN" output. At that, current not exceeding 5 mA can flow in a switch, and the maximum voltage drop at switch must not exceed 0,5 V. Turning on the module is performed by opening the switch in time of not more than 5 ms. In open condition, voltage up to 20 V is applied to the switch, allowed leak current through the switch is maximum 50 μA.

5.6.2 Typical connection scheme for remote on/off function for two modules is given in pic. 5.5. If remote on/off function is not used, the output terminal "ON" may be left unconnected.




Picture 5.5 - Typical connection scheme for remote on/off function

5.7 Power overload protection and output short circuit protection

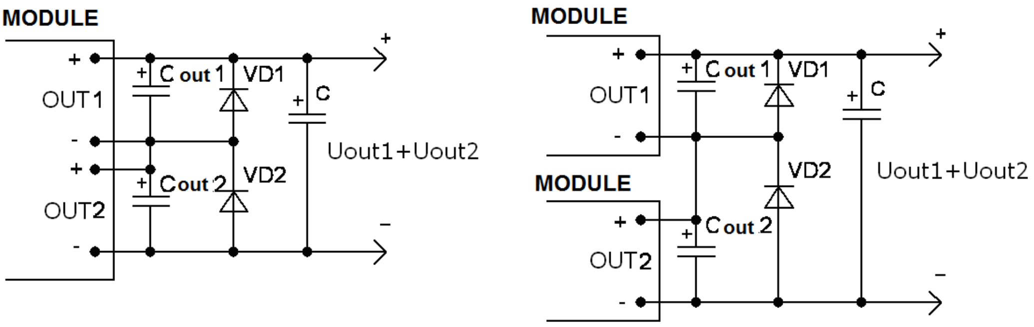
5.7.1 Overload protection is implemented by the output power limitation. When the output power goes beyond the protection activation threshold, control system starts decreasing output voltage of the module, limiting maximum output power. If output load increases further and output voltage decreases to 60-70 % of its nominal value, the PSU enters the relaxation mode. When the overload or short circuit is eliminated, normal operation is recovered automatically.

5.7.2 Control and output power limitation is carried out on the input side of the module.

5.7.3 Short circuit protection is snap-acting, which is why even a short-term nominal output power overshoot is recognized as a short-circuit mode by the module. Dramatic capacity values at the module's output or power-consuming operation (relay, electric motors), leading to short-period nominal output power overshoot, may cause failure to start or to enter steady work mode. Maximum total capacity of output capacitors Cout for the typical connection scheme is given in Table 8.

5.8 Connection of output channels in series

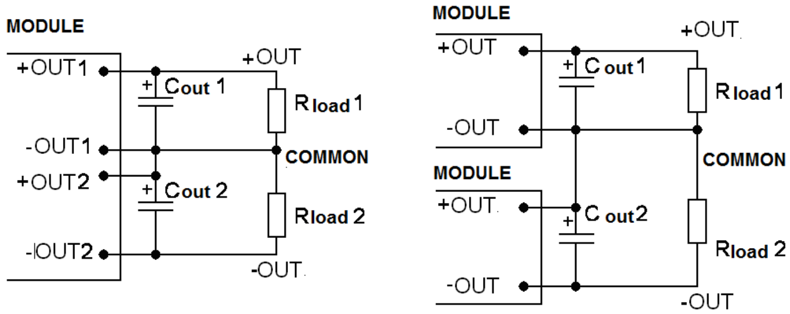
5.8.1 Output channels of single-channel and multi-channel modules can be connected in series to increase the output voltage. Along with that, the output of each channel must be bridged in reverse by diodes with maximum forward current higher than maximum load current and maximum reverse voltage higher than doubled nominal output voltage of the channel. Examples of series connection of modules' output channels with purpose of increasing the output voltage are shown in pic. 5.6.




Picture 5.6 - Examples of series connection of output channels of modules as a way to increase the output voltage

5.9 Bipolar output voltage

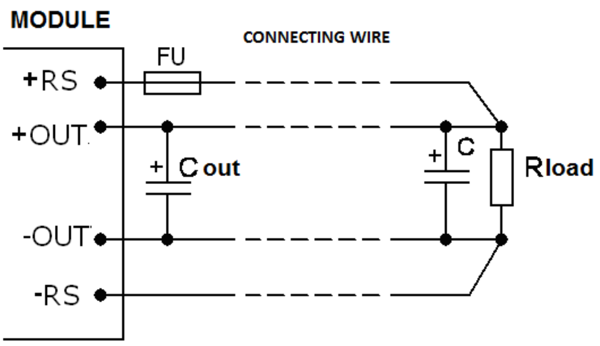
5.9.1 Picture 5.7 demonstrates examples of attaining bipolar output voltage from the module with two galvanically isolated outputs, and from two single-channel modules.




