



**MINMAX<sup>®</sup>**

MDHU100 Series

Electric Characteristic Note

# MDHU100 Series EC Note

DC-DC CONVERTER 2W, Reinforced Insulation, Medical Safety

## Features

- ▶ Industry Standard DIP-16 Package
- ▶ Unregulated Output Voltage
- ▶ I/O Isolation 4000VAC with Reinforced Insulation, rated for 300Vrms Working Voltage
- ▶ Low I/O Leakage Current < 2μA
- ▶ Operating Ambient Temp. Range -25°C to +80°C
- ▶ Medical EMC Standard with 4<sup>th</sup> Edition of EMI EN 55011 and EMS EN 60601-1-2 Approved
- ▶ Medical Safety with 1xMOPP & 2xMOOP per 3<sup>rd</sup> Edition of IEC/EN 60601-1 & ANSI/AAMI ES60601-1 Approved
- ▶ UL/cUL/IEC/EN 62368-1(60950-1) Safety Approval & CE Marking



## Applications

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

## Product Overview

The MINMAX MDHU100 series is a range of 2W DC-DC converter modules providing a high I/O isolation voltage of 4000 VAC with reinforced insulation, which rated for 300Vrms working voltage. The product comes in a small SMD-package. There are 15 models available with 5V, 12V or 24VDC input and single or dual output voltages. The MDHU100 DC-DC converters offer the best solution for many applications in instrumentation, industrial controls, medical equipment and everywhere where a certified supplementary- or reinforced insulation system is required to comply with requested safety standards.

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**Model Selection Guide**

Model Number	Input Voltage (Range)	Output Voltage	Output Current	Input Current		Load Regulation	Max. Capacitive Load	Efficiency (typ.)
			Max.	@Max. Load	@No Load			@Max. Load
	VDC	VDC	mA	mA (typ.)	mA (typ.)	% (max.)	μF	%
MDHU102	5 (4.5 ~ 5.5)	5	400	606	60	12	330	66
MDHU104		12	165	600		10		66
MDHU105		15	133	605		10		66
MDHU108		±12	±83	553		10	100#	72
MDHU109		±15	±66	542		10		73
MDHU112	12 (10.8 ~ 13.2)	5	400	253	30	12	330	66
MDHU114		12	165	250		10		66
MDHU115		15	133	252		10		66
MDHU118		±12	±83	224		10	100#	74
MDHU119		±15	±66	220		10		75
MDHU122	24 (21.6 ~ 26.4)	5	400	126	15	12	330	66
MDHU124		12	165	125		10		66
MDHU125		15	133	126		10		66
MDHU128		±12	±83	112		10	100#	74
MDHU129		±15	±66	110		10		75

# For each output

**Input Specifications**

Parameter	Model	Min.	Typ.	Max.	Unit
Input Voltage Range	5V Input Models	4.5	5	5.5	VDC
	12V Input Models	10.8	12	13.2	
	24V Input Models	21.6	24	26.4	
Input Surge Voltage (1 sec. max.)	5V Input Models	-0.7	---	9	VDC
	12V Input Models	-0.7	---	18	
	24V Input Models	-0.7	---	30	
Input Filter	All Models	Internal Capacitor			

**Output Specifications**

Parameter	Conditions	Min.	Typ.	Max.	Unit
Output Voltage Setting Accuracy		---	±2.0	±4.0	%Vnom.
Output Voltage Balance	Dual Output, Balanced Loads	---	±0.1	±1.0	%
Line Regulation	For Vin Change of 1%	---	±1.2	±1.5	%
Load Regulation	Io=20% to 100%	See Model Selection Guide			
Ripple & Noise	0-20 MHz Bandwidth	---	100	150	mV <sub>P-P</sub>
Temperature Coefficient		---	±0.01	±0.02	%/°C
Short Circuit Protection	0.5 Second Max., Automatic Recovery				

**Isolation, Safety Standards**

Parameter	Conditions	Min.	Typ.	Max.	Unit
I/O Isolation Voltage	60 Seconds	4000	---	---	VAC
	Reinforced insulation, rated for 300Vrms working voltage				
Leakage Current	240VAC, 60Hz	---	---	2	μA
I/O Isolation Resistance	500 VDC	10	---	---	GΩ
I/O Isolation Capacitance	100kHz, 1V	---	15	20	pF
Safety Standards	UL/cUL 60950-1, CSA C22.2 No. 60950-1				
	ANSI/AAMI ES 60601-1, CAN/CSA-C22.2 No. 60601-1				
	IEC/EN 60950-1, IEC/EN 60601-1 3 <sup>rd</sup> Edition 1xMOPP & 2xMOOP				
Safety Approvals	UL/cUL 60950-1 recognition (UL certificate), IEC/EN 60950-1 (CB-report)				
	UL/cUL 62368-1 recognition (UL certificate), IEC/EN 62368-1 (CB-report)				
	ANSI/AAMI ES 60601-1 1xMOPP & 2xMOOP recognition (UL certificate), IEC/EN 60601-1 3 <sup>rd</sup> Edition (CB-report)				

**General Specifications**

Parameter	Conditions	Min.	Typ.	Max.	Unit
Switching Frequency		50	80	100	kHz
MTBF (calculated)	MIL-HDBK-217F@25°C, Ground Benign	2,000,000	---	---	Hours

**Environmental Specifications**

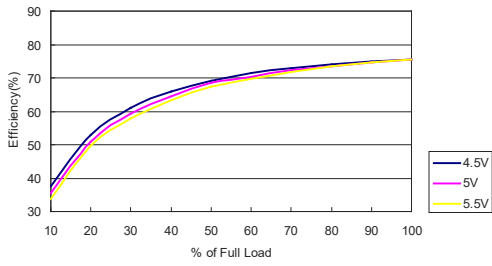
Parameter	Min.	Max.	Unit
Operating Ambient Temperature Range (See Power Derating Curve)	-25	+80	°C
Case Temperature	---	+105	°C
Storage Temperature Range	-50	+125	°C
Humidity (non condensing)	---	95	% rel. H
Lead Temperature (1.5mm from case for 10Sec.)	---	260	°C

**Notes**

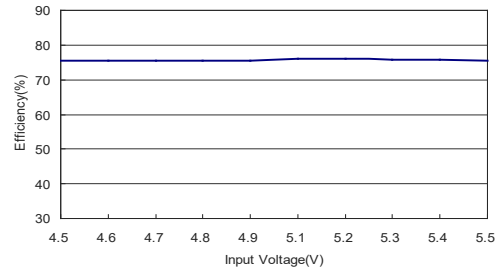
- 1 Specifications typical at Ta=+25°C, resistive load, nominal input voltage and rated output current unless otherwise noted.
- 2 These power converters require a minimum output loading to maintain specified regulation, operation under no-load conditions will not damage these modules; however they may not meet all specifications listed.
- 3 We recommend to protect the converter by a slow blow fuse in the input supply line.
- 4 Other input and output voltage may be available, please contact MINMAX.
- 5 Specifications are subject to change without notice.
- 6 The repeated high voltage isolation testing of the converter can degrade isolation capability, to a lesser or greater degree depending on materials, construction, environment and and reflow solder process. Any material is susceptible to eventual chemical degradation when subject to very high applied voltages thus implying that the number of tests should be strictly limited. We therefore strongly advise against repeated high voltage isolation testing, but if it is absolutely required, that the voltage be reduced by 20% from specified test voltage. Furthermore, the high voltage isolation capability after reflow solder process should be evaluated as it is applied on system.

