Rio Grande Micro

Rev. 7 Jun 06

RG78SA Series Switching Voltage Regulators

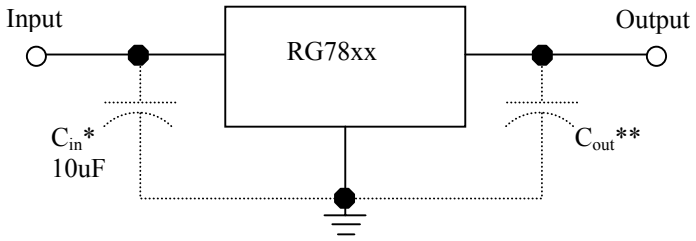
General Description

The RG78SA series of switching regulators incorporate all of the devices needed to make a modern, high frequency, high efficiency, step-down switching regulator in a 3 pin SIP package which is pin compatible with industry standard T0-220 LM78xx regulators. The package is available in horizontal or vertical mounts, and is slightly larger in size than T0-220. These regulators employ internal cycle-by-cycle current limiting and thermal shutdown protection, free convection cooling (no forced airflow).

Features

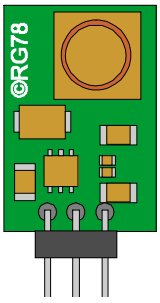
- Output current to 1.5 Amps
- Output power to 6.5 Watts with no heatsink
- Output Voltage from 800 milliVolts to 5.1 Volts
- Input Voltage to 16 Volts
- High efficiency > 90% @ 5.0V and 1250mA
- No external components required
- Very low noise – 20mVp-p typical at full load
- Exceptional transient response
- 1.5Mhz typical switching frequency
- Thermal overload and short circuit protected

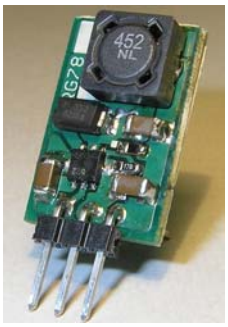
Typical Application



* C_{in} is required if regulator is located more than 6 inches from main power supply capacitors.

** C_{out} is not required, but will improve noise and transient response.





Part Number	V/I
RG78SA008	0.8V/1.5A
RG78SA018	1.8V/1.5A
RG78SA025	2.5V/1.5A
RG78SA033	3.3V/1.5A
RG78SA050	5.0V/1.25A
RG78SA051	5.1V/1.25A

Absolute Maximum Ratings

Input Voltage	16V
Power Dissipation	Internally Limited
Operational Temperature Range	-25C to +70C
Storage Temperature Range	-25C to +150C
Lead Temperature (Soldering, 5 Sec)	260C

Electrical Characteristics T_a = 25C (unless otherwise noted)

Common to all device types

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_o	Output Voltage Tolerance	$V_{in}=V_{in,min}$ I_o=750mA			+/- 2	%V_o
% V_o/T_a	Temperature Coefficient	T_a=0°C to 70°C		+/- 0.01		%V/°C
I_{omin}	Minimum Load Current (Note 1)		100			mA
I_{sc}	Short Circuit Current			2300		mA
V_n	Noise and Ripple	$I_o=I_{omax}$		20		mV_{p-p}
F_{sw}	Switching Frequency		1.2	1.5	1.8	MHz
T_{asu}	Thermal Shutdown (ambient temp)	V_{in}=16V, $I_o=I_{omax}$	70			°C
θ_{j-a}	IC Junction-Ambient Thermal Resistance	Convection cooling (zero forced airflow)		52		°C/W
T_{jsu}	IC Thermal-Shutdown Temperature		130			°C

Note 1: The device will operate down to 0mA load with reduced specifications.

RG78SA008 0.80V 1500mA T_a=25C

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{in}	Input Voltage		3.0		16.0	V
V_o	Output Voltage	V_{in}=3.0V, I_o=750mA	0.784	0.80	0.816	V
I_{omax}	Maximum Output Current		1500			mA
I_q	Quiescent Current	I_o=0mA		2.4	3	mA
% V_o/V_{in}	Line Regulation	3.0V<V_{in}<16V		0.02		%V/V
% V_o/I_{out}	Load Regulation	250mA<I_o<1500mA		0.5		%V/A
t_{tr}	Transient Response Recovery Time	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		50		µs
V_{tr}	Transient Response Over/Under Shoot	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		18		%V_o
η	Efficiency	V_{in}=3.0V, V_o=0.8V, I_o=750mA		69		%

RG78SA018 1.80V 1500mA T_a=25C

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{in}	Input Voltage		4.0		16.0	V
V_o	Output Voltage	V_{in}=4.0V, I_o=750mA	1.764	1.80	1.836	V
I_{omax}	Maximum Output Current		1500			mA
I_q	Quiescent Current	I_o=0mA		2.6	3.2	mA
% V_o/V_{in}	Line Regulation	4.0V<V_{in}<16V		0.01		%V/V
% V_o/I_{out}	Load Regulation	250mA<I_o<1500mA		0.8		%V/A
t_{tr}	Transient Response Recovery Time	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		50		µs
V_{tr}	Transient Response Over/Under Shoot	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		6		%V_o
η	Efficiency	V_{in}=4.0V, V_o=1.8V, I_o=750mA		83		%

