# NON-ISOLATED DC/DC CONVERTERS

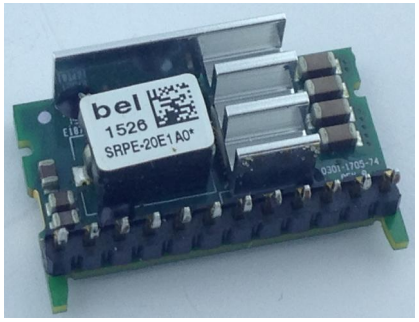
**4.5 Vdc – 13.2 Vdc Input  0.6 Vdc – 2.0 Vdc/20 A Output**

*May 17, 2016*

*Bel Power Inc., a subsidiary of Bel Fuse Inc.*

**SRPE-20E1A0  RoHS Compliant  Rev.M**

## Features




- Non-Isolated
- Fixed frequency
- High efficiency
- High Power Desity
- Overtemperature Shutdown
- Wide Input Voltage Range
- Low Cost
- Wide Output Trim Range
- Output Over-Voltage Shutdown
- OCP/SCP
- Power Good Signal
- Remote Sense
- Remote On/Off
- Undervoltage lockout
- Wide Operating Temperature Range (0 °C - 50 °C)
- Class 2, Category 2, Non-Isolated DC/DC Converter (refer to IPC-9592B)

## Applications

- Networking
- Computers and peripherals
- Telecommunications

## Description

The Bel SRPE-20E1A0 is part of the non-isolated dc to dc converter Power Module series. The modules use a Vertical SMT package. These converters are available in a range of output voltages from 0.6 Vdc to 2.0 Vdc over a wide range of input voltage (Vin = 4.5 – 13.2 Vdc).

## Part Selection

| Output Voltage | Input Voltage | Max. Output Current | Max. Output Power | Typical Efficiency | Model Number Active High |
|---|---|---|---|---|---|
| 0.6 Vdc – 2.0 Vdc | 4.5 Vdc - 13.2 Vdc | 20 A | 40 W | 92% | SRPE-20E1A0 |

**Notes**: 1. Add “G” suffix at the end of the model numbers listed above to indicate “Tray Packaging”.

### Ordering Part Number

| S | R | PE | – | 20 | E | 1A | 0 | x |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | | 4 | 5 | 6 | 7 | 8 |

**1---Mounting type,** **S –Surface mount**
**2---RoHS Status,** **R – RoHS 6**
**3---Series name,** **PE –SMD Series name**
**4---Output power,** **20 – 20A output**
**5---Input range,** **E – 4.5-13.2V input**
**6---Output voltage,** **1A – 0.6-2.0V output**
**7---Active logic and HSK feature,** **0 – active high, with HSK**
**8---Package type,** **G – Tray packaging**

## Absolute Maximum Ratings

| Parameter | Min | Typ | Max | Unit | Notes |
|---|---|---|---|---|---|
| Continuous non-operating Input Voltage | -0.3 | - | 15 | V | |
| Output Enable Terminal Voltage | -0.3 | - | 15 | V | |
| Ambient Temperature | 0 | - | 50 | °C | |
| Storage Temperature | -40 | - | 125 | °C | |
| Altitude | - | - | 2000 | m | |

**Note:** Ratings used beyond the maximum ratings may cause a reliability degradation of the converter or may permanently damage the device.

## Input Specifications

| Parameter | Min | Typ | Max | Unit | Notes |
|---|---|---|---|---|---|
| Input Voltage | 4.5 | 12 | 13.2 | V | |
| Input Current (full load) | - | - | 10.0 | A | |
| Input Current (no load) | - | 30 | 50 | mA | All Vin, Vout=0.6V, At Ta=25C. |
| | - | 50 | 70 | mA | All Vin, Vout=1.2V, At Ta=25C. |
| | - | 60 | 80 | mA | All Vin, Vout=2V, At Ta=25C. |
| Remote Off Input Current | - | 10 | - | mA | |
| Input Reflected Ripple Current (pk-pk) | - | - | 100 | mA | Vout=2V, Iout=20A. With simulated source impedance of 1uH, 5Hz to 20MHz. Use a 100uF/100V electrolytic capacitors with ESR < 0.2ohm max @ 25C. |
| Input Reflected Ripple Current (rms) | - | - | 20 | mA | |
| Turn-on Voltage Threshold | 3.8 | 4.3 | 5 | V | |
| Turn-off Voltage Threshold | 3.8 | 4.1 | 4.5 | V | |

**Note:** All specifications are typical at 25 °C unless otherwise stated.

## Output Specifications

| Parameter | | Min | Typ | Max | Unit | Notes |
|---|---|---|---|---|---|---|
| Output Voltage Set Point | Vo,set ⩾ 0.9Vdc | -2 | - | 2 | %Vo,set | Setpoint test condition: Vin=12V, Iout=half load, Ta=25°C |
| | Vo,set < 0.9Vdc | -3 | - | 3 | %Vo,set | |
| Load regulation | | -2 | - | 2 | %Vo,set | Vin=12V, Io=0-20A, Ta=25°C |
| Line Regulation | | -2 | - | 2 | %Vo,set | Vin=4.5-13.2V, Io=20A, Ta=25°C |
| Regulation Over Temperature | | - | ±3 | - | %Vo,set | |
| Output Ripple and Noise (pk-pk) | | - | - | 30 | mV | Condition: Vin=12V, Iout=full load, Ta=25°C, measured with a 10uF + 7*100uF ceramic cap and 3*470uF POSCAP ESR <= 12mohm at output. |
| Output Ripple and Noise (rms) | | - | - | 5 | mV | |
| Output Current Range | | 0 | - | 20 | A | |
| Output DC Current Limit | | 22 | - | 39 | A | |

## Output Specifications (continued)

| Parameter | | Min | Typ | Max | Unit | Notes |
|---|---|---|---|---|---|---|
| Turn On Time | | - | - | 5 | ms | |
| Overshoot at Turn on | | - | 0 | 5 | % | |
| Output Capacitance | | 470 | - | 6000 | uF | Required Cout_min = 470uF with ESR <= 12mohm. |
| **Transient Response** | | | | | | |
| △V50%~75% of Max Load | Overshoot | - | 25 | 40 | mV | Vin=12V, Vout=2.0V, di/dt=2.5A/us. Measured with a 10uF + 7*100uF ceramic cap and 3*470uF POSCAP ESR <= 12mohm at output. |
| | Settling Time | - | 20 | 40 | us | |
| △V75%~50% of Max Load | Overshoot | - | 25 | 40 | mV | |
| | Settling Time | - | 20 | 40 | us | |

