MINMAX®

M78SAR-0.5 Series

Electric Characteristic Note

M78SAR-0.5 Series EC Note

Switching Regulator 0.5A, SMD-Package

Features

- **Industrial SMD Package**
- **Fully Regulated Output Voltage**
- **Low Ripple & Noise**
- **Excellent Efficiency up to 97%**
- **Operating Ambient Temp. Range -40℃ to +90℃**
- **No Min. Load Requirement**
- **Over Temp. and Short Circuit Protection**
- **Remote ON/OFF Control, Output Voltage Trim**
- **Qualified for Lead-free Reflow Solder Process According to IPC/JEDEC J-STD-020D.1**
- **Tape & Reel Package Available**

Applications

- Distributed power architectures
- Workstations
- Computer equipment
- Communications equipment

Product Overview

The MINMAX M78SAR-0.5 series is a new range of switching regulators designed as a drop-in replacement for old LM78xx linear regulators with low efficiency. The very high efficiency of these step-down converters allow an operating temperature up to 80°C at full-load without need of any heatsink.
The high efficiency and low stand-by power consumption of these switching regulators offer the designer a new, cost-efficient solution for many applications.

Table of contents

Model Selection Guide

Model Number	Input Voltage Range(5)	Output Voltage		Output Current	Max. capacitive Load	Efficiency (typ.)	Efficiency (typ.)
		Normal	Adjust Range	Max.		@Min. Vin	@Max. Vin
	VDC	VDC	VDC	mA	μF	%	%
M78SAR015-0.5	4.75 ~ 32	1.5	1.4~2.5	500	220	73	63
M78SAR018-0.5		1.8	1.5~3	500	220	82	71
M78SAR025-0.5		2.5	1.5~3	500	220	87	77
M78SAR033-0.5		3.3	3~5.5	500	220	91	81
M78SAR05-0.5	6.5 ~ 32	5	3~8	500	220	94	86
M78SAR065-0.5	8 ~ 32	6.5	3.3~11	500	220	95	88
M78SAR09-0.5	11 ~ 32	9	4.5~12.6	500	220	96	92
M78SAR12-0.5	15 ~ 32	12	4.5~13.5	500	220	97	94
M78SAR15-0.5	18 ~ 32	15	4.5~15.5	500	220	97	95

Input Specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
Input Surge Voltage (1 sec. max.)		-0.3	---	34	VDC
Internal Filter Type		Capacitor			
Input Filter	All Models	Internal Capacitor			
Short Circuit Input Power		---	---	1.5	W
Input Current	@No Load	---	5	---	mA

Remote On/Off Control

Parameter	Conditions	Min.	Typ.	Max.	Unit
Converter On	Open or 2.4V<Vr<5V				
Converter Off	GND or 0<Vr<1.6V				
Standby Input Current	Nominal Vin	---	---	35	μA

Output Specifications

Parameter	Conditions		Min.	Typ.	Max.	Unit
Output Voltage Setting Accuracy			---	±2.0	±3.0	%Vnom.
Line Regulation	Vin=Min. to Max. @Full Load	1.5V to 6.5V	---	±0.2	±0.4	%
		9V to 15V	---	±0.1	±0.2	%
Load Regulation	Io=10% to 100%	1.5V to 6.5V	---	±0.4	±0.6	%
		9V to 15V	---	±0.25	±0.4	%
Minimum Load	No minimum Load Requirement					
Ripple & Noise	0-20MHz Bandwidth	1.5V to 6.5V	---	---	30	mV_{P-P}
		9V to 15V	---	---	40	mV_{P-P}
Transient Recovery Time	50% Load Step Change		---	100	---	μsec
Transient Response Deviation			---	±2	---	%
Temperature Coefficient			---	---	±0.015	%/°C
Short Circuit Protection	Continuous, Automatic Recovery					

General Specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
I/O Isolation Voltage	none				
Switching Frequency		280	330	380	kHz
MTBF(calculated)	MIL-HDBK-217F@25°C, Ground Benign	2,000,000			Hours
Moisture Sensitivity Level (MSL)	IPC/JEDEC J-STD-020D.1	Level 2			

EMC Specifications

Parameter	Standards & Level			Performance
EMI(4)	Conduction	EN 55022	With external components	Class A, B
	Radiation		Without external components	
EMS(4)	ESD	EN 61000-4-2 Air±8kV		A
	Radiated immunity	EN 61000-4-3 3V/m		A
	Fast transient	EN 61000-4-4 ±0.5kV		A
	Conducted immunity	EN 61000-4-6 3Vrms		A
	PFMF	EN 61000-4-8 3A/m		A

Environmental Specifications

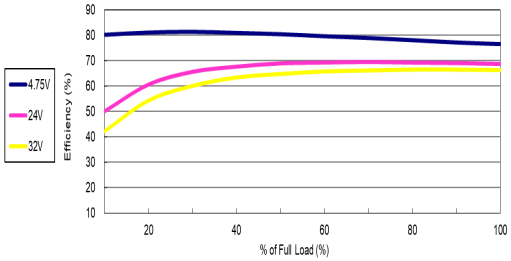
Parameter	Conditions	Min.	Typ.	Max.	Unit
Operating Ambient Temperature Range (See Power Derating Curve)		-40	---	+90	℃
Case Temperature		---	---	+100	℃
Storage Temperature		-55	---	+125	℃
Thermal Shutdown	Internal IC junction	---	160	---	℃
Humidity (non condensing)		---	---	95	% rel. H
Lead-free reflow solder process	IPC/JEDEC J-STD-020D.1				

Notes

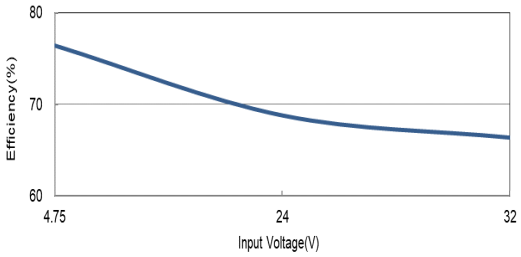
1. Specifications typical at Ta=+25℃, resistive load, nominal input voltage, rated output current unless otherwise noted.
2. Other input and output voltage may be available, please contact MINMAX.
3. We recommend to protect the converter by a slow blow fuse in the input supply line.
4. The external components might be required to meet EMI/EMS standard for some of test items. Please contact MINMAX for the solution in detail.
5. With a input capacitor 22μF/50V for input voltage >28VDC, the input voltage allows 32VDC, max.
6. Specifications are subject to change without notice.