RG78SA025 2.50V 1500mA T_a=25C

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{in}	Input Voltage		5.1		16.0	V
V_o	Output Voltage	V_{in}=5.1V, I_o=750mA	2.450	2.50	2.550	V
I_{omax}	Maximum Output Current		1500			mA
I_q	Quiescent Current	I_o=0mA		2.8	3.4	mA
% V_o/V_{in}	Line Regulation	5.1V<V_{in}<16V		0.02		%V/V
% V_o/I_{out}	Load Regulation	250mA<I_o<1500mA		1		%V/A
t_{tr}	Transient Response Recovery Time	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		50		µs
V_{tr}	Transient Response Over/Under Shoot	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		5		%V_o
η	Efficiency	V_{in}=5.1V, V_o=2.5V, I_o=750mA		86		%

RG78SA033 3.30V 1500mA T_a=25C

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{in}	Input Voltage		6.1		16.0	V
V_o	Output Voltage	V_{in}=6.1V, I_o=750mA	3.234	3.30	3.366	V
I_{omax}	Maximum Output Current		1500			mA
I_q	Quiescent Current	I_o=0mA		2.9	3.5	mA
% V_o/V_{in}	Line Regulation	6.1V<V_{in}<16V		0.05		%V/V
% V_o/I_{out}	Load Regulation	250mA<I_o<1500mA		1.5		%V/A
t_{tr}	Transient Response Recovery Time	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		50		µs
V_{tr}	Transient Response Over/Under Shoot	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		4		%V_o
η	Efficiency	V_{in}=6.1V, V_o=3.3V, I_o=750mA		88		%

RG78SA050 5.0V 1250mA T_a=25C

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{in}	Input Voltage		7.8		16.0	V
V_o	Output Voltage	V_{in}=7.8V, I_o=750mA	4.900	5.0	5.100	V
I_{omax}	Maximum Output Current		1250			mA
I_q	Quiescent Current	I_o=0mA		3.1	3.7	mA
% V_o/V_{in}	Line Regulation	7.8V<V_{in}<16V		0.01		%V/V
% V_o/I_{out}	Load Regulation	250mA<I_o<1250mA		1.5		%V/A
t_{tr}	Transient Response Recovery Time	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		50		µs
V_{tr}	Transient Response Over/Under Shoot	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		3		%V_o
η	Efficiency	V_{in}=7.8V, V_o=5.0V, I_o=750mA		92		%

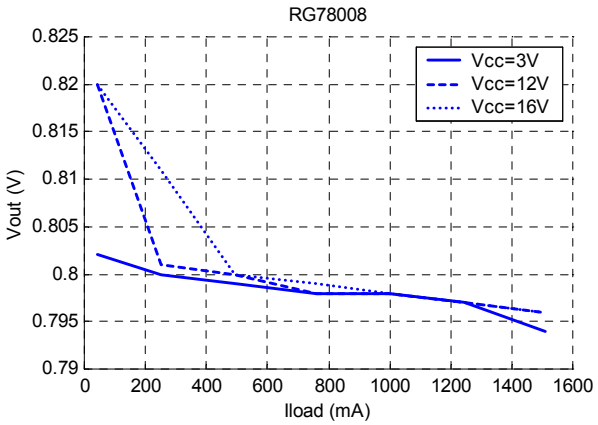
RG78SA051 5.1V 1250mA T_a=25C

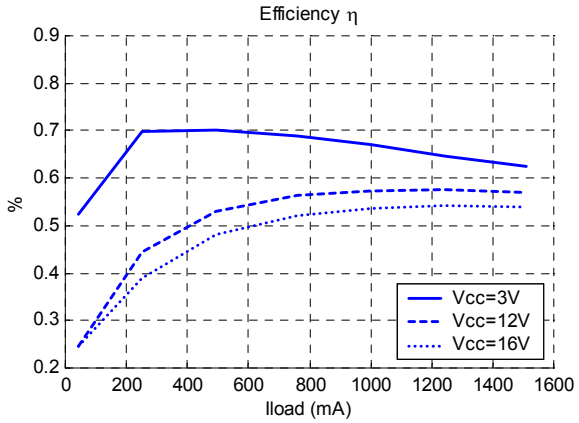
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{in}	Input Voltage		8.1		16.0	V
V_o	Output Voltage	V_{in}=8.1V, I_o=750mA	4.998	5.1	5.202	V
I_{omax}	Maximum Output Current		1250			mA
I_q	Quiescent Current	I_o=0mA		3.1	3.7	mA
% V_o/V_{in}	Line Regulation	8.1V<V_{in}<16V		0.06		%V/V
% V_o/I_{out}	Load Regulation	250mA<I_o<1250mA		2		%V/A
t_{tr}	Transient Response Recovery Time	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		50		µs
V_{tr}	Transient Response Over/Under Shoot	I_o: 90% -> 10% -> 90% of I_{omax}. 1us fall/rise time.		3		%V_o
η	Efficiency	V_{in}=8.1V, V_o=5.1V, I_o=750mA		91		%