Picture 5.7 - Examples of attaining bipolar output voltage from the module with two galvanically isolated outputs and from two single-channel modules

5.10 External feedback function application

5.10.1 Application of external feedback function allows compensating output voltage drop in connecting wires and separation diodes by as much as 5 % from output voltage value at $P_{out}$ nominal. To use external feedback function, outputs "+RS" and "-RS" must be connected directly to the load in compliance with polarity. Connection must be provided by twisted pair of conductors with a minimum cross-sectional area of 0,1 mm$^2$. Connection example is given in pic. 5.8.




Picture 5.8 - External feedback function realization

5.10.2 Capacity value of capacitor C depends on dynamic characteristics of the load. Total capacity, Cout and C, must not exceed the values given in Table 13.

5.10.3 In those cases when external feedback function is not used, "+RS" and "-RS" output terminals must be directly connected to "+OUT" and "-OUT" terminal outputs correspondingly.

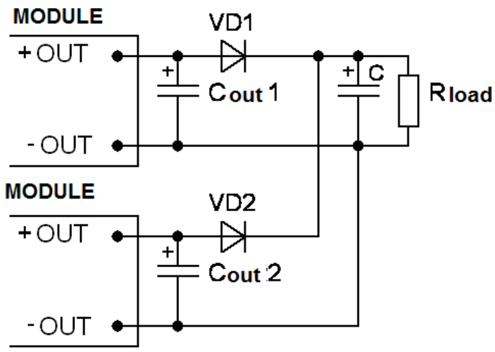
5.10.4 It is strictly forbidden to switch on and use a module with unconnected terminals "+RS" and "-RS".

5.10.5 It is strictly forbidden to commutate output circuits of the working module if "+RS" and "-RS" terminals are connected.

5.10.6 It is recommended to install fuses for current value from 0,1 to 0,125 A in external feedback circuit to eliminate breakdown of drive circuits in case load circuit disconnects (with connected external feedback circuit).

5.11 Parallel connection of the outputs through diodes

5.11.1 In many cases, in order to increase output power of the power system or to create back-up system, it is possible to connect outputs of a number of modules through isolation diodes. At that, it is necessary to monitor output voltages of the modules connected in parallel – they must not differ by more than 1 %. For output voltage regulation, it is possible to use output voltage adjustment function. To reduce power losses, it is recommended to use special Schottky ORing-diodes as isolation diodes with minimum voltage drop. Example of parallel connection of the outputs through isolation diodes is presented in Pic. 5.9.




Picture 5.9 – Example of parallel connection of the outputs (through isolation diodes)

5.12 Parallel operation function application

5.12.1 For currents equalization of the modules connected in parallel in JETD200, JETD400 series, there is a special output terminal, PAR, which must be connected in all modules used in parallel.

5.12.2 Modules JETD25…JETD100 do not have parallel operation function, to increase the output power of the power supply system, their outputs may be connected without isolation diodes.

5.12.3 The possibility of parallel connection of outputs to work with a common load (by means of parallel operation function application) allows to increase the total power output of the modules to the value of:

$$P_{total} = 0{,}7 \cdot N \cdot Pn, \qquad (5.3)$$

where:

0,7 – recommended load coefficient,

N – number of modules, connected in parallel,

$P_{nom}$– nominal output power of the module, W.

If the modules are properly connected in parallel, unbalance of input circuits of the modules at nominal total output power does not exceed 10–15 %. This given value of unbalance of input circuits of the modules connected in parallel is valid for the number of modules not exceeding 3 or 3+1 in a back-up system. If the quantity of modules connected in parallel exceeds 3, unbalance may grow, and parallel connection as a way to increase output power becomes ineffective. In this case, it is reasonable to use more powerful modules. For example, for reaching power of 600 W, it will be more reasonable to use 2 JETD400 modules instead of 4 JETD200 modules.