Characteristic Curves

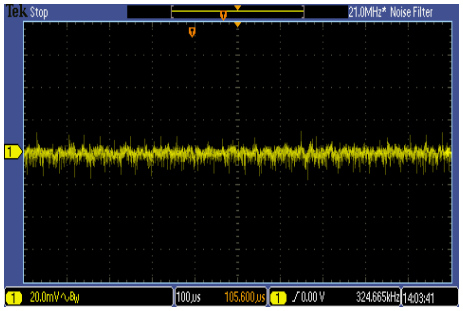
All test conditions are at 25℃ The figures are identical for M78SAR015-0.5



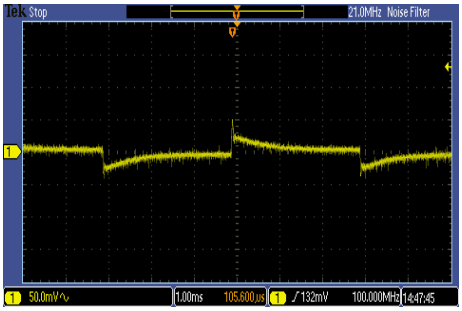
Efficiency Versus Output Current



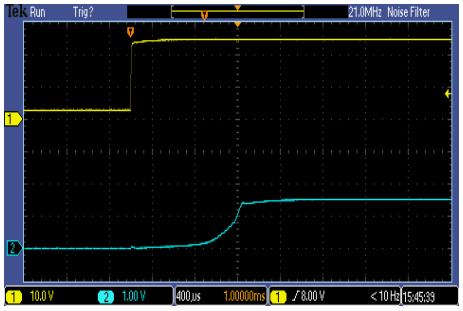
Efficiency Versus Input Voltage
Full Load



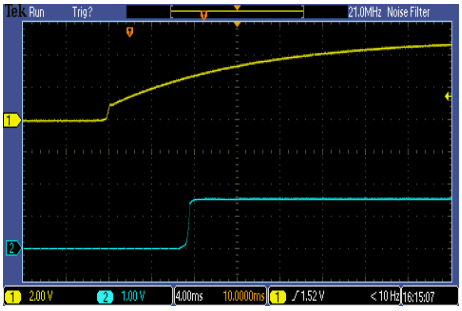
Typical Output Ripple and Noise
V_{in}=$V_{in\ nom}$; Full Load



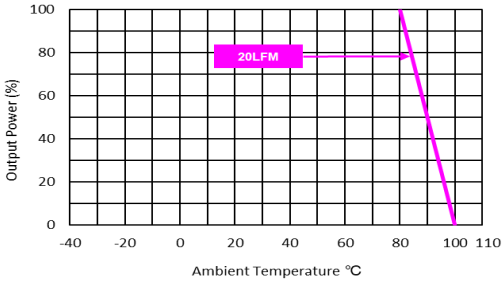
Transient Response to Dynamic Load Change
from 100% to 75% of Full Load ; V_{in}=$V_{in\ nom}$



Typical Input Start-Up and Output Rise Characteristic
V_{in}=$V_{in\ nom}$; Full Load



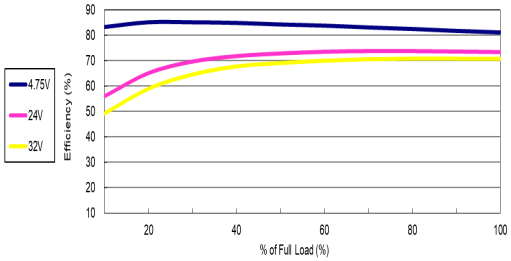
ON/OFF Voltage Start-Up and Output Rise Characteristic
V_{in}=$V_{in\ nom}$; Full Load



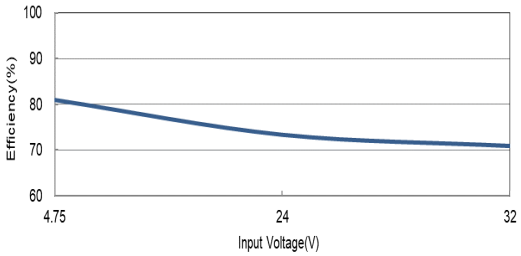
Derating Output Current Versus Ambient Temperature and Airflow
V_{in}=$V_{in\ nom}$

Characteristic Curves

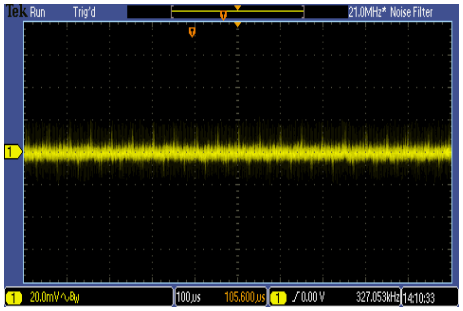
All test conditions are at 25°C The figures are identical for M78SAR018-0.5



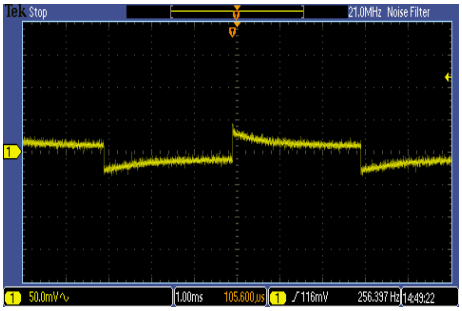
Efficiency Versus Output Current



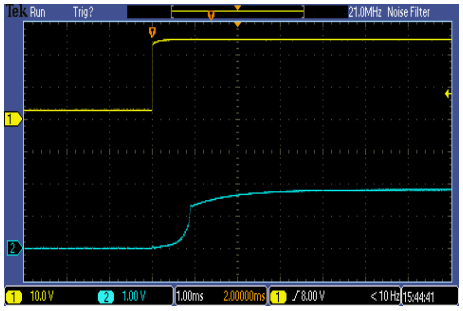
Efficiency Versus Input Voltage
Full Load



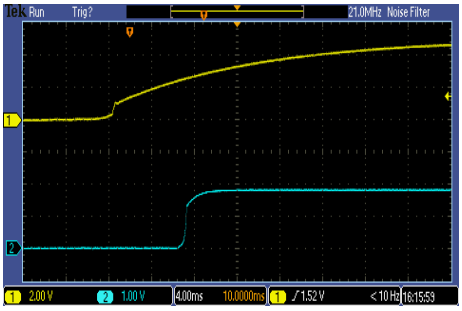
Typical Output Ripple and Noise
V_{in}=$V_{in\ nom}$; Full Load



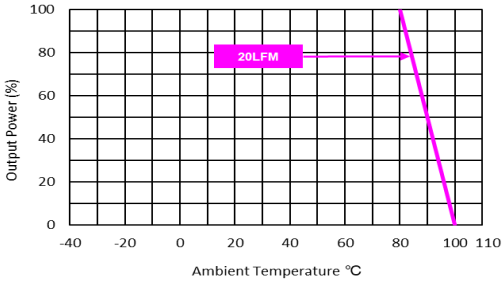
Transient Response to Dynamic Load Change
from 100% to 75% of Full Load ; V_{in}=$V_{in\ nom}$



Typical Input Start-Up and Output Rise Characteristic
V_{in}=$V_{in\ nom}$; Full Load



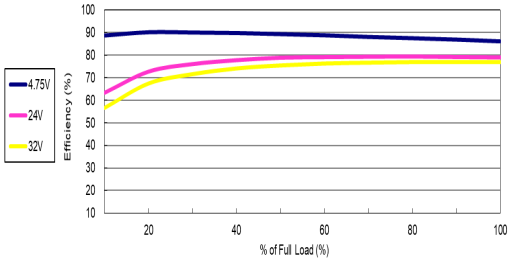
ON/OFF Voltage Start-Up and Output Rise Characteristic
V_{in}=$V_{in\ nom}$; Full Load