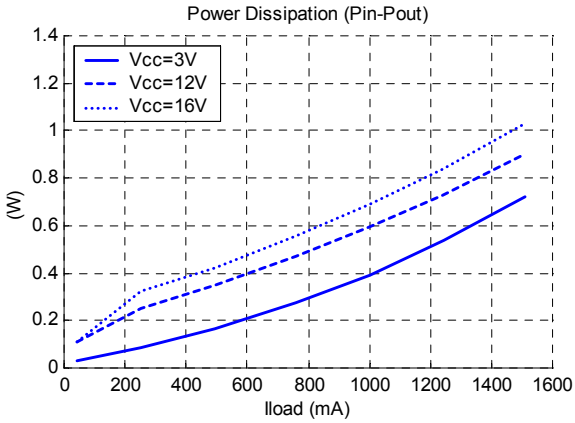
Application Information

This section shows examples of measurement data of the DC/DC modules; output voltage stability, efficiency, power dissipation, input and output noise, and transient response with a step-current load change.

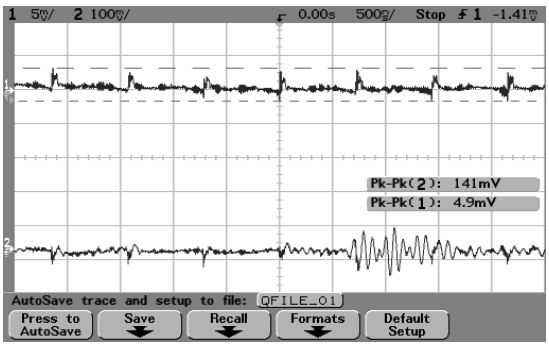
RG78SA008 0.80V 1500mA Ta=25C



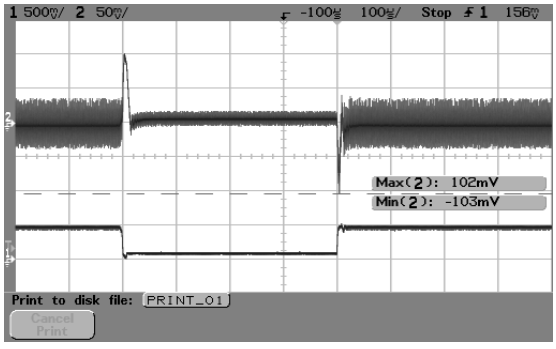




Graphs on (top-left) output voltage, (bottom-left) efficiency, and (bottom-right) power dissipation with varying load current and input voltage.

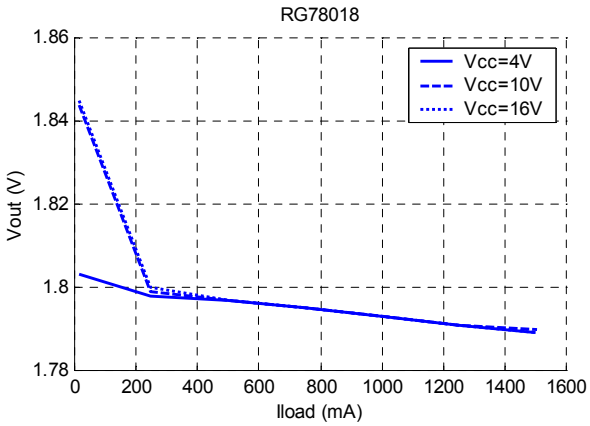


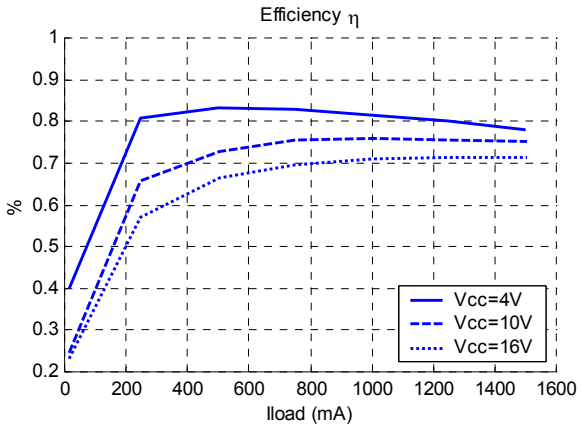
Oscilliscope screenshot showing: output voltage noise/ripple (top) and input voltage noise/ripple (bottom) with 250mA load current and 16V input voltage. The measurement bandwidth is 100MHz.

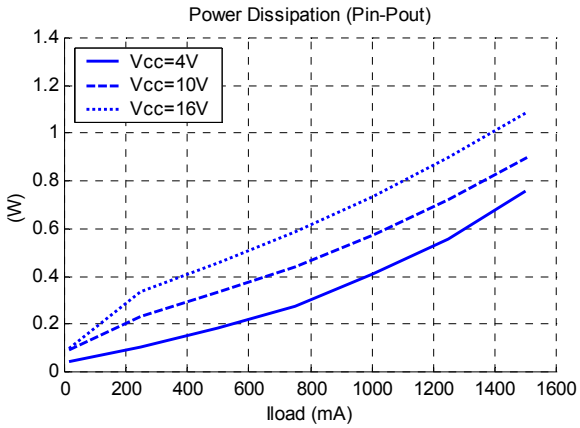


Output voltage transient response (top) with load current (bottom). The load current steps from 1350mA to 150mA to 1350mA. The measurement bandwidth is 100MHz.