5.12.4 Connection of the modules into parallel is carried out through paralleling of output circuits to powerful collector bars and their parallel operation outputs' interconnection as per Pic. 5.10-5.14. At that, it is necessary to follow these recommendations:

– modules must be located in immediate proximity. Isolation diodes and fuses must be connected with corresponding outputs of the modules in the shortest possible way;
– conductors that connect outputs with collector bars must be the same, of minimum length and large cross-section. In addition, special attention must be paid to "minus" outputs – they

must be as close to each other as possible. Voltage drop in such connection can cause additional voltage drift at "PAR" terminal, which may result in increase of input currents unbalance. Connection into "minus" terminals of output wires of isolation diodes and current-sense resistors is not allowed;

– collector bars also must be placed in immediate proximity to the output terminals, and these bars must have cross-sectional area N times bigger than of those conductors connecting the modules with collector bar, where N is a number of modules connected in parallel;

– connection of collector bars to the load must be done in the middle part of the bars;

– remote feedback circuits have to be connected by a twisted pair of wires directly to the load in compliance with polarity;

- conductor, connecting "PAR" terminals of the modules, must be placed far from the noise sources, should there be any of them in equipment. It is forbidden to connect capacitors, resistors or RC-circuits to "PAR" terminal, as it may cause unstable operation of modules.

5.12.5 It is strictly forbidden to switch the output circuits when the modules are in operation. Violation of these requirements leads to the failure of the control system of parallel operation of the module and entails waiver of the warranty.

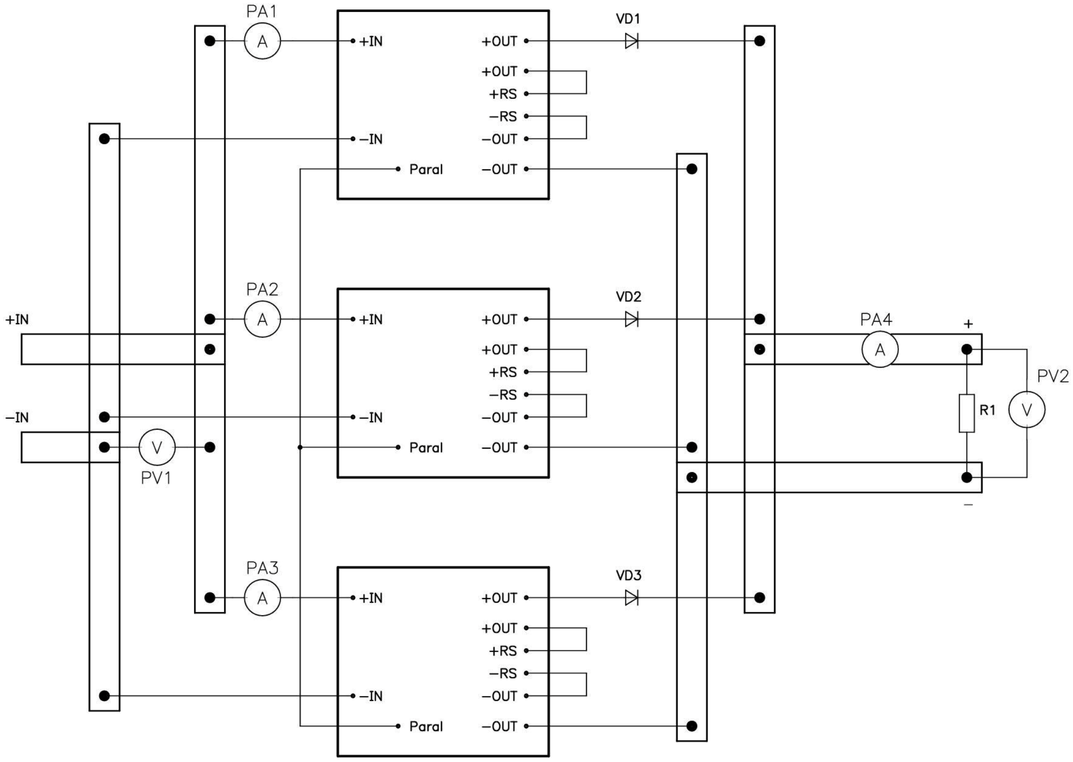
5.12.6 Ampermeters to monitor the uniform power distribution among the modules must be connected only to the input circuits of modules.

5.12.7 As the dividing diodes VD1, VD2, VD3, Schottky diodes, with minimum voltage drop, are used. Their maximum reverse voltage must be 1,5–2 times greater than nominal output voltage of the modules. The maximum forward current of diodes should be at least twice as the maximum output current of the single module.

5.12.8 For successful parallel operation, it is necessary to use modules of equivalent power with the same nominal output voltage, with a spread of not more than 1 %. It is strongly recommended to use modules from one production batch.

