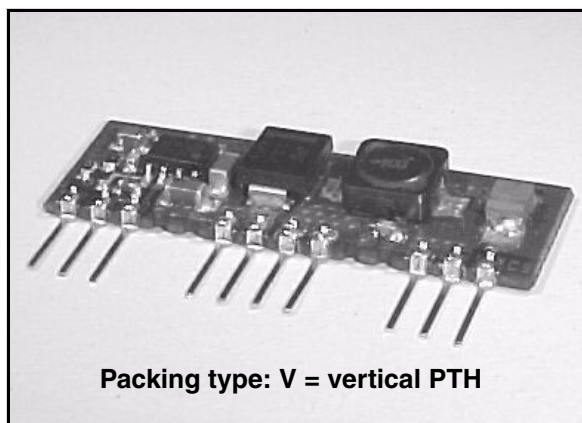


## 1.8 A DC-DC converter modules

### Features

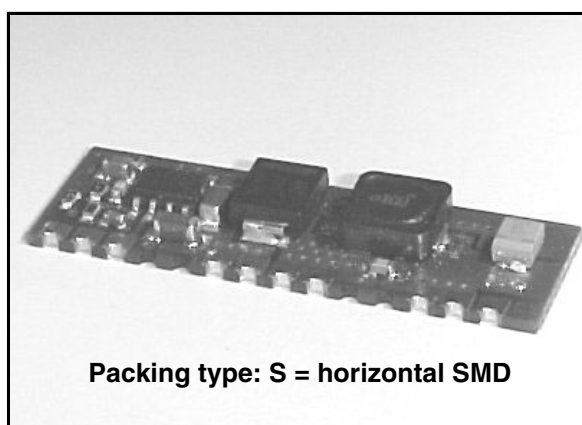
- MTBF 1 000 000 hours ( $T_A = 25\text{ }^{\circ}\text{C}$ )
- 1.8 A max output current
- 35 V max input voltage
- 1.5 V max drop-out voltage
- Remote logic inhibit/enable
- Synchronization
- Not-latching overload and short circuit protection
- Thermal shutdown
- Fixed or adjustable output
- No heatsink required
- Operating temperature range  $-25\text{ }^{\circ}\text{C} \div 85\text{ }^{\circ}\text{C}$



### Description

The GS-R24FP series is a family of high efficiency step down switching voltage regulator, designed to replace linear regulators.

Based on ST L5973A device, this non isolated family of regulators are suitable for the full spectrum of applications including telecom, industry, computer and distributed power system applications having a widely ranging input voltage.



**Table 1. Device summary**

| Order codes    | Output voltage [V] | Input voltage [V] | Output ripple [mVpp] | Efficiency [%] | Notes                 |
|----------------|--------------------|-------------------|----------------------|----------------|-----------------------|
| GS-R24FP0181.8 | $1.8 \pm 4\%$      | $16 \div 35$      | 25                   | 59 - 63        | Fixed output voltage  |
| GS-R24FP0251.8 | $2.5 \pm 4\%$      | $16 \div 35$      | 30                   | 66 - 70        | Fixed output voltage  |
| GS-R24FP0331.8 | $3.3 \pm 4\%$      | $16 \div 35$      | 30                   | 70 - 75        | Fixed output voltage  |
| GS-R24FP0501.8 | $5.0 \pm 4\%$      | $16 \div 35$      | 40                   | 79 - 83        | Fixed output voltage  |
| GS-R24FP0001.8 | $1.235 \div 5.5\%$ | $16 \div 35$      | 40                   | 56 - 83        | Progr. output voltage |