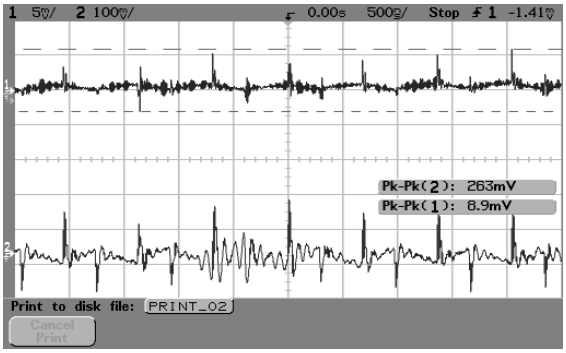
RG78SA018 1.80V 1500mA Ta=25C



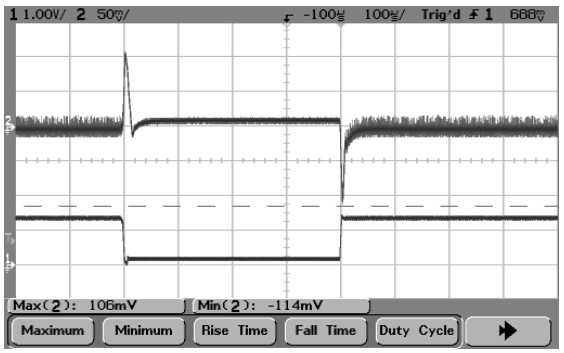




Graphs on (top-left) output voltage, (bottom-left) efficiency, and (bottom-right) power dissipation with varying load current and input voltage.

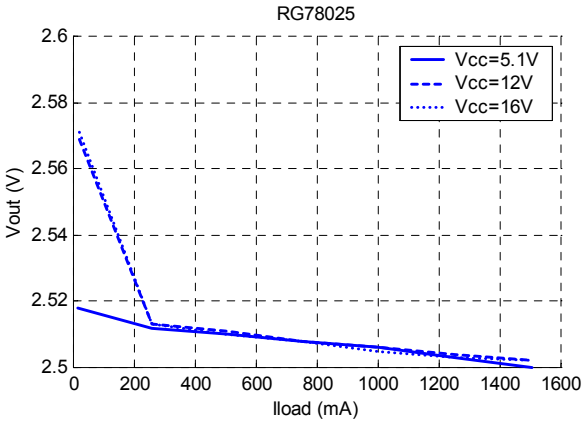


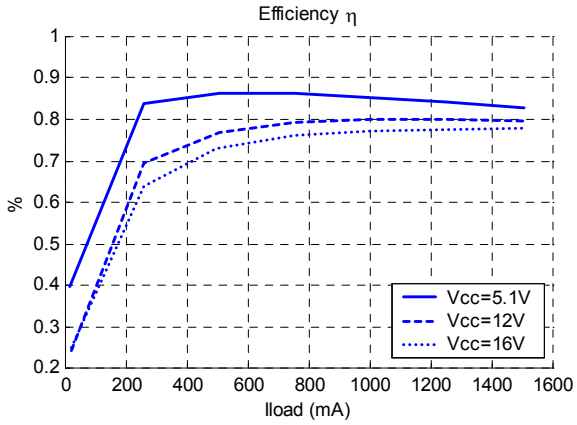
Output voltage noise/ripple (top) and input voltage noise/ripple (bottom) with 1500mA load current and 4V input voltage. The measurement bandwidth is 100MHz.

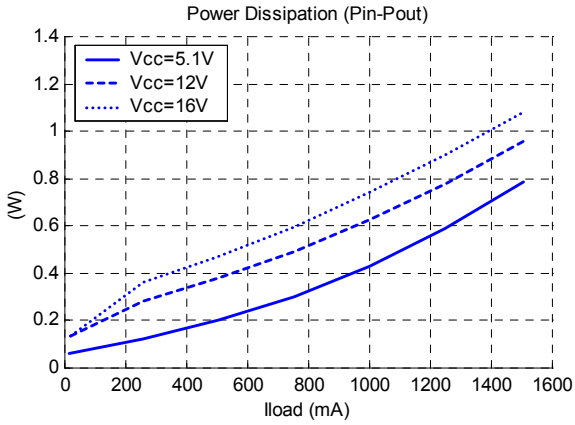


Output voltage transient response (top) with load current (bottom). The load current steps from 1350mA to 150mA to 1350mA. The measurement bandwidth is 100MHz.

