NON-ISOLATED DC/DC CONVERTERS
12V Input / 0.9V – 5.0V Output / 2A

bel POWER PRODUCTS

BP05xRAH-02A

SRAH-02A / VRAH-02A Series

- Nonisolated
- Compact, low profile surface mount package
- Fixed frequency
- High efficiency means less power dissipation
- Excellent thermal performance
- Optimized for cost
- Remote on/off
- Undervoltage lockout (UVLO)
- Over current and short circuit protection
- Industrial temperature range

Description

The Bel SRAH-02A and VRAH-02A modules are a series of non-isolated, step down DC/DC power converters that operate from a nominal 12V source. These converters are available in a range of output voltages from 0.9V to 5.0V. They are packaged in a compact, overmolded package rated at 2A. Optional lead forming provides a vertical mount product for minimal footprint or a surface mount option for a very low profile. Standard features include remote on/off, over current and short circuit protection, output voltage adjust and industrial temperature ranges (-40° to +85° C). The output is closely regulated and the efficiency is typically 89% at full load. These products may be used almost anywhere low voltage silicon is employed and a 12V source is available. Typical applications include file servers, routers, line cards and other computing and communications equipment.

Applications

- Distributed power architectures
- Data networking equipment
- Telecommunications
- Computers and peripherals

Part Number Selection

Output Voltage	Input Voltage	Max. Output Current	Max. Output Power	Typical Efficiency	Part Number Surface Mount	Part Number Vertical Mount
5.0V	12V	2A	10W	89%	SRAH-02A500	VRAH-02A500
5.0V	12V	2A	10W	89%	SRAH-02A50F*	VRAH-02A50F*
3.3V	12V	2A	6.6W	88%	SRAH-02A330	VRAH-02A330
2.5V	12V	2A	5.0W	86%	SRAH-02A250	VRAH-02A250
1.8V	12V	2A	3.6W	82%	SRAH-02A180	VRAH-02A180
1.5V	12V	2A	3.0W	78%	SRAH-02A150	VRAH-02A150
1.2V	12V	2A	2.4W	74%	SRAH-02A120	VRAH-02A120
0.9V	12V	2A	1.8W	70%	SRAH-02A090	VRAH-02A090
0.9 ~ 3.63V	12V	2A	7.3W	70%	SRAH-02A1A0	VRAH-02A1A0
0.9 ~ 3.63V	12V	2A	7.3W	70%	SRAH-02A1AF*	VRAH-02A1AF*

* F indicates fast start up.

Absolute Maximum Ratings

Parameter	Symbol	Min	Typical	Max	Unit
Continuous Input Voltage	Vin	-0.3		15	V
Output Enable Terminal Voltage	Vouten	-0.3		15	V
Ambient Temperature	Tamb	-40		85	°C
Storage Temperature	Tstor	-55		125	°C

Note: Use beyond the maximum ratings may cause a reliability degradation of the DC/DC converter or may permanently damage the device.

Input Specifications

Parameter	Module	Symbol	Min	Typical	Max	Units
Operating Input Voltage	All	Vin	10.8		13.2	V
Input Current	5.0V 3.3V 2.5V 1.8V 1.5V 1.2V 0.9V	Iin			1.2 0.85 0.7 0.5 0.45 0.4 0.35	A
No Load Input Current	All				50	mA
Remote Off Input Current	All			3	10	mA
Input Reflected Ripple Current[1]	All			100		mA_{rms}
Input Reflected Ripple Current (P-P)[1]	All			300		mApk
I^2t Inrush Current Transient	All			0.01	0.02	A^2s
Turn On Voltage Threshold	All			9.6		V
Turn Off Voltage Threshold	All		8.8		9.8	V

Note: 1. Use a 47uF/25V tan capacitor at the input.

Output Specifications

Parameter	Module	Symbol	Min	Typical	Max	Units
Output Voltage Set Point [1]		Vout				V
	5.0V		4.9	5.0	5.1	
	3.3V		3.247	3.3	3.353	
	2.5V		2.460	2.5	2.540	
	1.8V		1.771	1.8	1.829	
	1.5V		1.476	1.5	1.524	
	1.2V		1.181	1.2	1.219	
	0.9V		0.886	0.9	0.914	
Load Regulation						mV
	5.0V			15	30	
	3.3V			10	30	
	2.5V			8	20	
	1.8V			5	10	
	1.5V			5	10	
	1.2V			4	10	
	0.9V			3	10	
Line Regulation						mV
	5.0V			2	5	
	3.3V			2	5	
	2.5V			2	5	
	1.8V			1	5	
	1.5V			1	5	
	1.2V			1	5	
	0.9V			1	5	
Regulation Over Temperature (-40° to 85° C)						mV
	5.0V			35	45	
	3.3V			35	45	
	2.5V			20	30	
	1.8V			15	25	
	1.5V			10	20	
	1.2V			8	15	
	0.9V			2	5	
Total Output Voltage Regulation (-40° to 85° C)						mV
	5.0V			52	80	
	3.3V			47	80	
	2.5V			30	55	
	1.8V			21	40	
	1.5V			16	35	
	1.2V			13	30	
	0.9V			6	20	

Note: All specifications are typical at nominal input, full load at 25° C unless otherwise stated.
1. Vin=12V,Iout=half load,Ta=25° C.

Output Specifications

Parameter	Module	Symbol	Min	Typical	Max	Units
Output Ripple and Noise [2]	5.0V 3.3V 2.5V 1.8V 1.5V 1.2V 0.9V			60 60 50 40 35 35 35	80 80 70 60 60 60 60	mVp-p
Output Ripple and Noise [2]	5.0V 3.3V 2.5V 1.8V 1.5V 1.2V 0.9V			25 20 15 15 15 10 10	35 35 25 25 25 20 20	mVrms
Output Current Range	All	Iout	0		2	A
Output DC Current Limit	All	Ioutlim	2.5		6	A
Short Circuit Surge	5.0V 3.3V 2.5V 1.8V 1.5V 1.2V 0.9V	Ioutsurge		0.4 0.4 0.4 0.5 0.5 0.5 0.55	0.8 0.8 0.8 1.0 1.0 1.0 1.1	A^2s
Turn on Time	0.9V - 3.63V 5.0V	Ton		70 20	100 40	ms
Turn on Time[3]		Ton		10	20	ms
Overshoot at Turn On	All			0	3	%
Overshoot at Turn On[3]	1.5V - 5.0V 0.9V - 1.2V			0 0	3 10	%
Output Capacitance	All	Cout	100		1000	µF

Note: All specifications are typical at nominal input, full load at 25° C unless otherwise stated.
2. 0 - 20MHz BW with 100uF tan cap and 1uF ceramic cap.
3. For fast startup modules.

Output Specifications

Parameter	Module	Symbol	Min	Typical	Max	Units
Transient Response [3]						
ΔV 50% to 100% of Max Load	5.0V			150	200	mV
Settling Time		Ts		100	140	µs
ΔV 100% to 50% of Max Load				150	200	mV
Settling Time		Ts		100	140	µs
Transient Response [3]						
ΔV 50% to 100% of Max Load	3.3V			120	150	mV
Settling Time		Ts		40	60	µs
ΔV 100% to 50% of Max Load				120	150	mV
Settling Time		Ts		40	60	µs
Transient Response [3]						
ΔV 50% to 100% of Max Load	2.5V			100	130	mV
Settling Time		Ts		40	60	µs
ΔV 100% to 50% of Max Load				100	130	mV
Settling Time		Ts		40	60	µs
Transient Response [3]						
ΔV 50% to 100% of Max Load	1.8V			90	120	mV
Settling Time		Ts		40	60	µs
ΔV 100% to 50% of Max Load				90	120	mV
Settling Time		Ts		40	60	µs

Note: All specifications are typical at nominal input, full load at 25° C unless otherwise stated.
3. di/dt=0.1A/uS,Ta=25° C with 220uF/10V Tan cap.

Output Specifications

Parameter	Module	Symbol	Min	Typical	Max	Units
Transient Response [3]						
ΔV 50% to 100% of Max Load	1.5V			80	110	mV
Settling Time		Ts		40	60	µs
ΔV 100% to 50% of Max Load				80	110	mV
Settling Time		Ts		40	60	µs
Transient Response [3]						
ΔV 50% to 100% of Max Load	1.2V			70	100	mV
Settling Time		Ts		40	60	µs
ΔV 100% to 50% of Max Load				70	100	mV
Settling Time		Ts		40	60	µs
Transient Response [3]						
ΔV 50% to 100% of Max Load	0.9V			60	90	mV
Settling Time		Ts		40	60	µs
ΔV 100% to 50% of Max Load				60	90	mV
Settling Time		Ts		40	60	µs

Note: All specifications are typical at nominal input, full load at 25° C unless otherwise stated.
3. di/dt=0.1A/uS,Ta=25° C with 220uF/10V Tan cap.