**Note:** All specifications are typical at 25°C unless otherwise stated.

## General Specifications

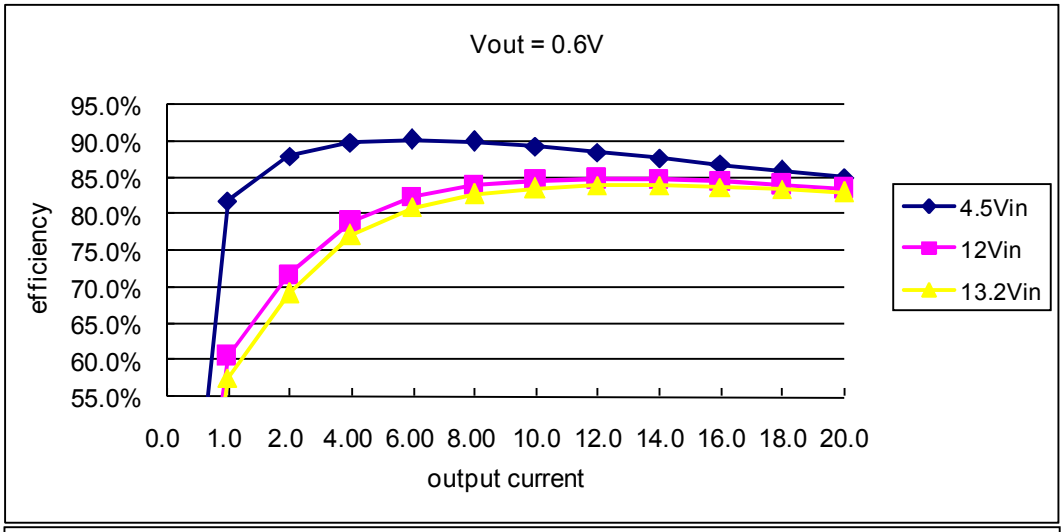
| | Min | Typ | Max | Unit | Notes |
|---|---|---|---|---|---|
| Efficiency<br>Vo=0.6 V,Io=20 A | 82 | 83.6 | - | % | |
| Vo=1.2V, Io=20 A | 88 | 89.3 | - | % | |
| Vo=2V, Io=20 A | 91 | 92.2 | - | % | |
| Switching Frequency | - | 500 | - | kHz | |
| Over Temperature Protection | - | 125 | - | °C | |
| Weight | - | 6.8 | - | g | |
| Output Voltage Trim Range(Wide Trim) | 0.6 | - | 2 | V | This voltage is achieved by trimming up output slowly. |
| MTBF | - | 88.4 | - | Mhrs | Calculated Per Telcordia SR-332, Issue 3 (Vin=12V,Vo=0.9V,Io=20A, Ta=40C，with 300 LFM，FIT=$10^9$/MTBF) |
| FIT | - | 11.3 | - | - | |
| Dimensions<br>Inches (L × W × H)<br>Millimeters (L × W × H) | 1.20 x0.65 x 0.43<br>30.48 x 16.51 x 10.92 | | | - | |

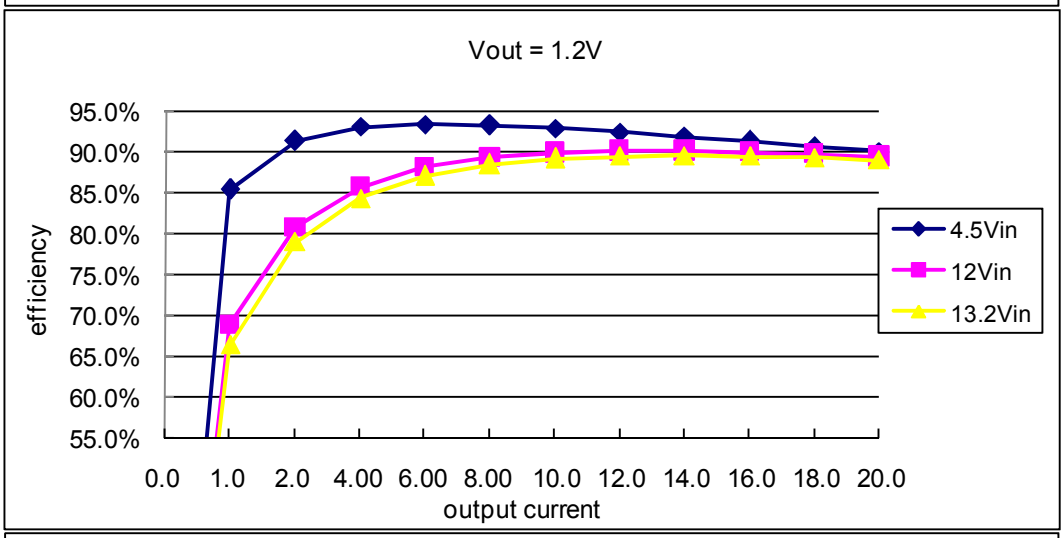
**Note**: All specifications are typical at 25 °C unless otherwise stated.

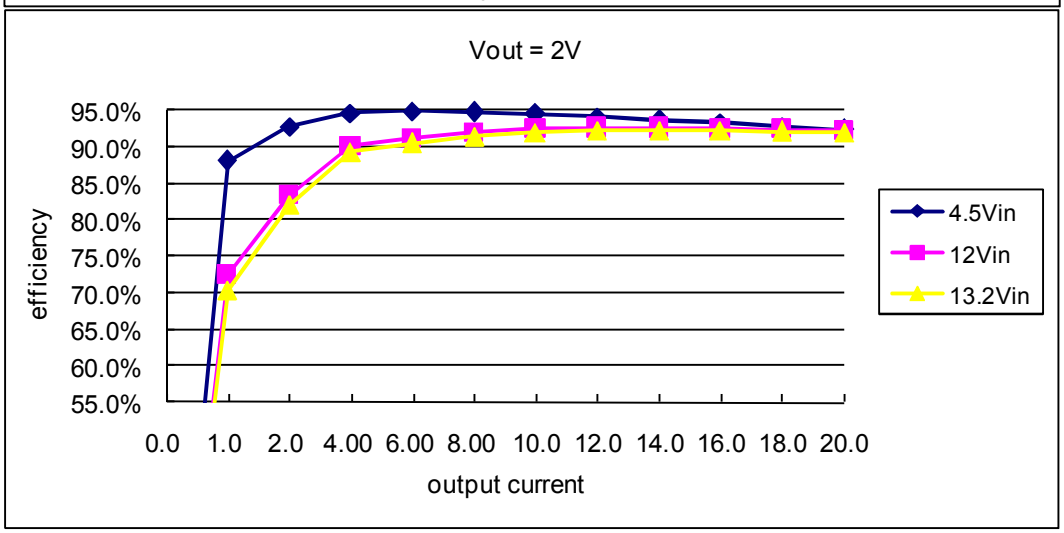
## Control Specifications

| Parameter | Min | Typ | Max | Unit | Notes |
|---|---|---|---|---|---|
| Remote On/Off | | | | | |
| Signal Low(Unit Off) | 0 | - | 0.5 | V | Remote On/Off pin open,unit off. |
| Signal High(Unit On) | 1.8 | - | 15 | V | |