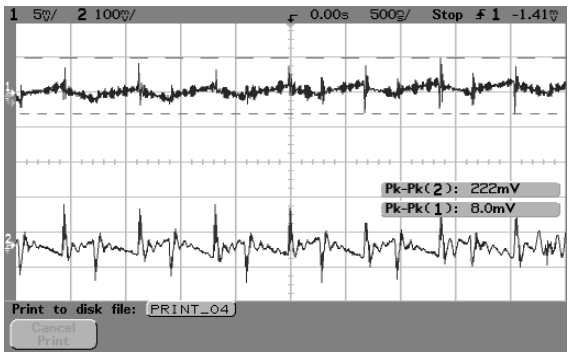
RG78SA025 2.50V 1500mA Ta=25C



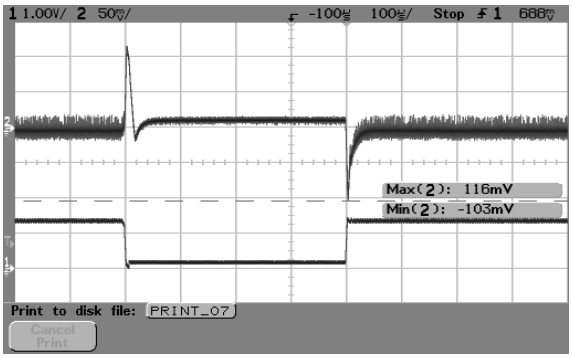




Graphs on (top-left) output voltage, (bottom-left) efficiency, and (bottom-right) power dissipation with varying load current and input voltage.

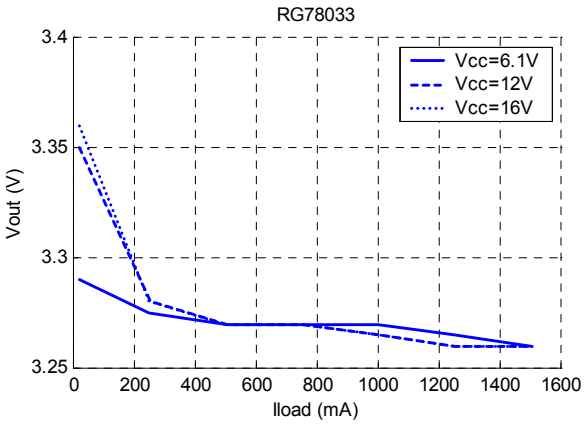


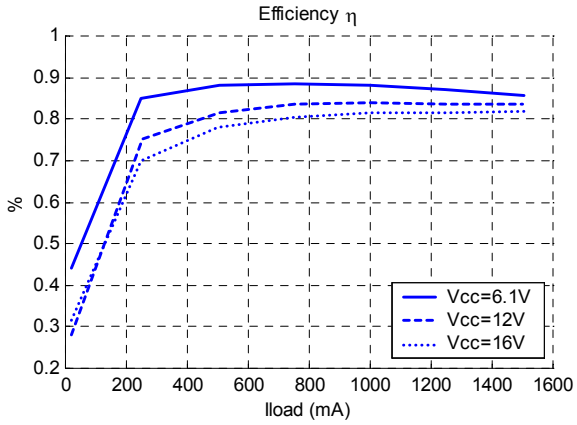
Output voltage noise/ripple (top) and input voltage noise/ripple (bottom) with 1500mA load current and 5.1V input voltage. The measurement bandwidth is 100MHz.

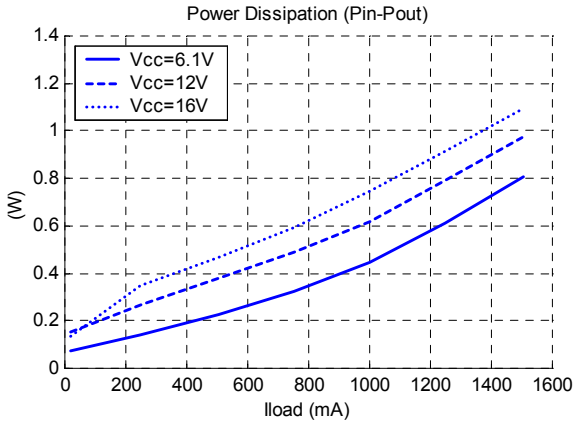


Output voltage transient response (top) with load current (bottom). The load current steps from 1350mA to 150mA to 1350mA. The measurement bandwidth is 100MHz.

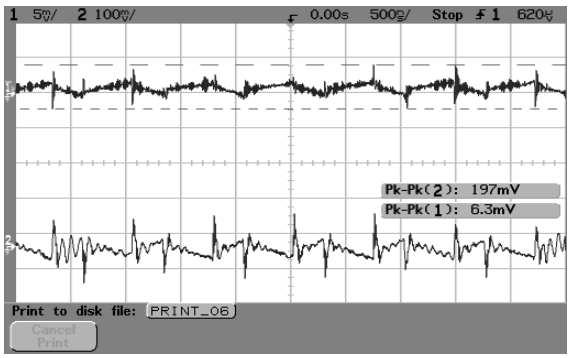
RG78SA033 3.30V 1500mA Ta=25C



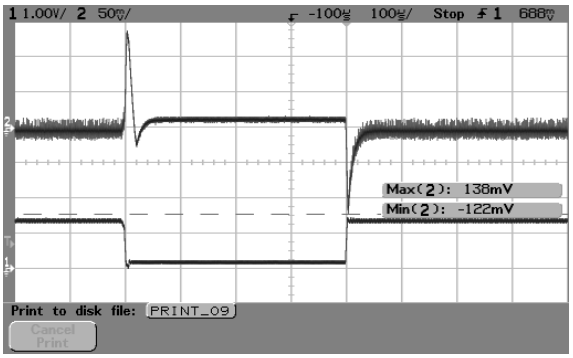




Graphs on (top-left) output voltage, (bottom-left) efficiency, and (bottom-right) power dissipation with varying load current and input voltage.