General Specifications

Parameter	Module	Symbol	Min	Typical	Max	Units
Efficiency[1]	5.0V 3.3V 2.5V 1.8V 1.5V 1.2V 0.9V	η	86 85 83 79 75 71 67	89 88 86 82 78 74 70		%
Switching Frequency	0.9V ~ 3.3V 5.0V	Fsw	210 280	250 320	290 360	kHz
Output Voltage Trim Range (Wide Trim)[2]	0.9V				403	%
Output Voltage Trim Range (Narrow Trim)[2]	5.0V 3.3V 2.5V 1.8V 1.5V 1.2V 0.9V		90 90 90 90 90 90 --		110 110 110 110 110 110 110	%
Weight	All			4.9		g

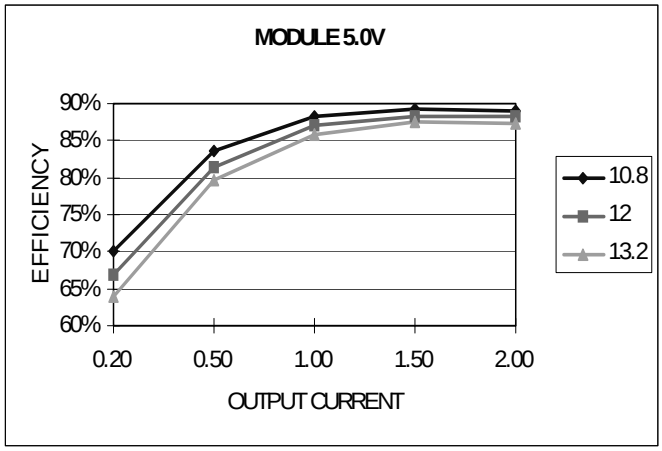
1. Efficiency is measured at Vin=12V, full load and Ta=25° C.
2. See graphs on pages 17-25.

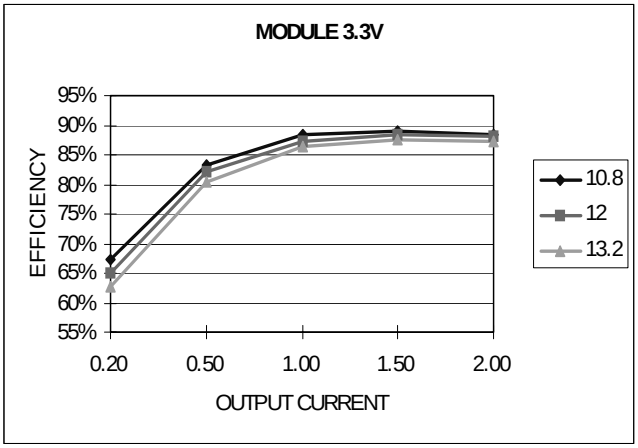
Control Specifications

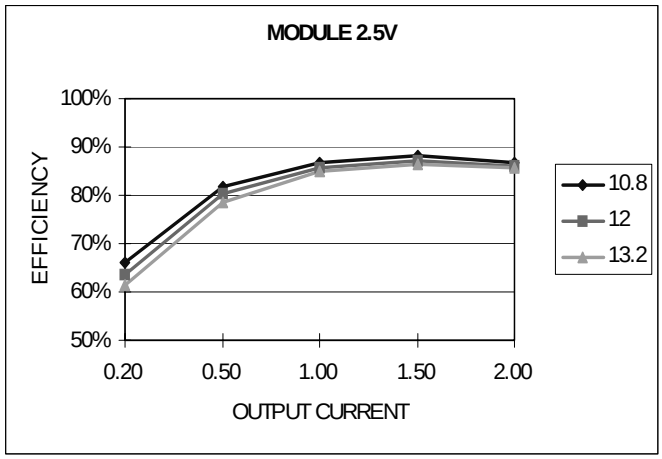
Parameter	Module	Symbol	Min	Typical	Max	Units
Remote On/Off [3]	All	Vouten				V
Signal Low (Unit Off)	All		-0.3		1	V
Signal High (Unit On)	All		2.8		13.2	V

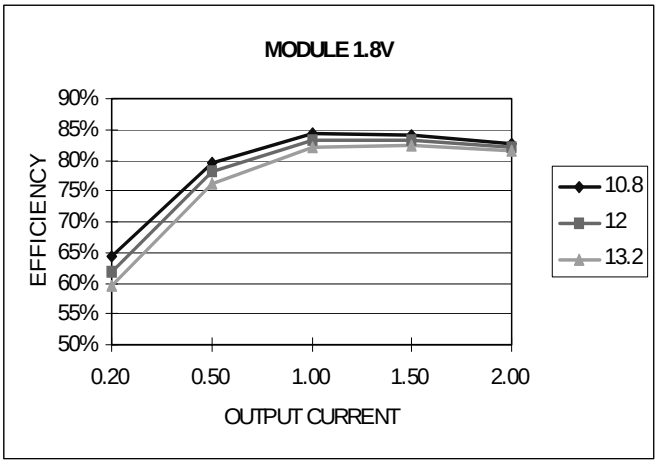
3. With remote on/off pin 1 open, unit on.