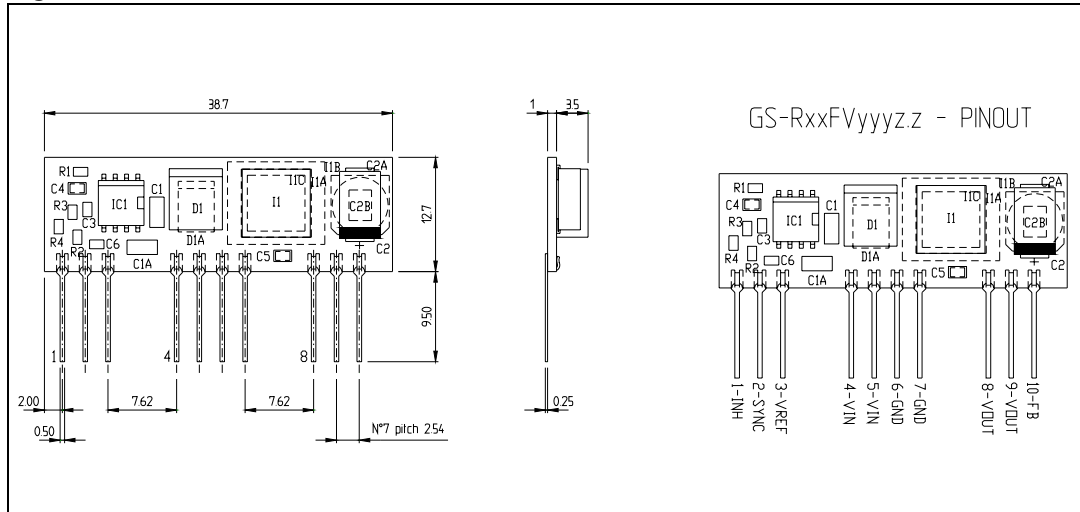
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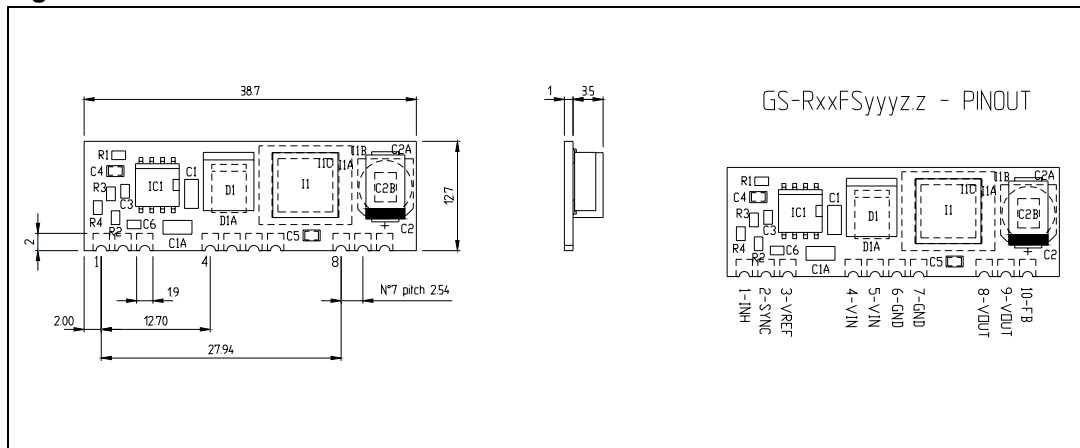
## 1 Pin settings

### 1.1 Pin connection and mechanical data (dimensions in mm)

**Figure 1. Pin connection GS-R24FVxxx1.8**



**Figure 2. Pin connection GS-R24FSxxx1.8**



## 1.2 Pin description

**Table 2. Pin description**

| Name | Function         | Description                                                                                           |
|------|------------------|-------------------------------------------------------------------------------------------------------|
| 1    | INH              | A logic high level disables the device. When the pin is open, an internal pull up disables the device |
| 2    | Sync             | Master/slave synchronization                                                                          |
| 3    | $V_{ref}$        | 3.3 V reference voltage                                                                               |
| 4    | Input +          | DC input voltage                                                                                      |
| 5    | Input +          | DC input voltage                                                                                      |
| 6    | Input/output GND | Return for input/output voltage source                                                                |
| 7    | Input/output GND | Return for input/output voltage source                                                                |
| 8    | $V_{out}$        | Regulated power output                                                                                |
| 9    | $V_{out}$        | Regulated power output                                                                                |
| 10   | FB               | Feedback input, available on adjustable device and on request for additional compensation             |