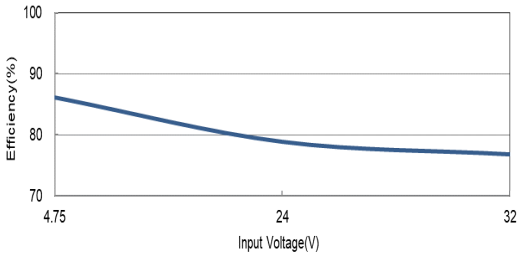
Derating Output Current Versus Ambient Temperature and Airflow
V_{in}=$V_{in\ nom}$

Characteristic Curves

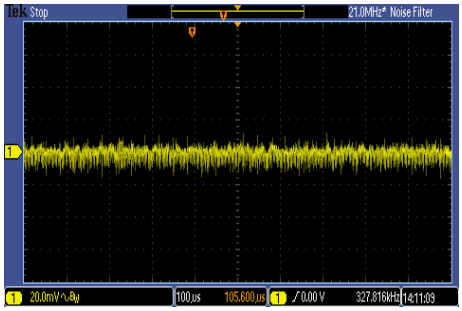
All test conditions are at 25°C The figures are identical for M78SAR025-0.5



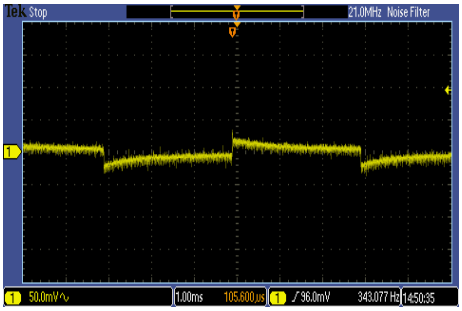
Efficiency Versus Output Current



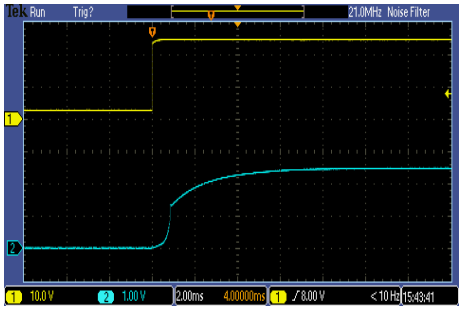
Efficiency Versus Input Voltage
Full Load



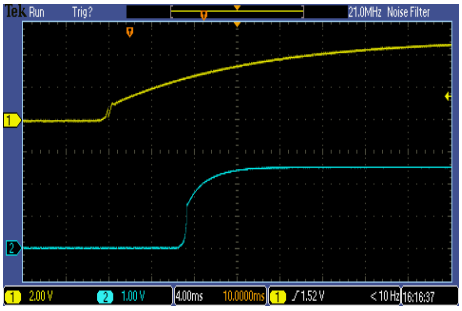
Typical Output Ripple and Noise
$V_{in}=V_{in\ nom}$; Full Load



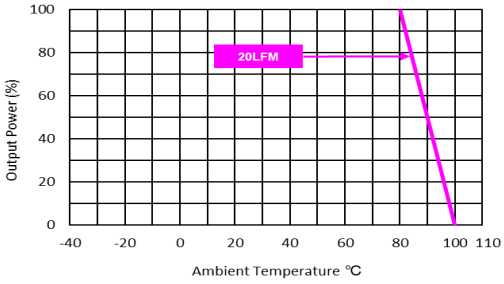
Transient Response to Dynamic Load Change
from 100% to 75% of Full Load ; $V_{in}=V_{in\ nom}$



Typical Input Start-Up and Output Rise Characteristic
$V_{in}=V_{in\ nom}$; Full Load



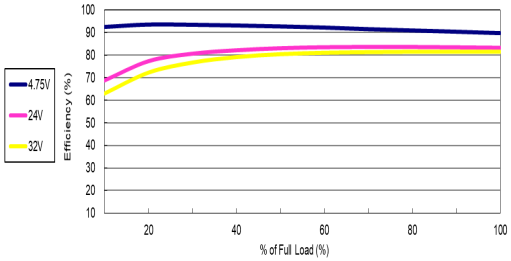
ON/OFF Voltage Start-Up and Output Rise Characteristic
$V_{in}=V_{in\ nom}$; Full Load



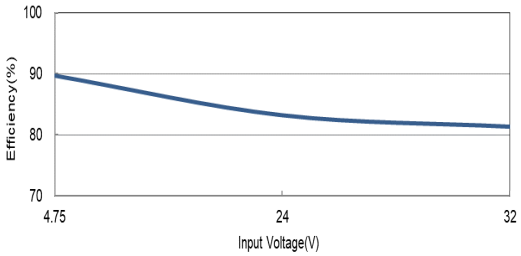
Derating Output Current Versus Ambient Temperature and Airflow
$V_{in}=V_{in\ nom}$

Characteristic Curves

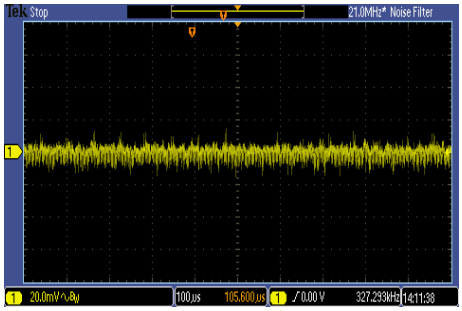
All test conditions are at 25°C The figures are identical for M78SAR033-0.5



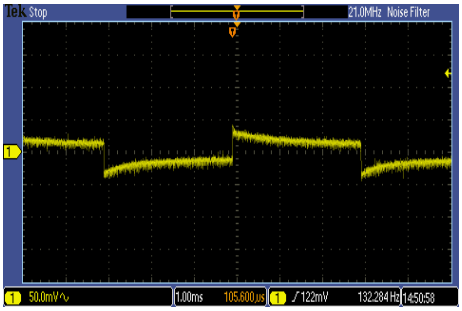
Efficiency Versus Output Current



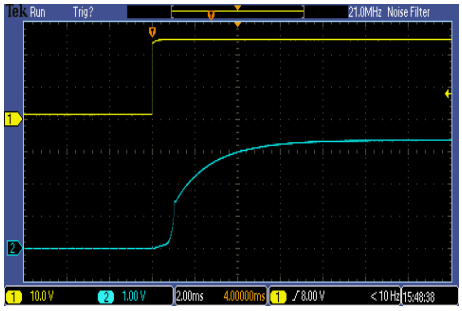
Efficiency Versus Input Voltage
Full Load



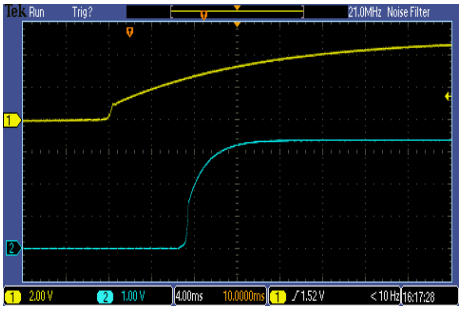
Typical Output Ripple and Noise
$V_{in}=V_{in\ nom}$; Full Load