5.12.9 Voltage from "PAR" terminal to "-OUT" terminal at 100 % load must be in range 2±0,2 V, and must alternate in direct proportion to the output current.

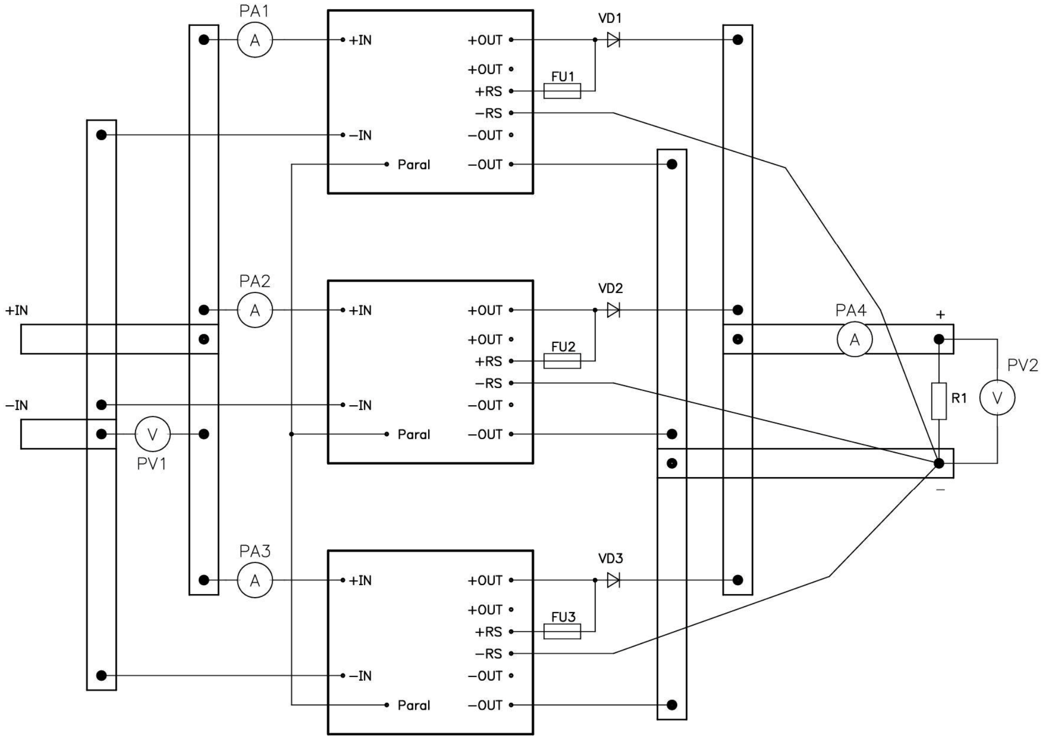
5.12.10 Back-up system construction by N+M method with interchangeable modules (Pic. 5.10). It is necessary to place isolation diodes at each module's output. Output voltage at the load directly would be less than the output voltage of the module by a voltage drop at VD1–VD3 and connecting wires. Voltage drop can be compensated by output voltage adjustment function, by means of variable resistor ADJ (installed in the module), in range of 5 % of the module's output voltage. For that matter, before connecting modules in parallel, output voltage of each module separately is adjusted to the necessary value.



Picture 5.10 Back-up system built by N+M method with interchangeable modules

5.12.11 Back-up system construction by N+M method with interchangeable modules (Pic. 5.11) and remote feedback function application. "+RS" and "-RS" outputs of each of the modules are connected directly to diode anodes VD1-VD3 and load in compliance with polarity. External feedback can compensate voltage drop in connecting wires for up to 10 %.

5.12.12 There exist other variants for back-up system construction, which can be stipulated by peculiarities of the powered equipment and primary power supplies. In this case, it is necessary to ask a manufacturer for assistance.