## Efficiency Data



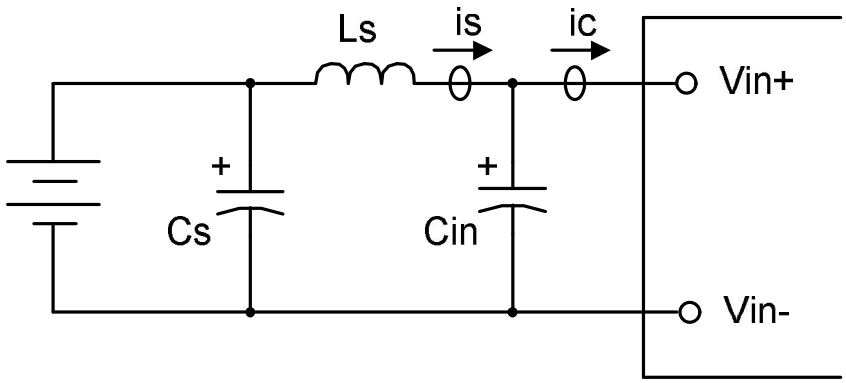



## Input noise

**Input reflected ripple current**

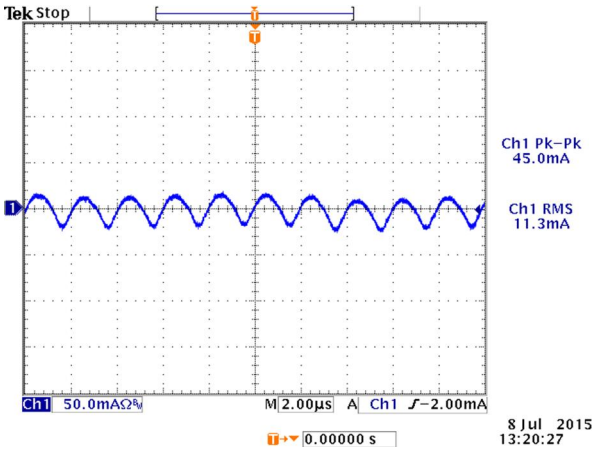
*Testing setup*



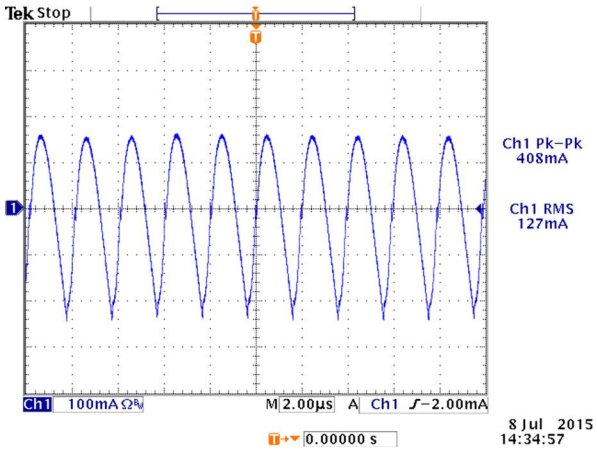

*Notes and values in testing*.

**is:** Input Reflected Ripple Current
**ic:** Input Terminal Ripple Current
**Ls:** Simulated Source Impedence (1μH)
**Cs:** Offset possilbe source Impedence (100μF, ESR<0.2Ω @ 100kHz, 20C )
**Cin:** Electrolytic capacitor, should be as closed as possible to the power module to swallow ic ripple current and help with stability. Recommendation: 100μF, ESR<0.2Ω @ 100kHz, 20C.

*Below measured waveforms are based on above simulated and recommended inductance and capacitance.*




is (input reflected ripple current), AC component

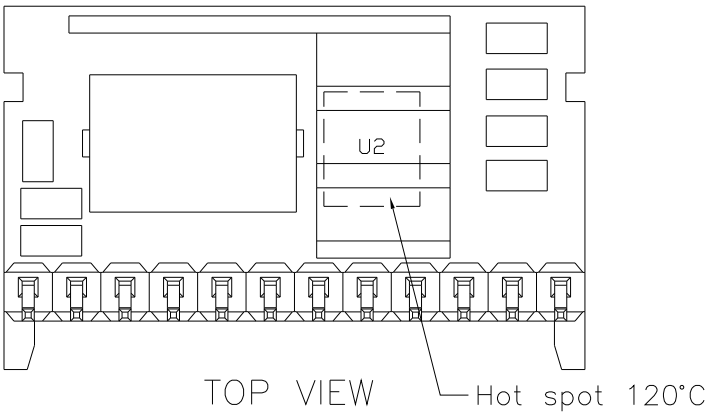


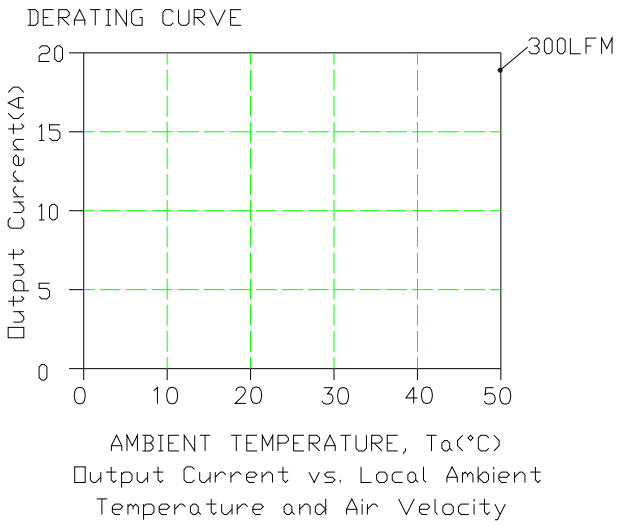

ic (input terminal ripple current), AC component

Note：Vin=12V,Vo=2V,Io=20A,with 1*10uF ceramic and 1*470uF polymer capacitor at the output，Ta=25 deg C.

## Thermal Derating Curves

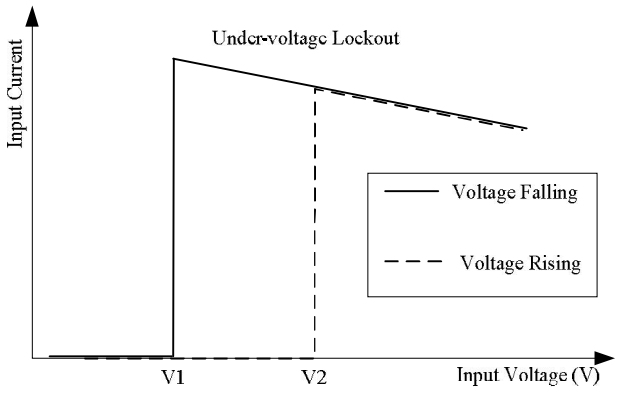
Hot spot location and allowed maximum temperature