**Characteristic Curves**

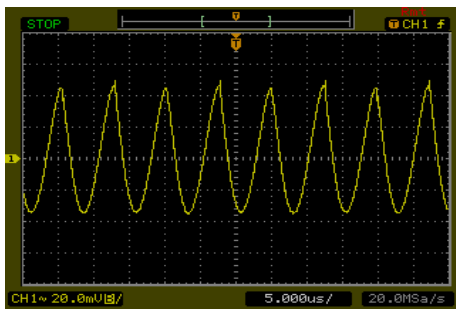
All test conditions are at 25°C The figures are identical for MDHU102



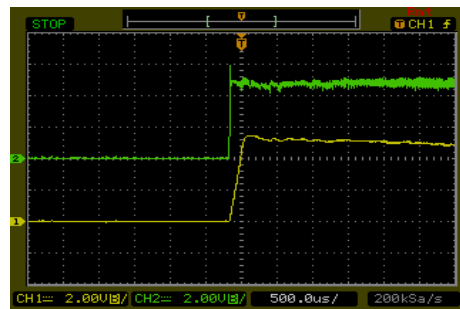
Efficiency Versus Output Current



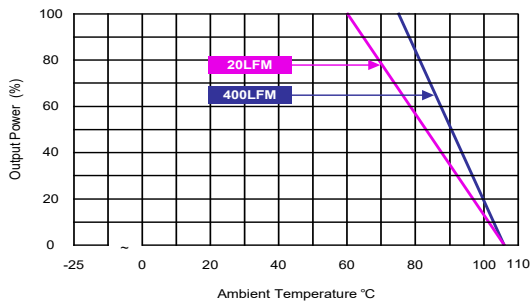
Efficiency Versus Input Voltage Full Load



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



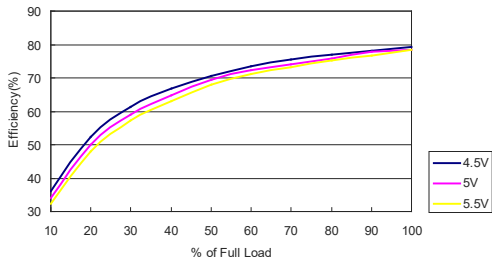
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



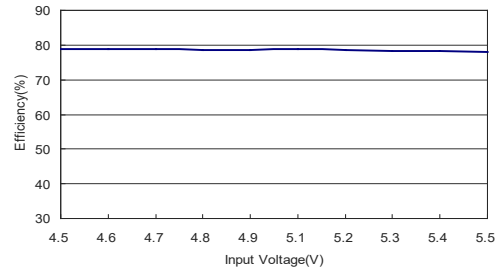
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

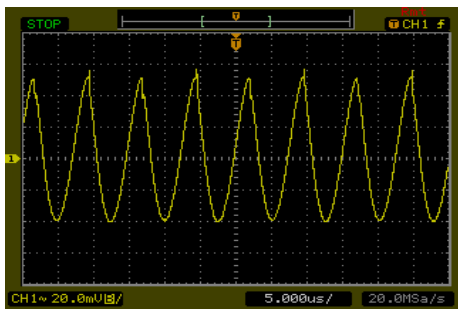
All test conditions are at 25°C The figures are identical for MDHU104



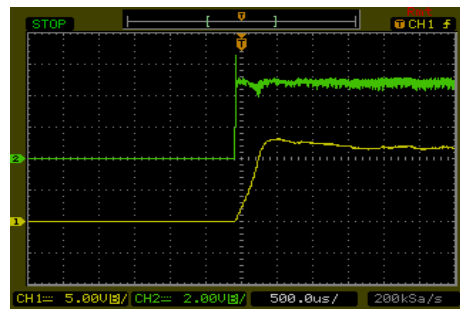
Efficiency Versus Output Current



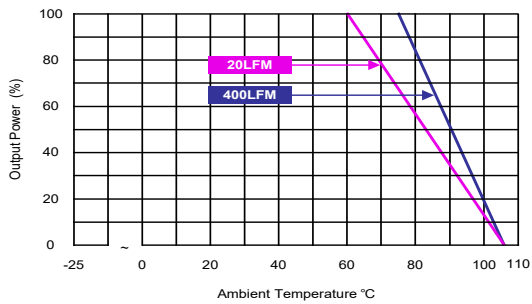
Efficiency Versus Input Voltage Full Load



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



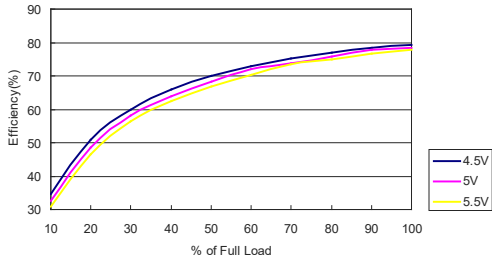
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



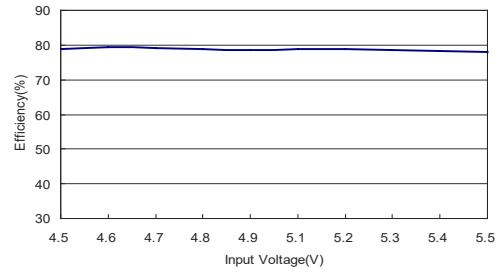
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

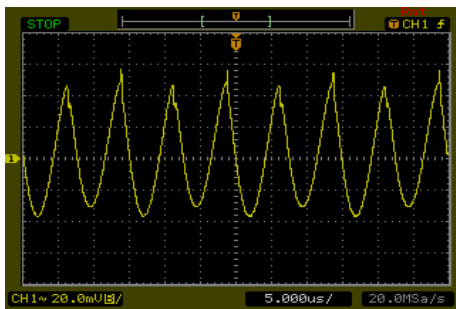
All test conditions are at 25°C The figures are identical for MDHU105



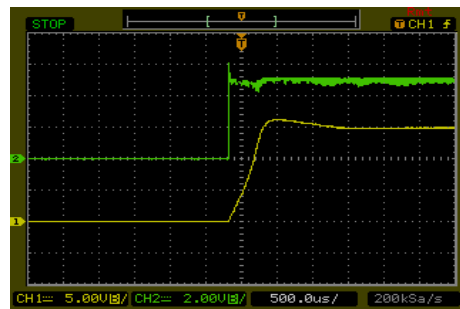
Efficiency Versus Output Current



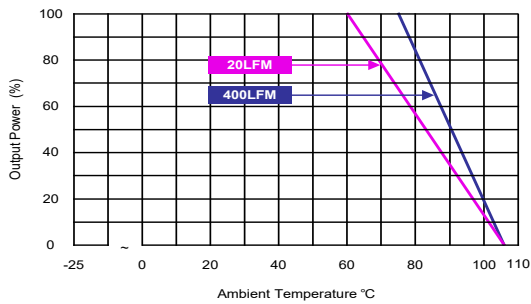
Efficiency Versus Input Voltage Full Load



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



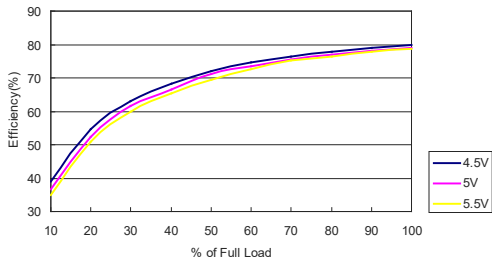
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