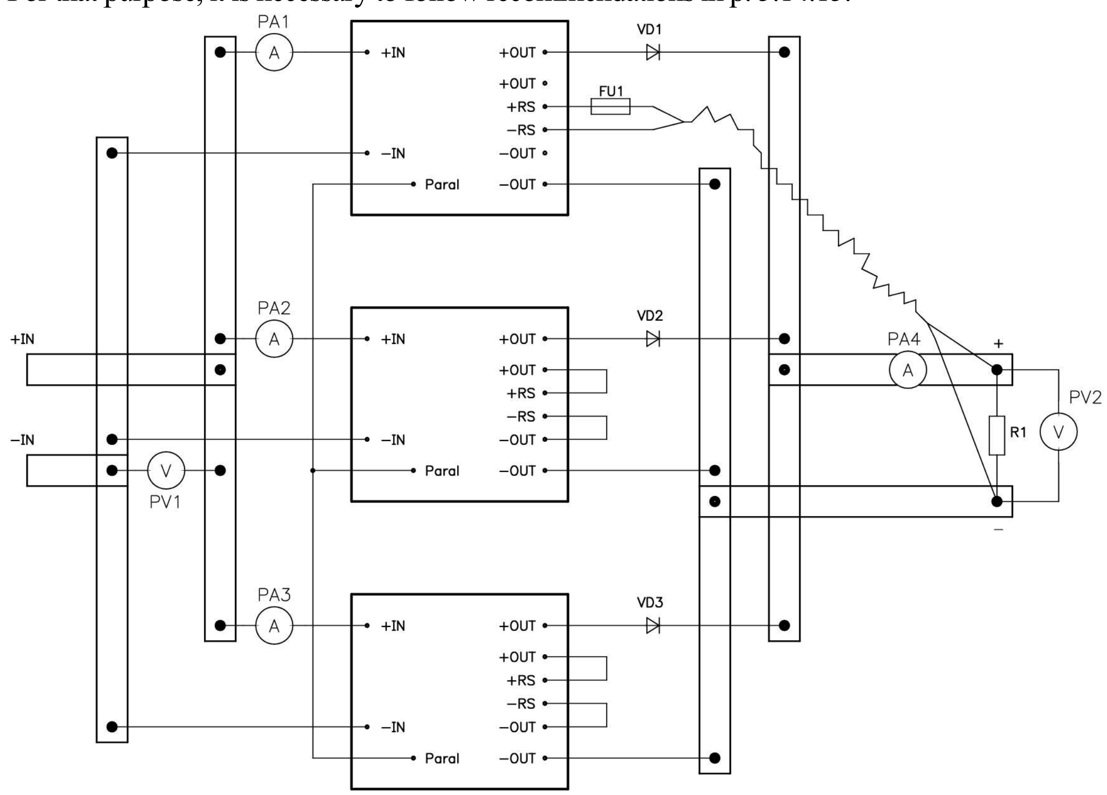
Picture 5.11 Back-up system built by N+M method with interchangeable modules and external feedback function application

5.12.13 System construction as per "master-slave" method, limited back-up (Pic.5.12). External feedback terminals "+RS" и "-RS" of only one module are connected directly to the load with polarity compliance. This module is a master, others are slaves. In slave modules, "+RS" и "-RS" terminals are connected directly to "+OUT" and "-OUT" correspondingly.