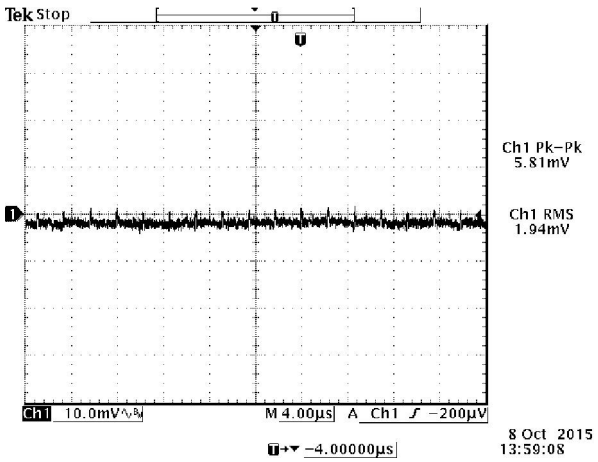

Vin=12V, Vo=0.6-2V

## Input under-voltage lockout

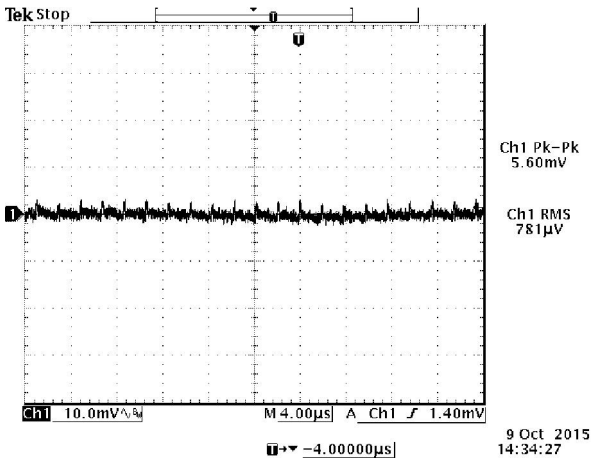



V1=4.1V
V2=4.3V

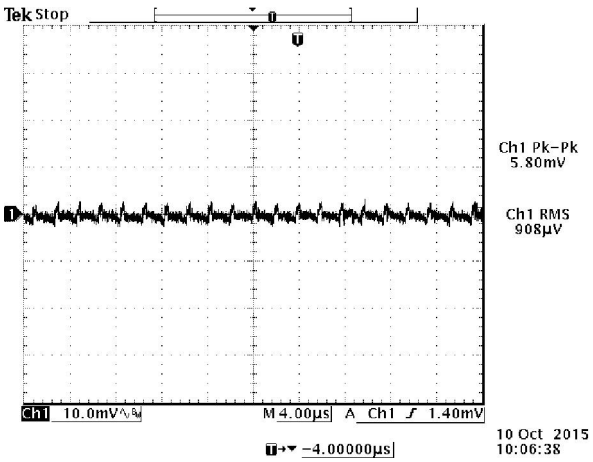
## Ripple and Noise Waveform




Ripple and noise at full load, 12Vdc input
0.6Vdc/20A output and Ta=25 deg C



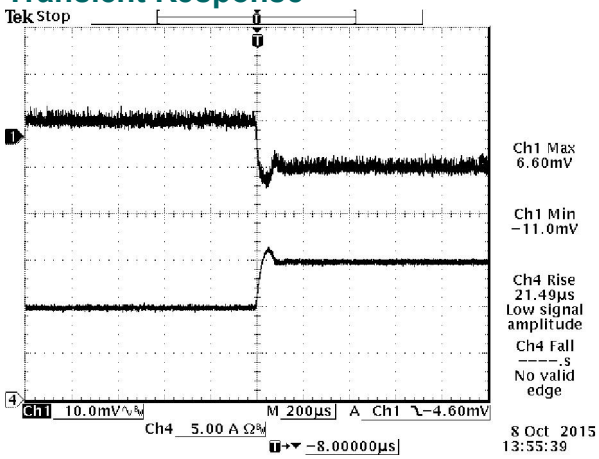

Ripple and noise at full load, 12Vdc input,
0.9Vdc/20A output and Ta=25 deg C,



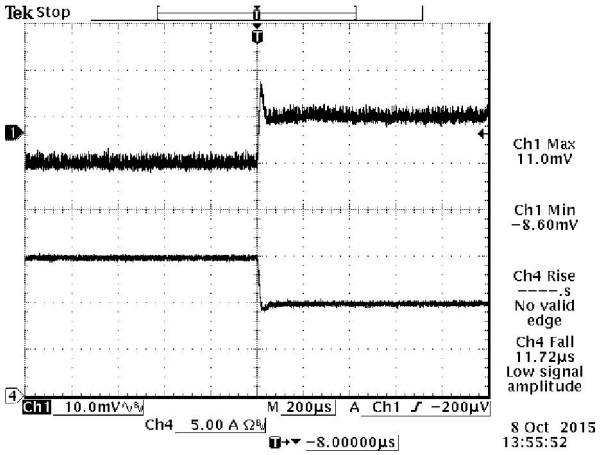

Ripple and noise at full load, 12Vdc input, 2.0Vdc/20A output and Ta=25 deg C

**Note:** Test condition of the output ripple and noise:
0-20MHz BW, with a 10uF + 7*100uF ceramic cap and 3*470uF POSCAP ESR <= 12mohm at output.