## 2 Maximum ratings

### 2.1 Absolute maximum ratings

Table 3. Absolute maximum ratings

| Symbol    | Parameter              | Value         | Unit |
|-----------|------------------------|---------------|------|
| $V_I$     | DC input voltage       | 36            | V    |
| $I_{out}$ | Maximum output current | int. limit    |      |
| $V_1$     | INH                    | -0.3 to $V_i$ | V    |
| $V_2$     | Sync                   | -0.3 to 4     | V    |
| $V_{10}$  | FB                     | 4             | V    |

### 2.2 Thermal data

Table 4. Thermal data

| Symbol    | Parameter                     | Value     | Unit |
|-----------|-------------------------------|-----------|------|
| $T_{STG}$ | Storage temperature range     | -40 ÷ 105 | °C   |
| $T_{OP}$  | Operating ambient temperature | -25 ÷ 85  | °C   |

## 2.3 Thermal de-rating

Table 5. Thermal de-rating for free air condition (all versions)

| Symbol | Parameter       | Test condition                                        | Value | Unit |
|--------|-----------------|-------------------------------------------------------|-------|------|
| $I_o$  | Output current  | $V_I = 16\text{ V}, T_A = 30\text{ }^{\circ}\text{C}$ | 1.80  | A    |
|        |                 | $V_I = 16\text{ V}, T_A = 40\text{ }^{\circ}\text{C}$ | 1.80  |      |
|        |                 | $V_I = 16\text{ V}, T_A = 50\text{ }^{\circ}\text{C}$ | 1.75  |      |
|        |                 | $V_I = 16\text{ V}, T_A = 55\text{ }^{\circ}\text{C}$ | 1.70  |      |
|        |                 | $V_I = 16\text{ V}, T_A = 60\text{ }^{\circ}\text{C}$ | 1.65  |      |
|        |                 | $V_I = 16\text{ V}, T_A = 65\text{ }^{\circ}\text{C}$ | 1.50  |      |
|        |                 | $V_I = 16\text{ V}, T_A = 70\text{ }^{\circ}\text{C}$ | 1.35  |      |
|        |                 | $V_I = 16\text{ V}, T_A = 75\text{ }^{\circ}\text{C}$ | 1.25  |      |
|        |                 | $V_I = 16\text{ V}, T_A = 80\text{ }^{\circ}\text{C}$ | 1.10  |      |
|        |                 | $V_I = 16\text{ V}, T_A = 85\text{ }^{\circ}\text{C}$ | 0.90  |      |
| $I_o$  | Output c urrent | $V_I = 24\text{ V}, T_A = 30\text{ }^{\circ}\text{C}$ | 1.80  | A    |
|        |                 | $V_I = 24\text{ V}, T_A = 40\text{ }^{\circ}\text{C}$ | 1.75  |      |
|        |                 | $V_I = 24\text{ V}, T_A = 50\text{ }^{\circ}\text{C}$ | 1.70  |      |
|        |                 | $V_I = 24\text{ V}, T_A = 55\text{ }^{\circ}\text{C}$ | 1.60  |      |
|        |                 | $V_I = 24\text{ V}, T_A = 60\text{ }^{\circ}\text{C}$ | 1.45  |      |
|        |                 | $V_I = 24\text{ V}, T_A = 65\text{ }^{\circ}\text{C}$ | 1.30  |      |
|        |                 | $V_I = 24\text{ V}, T_A = 70\text{ }^{\circ}\text{C}$ | 1.20  |      |
|        |                 | $V_I = 24\text{ V}, T_A = 75\text{ }^{\circ}\text{C}$ | 1.05  |      |
|        |                 | $V_I = 24\text{ V}, T_A = 80\text{ }^{\circ}\text{C}$ | 0.85  |      |
|        |                 | $V_I = 24\text{ V}, T_A = 85\text{ }^{\circ}\text{C}$ | 0.60  |      |
| $I_o$  | Output current  | $V_I = 35\text{ V}, T_A = 30\text{ }^{\circ}\text{C}$ | 1.75  | A    |
|        |                 | $V_I = 35\text{ V}, T_A = 40\text{ }^{\circ}\text{C}$ | 1.60  |      |
|        |                 | $V_I = 35\text{ V}, T_A = 50\text{ }^{\circ}\text{C}$ | 1.45  |      |
|        |                 | $V_I = 35\text{ V}, T_A = 55\text{ }^{\circ}\text{C}$ | 1.35  |      |
|        |                 | $V_I = 35\text{ V}, T_A = 60\text{ }^{\circ}\text{C}$ | 1.20  |      |
|        |                 | $V_I = 35\text{ V}, T_A = 65\text{ }^{\circ}\text{C}$ | 1.05  |      |
|        |                 | $V_I = 35\text{ V}, T_A = 70\text{ }^{\circ}\text{C}$ | 0.90  |      |
|        |                 | $V_I = 35\text{ V}, T_A = 75\text{ }^{\circ}\text{C}$ | 0.75  |      |
|        |                 | $V_I = 35\text{ V}, T_A = 80\text{ }^{\circ}\text{C}$ | 0.50  |      |
|        |                 | $V_I = 35\text{ V}, T_A = 85\text{ }^{\circ}\text{C}$ | 0.30  |      |