Efficiency Data

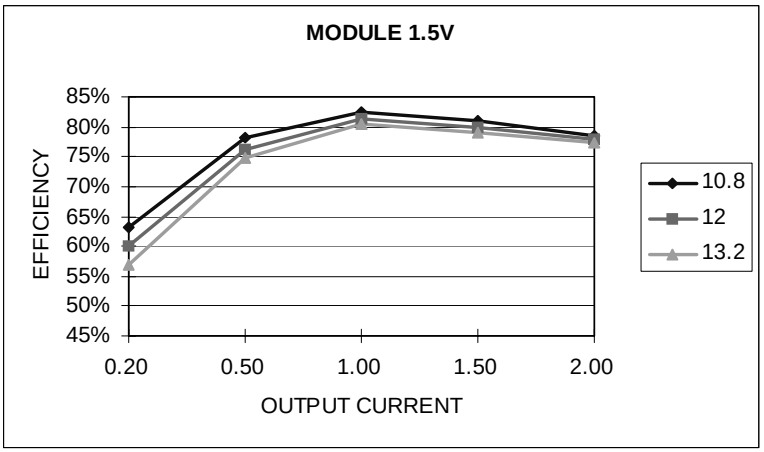


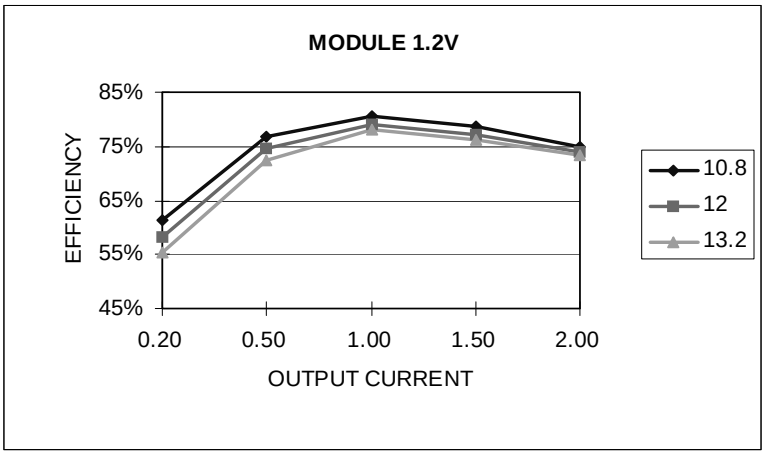


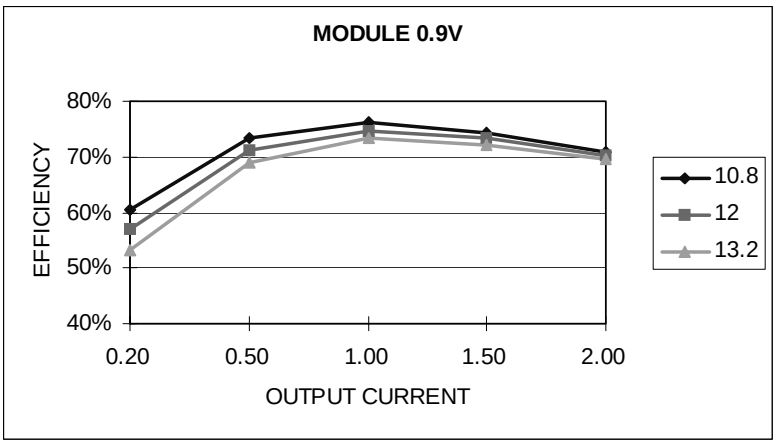




Efficiency Data

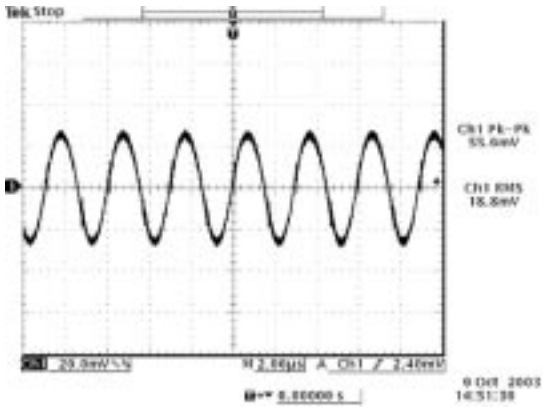




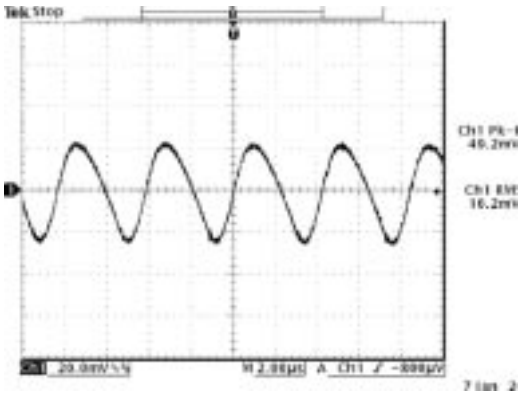


Ripple and Noise

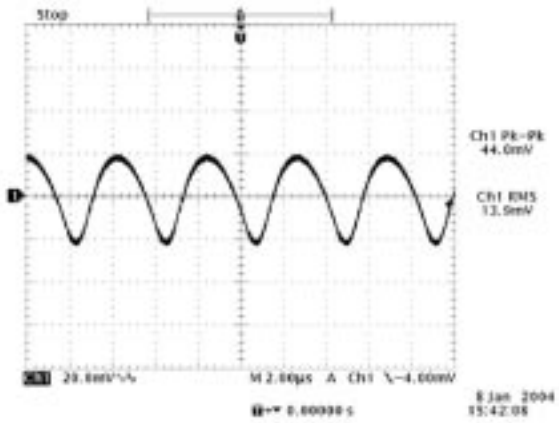
With 100µF tan cap and 1uF ceramic cap at the output.



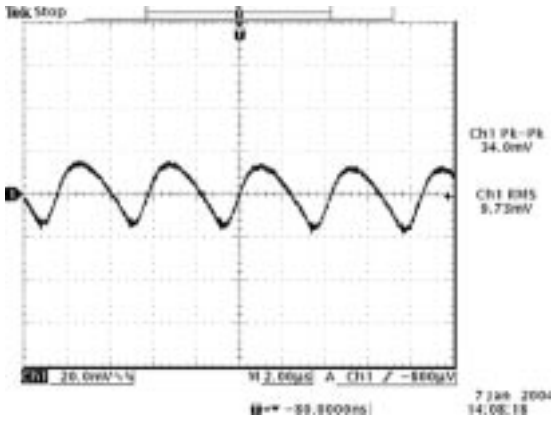
Ripple and noise at full load and 12Vdc input, 5.0Vdc output and Ta=25° C



Ripple and noise at full load and 12Vdc input, 3.3Vdc output and Ta=25° C



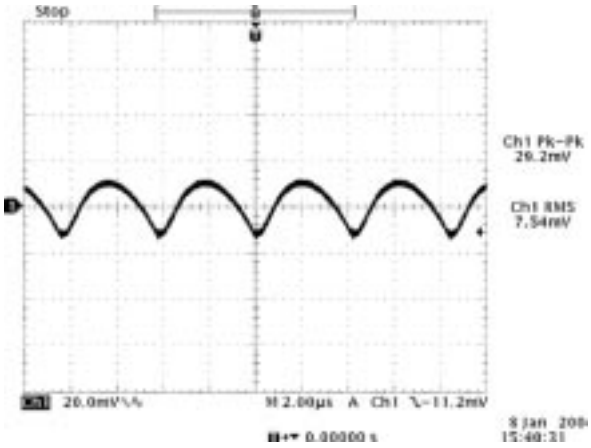
Ripple and noise at full load and 12Vdc input, 2.5Vdc output and Ta=25° C



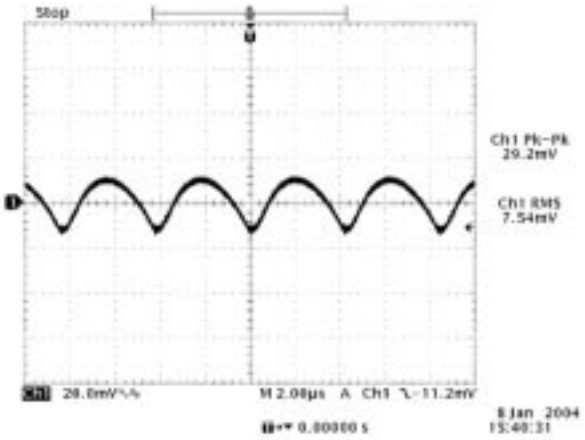
Ripple and noise at full load and 12Vdc input, 1.8Vdc output and Ta=25° C

Ripple and Noise

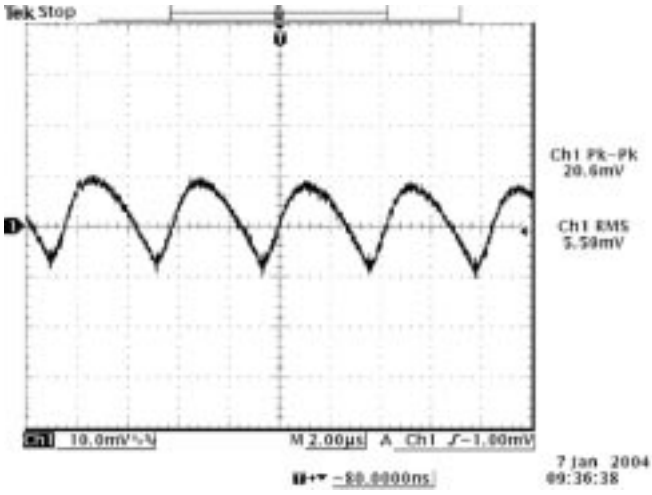
With 100µF tan cap and 1uF ceramic cap at the output.



Ripple and noise at full load and 12Vdc input, 1.5Vdc output and Ta=25° C



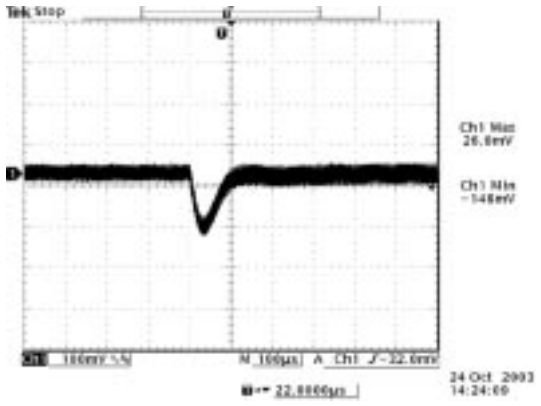
Ripple and noise at full load and 12Vdc input, 1.2Vdc output and Ta=25° C



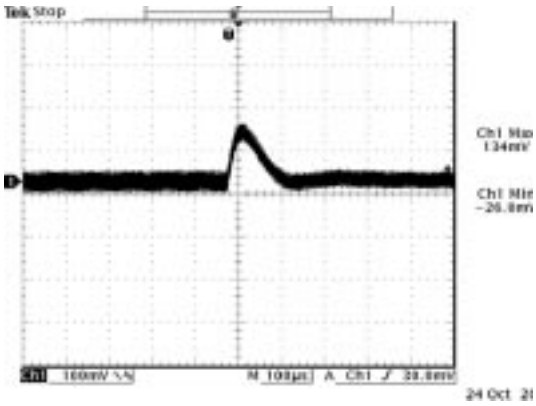
Ripple and noise at full load and 12Vdc input, 0.9Vdc output and Ta=25° C

Transient Response

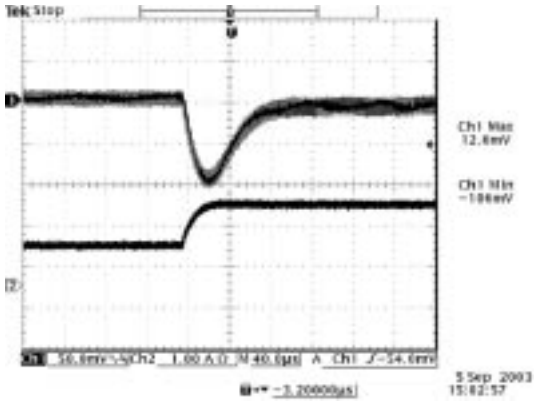
Transient response: di/dt = 0.1A/µS, with 220µF Tan capacitor.