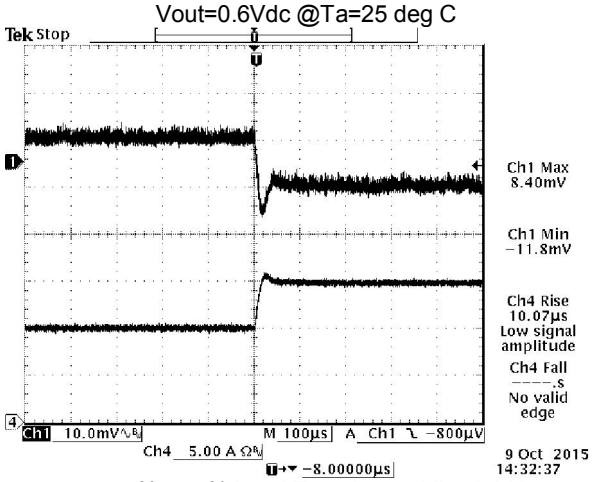
## Transient Response



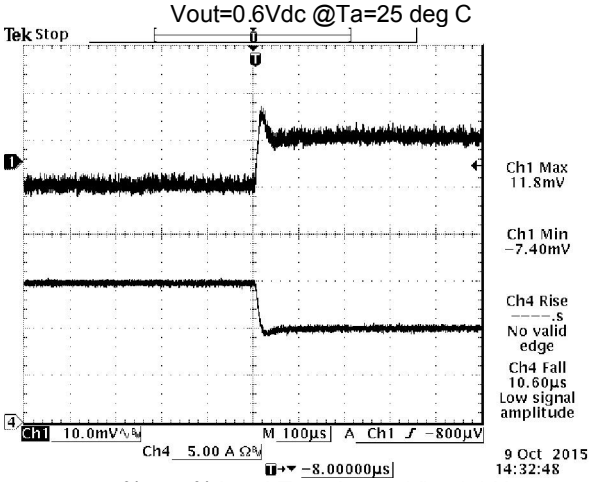

50%—75% Load Transient at Vin=12Vdc,
Vout=0.6Vdc @Ta=25 deg C



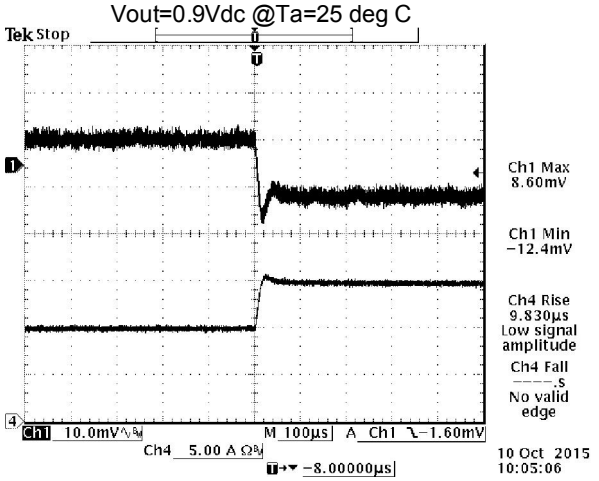

75%—50% Load Transient at Vin=12Vdc
Vout=0.6Vdc @Ta=25 deg C



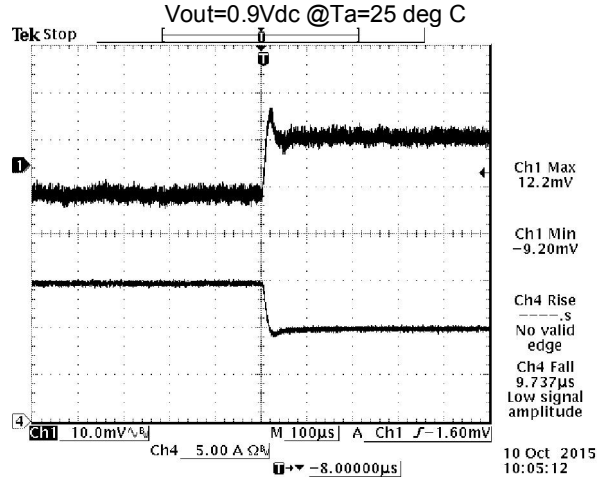

50%—75% Load Transient at Vin=12Vdc
Vout=0.9Vdc @Ta=25 deg C




75%—50% Load Transient at Vin=12Vdc
Vout=0.9Vdc @Ta=25 deg C




50%—75% Load Transient at Vin=12Vdc
Vout=2.0Vdc @Ta=25 deg C

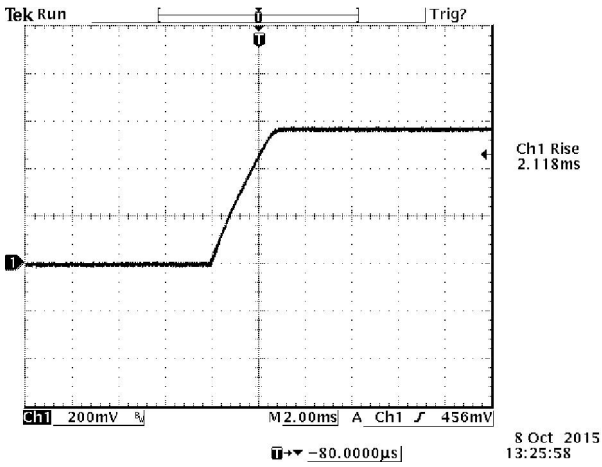



75%—50% Load Transient at Vin=12Vdc
Vout=2.0Vdc @Ta=25 deg C

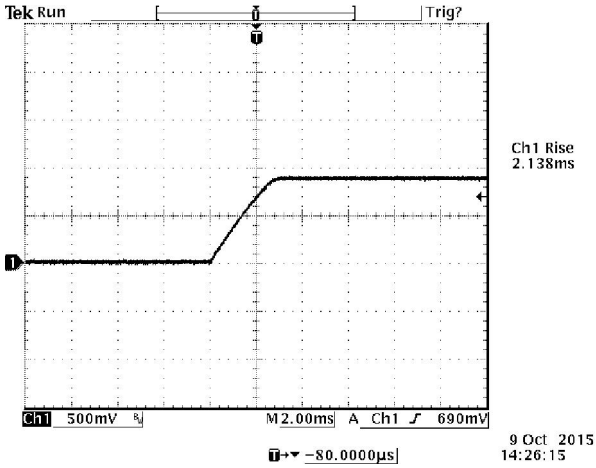
**Note:** Test condition of the Transient response:
di/dt=2.5A/us,with a 10uF + 7*100uF ceramic cap and 3*470uF POSCAP ESR <= 12mohm at output.

## Startup&Shutdown

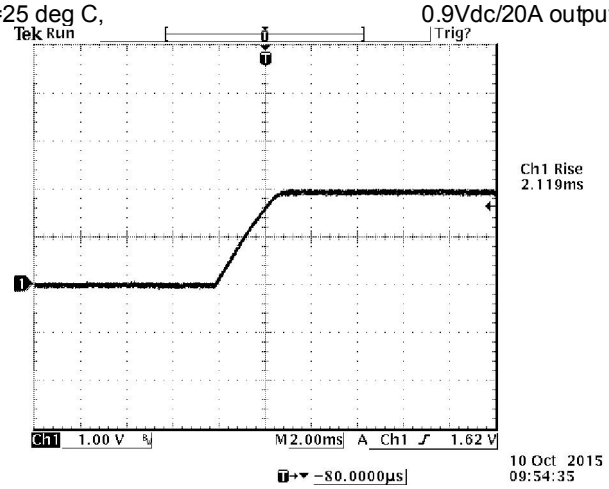
Rise time




Rise time at full load, 12Vdc input, 0.6Vdc/20A output and Ta=25 deg C,




Rise time at full load, 12Vdc input, 0.9Vdc/20A output and Ta=25 deg C,

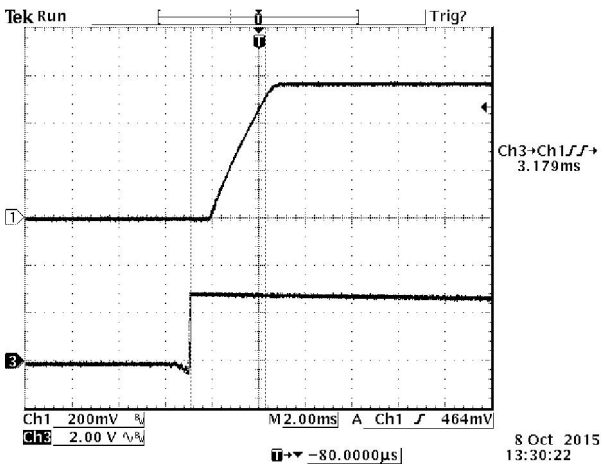



Rise time at full load, 12Vdc input, 2.0Vdc/20A output and Ta=25 deg C,

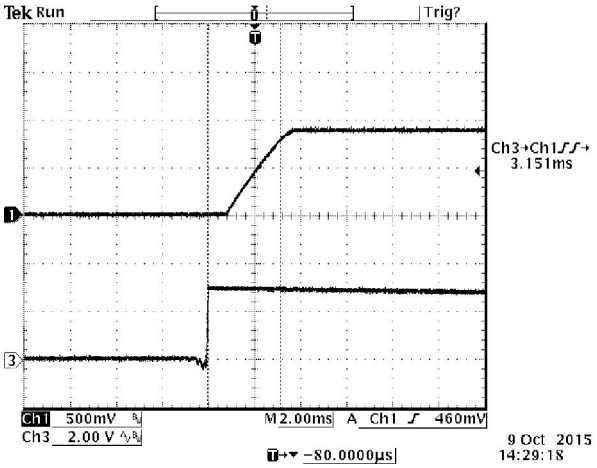
**Note:** Test condition of the Rise time: With a 10uF + 7*100uF ceramic cap and 3*470uF POSCAP ESR <= 12mohm at output.

## Startup&Shutdown(continued)

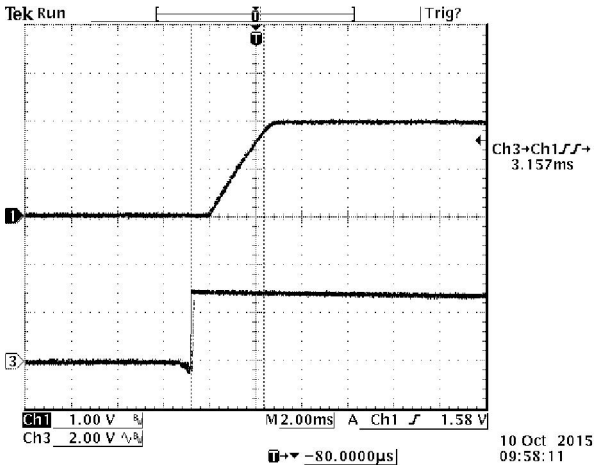
Startup time
Startup from remote on/off
Ch1: Vo
Ch3: remote on/off
Test Condition: With a 10uF + 7*100uF ceramic cap and 3*470uF POSCAP ESR <= 12mohm at output.




Start up time at full load, 12Vdc input,
0.6Vdc/20A output and Ta=25 deg C,




Start up time at full load, 12Vdc input,
0.9Vdc/20A output and Ta=25 deg C,



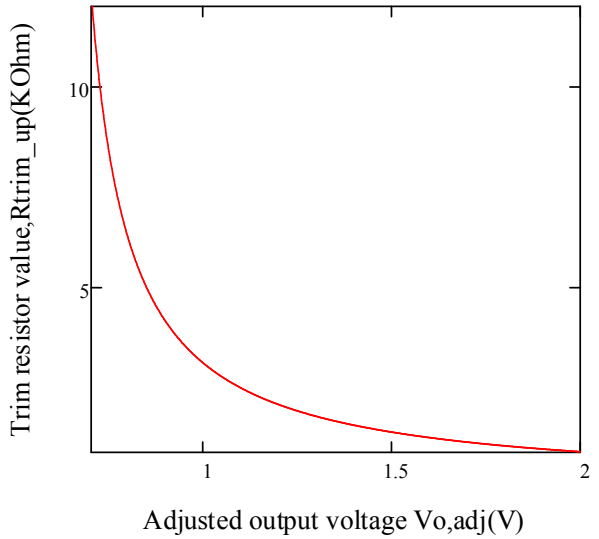

Start up time at full load, 12Vdc input, 2.0Vdc/20A output and Ta=25 deg C,

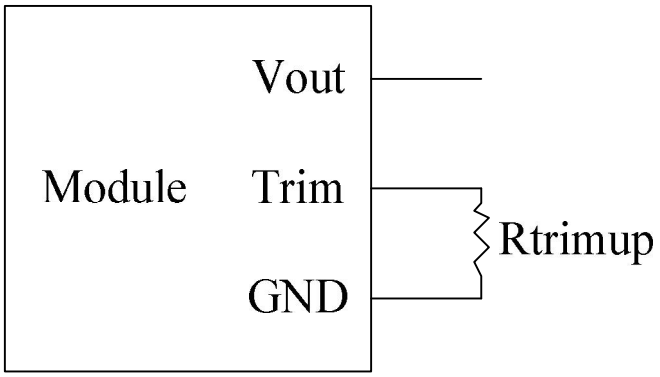
## Trim

Output Voltage Set-Point Adjustment
Maximum trim up voltage is 2V.
Mimimum trim up voltage is 0.6V.