### 3 Electrical characteristics

$T_A = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified

**Table 6. Electrical characteristics (all version)**

| Symbol       | Parameter                           | Test condition                                                 | Min  | Typ   | Max   | Unit                   |
|--------------|-------------------------------------|----------------------------------------------------------------|------|-------|-------|------------------------|
| $V_r$        | Ripple voltage                      | $V_i = 24\text{ V}$ $I_o = 1.8\text{ A}$<br>for GS-R24FPyyy1.8 |      | 30    | 60    | mVpp                   |
|              | Temperature stability               | $V_i = V_o + 1.5\text{ V}$ $I_o = 1.8\text{ A}$                |      |       |       | mV/ $^{\circ}\text{C}$ |
| $I_o$        | Output current                      | $V_i = 16 \div 35\text{ V}$<br>for GS-R24FPyyy1.8              | 0    |       | 1.8   | A                      |
| $I_{oL}$     | Current limit                       | $V_i = 16 \div 35\text{ V}$                                    |      | 2.3   |       | A                      |
| $I_q$        | Quiescent current                   | $V_i = 24\text{ V}$ $I_o = 0\text{ A}$                         |      |       | 2.7   | mA                     |
| $I_{qst-by}$ | Total stand-by<br>quiescent current | $V_{inh} > 2.2\text{ V}$ $V_i = 35\text{ V}$                   |      | 80    | 150   | $\mu\text{A}$          |
| $f_s$        | Switching frequency                 | $V_i = 24\text{ V}$ $I_o = 1.8\text{ A}$                       |      | 500   |       | kHz                    |
| $V_{ref}$    | Reference voltage                   | $V_i = 16 \div 35\text{ V}$ $I_{ref} = 0 \div 5\text{ mA}$     | 3.2  | 3.3   | 3.399 | V                      |
|              | Short circuit current               |                                                                | 8    | 10    | 30    | mA                     |
| INH          | INH threshold voltage               | Device ON                                                      |      |       | 0.8   | V                      |
|              |                                     | Device OFF                                                     | 2.2  |       |       | V                      |
| $V_{FB}$     | Feedback voltage                    | $V_i = 16 \div 35\text{ V}$ $I_o = 0 \div 1.8\text{ A}$        | 1.22 | 1.235 | 1.25  | V                      |

## 4 Application information

### 4.1 Input voltage

The recommended maximum operating DC input voltage is 35 V including ripple voltage.

### 4.2 Reference voltage

No capacitor is required for stability.

### 4.3 Inhibit function

The inhibit feature allows to put the device in stand-by mode.

With INH pin 1 is higher than 2.2 V the device is disabled and the current consumption is reduced to less than 150  $\mu$ A for  $V_i = 35$  V.

With INH pin lower than 0.8 V, the device is enabled.