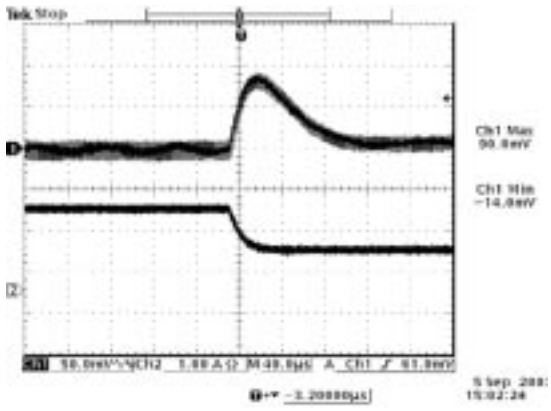
Vout=5.0V
50% to 100% load transients at 12V input and Ta=25° C



Vout=5.0V
100% to 50% load transients at 12V input and Ta=25° C



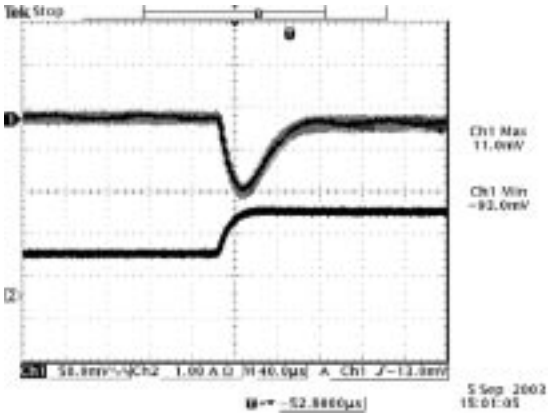
Vout=3.3V
50% to 100% load transients at 12V input and Ta=25° C



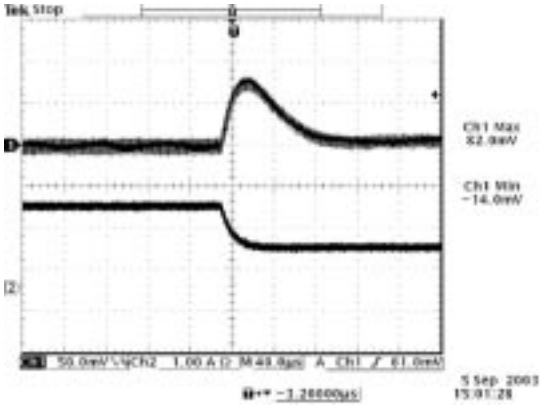
Vout=3.3V
100% to 50% load transients at 12V input and Ta=25° C

Transient Response

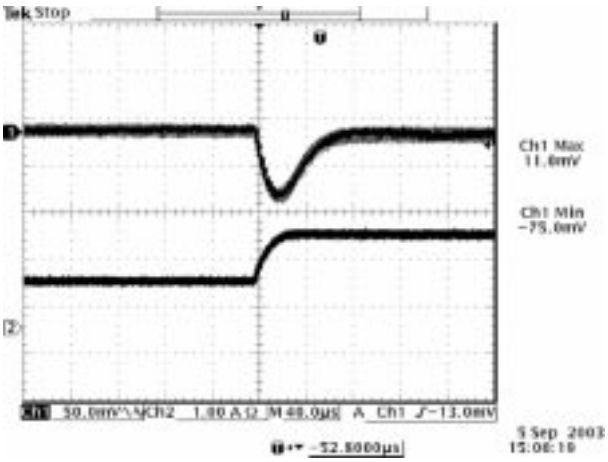
Transient response: di/dt = 0.1A/µS, with 220µF Tan capacitor..



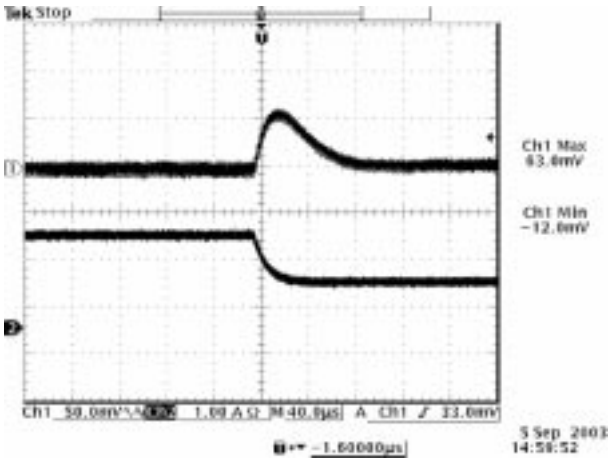
Vout=2.5V
50% to 100% load transients at 12V input and Ta=25° C



Vout=2.5V
100% to 50% load transients at 12V input and Ta=25° C



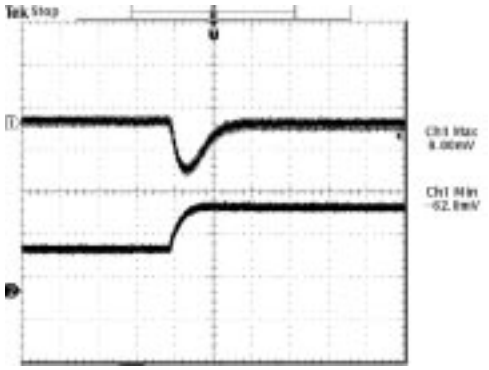
Vout=1.8V
50% to 100% load transients at 12V input and Ta=25° C



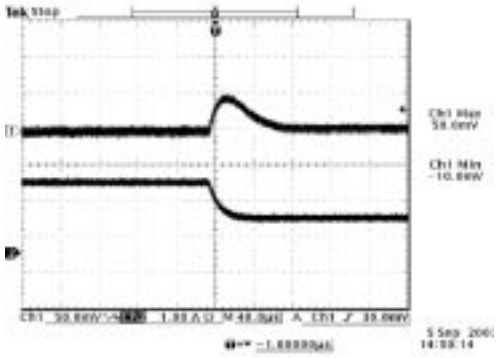
Vout=1.8V
100% to 50% load transients at 12V input and Ta=25° C

Transient Response

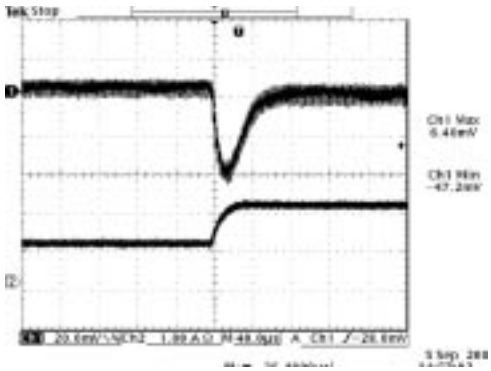
Transient response: di/dt = 0.1A/µS, with 220µF Tan capacitor..



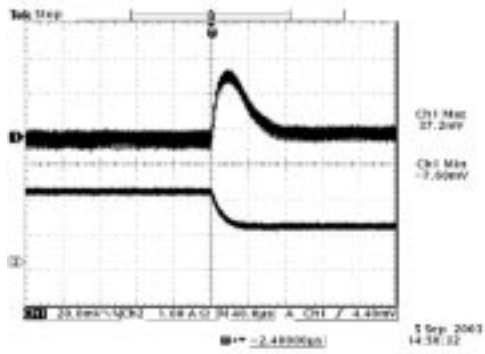
Vout=1.5V
50% to 100% load transients at 12V input and Ta=25° C



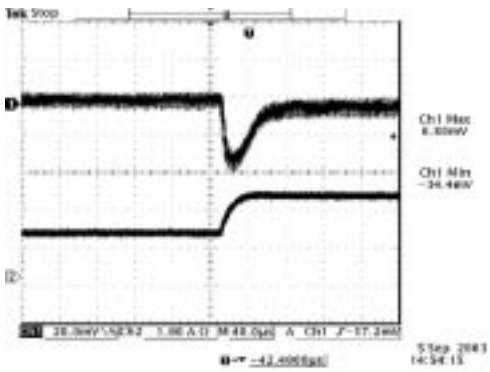
Vout=1.5V
100% to 50% load transients at 12V input and Ta=25° C