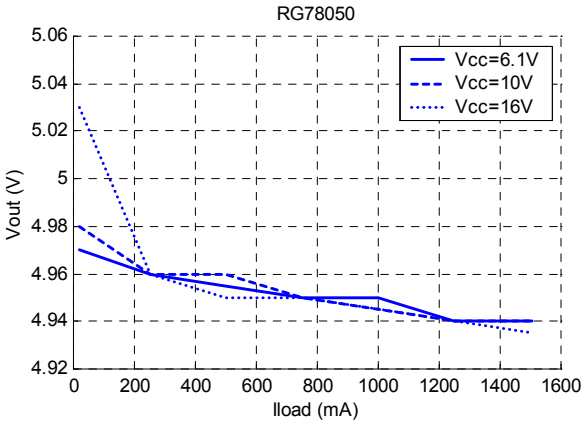


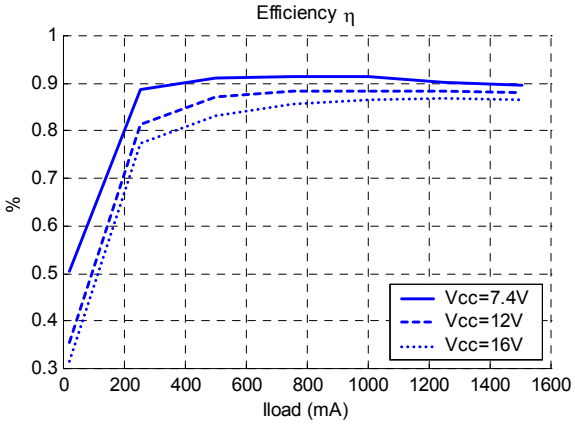
Output voltage noise/ripple (top) and input voltage noise/ripple (bottom) with 1500mA load current and 6.1V input voltage. The measurement bandwidth is 100MHz.

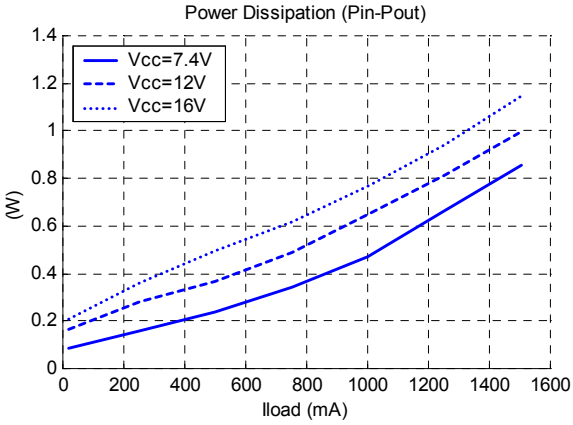


Output voltage transient response (top) with load current (bottom). The load current steps from 1350mA to 150mA to 1350mA. The measurement bandwidth is 100MHz.

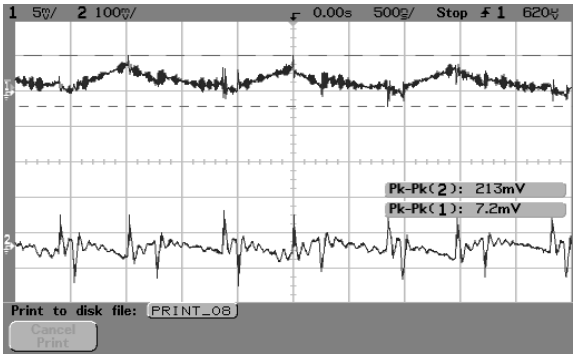
RG78SA050 5.0V 1250mA Ta=25C



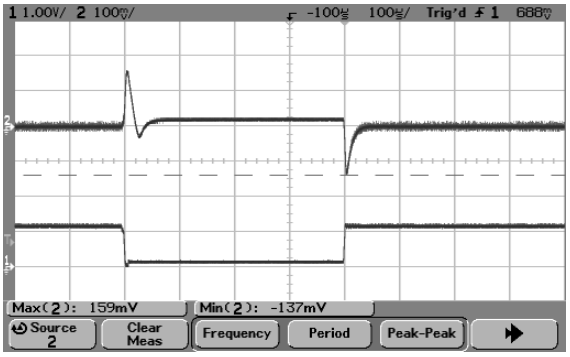




Graphs on (top-left) output voltage, (bottom-left) efficiency, and (bottom-right) power dissipation with varying load current and input voltage.