If the INH pin is left floating, an internal pull up ensures that the voltage at the pin reaches the inhibit threshold and the device is disabled.

The pin can be pulled to  $V_i$  to disable the device.

### 4.4 Multiple units synchronization

Using more than one unit on the same circuit, it is possible to synchronize the switching frequency, connecting all pin 2 together (see [Figure 6](#)).

The unit with higher frequency becomes the master.

### 4.5 Current limitation

The device has two current limit protections, pulse by pulse and frequency fold back.

The current is sensed through a resistor and if it reaches the threshold, the on time is reduced and consequently the output voltage, too.

Since the minimum switch ON time (necessary to avoid false overcurrent signal) is not enough to obtain a sufficiently low duty cycle at 500 kHz, the output current could increase again, in strong overcurrent or short circuit conditions.

For this reason the switching frequency is also reduced to keep the inductor current within its maximum threshold limit.

The frequency depends on the feedback voltage.

As the feedback voltage decreases (due to the reduced duty cycle), the switching frequency decrease too.



## 4.6 Thermal shutdown

The shutdown block generates a signal that turns OFF the power stage if the temperature of the internal chip goes higher than a fixed internal threshold (150 °C min).

The sensing element of the chip is very close to the PDMOS area, so ensuring an accurate and fast temperature detection.

An hysteresis of approximately 20 °C avoids that the devices turns ON and OFF continuously.

## 4.7 Output voltage programming (GS-R24FP0001.8 only)

The GS-R24FP0001.8 output voltage is 5.54 V  $\pm$  4 %, to reduce this value connect a resistor between pin 10 (FB) and pin 9 ( $V_{out}$ ).

The resistor must be located very close to the proper pins, to minimize the injected noise (see [Figure 4](#)).

The resistor value is calculated using the following formula:

$$\text{for GS-R24FP0001.8 } R_v = [(V_{out} - 1.235) * 11.3] / 5.54 - V_{out} \quad [\text{k}\Omega]$$

$V_{out}$  can be adjusted between 1.235 V ( $R_v = 0 \Omega$ ) and 5.54V ( $R_v = \text{open}$ )

## 4.8 Loop compensation (GS-R24FP0001.8 only)

If required by particular load conditions, it is possible to change the feedback loop compensation, adding an external capacitor between pin 10 (FB) and pin 9 ( $V_{out}$ ), which will act as speed up (see [Figure 5](#)).

## 4.9 Soldering

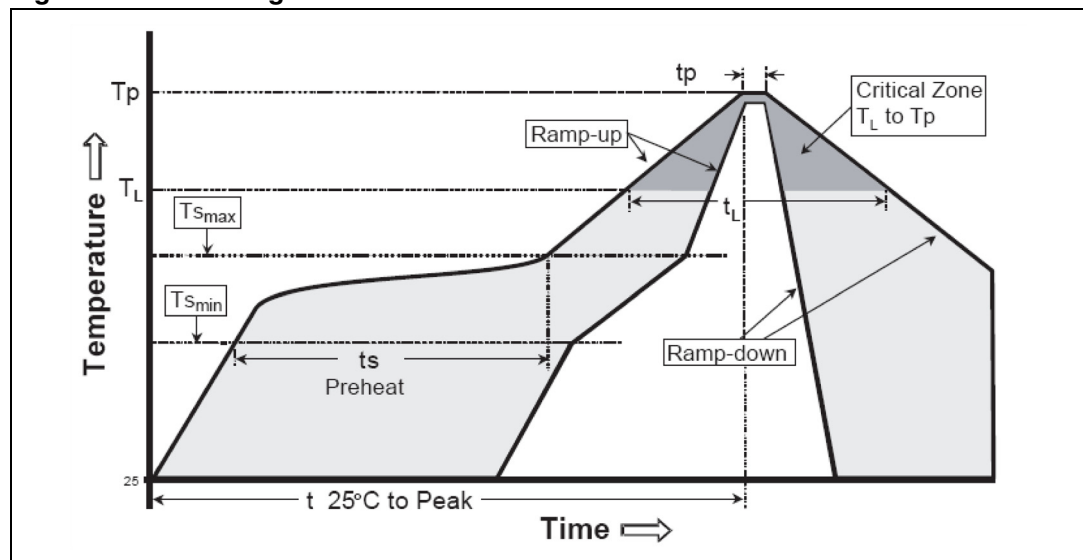
Soldering phase has to be executed with care : in order to avoid undesired melting phenomenon, particular attention has to be taken on the set up of the peak temperature.