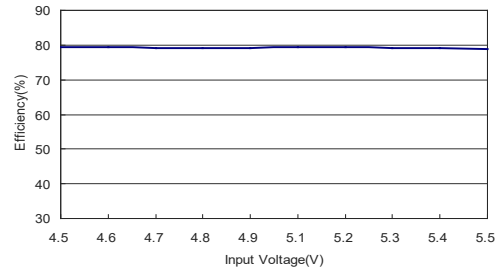
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

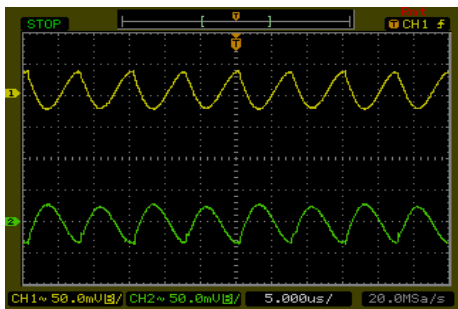
All test conditions are at 25°C The figures are identical for MDHU108



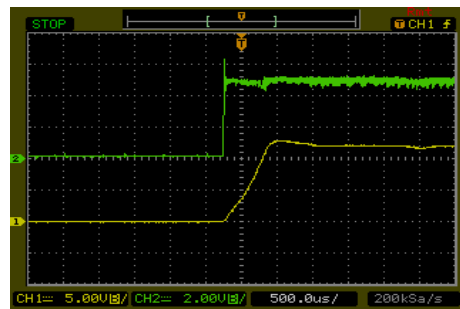
Efficiency Versus Output Current



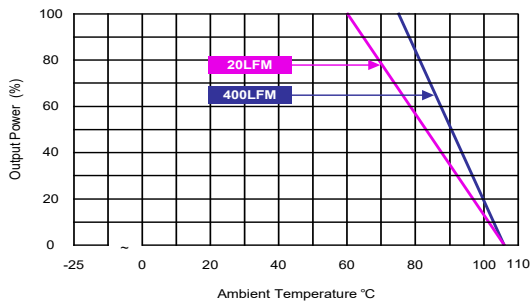
Efficiency Versus Input Voltage Full Load



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



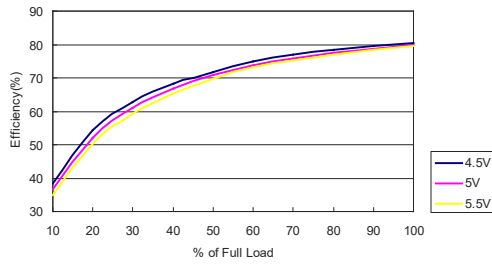
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



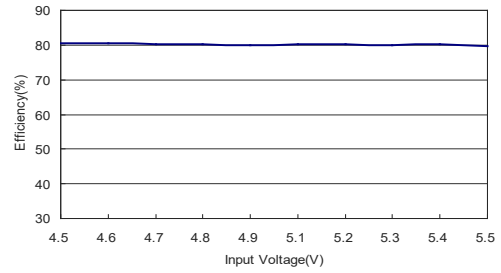
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

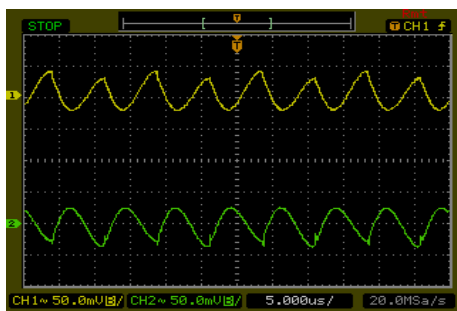
All test conditions are at 25°C The figures are identical for MDHU109



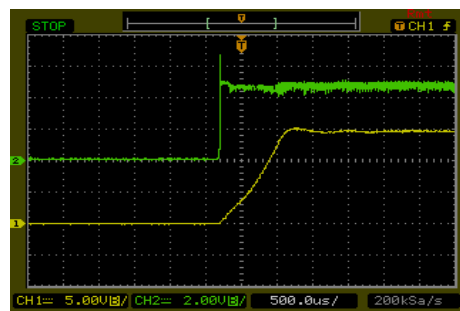
Efficiency Versus Output Current



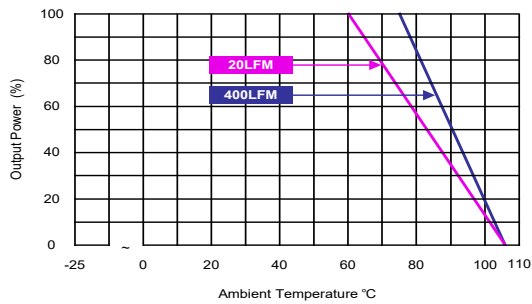
Efficiency Versus Input Voltage Full Load



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



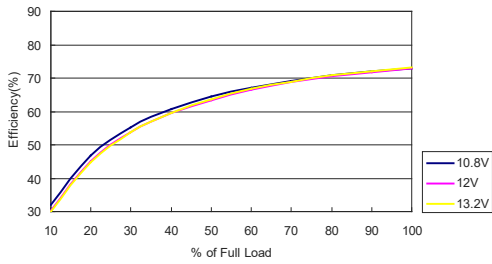
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



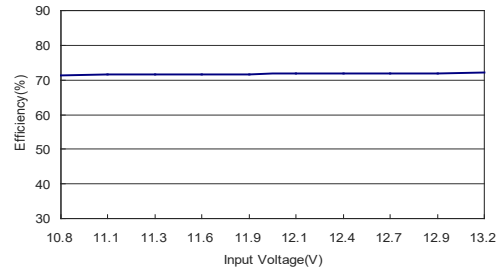
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

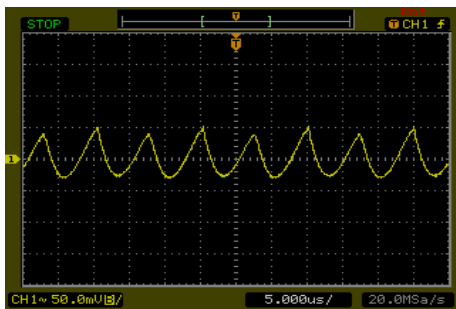
All test conditions are at 25°C The figures are identical for MDHU112



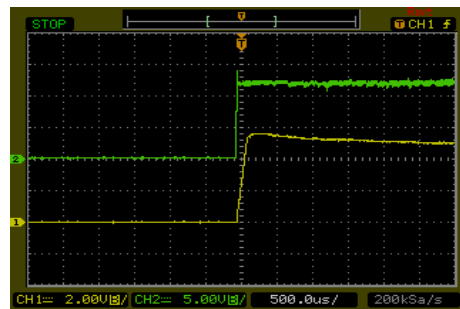
Efficiency Versus Output Current



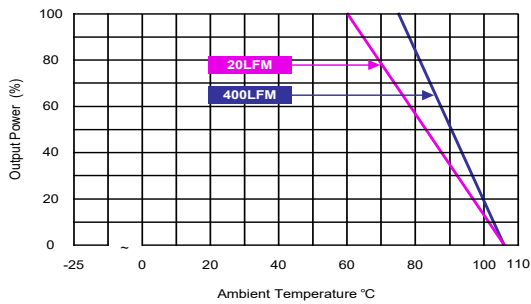
Efficiency Versus Input Voltage Full Load