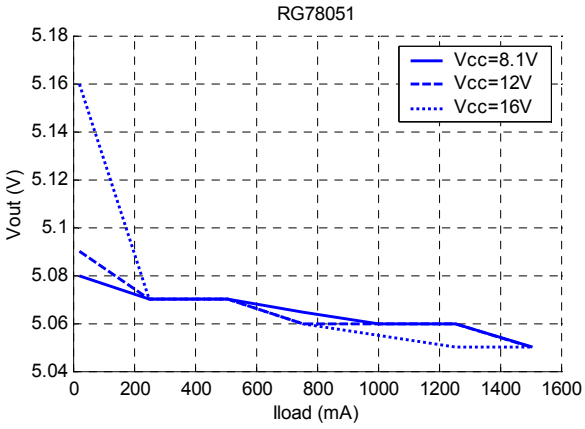


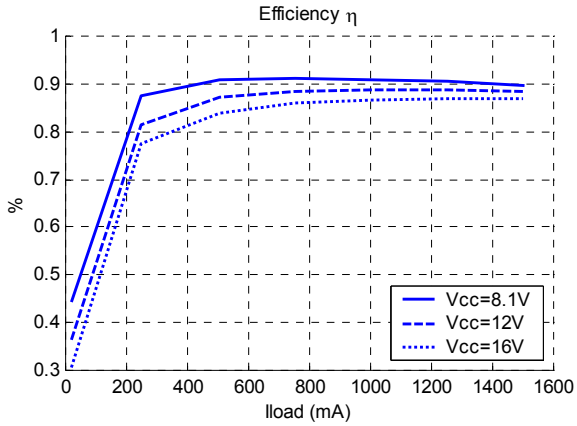
Output voltage noise/ripple (top) and input voltage noise/ripple (bottom) with 1250mA load current and 7.4V input voltage. The measurement bandwidth is 100MHz.

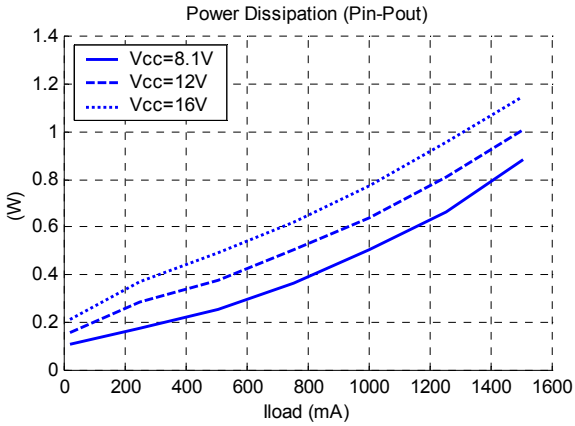


Output voltage transient response (top) with load current (bottom). The load current steps from 1350mA to 150mA to 1350mA. The measurement bandwidth is 100MHz.

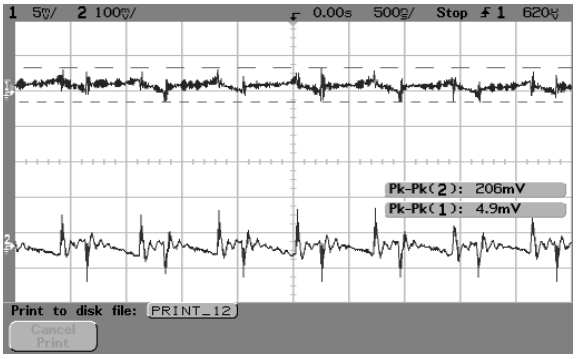
RG78SA051 5.1V 1250mA Ta=25C



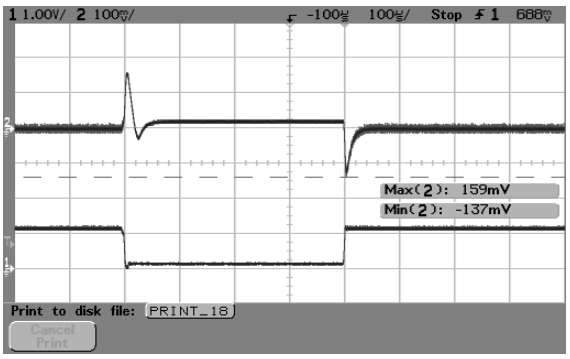




Graphs on (top-left) output voltage, (bottom-left) efficiency, and (bottom-right) power dissipation with varying load current and input voltage.



Output voltage noise/ripple (top) and input voltage noise/ripple (bottom) with 1250mA load current and 8.1V input voltage. The measurement bandwidth is 100MHz.

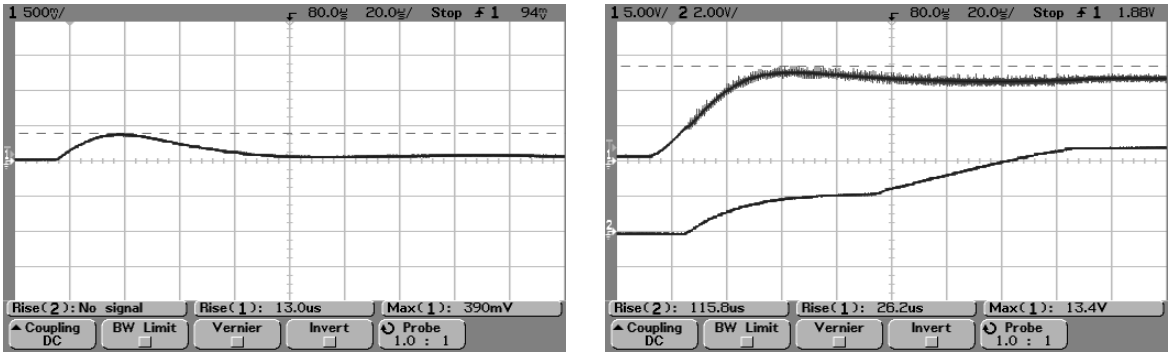


Output voltage transient response (top) with load current (bottom). The load current steps from 1350mA to 150mA to 1350mA. The measurement bandwidth is 100MHz.