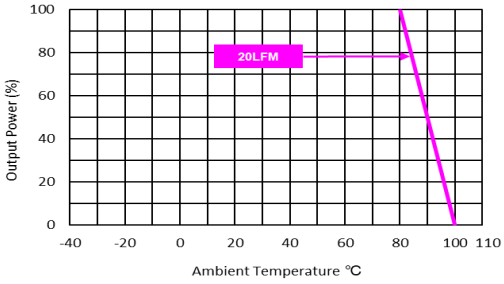
Transient Response to Dynamic Load Change
from 100% to 75% of Full Load ; $V_{in}=V_{in\ nom}$



Typical Input Start-Up and Output Rise Characteristic
$V_{in}=V_{in\ nom}$; Full Load



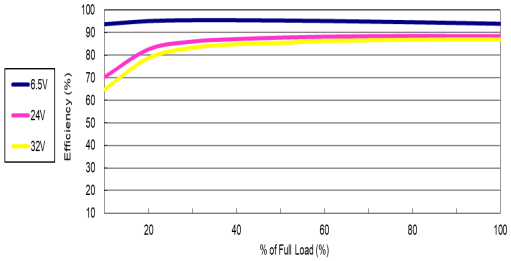
ON/OFF Voltage Start-Up and Output Rise Characteristic
$V_{in}=V_{in\ nom}$; Full Load



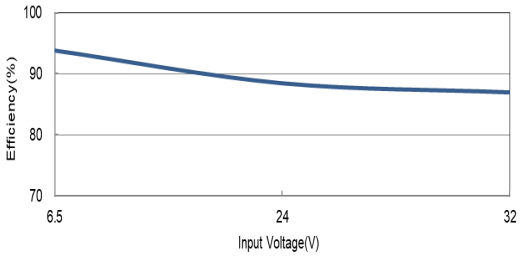
Derating Output Current Versus Ambient Temperature and Airflow
$V_{in}=V_{in\ nom}$

Characteristic Curves

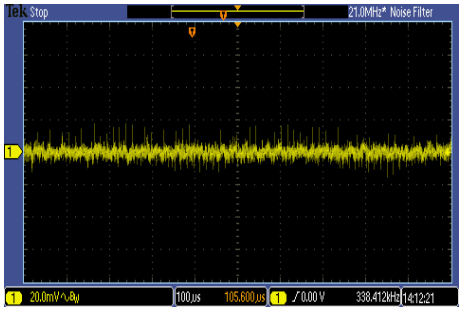
All test conditions are at 25°C The figures are identical for M78SAR05-0.5



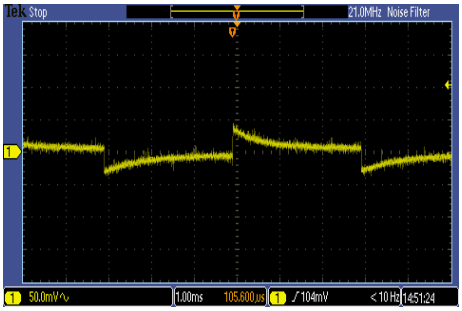
Efficiency Versus Output Current



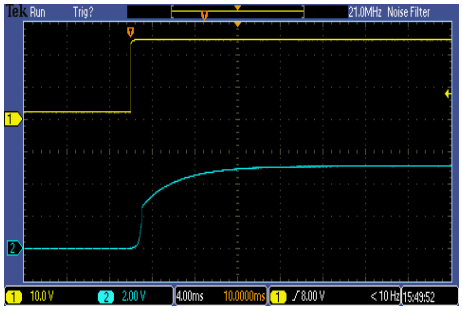
Efficiency Versus Input Voltage
Full Load



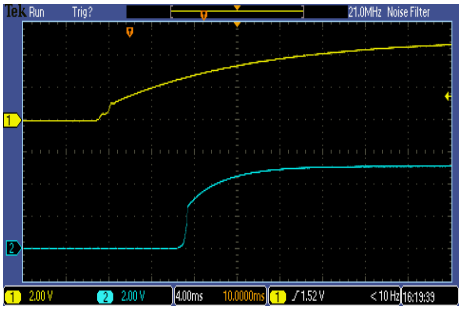
Typical Output Ripple and Noise
V_{in}=$V_{in\ nom}$; Full Load



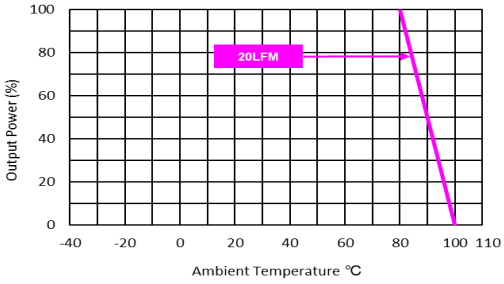
Transient Response to Dynamic Load Change
from 100% to 75% of Full Load ; V_{in}=$V_{in\ nom}$



Typical Input Start-Up and Output Rise Characteristic
V_{in}=$V_{in\ nom}$; Full Load



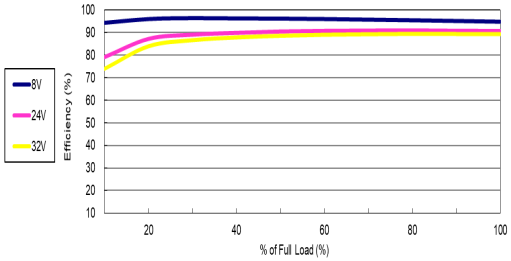
ON/OFF Voltage Start-Up and Output Rise Characteristic
V_{in}=$V_{in\ nom}$; Full Load



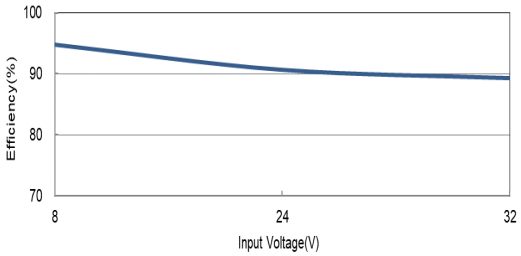
Derating Output Current Versus Ambient Temperature and Airflow
V_{in}=$V_{in\ nom}$

Characteristic Curves

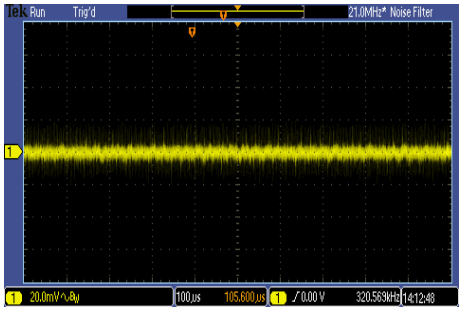
All test conditions are at 25°C The figures are identical for M78SAR065-0.5



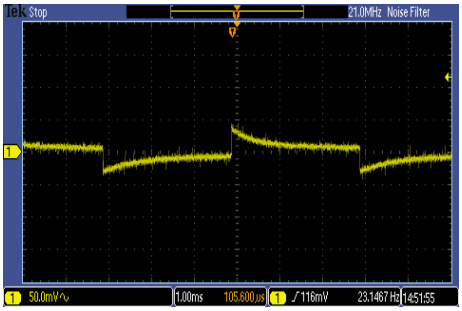
Efficiency Versus Output Current



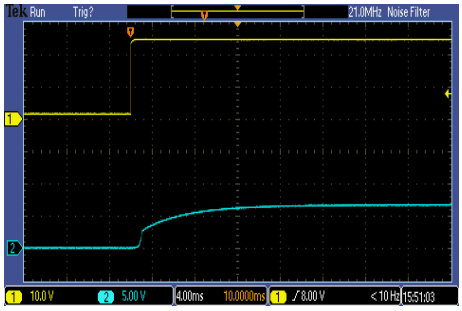
Efficiency Versus Input Voltage
Full Load