1.Trim up circuit (using an external resistor)
Equations for calculating the trim resistor are shown below.
The Trim Up resistor should be connected between the Trim pin and the GND.

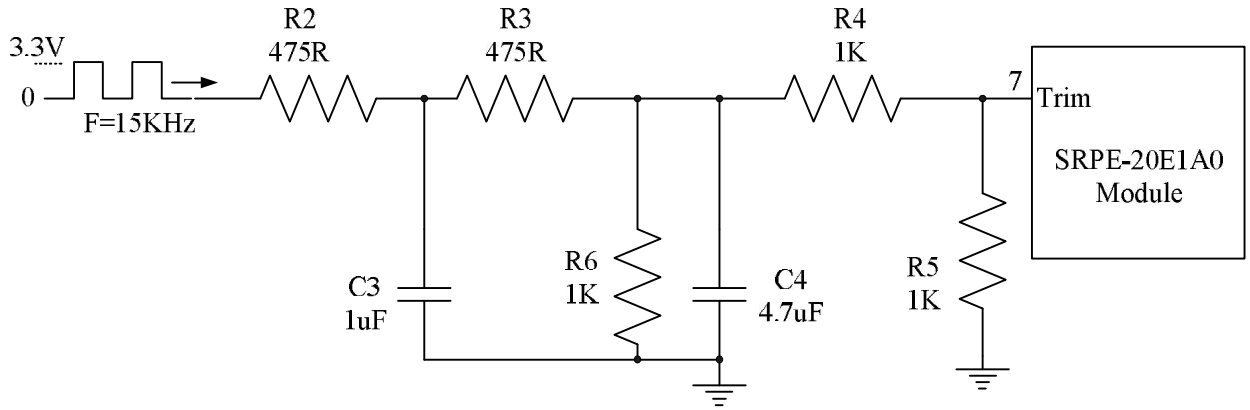
SRP1-20E1A0 Trim up Resistor Calculate Unit: KΩ
Vo is the desired output voltage
Rtrimup is the required resistance between TRIM and GND




$$Rtrimup = \frac{1.2}{Vo - 0.6}$$

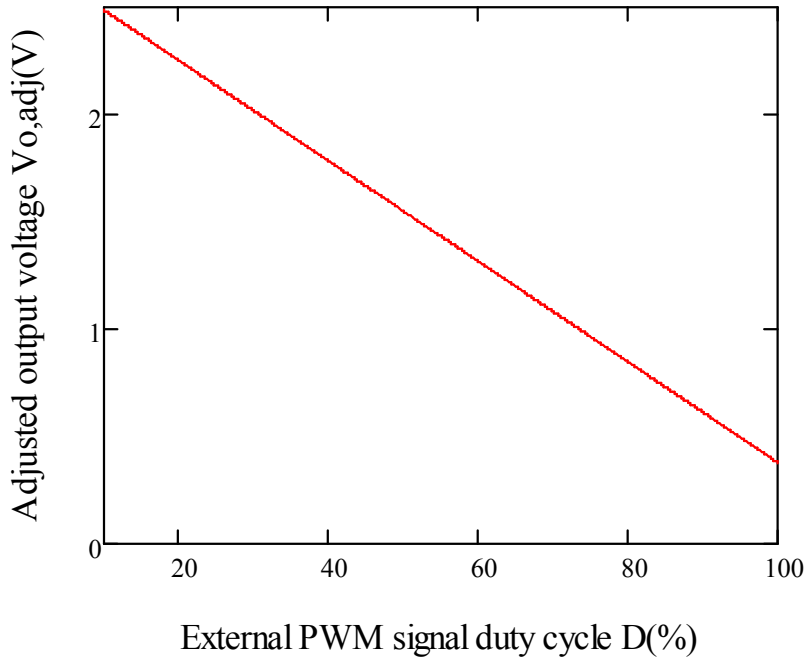
2.Trim up circuit (using external PWM signal)
Equations for calculating the duty cycle are shown below.




$$Vo(\mathrm{D}) = 2.72 - 0.0234D$$

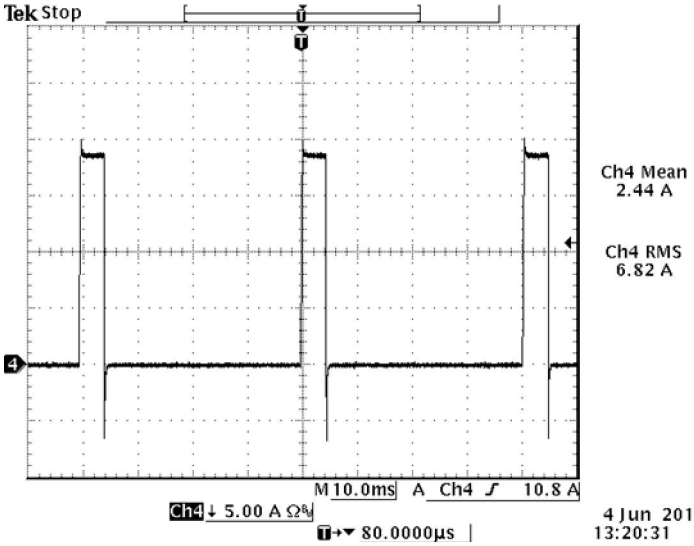
## Trim(continued)

SRP1-20E1A0 Trim up duty cycle Calculate Unit: %
Vo is the desired output voltage
D is the external PWM signal duty cycle.

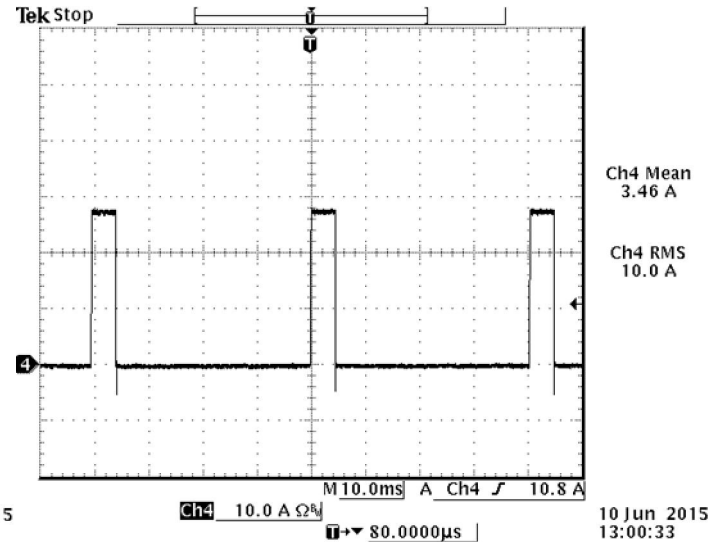


## OCP

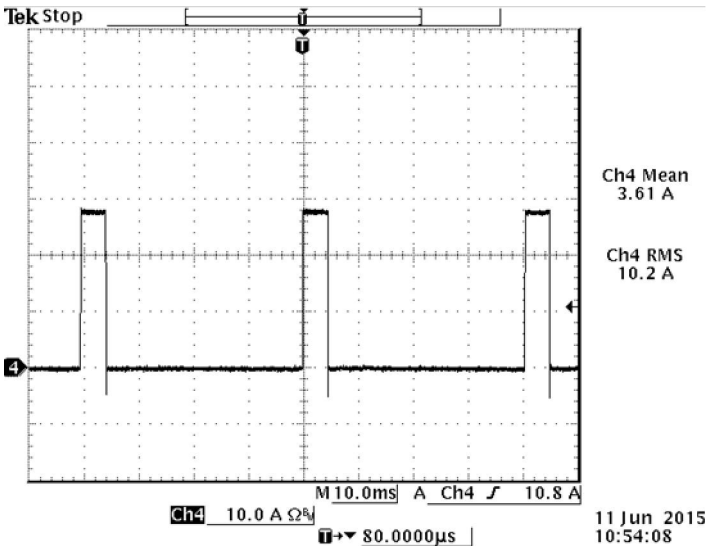
To provide protection in a fault output overload condition, the module is equipped with internal current-limiting circuitry and can endure current limiting for a few mili-seconds. If the overcurrent condition persists beyond a few milliseconds, the module will shut down into hiccup mode and restart once every 40mS. The module operates normally when the output current goes into specified range. The typical average output current is 3.5A during hiccup.