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



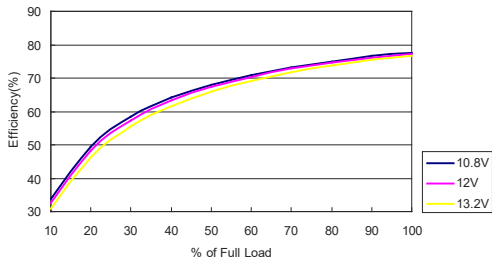
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



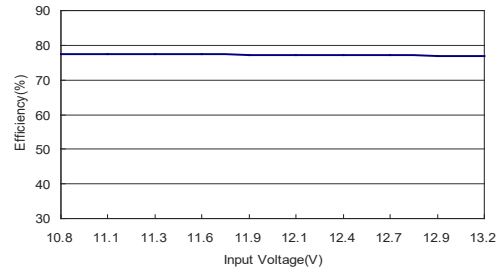
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

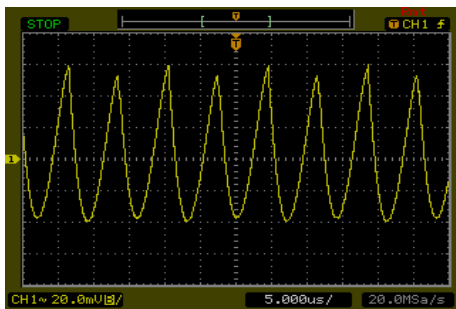
All test conditions are at 25°C The figures are identical for MDHU114



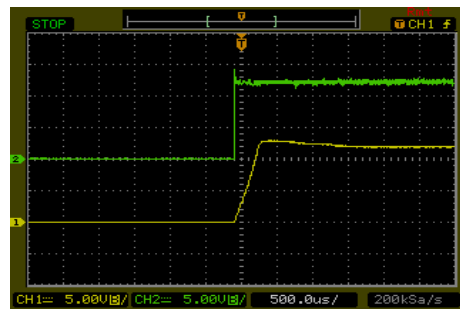
Efficiency Versus Output Current



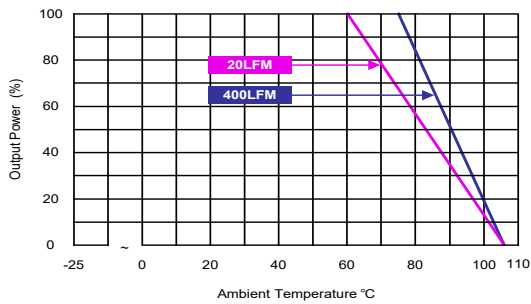
Efficiency Versus Input Voltage Full Load



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



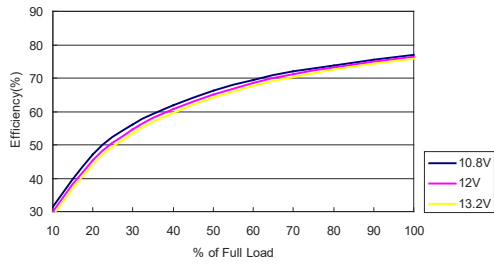
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



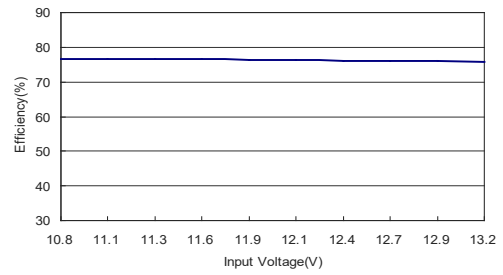
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

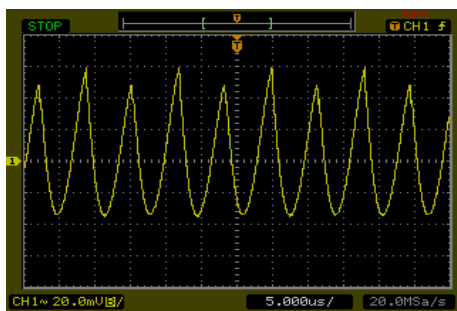
All test conditions are at 25°C The figures are identical for MDHU115



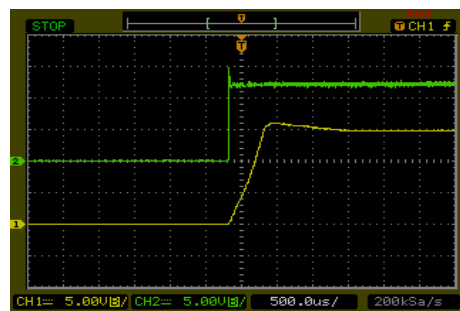
Efficiency Versus Output Current



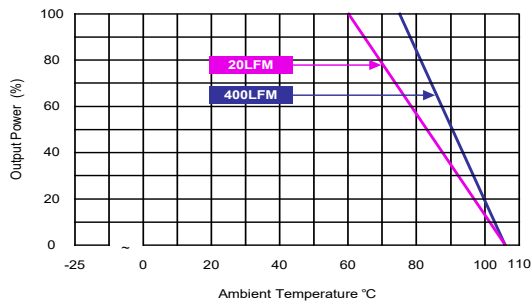
Efficiency Versus Input Voltage Full Load



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



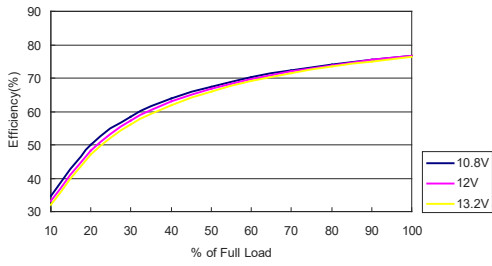
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



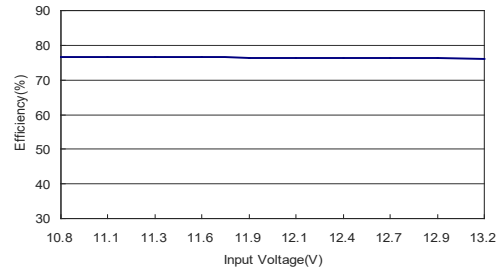
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

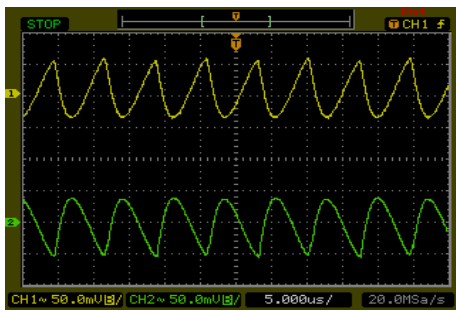
All test conditions are at 25°C The figures are identical for MDHU118



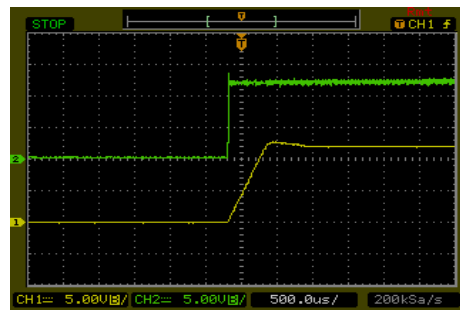
Efficiency Versus Output Current



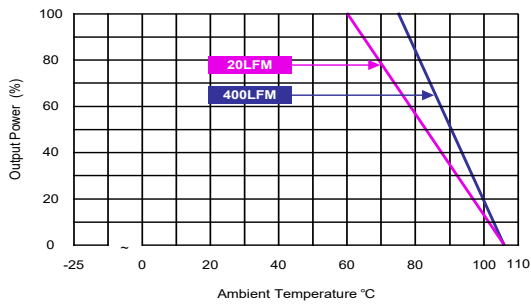
Efficiency Versus Input Voltage Full Load