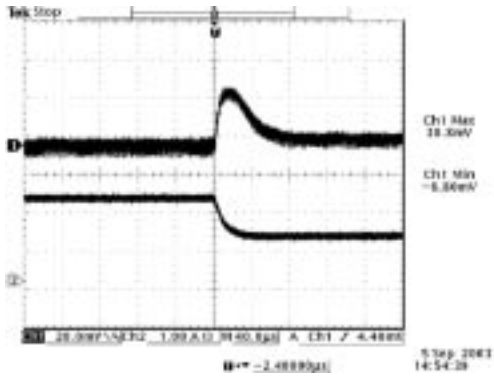
Vout=1.2V
50% to 100% load transients at 12V input and Ta=25° C



Vout=1.2V
100% to 50% load transients at 12V input and Ta=25° C



Vout=0.9V
50% to 100% load transients at 12V input and Ta=25° C

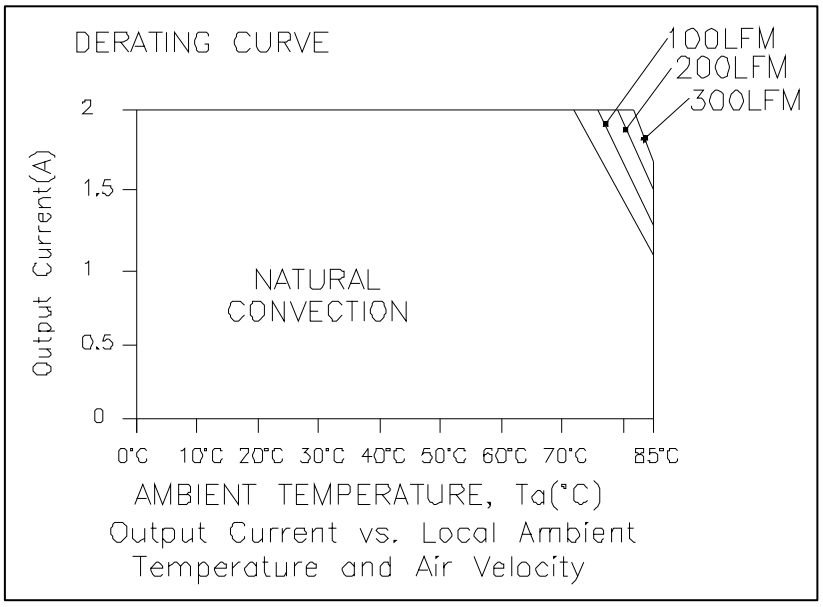


Vout=0.9V
100% to 50% load transients at 12V input and Ta=25° C

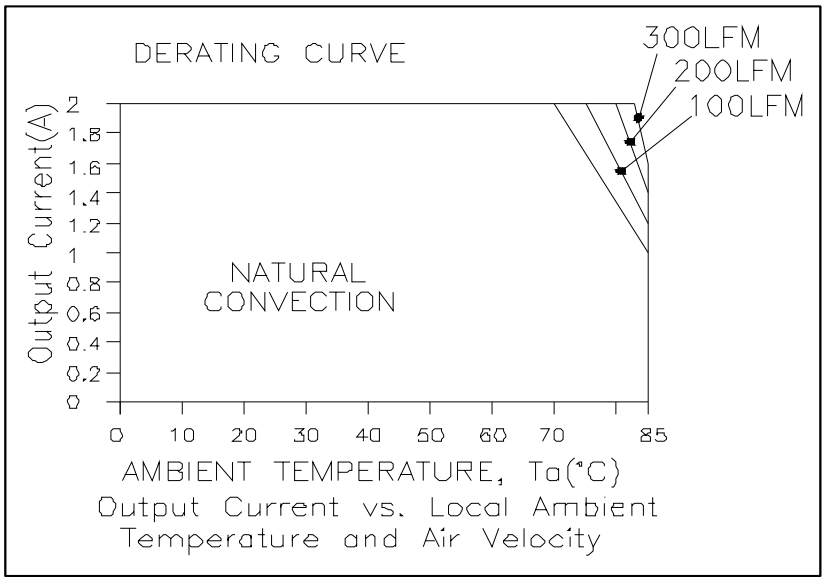
Thermal Considerations

Vin = 12V

xRAH-02A1Ax
0.9 ~ 3.3V

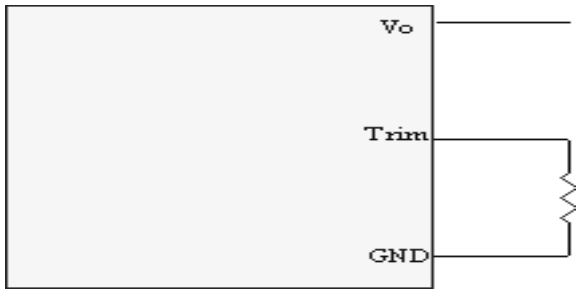


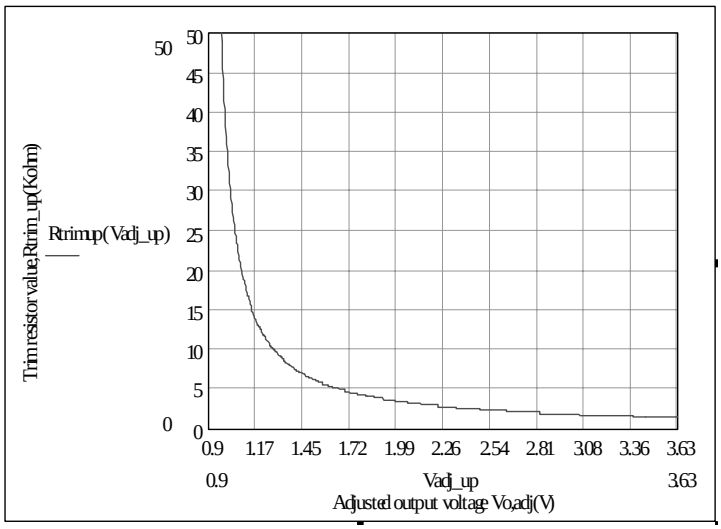
xRAH-02A50x



Output Voltage Set-Point Adjustment

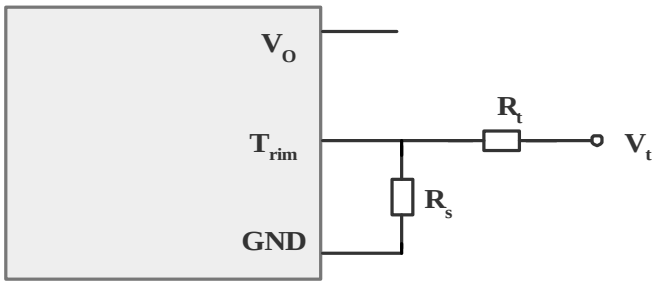
xRAH-02A1Ax Trim Resistor Calculation





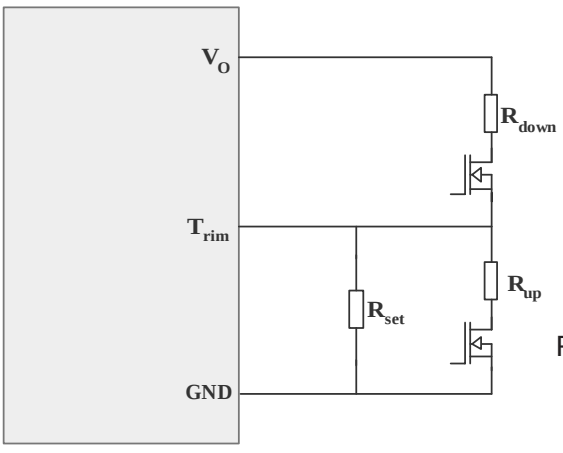
$$\text{Rtrim up} = \left(\frac{3.712}{\text{Vo, adj} - \text{Vo}}\right) \text{Kohm}$$

Note: Output voltage Vo=0.90 3V when trim pin is not connected.



$$\text{Rt (Kohm)} = \left(\frac{\text{Rs (4.64Vt - 3.712)}}{\text{3.712 - Rs(Vout - 0.903)}}\right) \text{Kohm}$$

Note: Output voltage Vo=0.90 3V when trim pin is not connected.



$$\text{Rset} = \left(\frac{3.712}{\text{Vout - 0.903}}\right) \text{Kohm}$$

Vout is desired output voltage.

$$\text{Rup} = \left(\frac{3.712\ \text{Rset}}{\text{Rset} \bullet \text{Vm up} - 0.903\ \text{Rset} - 3.712}\right) \text{Kohm}$$

Margin up value after output voltage is set with Rset

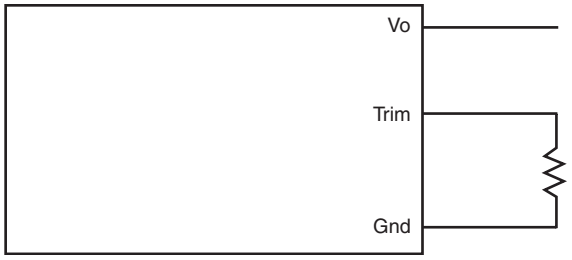
$$\text{Rdown} = \left(\frac{4.64\ \text{Rset} \bullet \text{Vm down} - 3.712\ \text{Rset}}{0.903\ \text{Rset} + 3.712 - \text{Rset} \bullet \text{Vm down}}\right) \text{Kohm}$$

Margin down value after output volatge is set with Rset
Vm down ≥ 90% Vout

Note: Output voltage Vo=0.90 3V when trim pin is not connected.