Output current @ SCP，Vin = 12V, Vout = 0.6V, Ta=25 deg




Output current @ SCP，Vin = 12V, Vout = 1.2V, Ta=25 deg C




Output current @ SCP，Vin = 12V, Vout = 2.0V, Ta=25 deg C

**Note:** Test condition of SCP:
With a 10uF ceramic cap and a 470uF POSCAP ESR <= 12mohm at output.

## Power Good

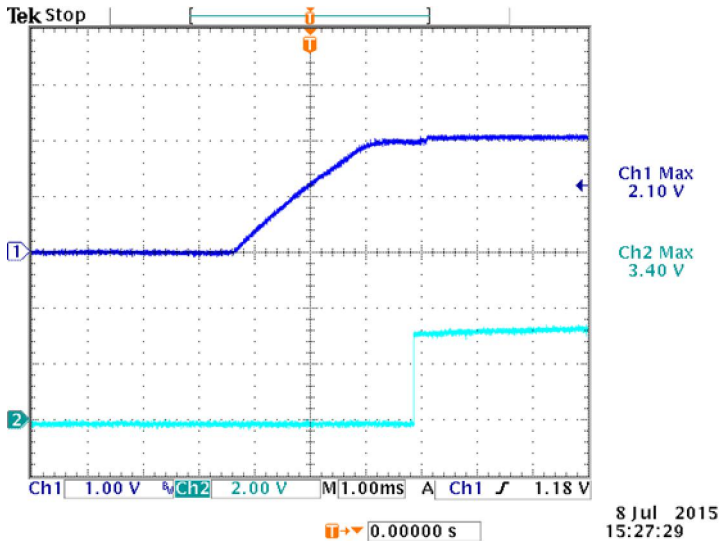
1. This module has a power good indicator output. Power good pin used positive logic and is open collector.

2. The maximum voltage pulled up externally on Power Good pin should not exceed 7V.

3. If the output voltage becomes within +10% and –5% of the target value, internal comparators detect power-good state and the power-good signal becomes high after a 1ms internal delay.

4. If the output voltage goes outside of +15% or –10% of the target value, the power-good signal becomes low after two microsecond (2-µs) internal delay.

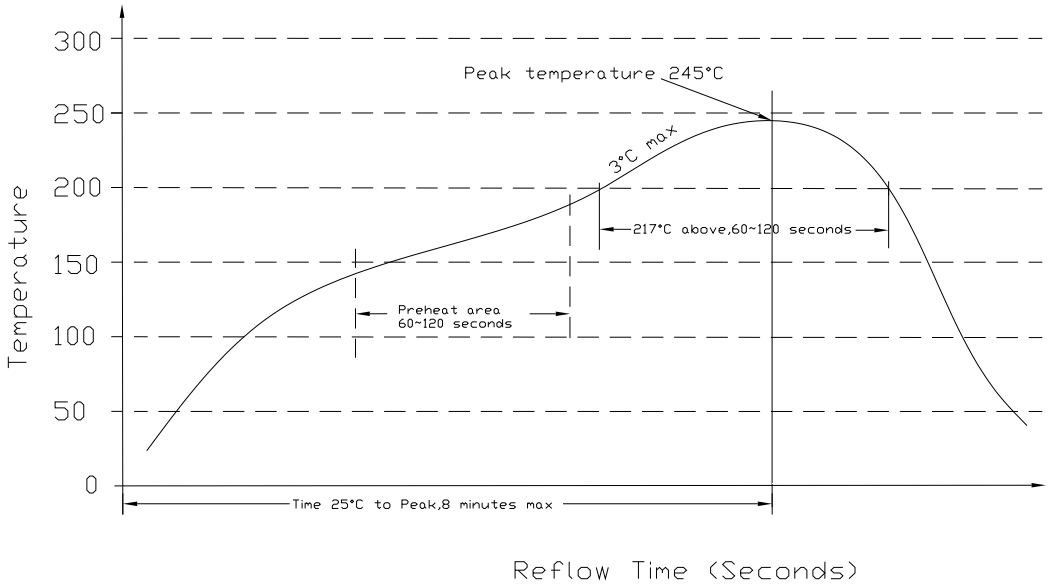
5. The pull up resistance must be larger than 10k ohm.




Typical Start-up using Remote on/off, Vin=12V, Vo=2V, Io=0A
CH1=Vout CH2=PG

## Soldering Information

The SRPE-20E1A0G modules are designed to be compatible with a Paste-In-Hole assembly process. The suggested Pb-free solder paste is Sn/Ag/Cu(SAC). The recommended reflow profile using Sn/Ag/Cu solder is shown in the following. Recommended reflow peak temperature is 245℃ while the part can withstand peak temperature of 260℃ maximum for 10seconds. This profile should be used only as a guideline. Many other factors influence the success of SMT reflow soldering. Since your production environment may differ, please thoroughly review these guidelines with your process engineers.




## MSL Rating

The SRPE-20E1A0G modules have a MSL rating of 3.