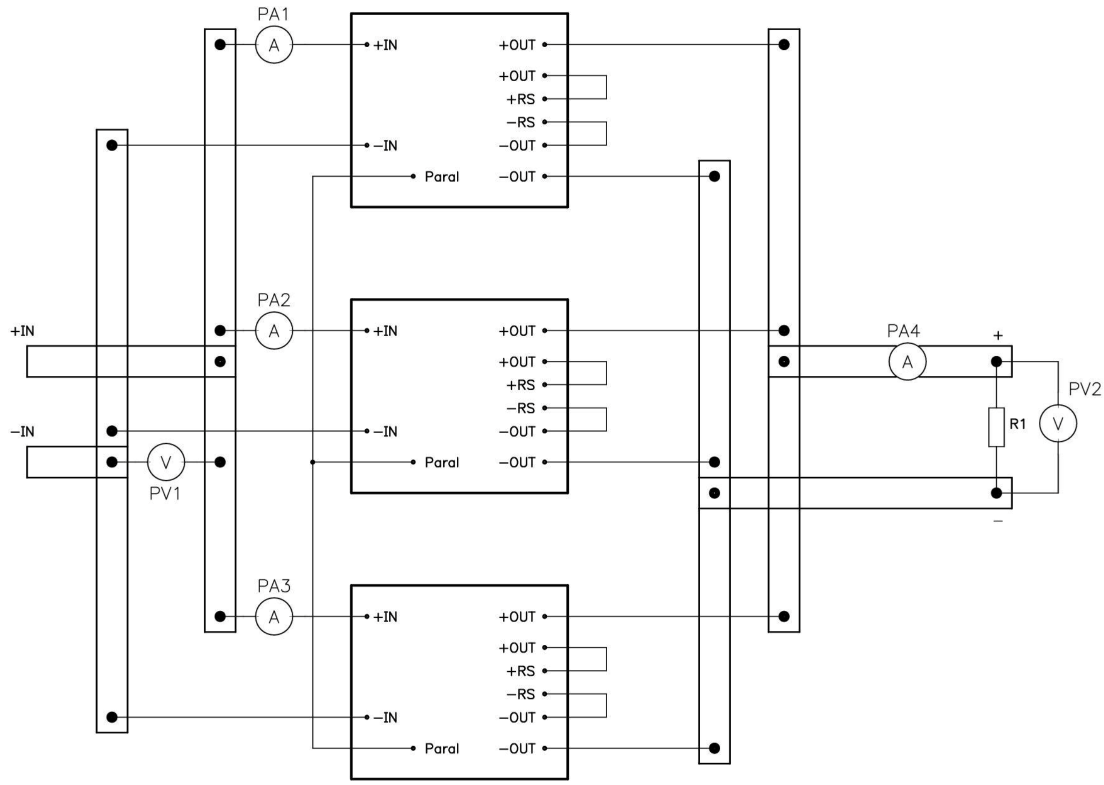
5.12.14 Increasing the output power. In those cases, when no back-up is needed, but still it is necessary to increase the output power, it is possible to apply the scheme without isolation diodes (Pic.5.13). When using such method, it is extremely important to check all the modes, in which the equipment will be working, with respect to stable operation (stability of the output voltage, current unbalance, launching). As far as stable operation mode is concerned, scheme with isolation diodes is more preferable, because the diodes exclude influence of the modules on each other.

5.12.15 Total output voltage adjustment of the modules connected in parallel (Pic.5.14). Output voltage adjustment is carried out within a range from –30 % to +10 % of the nominal value of the parameter. "ADJ" terminals of the modules, connected in parallel, must be connected together and connected to the middle pin of external regulation potentiometer. To secure stable operation of the modules connected in parallel, plus and minus conductors of potentiometer must be connected to "+RS" and "–RS" terminals of one of the modules. Conductors to the external adjustment must be short and twisted together, if possible. Output voltage adjustment has no influence on input current distribution among the modules.

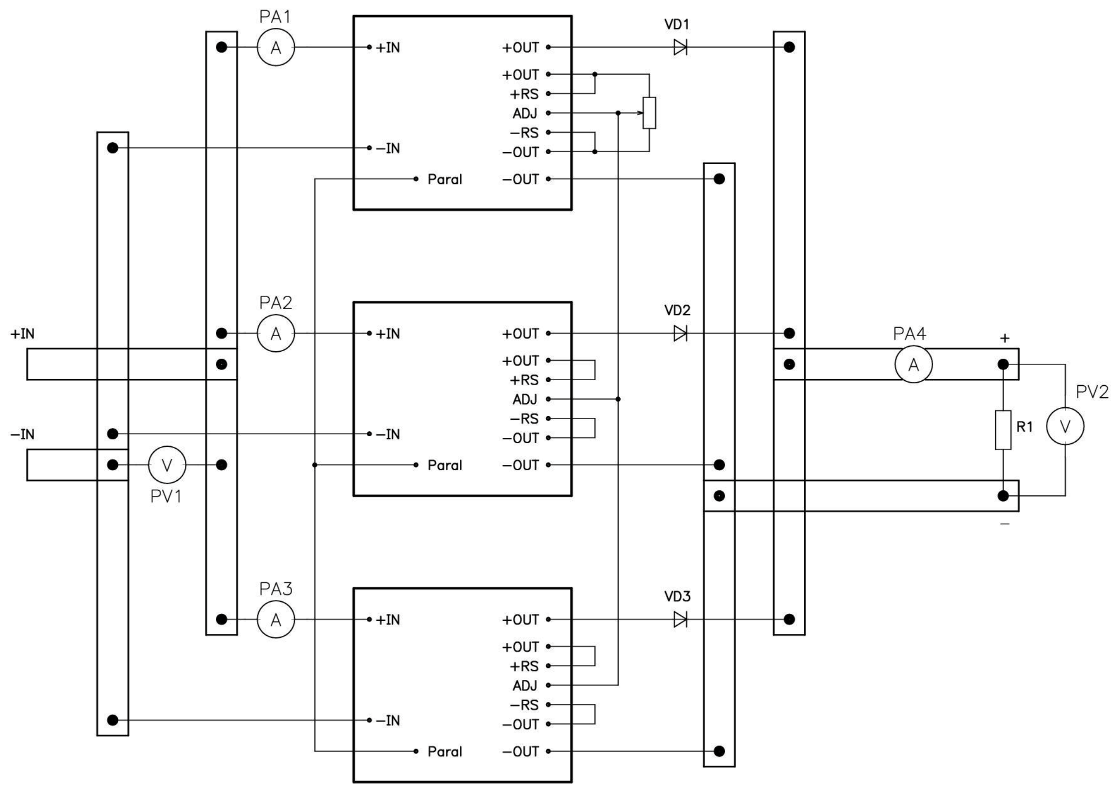
5.12.16 When applying parallel connection of the modules' outputs, it is strictly forbidden, during modules functioning, to perform output voltage adjustment by means of variable resistor ADJ installed in the modules. For that purpose, it is necessary to follow recommendations in p. 5.14.15.