Here following some suggestions for the temperature profile based on IPC/JEDEC J-STD-020C ,July 2004 recommendations.

**Table 7. Soldering**

| Profile feature                                                                                                         | PB free assembly                 |
|-------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| Average ramp up rate ( $T_{S\text{MAX}}$ to $T_P$ )                                                                     | 3 °C / sec max                   |
| Preheat:<br>Temperature min ( $T_S$ MIN )<br>Temperature max ( $T_S$ MAX )<br>Time ( $T_S$ MIN to $T_S$ MAX ) ( $t_S$ ) | 150 °C<br>200 °C<br>60 – 100 sec |
| Time maintained above :<br>Temperature $T_L$<br>Time $t_L$                                                              | 217 °C<br>40 – 70 sec            |
| Peak temperature ( $T_P$ )                                                                                              | 240 + 0 °C                       |
| Time within 5 °C of actual peak temperature ( $t_P$ )                                                                   | 10 – 20 sec                      |
| Ramp down rate                                                                                                          | 6 °C / sec                       |
| Time from 25 °C to peak temperature                                                                                     | 8 minutes max                    |

**Figure 3. Soldering**



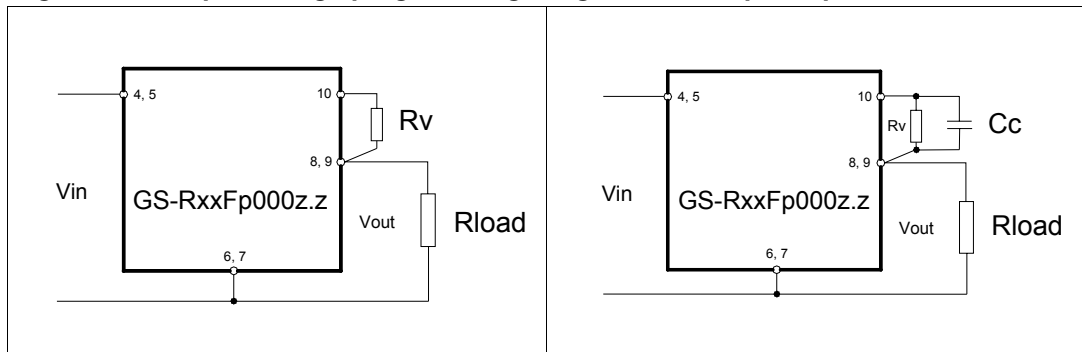
## 5 Additional features and protections

### 5.1 Output overvoltage protection

The overvoltage protection, OVP, is realized by using an internal comparator, whose input is connected to the feedback. It turns off the power stage when the OVP threshold is reached.

This threshold is typically 30 % higher than the feedback voltage.