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



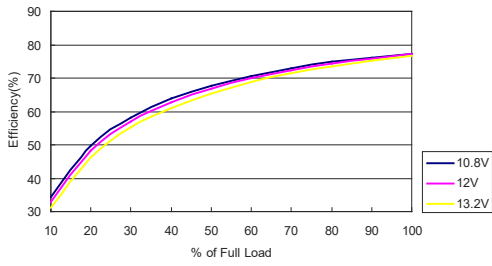
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



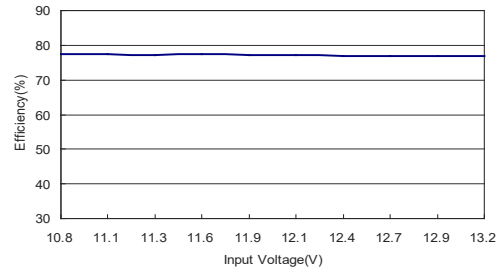
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

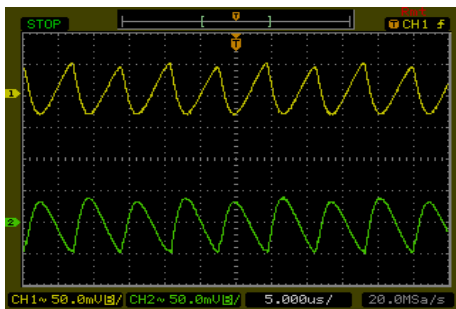
All test conditions are at 25°C The figures are identical for MDHU119



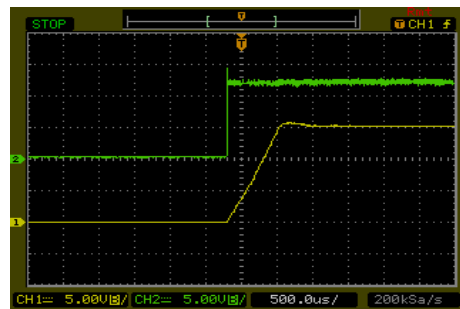
Efficiency Versus Output Current



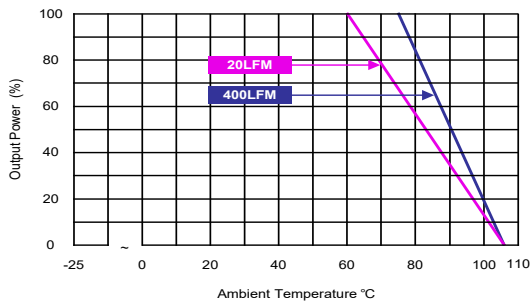
Efficiency Versus Input Voltage Full Load



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



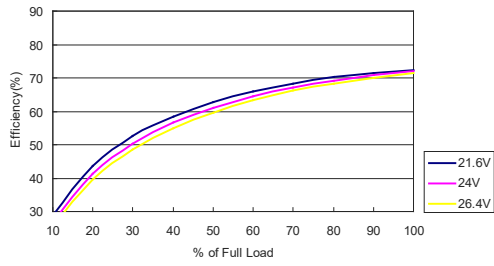
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



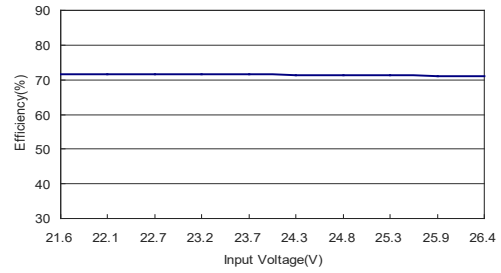
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

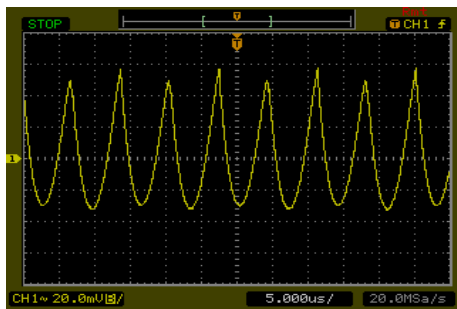
All test conditions are at 25°C The figures are identical for MDHU122



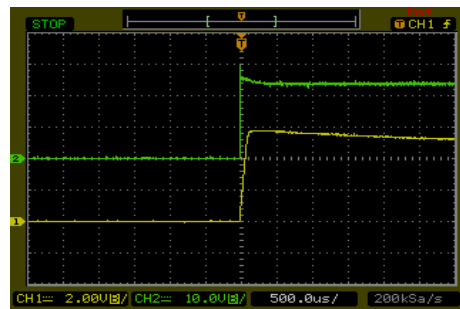
Efficiency Versus Output Current



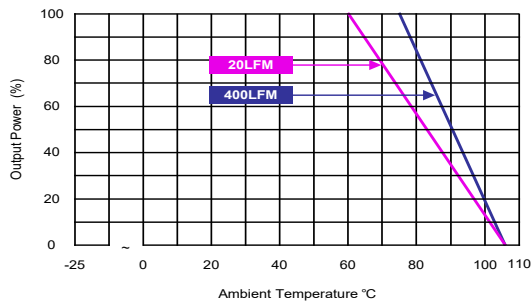
Efficiency Versus Input Voltage Full Load



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



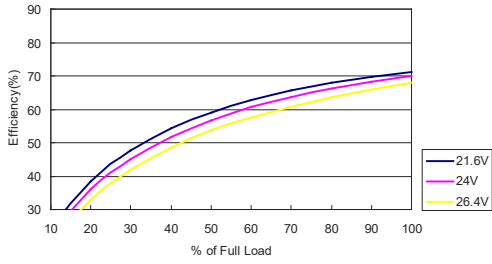
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



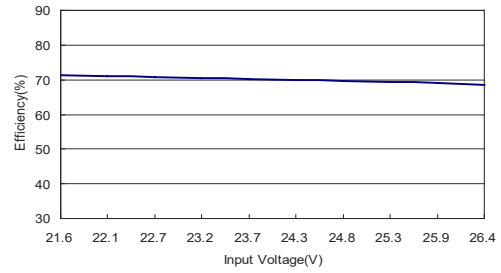
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

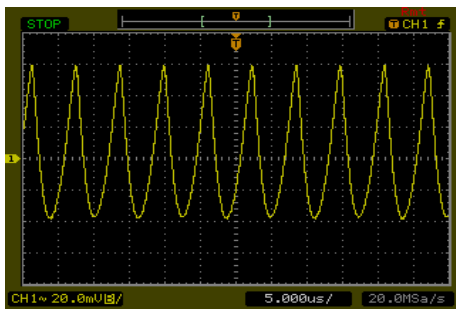
All test conditions are at 25°C The figures are identical for MDHU124