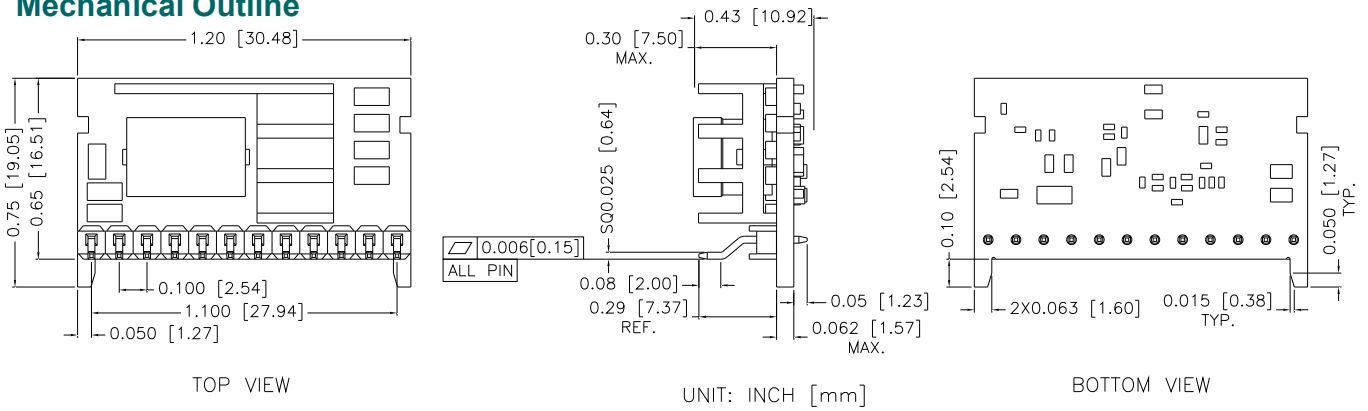
## Storage and Handling

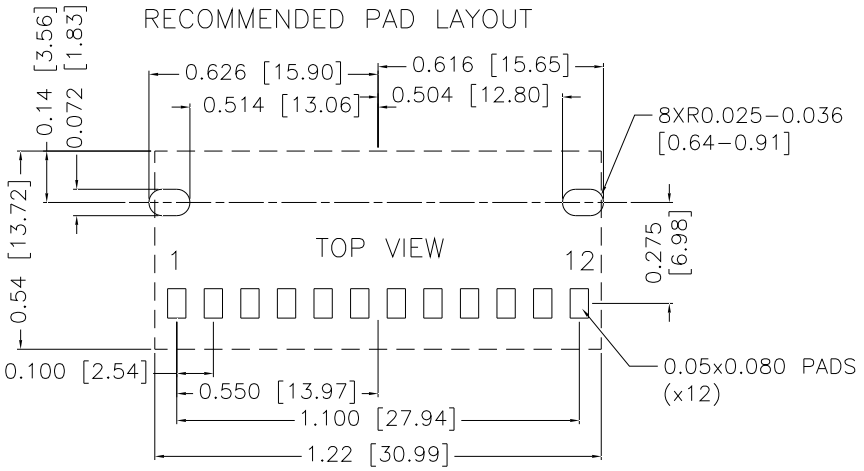
The SRPE-20E1A0G modules are designed to be compatible with J-STD-033 Rev:A (Handling, Packing, Shipping and Use of Moisture /Reflow Sensitive surface Mount devices). Moisture barrier bags (MBB) with desiccant are applied. The recommended storage environment and handling procedure is detailed in J-STD-033.

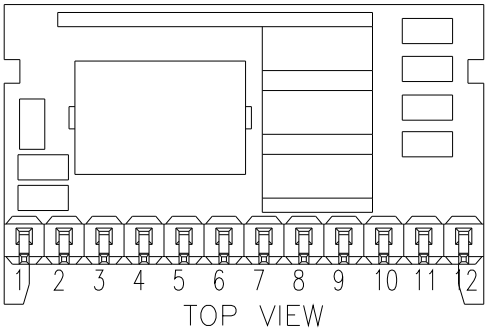
## Pre-baking

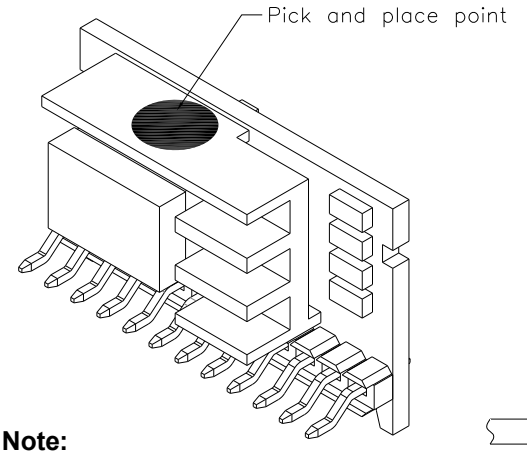
This component has been designed, handled, and packaged ready for pb-free reflow soldering. If the assembly shop follows J-STD-033 guidelines, no pre-bake of this component is required before being reflowed to a PCB. However, if the J-STD-033 guidelines are not followed by the assembler, Bel recommends that the modules should be pre-baked @ 120~125℃ for a minimum of 4 hours (preferably 24 hours) before reflow soldering.

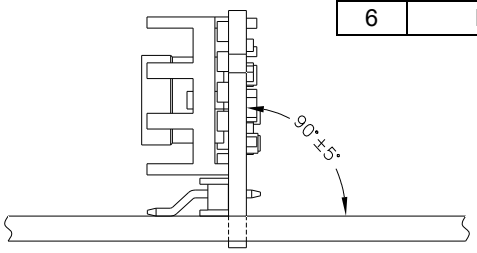
## Mechanical Outline




## Pin Connections

| Pin | Function | Pin | Function |
|---|---|---|---|
| 1 | Vout | 7 | Trim |
| 2 | Vout | 8 | PWRGD |
| 3 | Vout | 9 | Vsense+ |
| 4 | GND | 10 | Vsense- |
| 5 | GND | 11 | GND |
| 6 | Enable | 12 | Vin |

**Note:**

1) All Pins: Material - Copper Alloy;
   Finish – 3 micro inches minimum Gold over 50 micro inches minimum Nickel plate.
2) Undimensioned components are shown for visual reference only.
3) All dimensions in inches (mm); Tolerances: x.xx +/-0.02 in [0.5mm]. x.xxx +/-0.010 in [0.25mm].

## Datasheet Revision History

| Date | Revision | Changes Detail | Approval |
|---|---|---|---|
| 2013-08-19 | PA | First release | Jessica |
| 2013-10-10 | PB | Update mechanical drawing | Jessica |
| 2014-01-10 | PC | Update input / output spec, efficiency, remote on/off and mechanical drawing. | Jessica |
| 2014-4-17 | PD | Update input specs, output specs, general, efficiency, NR, TR, start up and SCP. | Jessica |
| 2014-7-3 | PE | Update part number explanation, RoHS compliance，Add MD Note. | Jessica |
| 2014-7-10 | PF | Update Cover ,mechanical drawing | Jessica |
| 2014-7-29 | G | Added assembly guide drawing | Jessica |
| 2014-11-18 | H | Added trim resistor equation | Jessica |
| 2015-07-21 | I | Input specs :<br>1. Update no load input current.<br>2. Update input reflected ripple current.<br>3. Update turn on voltage threshold : min value 3.8V, typical value 4.3V, max value 5V.<br>4. Update turn off voltage threshold : min value 3.8V, typical value 4.1V, max value 4.5V.<br>Output specs:<br>1. Change output voltage set point max to 10%Vo, change the min to -5%Vo.<br>2. Update the load/line regulation range as ±5%Vo.<br>3. Change output ripple and noise max value to 30mV.<br>4. Change output DC current limit max value to 39A.<br>5. Update transient response.<br>6. Add the regulation over temperature.<br>General:<br>1. Update the efficiency. Include efficiency data and graph.<br>2. Update the weight of module.<br>Update the UVLO, TD, TR, OCP.<br>Add the input noise.<br>Add the PG signal section.<br>Update mechanical drawing, change the thickness of module to 0.402 inch. | Jessica |

## Datasheet Revision History

| Date | Revision | Changes Detail | Approval |
|---|---|---|---|
| 2015-11-16 | J | Output specs :<br>Shrink the output voltage set point, line regulation, load regulation range.<br>Update the waveform of ripple and noise/transient response/Startup&Shutdown.<br>Add tilt dimension in mechanical drawing, update recommended pad layout. | Jessica |
| 2016-01-05 | K | Output specs :<br>Shrink the output voltage set point, line regulation, load regulation range. | Jessica |
| 2016-01-22 | L | Update MTBF, FIT. | Jessica |
| 2016-05-17 | M | Add hot spot location. | Jessica |

## RoHS Compliance

Complies with the European Directive 2011/65/EU, calling for the elimination of lead and other hazardous substances from electronic products.





**CORPORATE**

**Bel Fuse Inc.**
206 Van Vorst Street
Jersey City, NJ 07302
Tel 201-432-0463
Fax 201-432-9542
www.belfuse.com

**FAR EAST**

**Bel Fuse Ltd.**
8F/ 8 Luk Hop Street
San Po Kong
Kowloon, Hong Kong
Tel 852-2328-5515
Fax 852-2352-3706
www.belfuse.com

**EUROPE**

**Bel Fuse Europe Ltd.**
Preston Technology Management Centre
Marsh Lane, Suite G7, Preston
Lancashire, PR1 8UD, U.K.
Tel 44-1772-556601
Fax 44-1772-888366
www.belfuse.com