Output Voltage Set-Point Adjustment

Trim Up Test Circuit

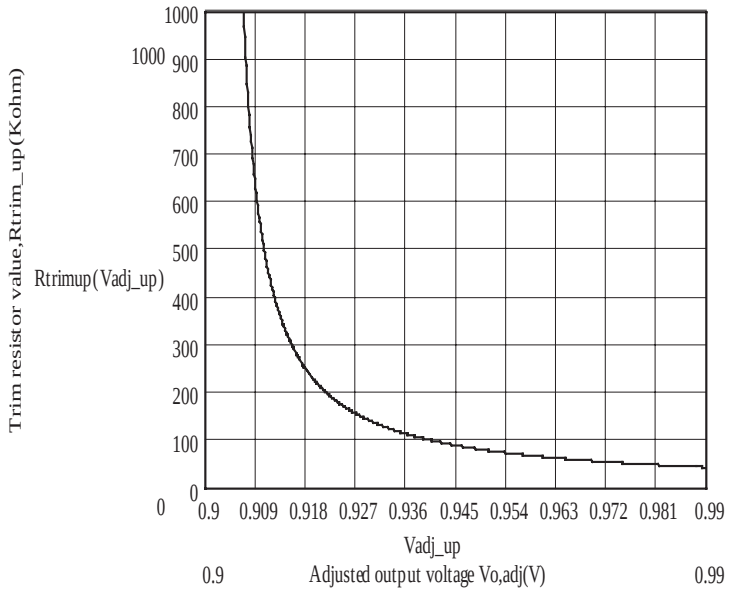


xRAH-02A090 Trim Resistor Calculation

$$Rtrim\_up = \frac{3.712}{Vo,adj - Vo} \quad Kohm$$

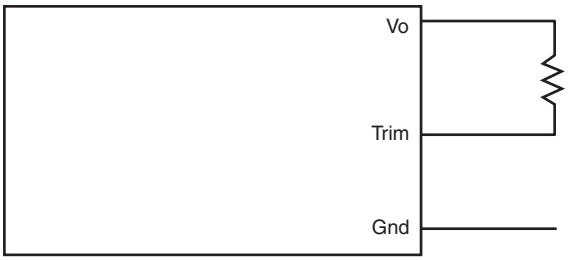
where,

Vo is the nominal output voltage setpoint when trim pin is open ,Vo=0.903V
Vo,adj is the adjusted output voltage.
Rtrim-up is the resistance required between TRIM and GND.

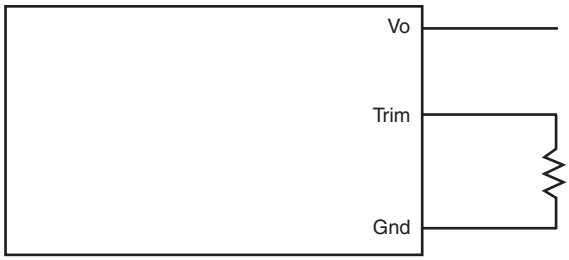


Output Voltage Set-Point Adjustment

Trim Down Test Circuit



Trim Up Test Circuit

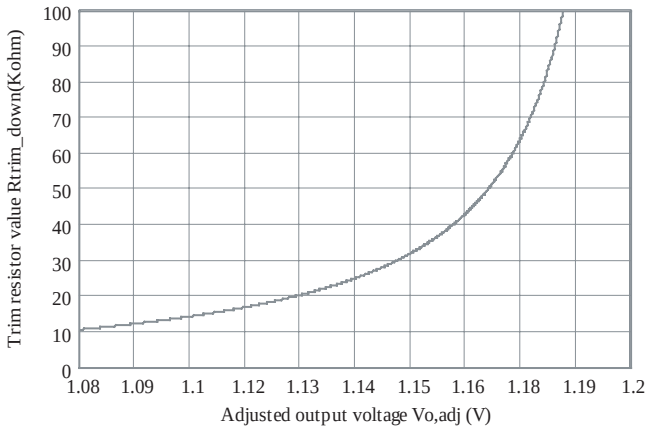


xRAH-02A120 Trim Resistor Calculation

$$Rtrim\_down = \frac{1.87}{Vo - Vo,adj} - 4.64 \quad Kohm$$

where,

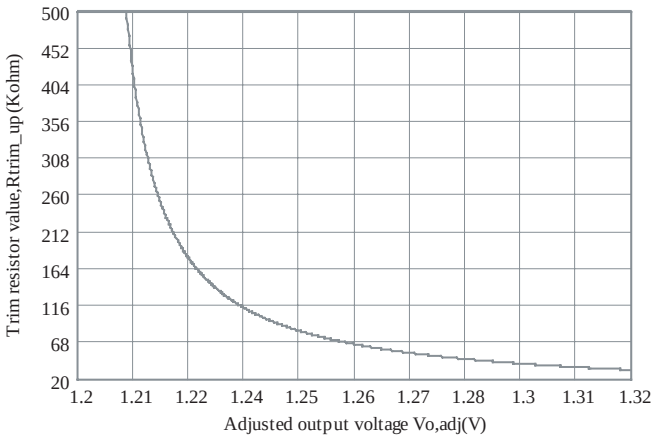
Vo is the nominal output voltage setpoint when trim pin is open ,Vo=1.203V
Vo,adj is the adjusted output voltage.
Rtrim-down is the resistance required between TRIM and Vo.



$$Rtrim\_up = \frac{3.712}{Vo,adj - Vo} \quad Kohm$$

where,

Vo is the nominal output voltage setpoint when trim pin is open ,Vo=1.203V
Vo,adj is the adjusted output voltage.
Rtrim-up is the resistance required between TRIM and GND.



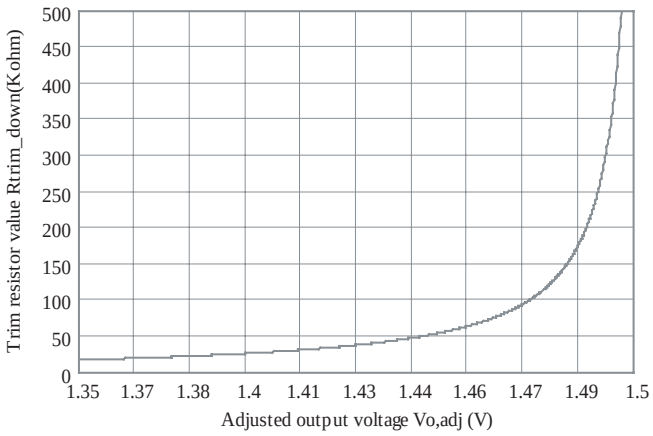
Output Voltage Set-Point Adjustment

xRAH-02A150 Trim Resistor Calculation

$$Rtrim\_down = \frac{3.2633}{Vo - Vo,adj} - 4.64 \ Kohm$$

where,

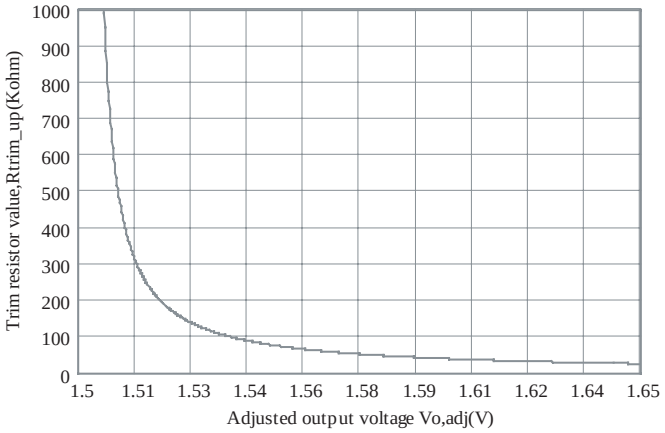
Vo is the nominal output voltage setpoint when trim pin is open ,Vo=1.503V
Vo,adj is the adjusted output voltage.
Rtrim-down is the resistance required between TRIM and Vo.



$$Rtrim\_up = \frac{3.712}{Vo,adj - Vo} \ Kohm$$

where,

Vo is the nominal output voltage setpoint when trim pin is open ,Vo=1.503V
Vo,adj is the adjusted output voltage.
Rtrim-up is the resistance required between TRIM and GND.