Picture 5.12 System built according to "master-slave" method




Picture 5.13 Scheme for output power increasing



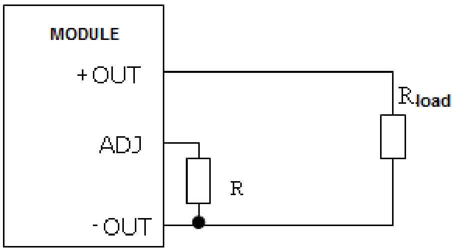

Picture 5.14 Total output voltage adjustment function for modules connected in parallel

5.12.17 Common output of the modules connected in parallel must be bridged by tantalum and aluminum capacitors with low full resistance (Low ESR). Capacity and recommended types of capacitors are given in Table 11, capacity has to be increased by N-times, where N is a number of modules being connected in parallel.

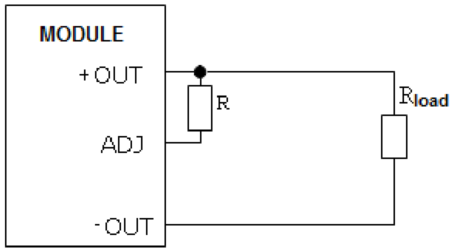
5.13 Output voltage adjustment function application

5.13.1 Output voltage adjustment in range not less than ±5 % in modules with "ADJ" terminal can be carried out by means of connection of "ADJ" to "-OUT" terminal through resistor (for example, for output voltage increase, see pic. 5.15) or to "+OUT" terminal (to decrease output voltage, see pic. 5.16).

5.13.2 To increase the output voltage, it is recommended to use resistance values in a range from 4,7 kOhm to 47 kOhm, to decrease output voltage for modules with $U_{out}$ = 3 V, it is recommended to use resistance values in a range from 750 Ohm to 7,5 kOhm; for modules with $U_{out}$ = 5 V – from 4,7 kOhm to 47 kOhm; for modules with $U_{out}$ = 12 V – from 75 kOhm to 750 kOhm; for modules with $U_{out}$ = 24 V – from 240 kOhm to 2,4 MOм; for modules with $U_{out}$ = 48 V – from 560 kOhm to 5,6 MOhm (data is given for reference). The exact value of resistor is defined experimentally during the process of equipment elaboration.




Picture 5.15 Output voltage increase




Picture 5.16 Output voltage decrease

5.14 Minimal output currents

5.14.1 Application of modules with current loads less than 0,1•$I_l$ is allowed. In that case, the amplitude of the output voltage ripple does not exceed 20 % of the nominal output voltage, value of the output voltage in this case does not exceed 1,1•$U_l$.

5.15 Maximum output currents

5.15.1 Long-term operation of the module (more than 1 minute) with load currents exceeding nominal values, is prohibited.

5.15.2 When connecting output terminals of the modules, it is necessary to use all available contacts for a more even load current distribution.

5.16 Input voltage increase/decrease protection

5.16.1 JETD modules possess built-in auto shutdown system, which is activated in case input voltage drops by 2–10 % lower than minimum allowed values, given in Table 2, or in case input voltage rises by 2–10 % higher than maximum allowed limits (as per Table 2).