Start-Up Transient and Inrush Current

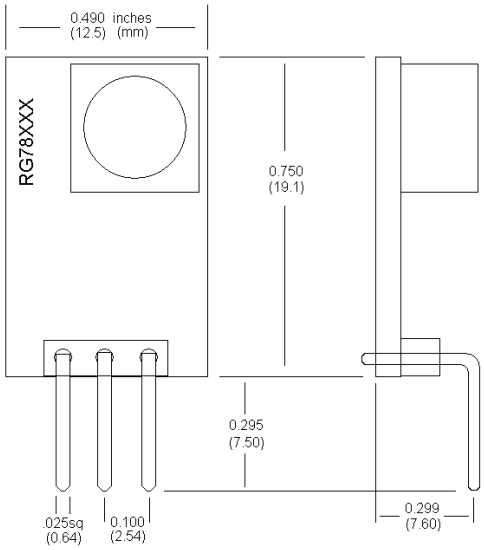
A DC/DC module is powered by a voltage supply through a power cord. When the power supply is switched on, the power cord may initially conduct large amount of current – a rush current. This is in particular true if a power supply is already turned on when a mechanical or electrical switch connects the power supply to the DC/DC module. This rush current causes a transient voltage on the DC/DC module input terminal. This concerns the power supply, which must be able to provide the high rush current, and the DC/DC regulator that is susceptible to overvoltage. Limiting the slew rate alleviates both inrush current and overvoltage – input voltage ramp-up time of 20µs is usually enough to prevent destructive overvoltage on RG78SA series switching regulator parts. Examples of power-supply-to-DC/DC-module network design are provided in the application note "Application Note – Start-Up Transient and Inrush Current: RG78SA Series Switching Regulator".

In a power-on test using the RG78SA050 device, the input voltage, output voltage, and inrush current is recorded with oscilloscopes. A power supply connects to a power switch, a current probe, and an LC filter (L=27µH, C=22µF), to the DC/DC module input. This limits the input slew rate to 20us, the input overvoltage is 1.4V (13.4V vs. 12V), and the inrush current peaks at 7.1A.

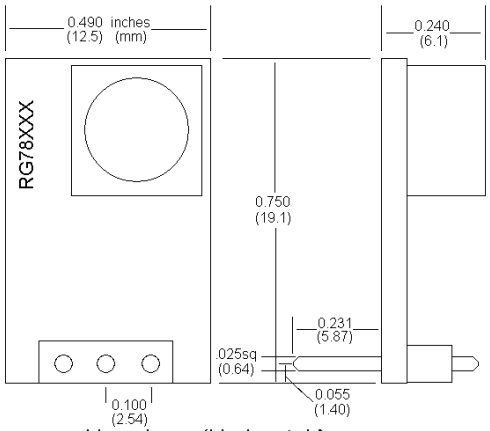


Power-on switch event with a 27µH inductor and a 22µF electrolyte capacitor in the power line path. Oscilloscope screenshots show (left) power cord current at 9.1A/div, and (right) input and output voltage probed at the DC/DC module pins.

Mechanical Data

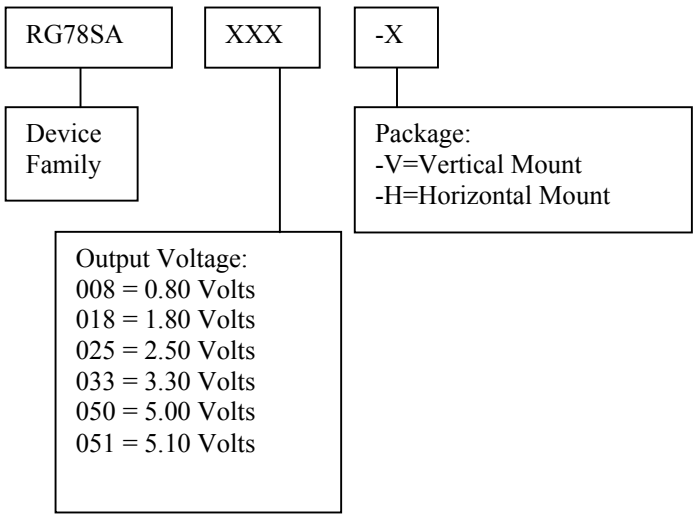


-V package (Vertical Mount)



-H package (Horizontal Mount)

Ordering Information



Example, RG78SA050-V is a 5.0V output, vertical mount device.