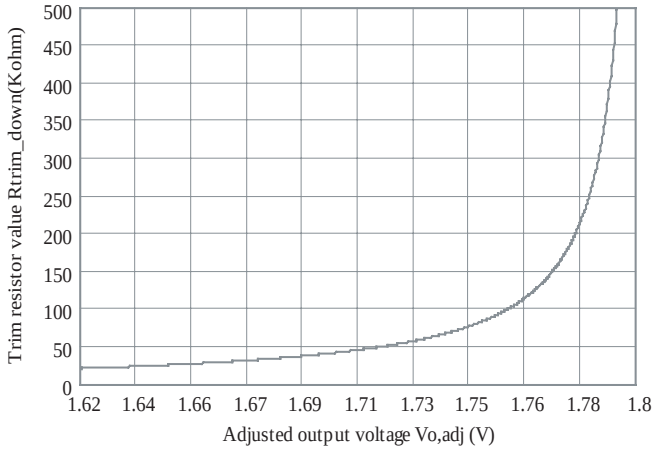
Output Voltage Set-Point Adjustment

xRAH-02A180 Trim Resistor Calculation

$$Rtrim\_down = \frac{4.6538}{Vo - Vo,adj} - 4.64 \quad Kohm$$

where,

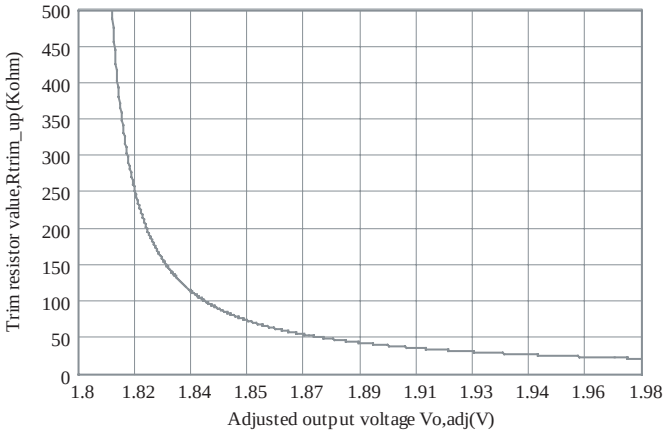
Vo is the nominal output voltage setpoint when trim pin is open ,Vo=1.803V
Vo,adj is the adjusted output voltage.
Rtrim-down is the resistance required between TRIM and Vo.



$$Rtrim\_up = \frac{3.712}{Vo,adj - Vo} \quad Kohm$$

where,

Vo is the nominal output voltage setpoint when trim pin is open ,Vo=1.803V
Vo,adj is the adjusted output voltage.
Rtrim-up is the resistance required between TRIM and GND.



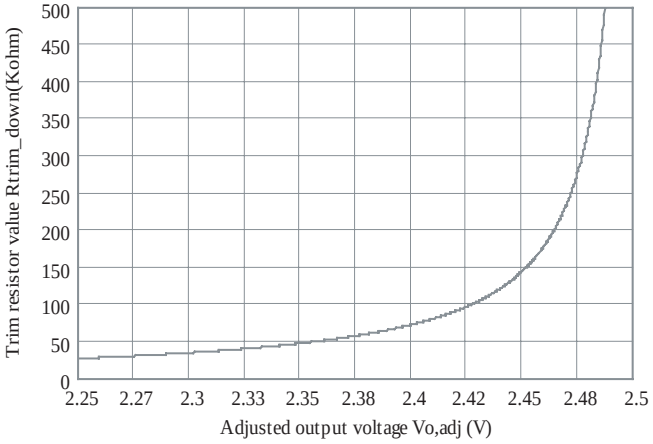
Output Voltage Set-Point Adjustment

xRAH-02A250 Trim Resistor Calculation

$$Rtrim\_down = \frac{7.9117}{Vo - Vo,adj} - 4.64 \quad Kohm$$

where,

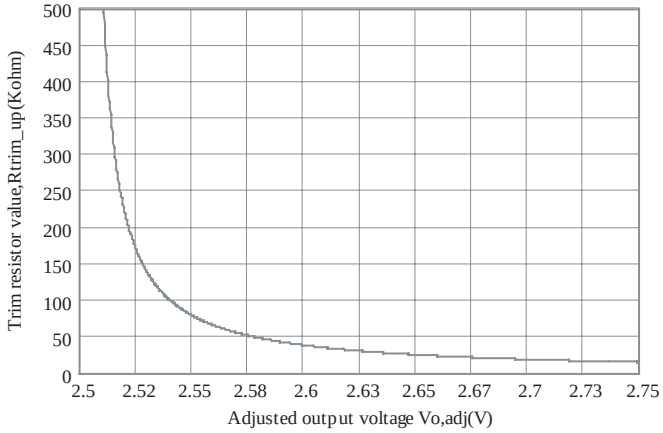
Vo is the nominal output voltage setpoint when trim pin is open ,Vo=2.503V
Vo,adj is the adjusted output voltage.
Rtrim-down is the resistance required between TRIM and Vo.



$$Rtrim\_up = \frac{3.712}{Vo,adj - Vo} \quad Kohm$$

where,

Vo is the nominal output voltage setpoint when trim pin is open ,Vo=2.503V
Vo,adj is the adjusted output voltage.
Rtrim-up is the resistance required between TRIM and GND.



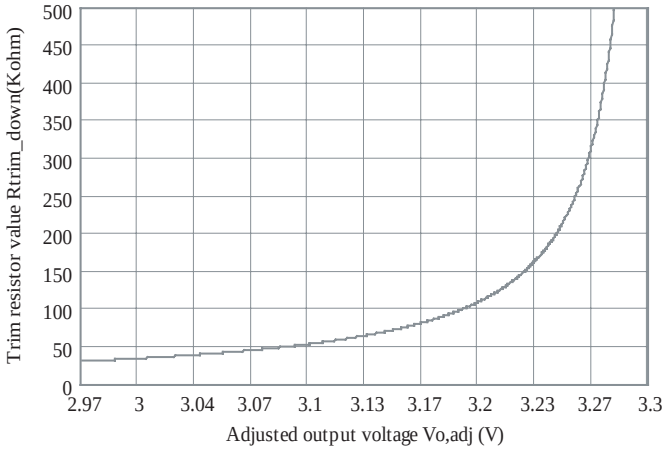
Output Voltage Set-Point Adjustment

xRAH-02A330 Trim Resistor Calculation

$$Rtrim\_down = \frac{11.614}{Vo - Vo,adj} - 4.64 \quad Kohm$$

where,

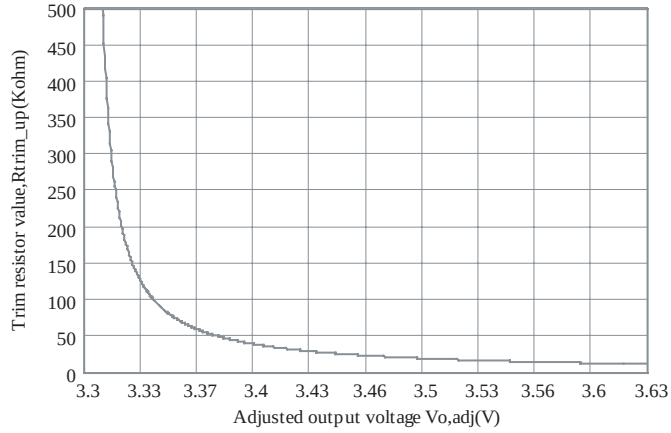
Vo is the nominal output voltage setpoint when trim pin is open ,Vo=3.303V
Vo,adj is the adjusted output voltage.
Rtrim-down is the resistance required between TRIM and Vo.



$$Rtrim\_up = \frac{3.712}{Vo,adj - Vo} \quad Kohm$$

where,

Vo is the nominal output voltage setpoint when trim pin is open ,Vo=3.303V
Vo,adj is the adjusted output voltage.
Rtrim-up is the resistance required between TRIM and GND.