**Figure 4. Output voltage programming**    **Figure 5. Loop compensation**



**Figure 6. Multiple units synchronization**

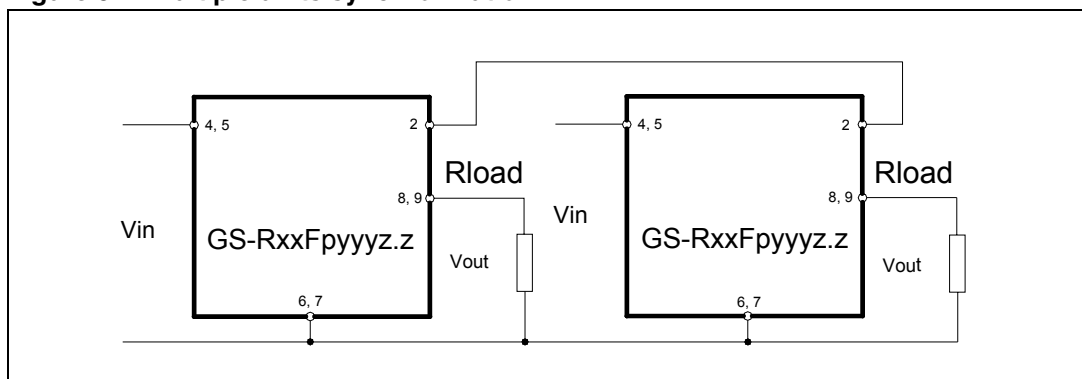
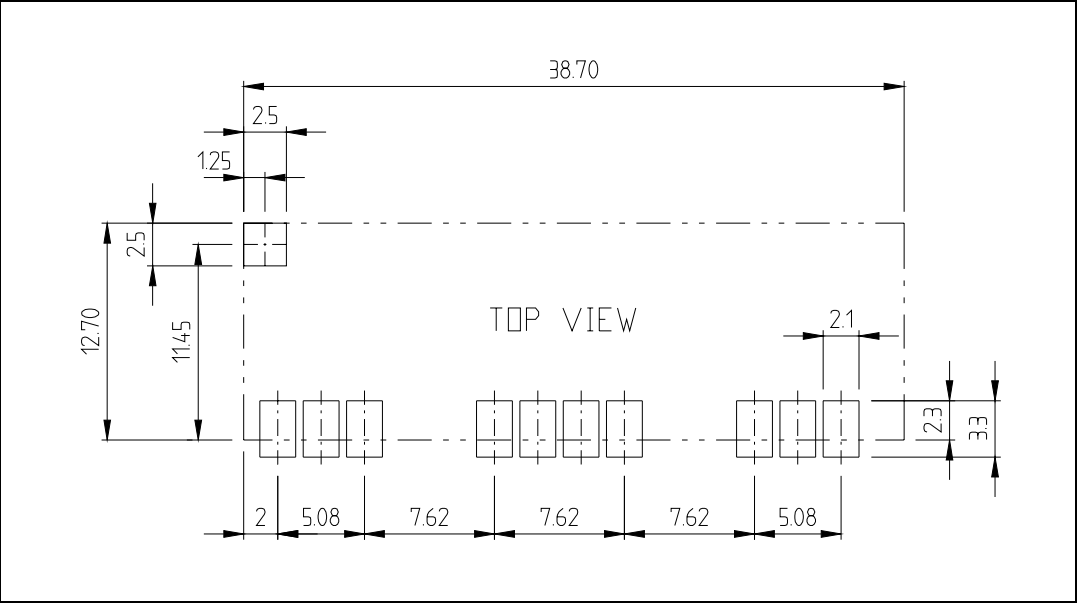


Figure 7. PCB footprint for GS-R24FSxxx1.8 (dimensions in mm)



6      Ordering scheme

Table 8.      Ordering information scheme

|                       | GS- | R12 | FV | 018 | 1.8 |
|-----------------------|-----|-----|----|-----|-----|
| <b>Input voltage</b>  |     |     |    |     |     |
| 24 = 24 V             |     |     |    |     |     |
| <b>Package</b>        |     |     |    |     |     |
| V = Vertical          |     |     |    |     |     |
| S = SMD               |     |     |    |     |     |
| <b>Output voltage</b> |     |     |    |     |     |
| 018 = 1.8 V           |     |     |    |     |     |
| 025 = 2.5 V           |     |     |    |     |     |
| 033 = 3.3 V           |     |     |    |     |     |
| 050 = 5.0 V           |     |     |    |     |     |
| 000 = 1.235 ÷ 5.5 V   |     |     |    |     |     |
| <b>Output current</b> |     |     |    |     |     |
| 1.8 = 1.8 A           |     |     |    |     |     |

## 7 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes                                                  |
|-------------|----------|----------------------------------------------------------|
| 13-Oct-2006 | 1        | Initial release                                          |
| 27-Feb-2008 | 2        | Added: <a href="#">Section 4.9: Soldering on page 10</a> |

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