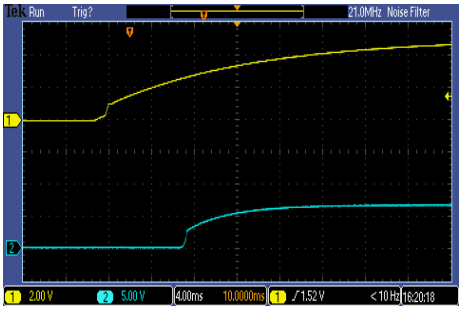
Typical Output Ripple and Noise
$V_{in}=V_{in\ nom}$; Full Load



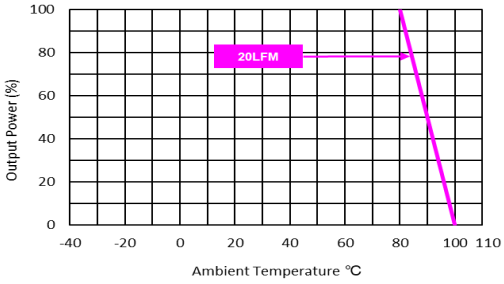
Transient Response to Dynamic Load Change
from 100% to 75% of Full Load ; $V_{in}=V_{in\ nom}$



Typical Input Start-Up and Output Rise Characteristic
$V_{in}=V_{in\ nom}$; Full Load



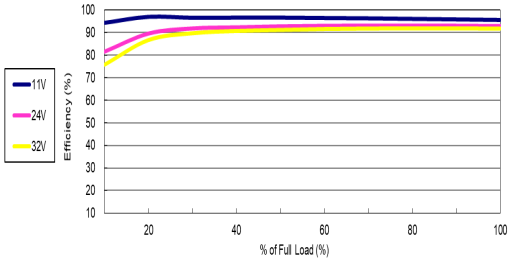
ON/OFF Voltage Start-Up and Output Rise Characteristic
$V_{in}=V_{in\ nom}$; Full Load



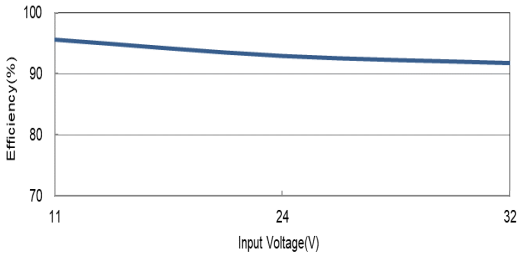
Derating Output Current Versus Ambient Temperature and Airflow
$V_{in}=V_{in\ nom}$

Characteristic Curves

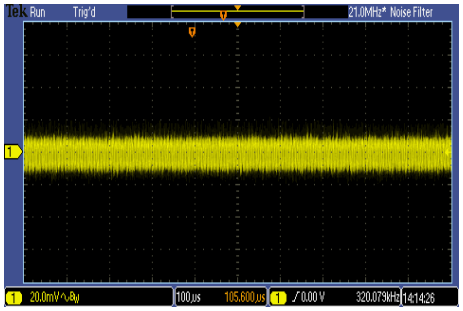
All test conditions are at 25℃ The figures are identical for M78SAR09-0.5



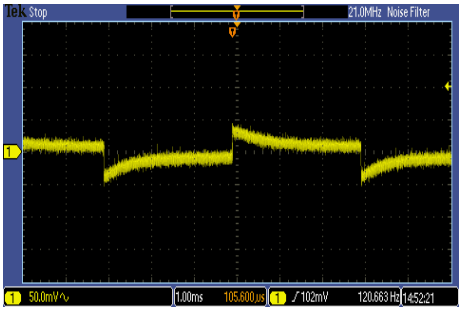
Efficiency Versus Output Current



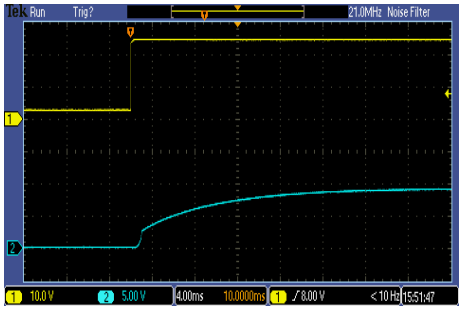
Efficiency Versus Input Voltage
Full Load



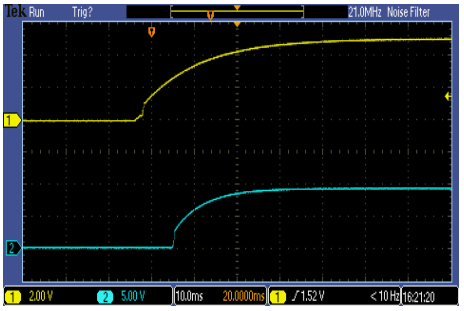
Typical Output Ripple and Noise
$V_{in}=V_{in\ nom}$; Full Load



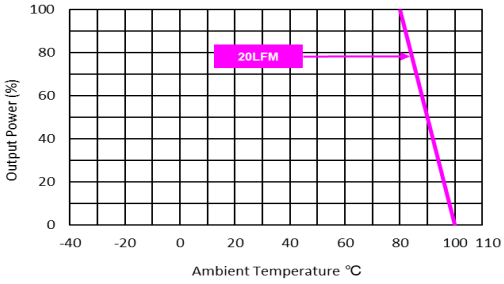
Transient Response to Dynamic Load Change
from 100% to 75% of Full Load ; $V_{in}=V_{in\ nom}$



Typical Input Start-Up and Output Rise Characteristic
$V_{in}=V_{in\ nom}$; Full Load



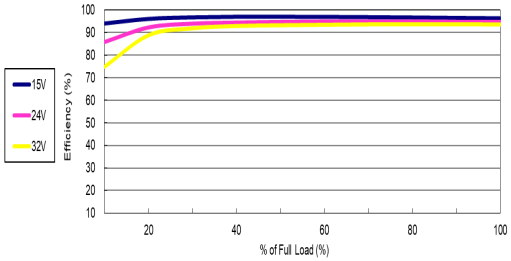
ON/OFF Voltage Start-Up and Output Rise Characteristic
$V_{in}=V_{in\ nom}$; Full Load



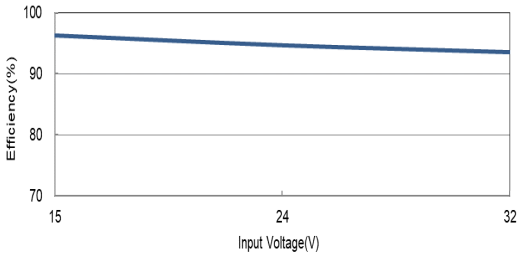
Derating Output Current Versus Ambient Temperature and Airflow
$V_{in}=V_{in\ nom}$