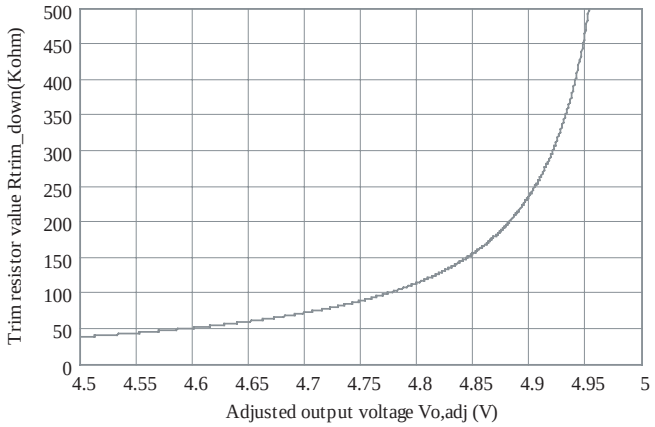
Output Voltage Set-Point Adjustment

xRAH-02A50x Trim Resistor Calculation

$$Rtrim\_down = \frac{26.02}{Vo - Vo,adj} - 13.69 \ \ Kohm$$

where,

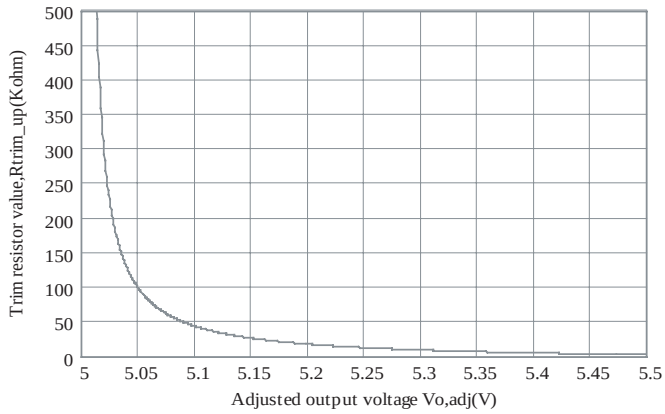
Vo is the nominal output voltage setpoint when trim pin is open ,Vo=5.003V
Vo,adj is the adjusted output voltage.
Rtrim-down is the resistance required between TRIM and Vo.



$$Rtrim\_up = \frac{4.952}{Vo,adj - Vo} - 7.5 \ \ Kohm$$

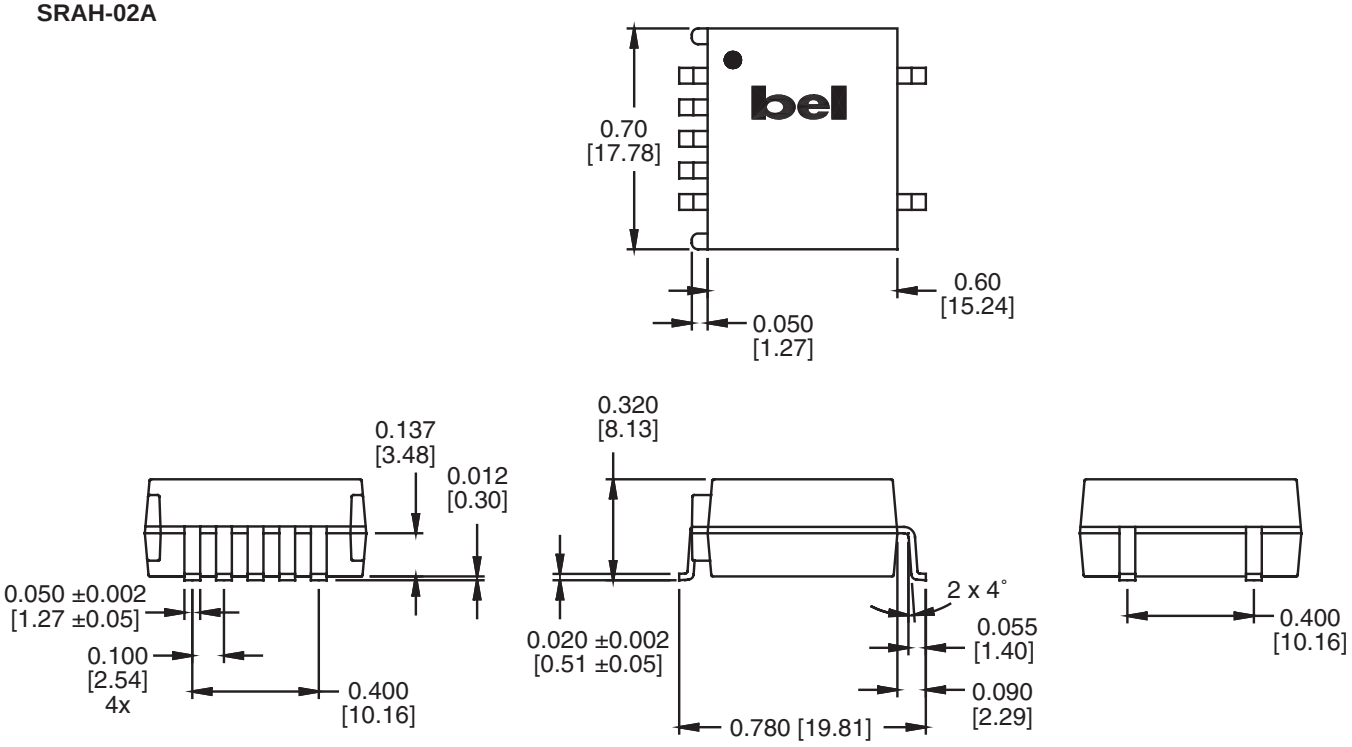
where,

Vo is the nominal output voltage setpoint when trim pin is open ,Vo=5.003V
Vo,adj is the adjusted output voltage.
Rtrim-up is the resistance required between TRIM and GND.



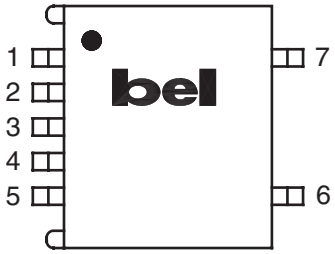
Mechanical

SRAH-02A



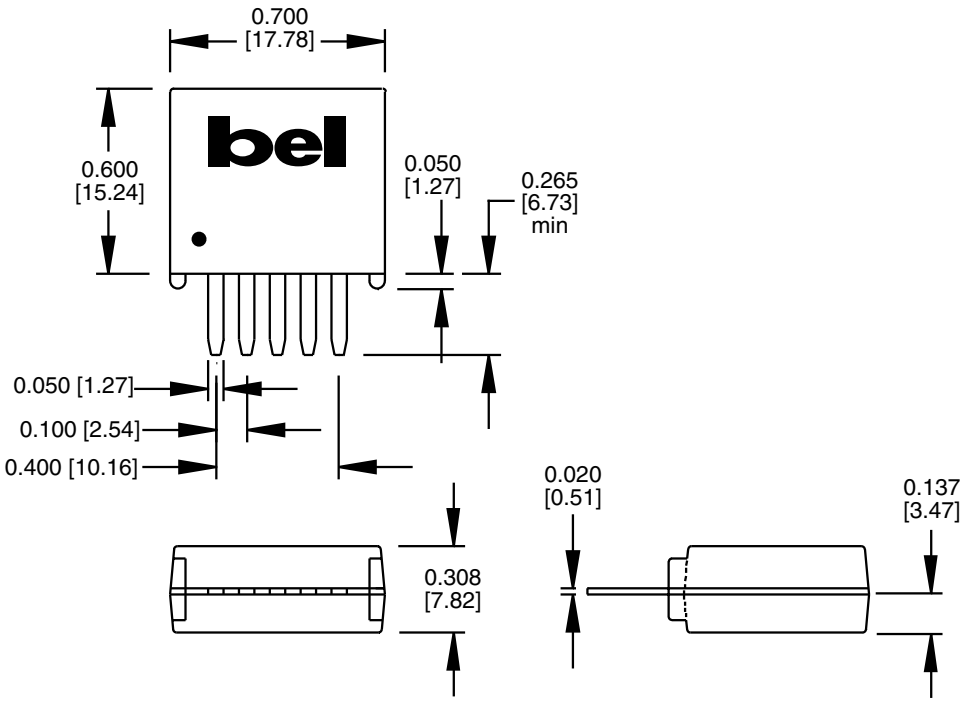
Dimensions are in inches [millimeters].
Standard dimension tolerance is ±0.005 [0.13] unless otherwise noted.

Pin	Function
1	Remote On/Off
2	+Vin
3	Ground
4	+Vo
5	Trim
6	No Connection
7	No Connection



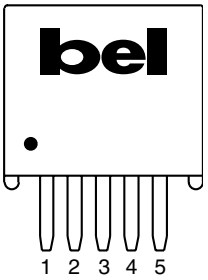
Mechanical

VRAH-02A



Dimensions are in inches [millimeters].
Standard dimension tolerance is ±0.005 [0.13] unless otherwise noted.

Pin	Function
1	Remote On/Off
2	+Vin
3	Ground
4	+Vo
5	Trim



RoHS Compliance
Complies with the European Directive 2002/95/EC, calling for the elimination of lead and other hazardous substances from electronic products. These parts are not however compatible with the higher temperatures associated with lead free solder processes and must be soldered using a reflow profile with a peak temperature of no more than 240ºC.

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