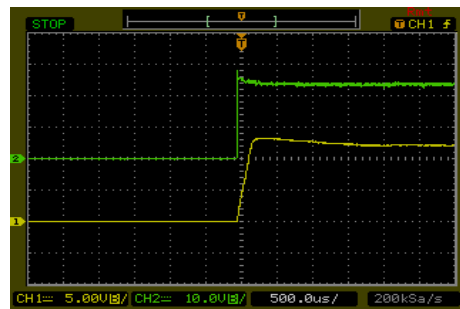
Efficiency Versus Output Current



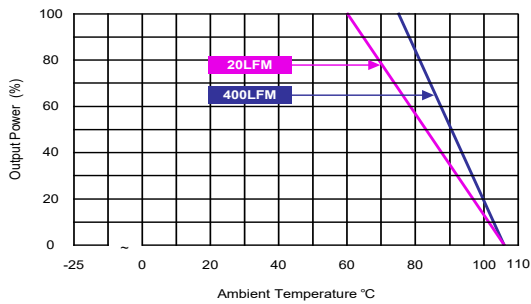
Efficiency Versus Input Voltage Full Load



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



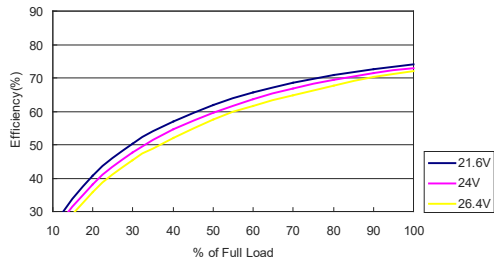
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



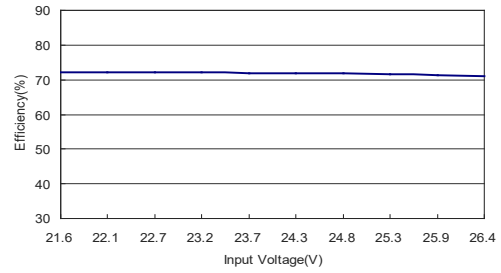
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

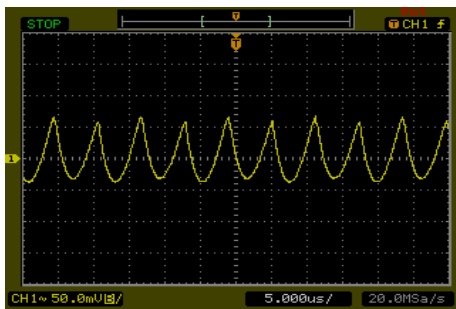
All test conditions are at 25°C The figures are identical for MDHU125



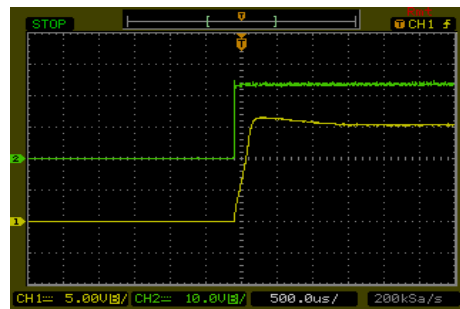
Efficiency Versus Output Current



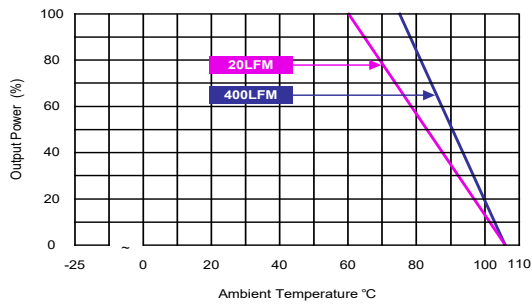
Efficiency Versus Input Voltage Full Load



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



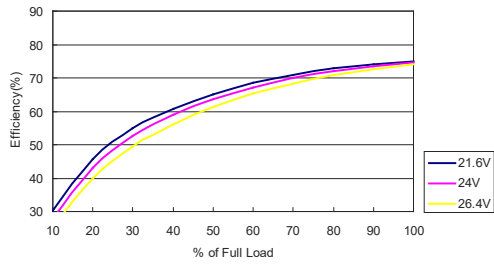
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



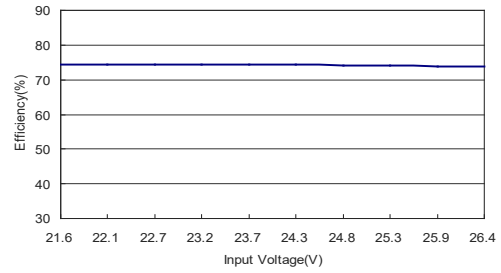
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

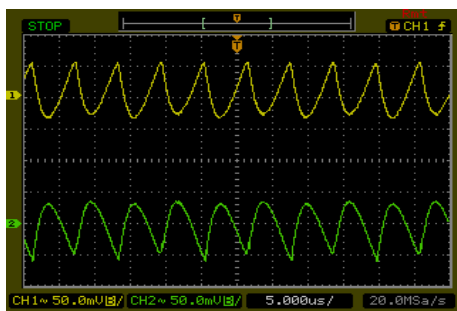
All test conditions are at 25°C The figures are identical for MDHU128



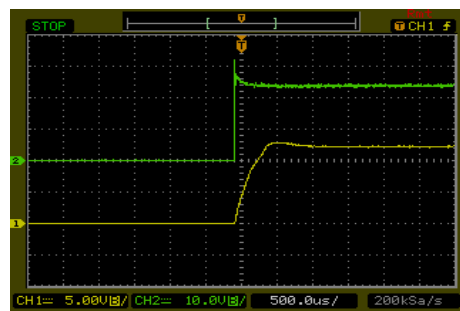
Efficiency Versus Output Current



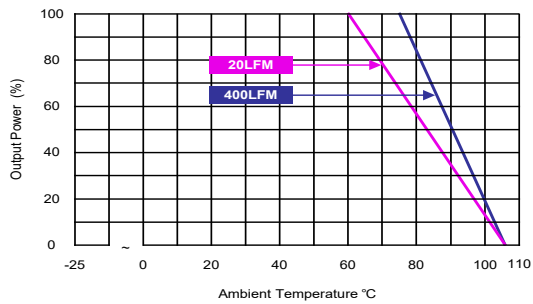
Efficiency Versus Input Voltage Full Load



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



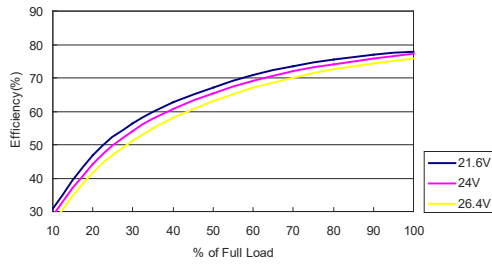
Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



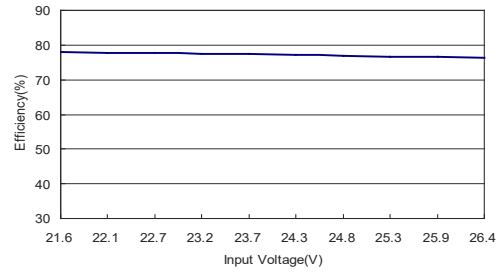
Derating Output Current Versus Ambient Temperature and Airflow  
 $V_{in}=V_{in\ nom}$

**Characteristic Curves**

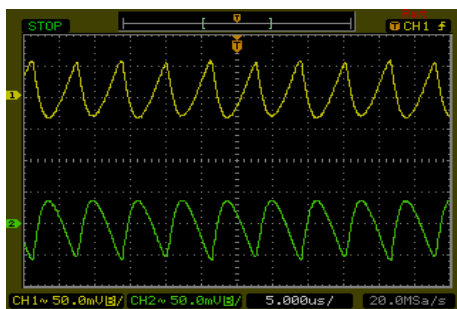
All test conditions are at 25°C The figures are identical for MDHU129