Characteristic Curves

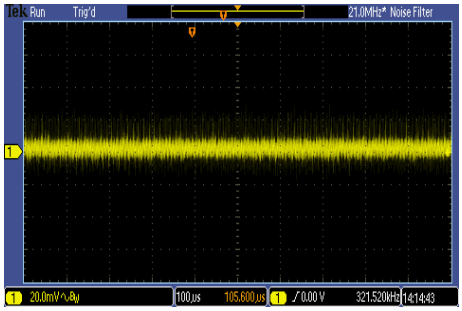
All test conditions are at 25℃ The figures are identical for M78SAR12-0.5



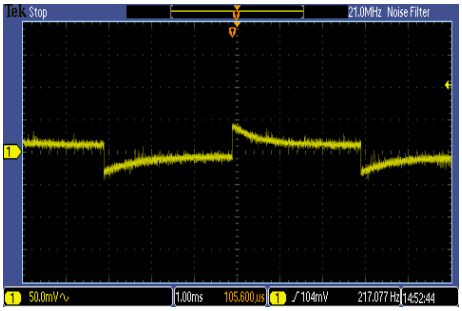
Efficiency Versus Output Current



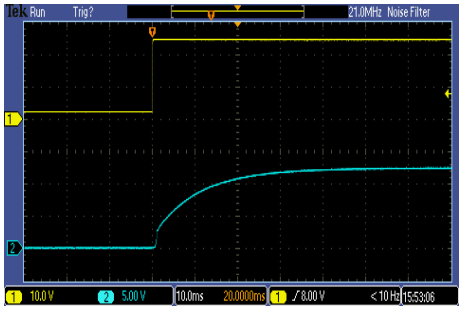
Efficiency Versus Input Voltage
Full Load



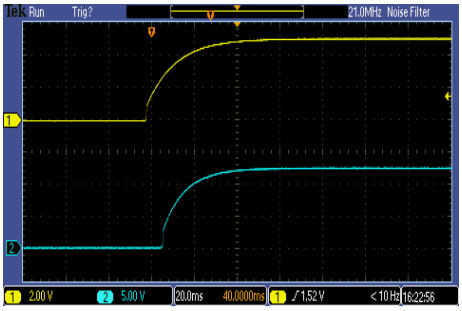
Typical Output Ripple and Noise
V_{in}=$V_{in\ nom}$; Full Load



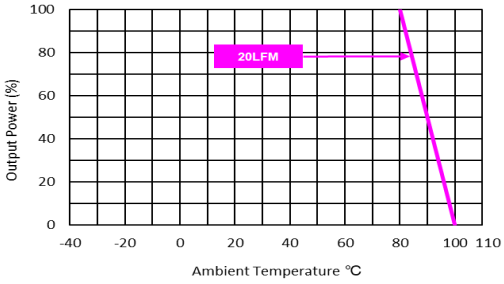
Transient Response to Dynamic Load Change
from 100% to 75% of Full Load ; V_{in}=$V_{in\ nom}$



Typical Input Start-Up and Output Rise Characteristic
V_{in}=$V_{in\ nom}$; Full Load



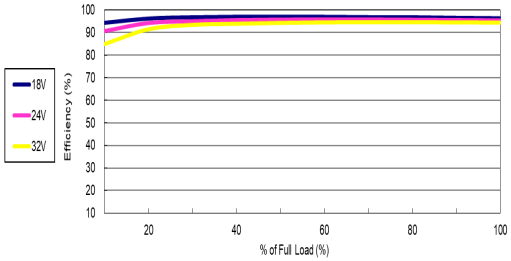
ON/OFF Voltage Start-Up and Output Rise Characteristic
V_{in}=$V_{in\ nom}$; Full Load



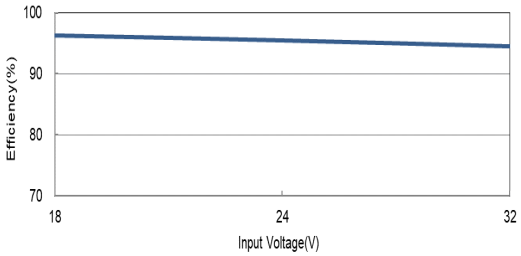
Derating Output Current Versus Ambient Temperature and Airflow
V_{in}=$V_{in\ nom}$

Characteristic Curves

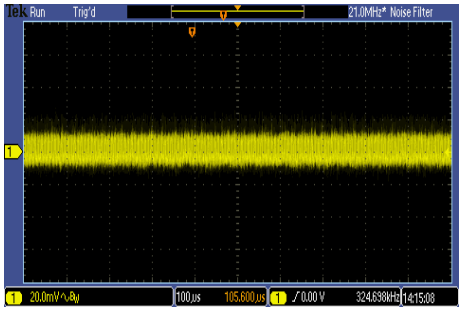
All test conditions are at 25℃ The figures are identical for M78SAR15-0.5



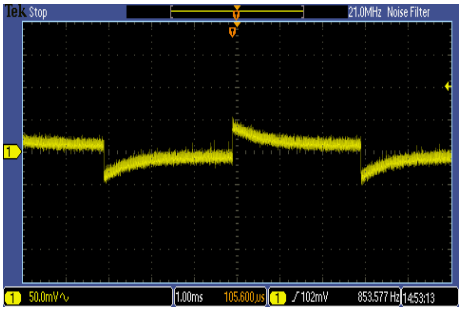
Efficiency Versus Output Current



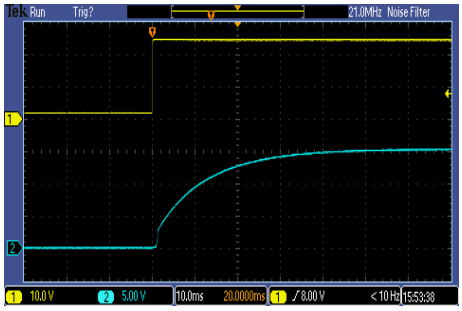
Efficiency Versus Input Voltage
Full Load



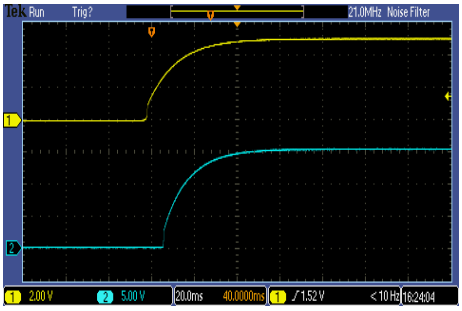
Typical Output Ripple and Noise
$V_{in}=V_{in\ nom}$; Full Load



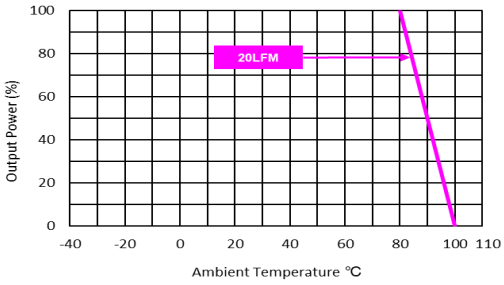
Transient Response to Dynamic Load Change
from 100% to 75% of Full Load ; $V_{in}=V_{in\ nom}$



Typical Input Start-Up and Output Rise Characteristic
$V_{in}=V_{in\ nom}$; Full Load