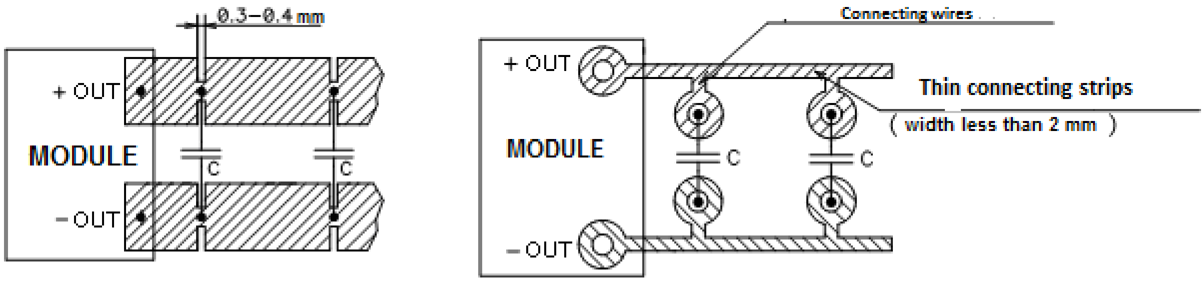
5.16.2 At the moment of current surge during start-up of a module, as well as when modules are operating at transient load, input voltage must remain higher than minimum allowed value. At high-amperage current, parallel connection of cable conductors and connector contacts is applied.

5.17 Output overvoltage protection

5.17.1 JETD modules possess built-in auto shutdown system, which is activated as soon as output voltage reaches value of 1,1-1,4 of $U_{out}$ nom with the following automatic return to stable mode after output overvoltage is eliminated.

5.18 PCB layout, three-dimensional wiring for the modules

5.18.1 It is recommended to connect modules to the equipment by means of two- and more layered PCB made of FR4 with foil thickness 0,07-0,105 mm. It is necessary to pay special attention to the PCB layout (accuracy of connection of discrete conductors) in the area of input and output capacitors, as per pic. 5.17.




a) Correct b) Incorrect

Picture 5.17 – Variants of PCB-layouts for modules in the areas of input and output capacitors placement

5.18.2 It is necessary to choose thickness of foil and traces width for PCBs with regard to input and output current values of the module. Traces' length must be as short as possible.

5.18.3 Power circuits and drive circuits of the equipment must be spaced as far as possible from each other. It is unacceptable to place any conductors under the module to exclude any possibility of creating interference from module in drive circuits of the equipment.

5.18.4 Grounding of the case is necessary to provide through "CASE" terminal or by soldering of the case to grounding conductors.

5.18.5 To provide required insulation strength value between input and output sides of the power supply scheme, distance between the closest conductors of these circuits must be 1 mm at least.

5.18.6 Important remarks on recommended lay-outs from electromagnetic compatibility and heat dissipation perspectives are:

- maximum use of PCB metallization from both sides to screen out radiation from the module's outputs and compound-potted surface;
- between the module and PCB there must be a grounded layer of metallization of maximum surface area with free spaces for direct soldering of the modules' case, the module itself must be set upon PCB till immediate contact of the module's case and metallization of PCB;
- in the area of outputs of input and output filtering capacitors, there should be made cut-ins on PCB traces (pic. 5.17a) to eliminate parasitic paths for noise propagation.

5.18.7 Nearfield of radiated noise, effective at the distance 5-15 mm of the case's surface in frequency range from 100 kHz to 100 MHz, is hardly screenable, which is why it is necessary to avoid placement of any sensitive circuits and devices of the equipment into this field.

5.19 Recommendations on the module's constructive placement and grounding

5.19.1 The modules comply with the standard requirements, EN55022 class A in conductive noise, in frequency range from 10 kHz to 30 MHz at the input provided that the load is located at distance of not more than 10 cm. To connect the load, it is necessary to use twisted pairs of wires or wires parallelly close to each other; common wires must be connected by busbar, providing minimum resistance between connection points. Long connecting strips, providing load connection, may radiate common noise with frequency of 20 MHz and higher onto the wires, feeding input electric power.

5.19.2 Noise interference by wires must be prevented at system level. In case the module does not comply with requirements of class A at frequencies higher than 20 MHz as a result of lay-out of wires, it is necessary to connect additional "Y" capacitor between common busbar of the input power source and common grounding point of the output supply voltages for common-mode interference isolation in a certain place. Recommended type of capacitor — 250VAC 2200pF class Y2 (DE2E3KY222MA2BM01) by Murata, or similar to this one.

## Revision registration list

| Cha nge | Number of pages | | | | Total number of pages | № doc. | As per incoming letter # | Signed | Date |
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| | Changed | Changed for | New | Deleted | | | | | |
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