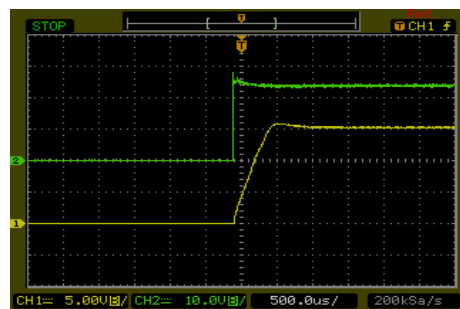
Efficiency Versus Output Current



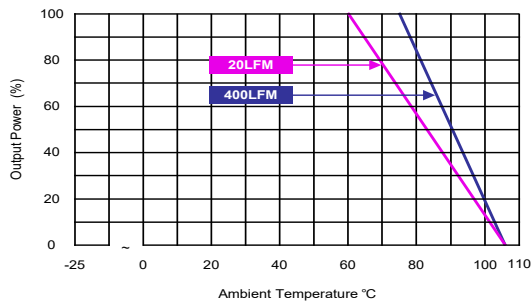
Efficiency Versus Input Voltage Full Load



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

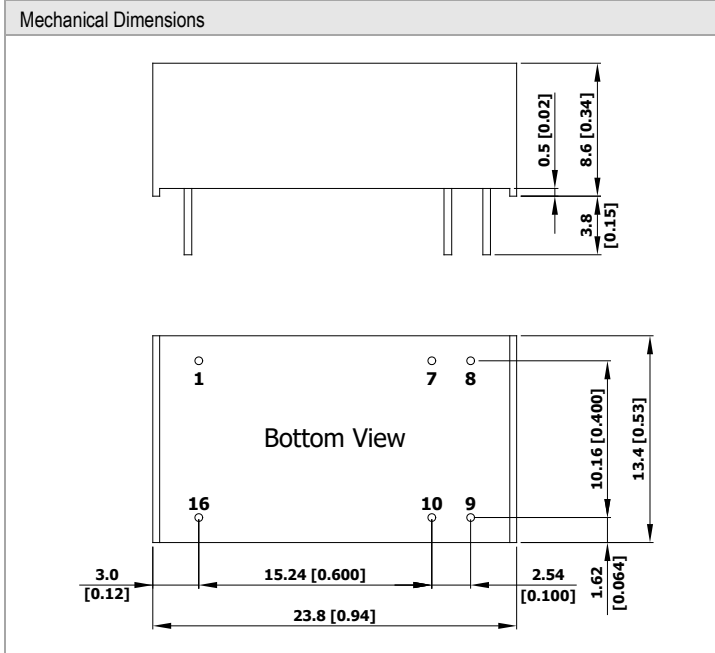


Typical Input Start-Up and Output Rise Characteristic  
 $V_{in}=V_{in\ nom}$ ; Full Load



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

### Package Specifications



Pin Connections

Pin	Single Output	Dual Output	Diameter mm (inches)
1	-Vin	-Vin	∅ 0.5 [0.02]
7	NC	NC	∅ 0.5 [0.02]
8	NC	Common	∅ 0.5 [0.02]
9	+Vout	+Vout	∅ 0.5 [0.02]
10	-Vout	-Vout	∅ 0.5 [0.02]
16	+Vin	+Vin	∅ 0.5 [0.02]

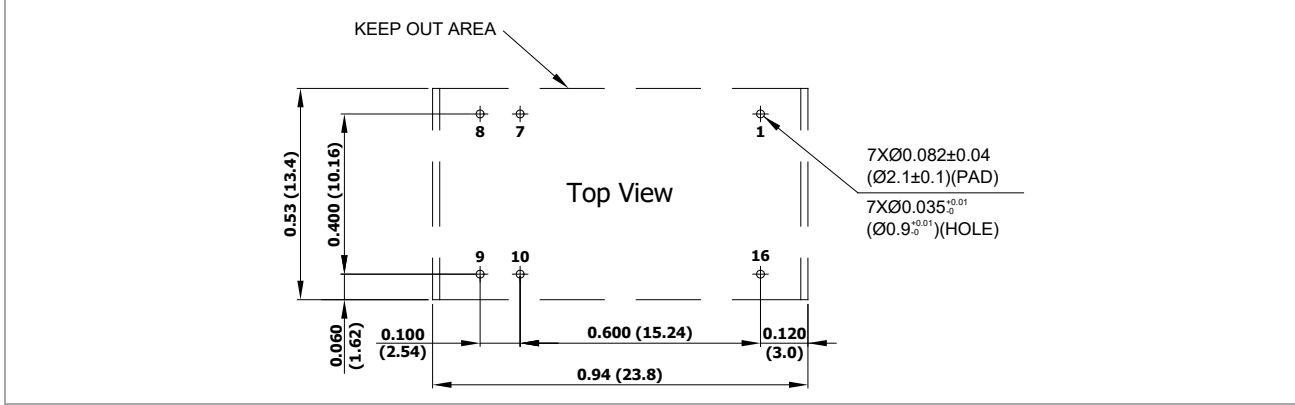
NC: No Connection

- ▶ All dimensions in mm (inches)
- ▶ Tolerance: X.X±0.25 (X.XX±0.01)  
X.XX±0.13 (X.XXX±0.005)
- ▶ Pin diameter tolerance: X.X±0.05 (X.XX±0.002)

### Physical Characteristics

Case Size	: 23.8x13.4x8.6mm (0.94x0.53x0.34 inches)
Case Material	: Plastic resin (flammability to UL 94V-0 rated)
Pin Material	: Phosphor Bronze
Weight	: 5.1g

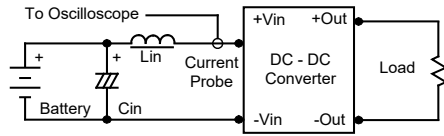
### Recommended Pad Layout for Single & Dual Output Converter



### Test Setup

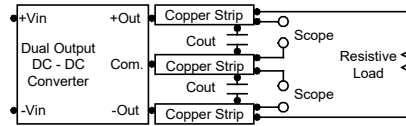
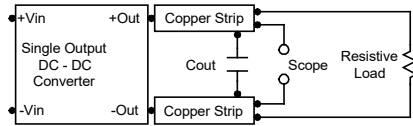
#### Input Reflected-Ripple Current Test Setup

Input reflected-ripple current is measured with an inductor  $L_{in}$  (4.7 $\mu$ H) and  $C_{in}$  (220 $\mu$ F, ESR < 1.0 $\Omega$  at 100 kHz) to simulate source impedance. Capacitor  $C_{in}$  offsets possible battery impedance. Current ripple is measured at the input terminals of the module, measurement bandwidth is 0-500 kHz.



#### Peak-to-Peak Output Noise Measurement Test

Use a  $C_{out}$  0.47 $\mu$ F 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.



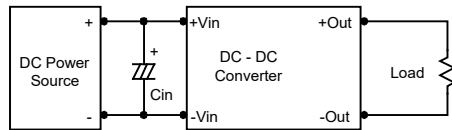
### Technical Notes

#### Maximum Capacitive Load

The MDHU100 series has limitation of maximum connected capacitance at the output. The power module may be operated in current limiting mode during start-up, affecting the ramp-up and the startup time. For optimum performance we recommend 100 $\mu$ F maximum capacitive load for dual outputs and 330 $\mu$ F capacitive load for single outputs. The maximum capacitance can be found in the data sheet.