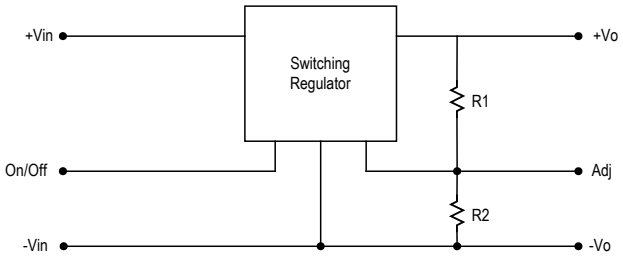
ON/OFF Voltage Start-Up and Output Rise Characteristic
$V_{in}=V_{in\ nom}$; Full Load



Derating Output Current Versus Ambient Temperature and Airflow
$V_{in}=V_{in\ nom}$

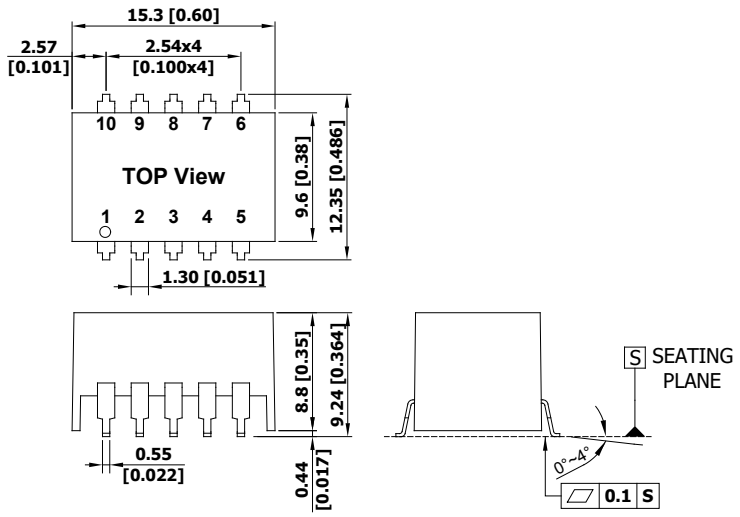
Adjustment Resistor Values

	M78SAR015-0.5		M78SAR018-0.5		M78SAR025-0.5		M78SAR033-0.5		M78SAR05-0.5		M78SAR065-0.5		M78SAR09-0.5		M78SAR12-0.5		M78SAR15-0.5	
Vout(nom.)	1.5VDC		1.8VDC		2.5VDC		3.3VDC		5.0VDC		6.5VDC		9.0VDC		12VDC		15VDC	
Vout(adj)	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
1.4 (V)	1 KΩ																	
1.5 (V)			3KΩ		200Ω													
1.8 (V)		6.49 KΩ			12KΩ													
2.5 (V)		0.47 KΩ		11.8KΩ														
3.0 (V)				4.64KΩ		44.2KΩ	88.4KΩ		17KΩ									
3.3 (V)									27KΩ		15KΩ							
3.6 (V)								60.4KΩ	42KΩ		21.5KΩ							
3.9 (V)								28KΩ	58KΩ		30.1KΩ							
4.5 (V)								11.3KΩ	180KΩ		56.3KΩ		26KΩ		17KΩ		10.5 KΩ	
4.9 (V)								7.15KΩ	850KΩ		78.7KΩ		36KΩ		24KΩ		15.8 KΩ	
5.0 (V)								6.34KΩ			86KΩ		39KΩ		26KΩ		17.4 KΩ	
5.1 (V)								5.9KΩ		231KΩ	97KΩ		42KΩ		28KΩ		18.7 KΩ	
5.5 (V)								3.9KΩ		56.2KΩ	154KΩ		56KΩ		36KΩ		24.9 KΩ	
6.5 (V)										14KΩ			112KΩ		63KΩ		42.2 KΩ	
8.0 (V)										2.32KΩ		22.6KΩ	400KΩ		125KΩ		78.7 KΩ	
9.0 (V)												9.53KΩ			200KΩ		113 KΩ	
10 (V)												3.92KΩ		54.9KΩ	345KΩ		160 KΩ	
11 (V)												825Ω		16.5KΩ	740KΩ		232 KΩ	
12 (V)														3.6KΩ			340 KΩ	
12.6 (V)														0Ω		180KΩ	464 KΩ	
13.5 (V)																57.6 KΩ	787 KΩ	
15.5 (V)																		300 KΩ

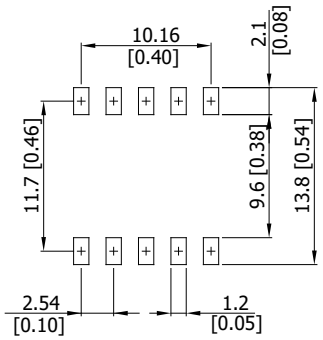


Package Specifications

Mechanical Dimensions



Connecting Pin Patterns



- All dimensions in mm (inches)
- Tolerance: X.X±0.5 (X.XX±0.02)
  X.XX±0.25 (X.XXX±0.01)
- Pins ±0.05(±0.002)

Pin Connections

Pin	Function
1	+Vin
2	+Vin
3	GND
4	+Vout
5	+Vout
6	Vadj.
7	GND
8	GND
9	GND
10	Remote On/Off

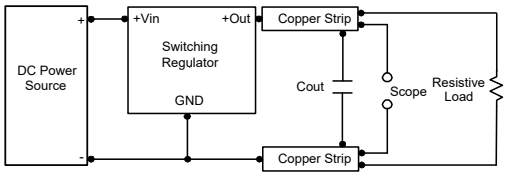
Physical Characteristics

Case Size	:	15.3x9.6x8.8mm (0.60x0.38x0.35 inches)
Case Material	:	Plastic resin (flammability to UL 94V-0 rated)
Pin Material	:	Phosphor Bronze
Weight	:	1.7g

Test Setup

Peak-to-Peak Output Noise Measurement Test

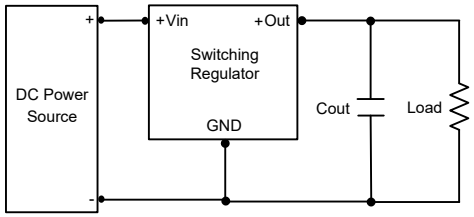
Use a Cout 0.47μF ceramic capacitor. Scope measurement should be made by using a BNC socket, measurement bandwidth is 0-20 MHz. Position the load between 50 mm and 75 mm from the DC-DC Converter.



Technical Notes

Output Ripple Reduction

A good quality low ESR capacitor placed as close as practicable across the load will give the best ripple and noise performance. To reduce output ripple, it is recommended to use 3.3μF capacitors at the output.

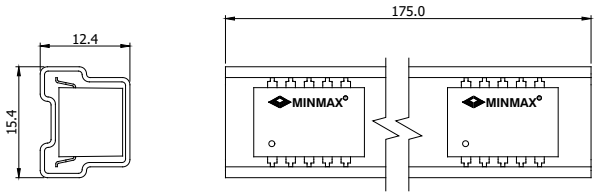


Maximum Capacitive Load

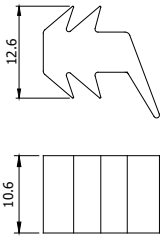
The M78SAR-0.5 series has limitation of maximum connected capacitance on the output. The power module may operate in current limiting mode during start-up, affecting the ramp-up and the startup time. The maximum capacitance can be found in the data sheet.