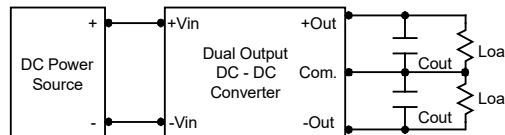
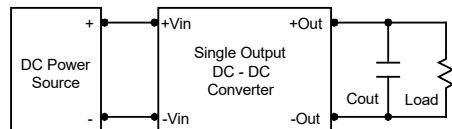
#### Input Source Impedance

The power module should be connected to a low ac-impedance input source. Highly inductive source impedances can affect the stability of the power module. In applications where power is supplied over long lines and output loading is high, it may be necessary to use a capacitor at the input to ensure startup. Capacitor mounted close to the power module helps ensure stability of the unit, it is recommended to use a good quality low Equivalent Series Resistance (ESR < 1.0 $\Omega$  at 100 kHz) capacitor of a 2.2 $\mu$ F for the 5V input devices, a 1.0 $\mu$ F for the 12V input devices and a 0.47 $\mu$ F for the 24V input devices.



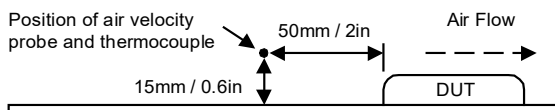
#### Output Ripple Reduction

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 3.3 $\mu$ F capacitors at the output.

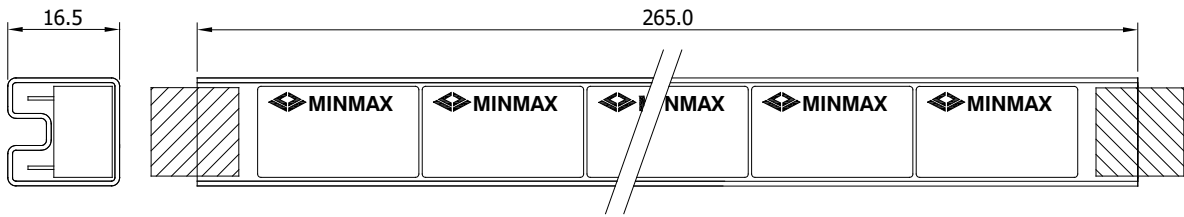


#### Thermal Considerations

Many conditions affect the thermal performance of the power module, such as orientation, airflow over the module and board spacing. To avoid exceeding the maximum temperature rating of the components inside the power module, the case temperature must be kept below 105°C. The derating curves are determined from measurements obtained in a test setup.



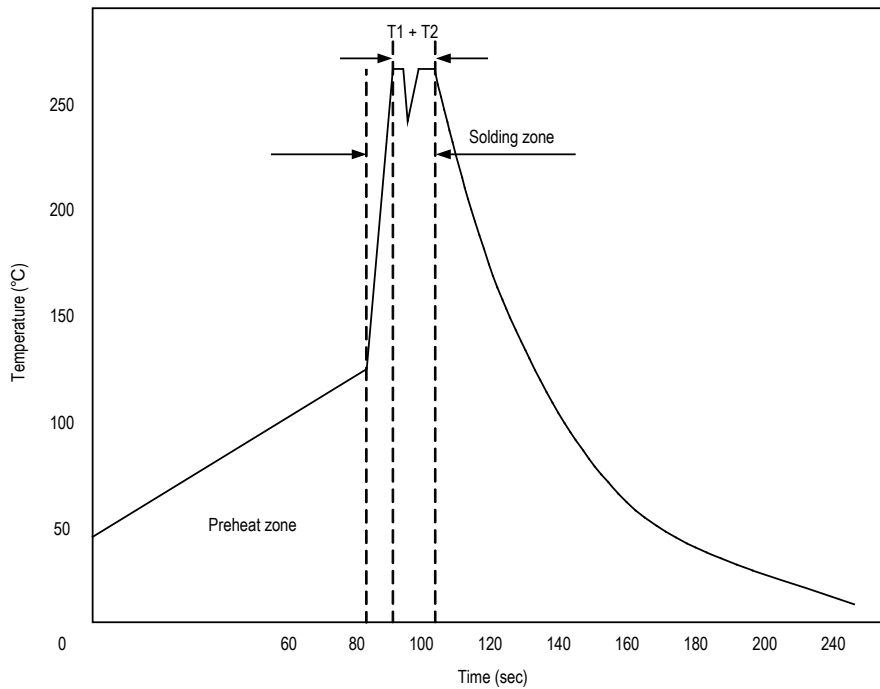
**Packaging Information**



Unit: mm  
10 PCS per TUBE

**Wave Soldering Considerations**

Lead free wave solder profile



Zone	Reference Parameter
Preheat	Rise temp. speed : 3°C/sec max.
zone	Preheat temp. : 100~130°C
Actual	Peak temp. : 250~260°C
heating	Peak time(T1+T2) : 4~6 sec

**Hand Welding Parameter**

Reference Solder: Sn-Ag-Cu : Sn-Cu : Sn-Ag

Hand Welding: Soldering iron : Power 60W

Welding Time: 2~4 sec

Temp.: 380~400°C

Part Number Structure																																
M	D	H	U	10	2																											
<table border="1"> <tr> <td>Package Type DIP-16</td> </tr> </table>		Package Type DIP-16	<table border="1"> <tr> <td>I/O Isolation Voltage 4000 VAC</td> </tr> </table>		I/O Isolation Voltage 4000 VAC	<table border="1"> <tr> <td>Output Regulation Unregulated</td> </tr> </table>		Output Regulation Unregulated	<table border="1"> <tr> <td colspan="2">Input Voltage Range</td> </tr> <tr> <td>10:</td> <td>4.5 ~ 5.5 VDC</td> </tr> <tr> <td>11:</td> <td>10.8 ~ 13.2 VDC</td> </tr> <tr> <td>12:</td> <td>21.6 ~ 26.4 VDC</td> </tr> </table>		Input Voltage Range		10:	4.5 ~ 5.5 VDC	11:	10.8 ~ 13.2 VDC	12:	21.6 ~ 26.4 VDC	<table border="1"> <tr> <td colspan="2">Output Voltage</td> </tr> <tr> <td>2:</td> <td>5 VDC</td> </tr> <tr> <td>4:</td> <td>12 VDC</td> </tr> <tr> <td>5:</td> <td>15 VDC</td> </tr> <tr> <td>8:</td> <td>±12 VDC</td> </tr> <tr> <td>9:</td> <td>±15 VDC</td> </tr> </table>		Output Voltage		2:	5 VDC	4:	12 VDC	5:	15 VDC	8:	±12 VDC	9:	±15 VDC
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MTBF and Reliability		
The MTBF of MDHU100 series of DC-DC converters has been calculated using MIL-HDBK 217F NOTICE2, Operating Temperature 25°C, Ground Benign.		
Model	MTBF	Unit
MDHU102	3,297,610	Hours
MDHU104	3,368,421	
MDHU105	3,368,421	
MDHU108	3,194,888	
MDHU109	3,202,562	
MDHU112	3,395,586	
MDHU114	3,488,879	
MDHU115	3,488,879	
MDHU118	3,399,915	
MDHU119	3,399,915	
MDHU122	3,344,482	
MDHU124	3,499,562	
MDHU125	3,499,562	
MDHU128	3,154,574	
MDHU129	3,154,574	