Packaging Information for Tube

Tube



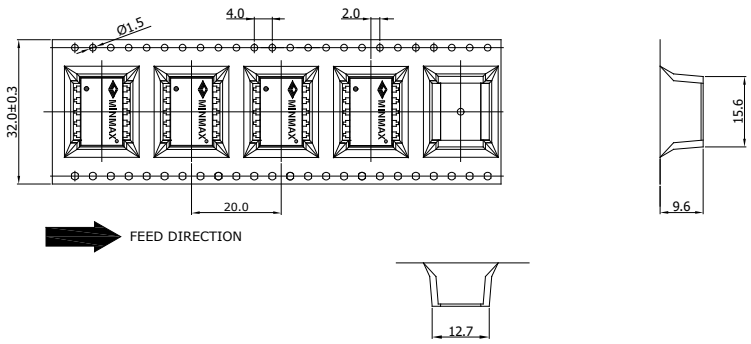
Plug



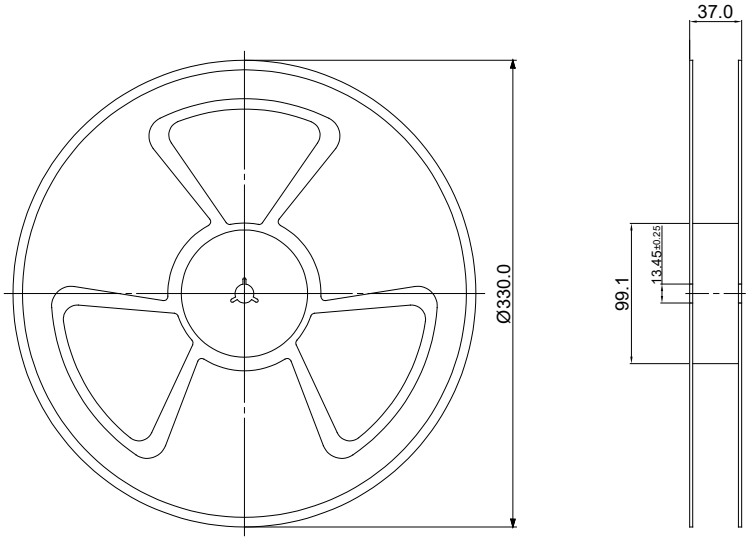
Unit: mm
10 PCS per TUBE

Packaging Information for Tape & Reel

Tape



Reel



Packaging Style	Quantity
With Heatsink Tube	N/A
Tape and Reel to IEC 286-3 Specifications	350

Soldering and Reflow Considerations

Profile	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average ramp-up rate(Ts max. To Tp)	3°C/second max.	3°C/second max.
Preheat · Temperature Min ($Ts_{min.}$) · Temperature Max ($Ts_{max.}$) · Time (Ts_{min} to Ts_{max}) (ts)	 100°C 150°C 60~120 seconds	 150°C 200°C 60~180 seconds
Time maintained above: · Temperature (T_L) · Time (t_L)	 183°C 60~150 seconds	 217°C 60~150 seconds
Peak Temperature (Tp)	See Table 4-1	See Table 4-2
Time within 5°C of actual Peak Temperature $(tp)^2$	10~30 seconds	20~40 seconds
Ramp-down Rate	6°C/second max.	6°C/second max.
Time 25°C to Peak Temperature	6 minutes max.	8 minutes max.

Note 1: All temperatures refer to topside of the package, measured on the package body surface.
Note 2: Time within 5°C of actual peak temperature (tp) specified for the reflow profiles is a "supplier" minimum and "user" maximum.

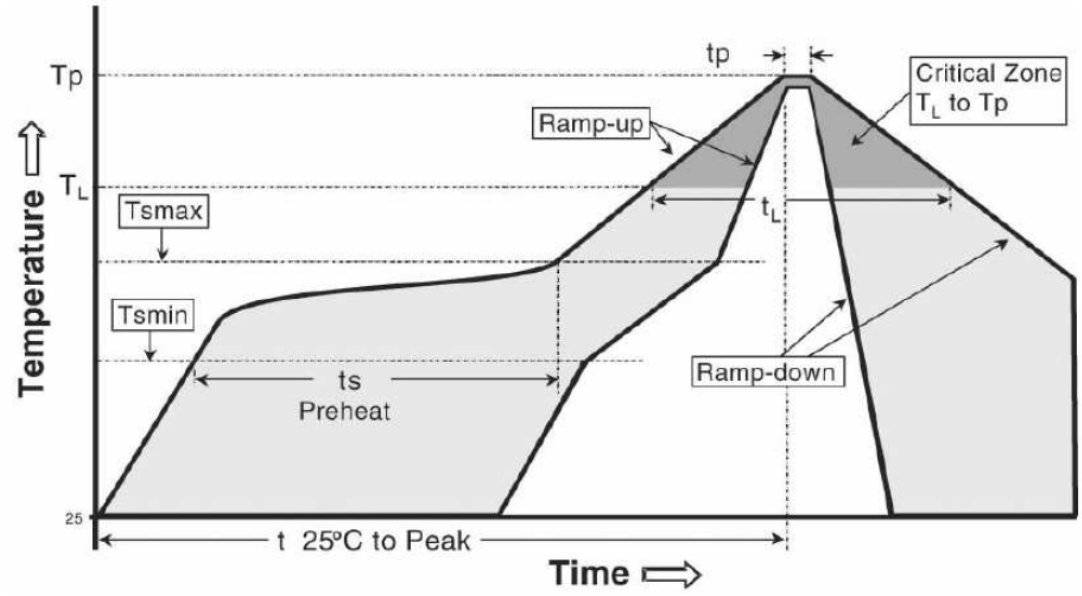


Table 4-1 SnPb Eutectic Process-Classification Temperatures (T_C)

	Volume mm^3	Volume mm^3
Package Thickness	<350	≥350
<2.5mm	235°C	220°C
≥2.5mm	220°C	220°C

Table 4-2 Pb-Free Process-Classification Temperatures (T_C)

	Volume mm^3	Volume mm^3	Volume mm^3
Package Thickness	<350	350-2000	>2000
<1.6mm	260°C	260°C	260°C
1.6mm-2.5mm	260°C	250°C	245°C
>2.5mm	250°C	245°C	245°C

Part Number Structure

M	78	SA	R	015	-	0.5
	Pin-out compatible With LM78xx Linear Regulator	Package Type SMD	Output Regulation Regulated	Output Voltage 015: 1.5 VDC 018: 1.8 VDC 025: 2.5 VDC 033: 3.3 VDC 05: 5 VDC 065: 6.5 VDC 09: 9 VDC 12: 12 VDC 15: 15 VDC		Output Current 0.5: 0.5 A

MTBF and Reliability

The MTBF of M78SAR-0.5 series of DC-DC converters has been calculated using

MIL-HDBK 217F NOTICE2, Operating Temperature 25°C, Ground Benign.

Model	MTBF	Unit
M78SAR015-0.5	2,114,508	Hours
M78SAR018-0.5	3,464,940	
M78SAR025-0.5	3,329,876	
M78SAR033-0.5	3,036,568	
M78SAR05-0.5	2,428,125	
M78SAR065-0.5	2,018,773	
M78SAR09-0.5	2,598,682	
M78SAR12-0.5	2,445,796	
M78SAR15-0.5	2,500,910	