TOS Series

Application Note

DC/DC Point-of-Load (POL) Converter
Input: 2.4 to 5.5Vdc or 8.3 to 14Vdc, Output: Vout = 0.75 to 3.3Vdc or 0.75 to 5.0Vdc, I_{out} = 6A, 10A or 16A

Application Note for 30A Models see:
http://www.tracopower.com/products/tos30-application.pdf

Features

- RoHS directive compatible
- High efficiency - up to 94%
- SMD & SIP packages
- Low profile:
  - TOS 06-xxSM: 20.3x11.4x6.55mm (0.8x0.45x0.258 inch)
  - TOS 06-xxSIL: 22.9x10.4x6.10mm (0.9x0.40x0.240 inch)
  - TOS 10-xxSM: 33.0x13.5x7.75mm (1.3x0.53x0.305 inch)
  - TOS 10-xxSIL: 50.8x12.7x7.30mm (2.0x0.50x0.287 inch)
  - TOS 16-xxSM: 33.0x13.5x7.75mm (1.3x0.53x0.305 inch)
  - TOS 16-xxSIL: 50.8x12.7x7.30mm (2.0x0.50x0.287 inch)
- Output voltage adjustable from 0.75Vdc to 3.3Vdc or from 0.75Vdc to 5.0Vdc via external resistor
- Delivers up to 6A (TOS 06), 10A (TOS 10) or 16A (TOS 16)
- No minimum load
- Low output ripple and noise
- Fixed switching frequency (300KHz)
- Remote ON/OFF
- Input under-voltage lockout
- Output over-current protection
- Over temperature protection
- Cost – efficient open frame design
- ISO 9001 certified manufacturing facilities
- UL 60950-1 and CB pending

Option

- Negative remote ON/OFF

Applications

- Intermediate Bus architecture
- Workstations and Servers
- Distributed power architecture
- Telecommunications equipment
- LANs/WANs
- Enterprise Networks
- Latest generation IC's (DSP, FPGA, ASIC) and Microprocessor powered applications

Complete TOS datasheet can be downloaded at: http://www.tracopower.com/products/tos.pdf

General Description

TOS xx-xxSM (SMD package) and TOS xx-xxSIL (SIP package) are non-isolated DC/DC Point-of-Load converters that can deliver up to 6A (TOS 06-xxyyy), 10A (TOS 10-xxyyy) or 16A (TOS 16-xxyyy) of output current with an efficiency of up to 94% at 3.3V output voltage. These modules provide precisely regulated output voltage adjustable via external resistor between 0.75Vdc and 3.3Vdc (TOS xx-05yyy) or 0.75Vdc and 5.0Vdc (TOS xx-12yyy) over a wide input voltage range between V_{in} = 2.4 and 5.5Vdc (TOS xx-05yyy) or 8.3Vdc and 14.0Vdc (TOS xx-12yyy). Their open frame construction and small footprint enable designers to develop cost- and space-efficient solutions.

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ABSOLUTE MAXIMUM RATINGS				
Parameter	Device	Min	Max	Unit
Input Voltage (Continuous)	TOS xx-05yyy TOS xx-12yyy	-0.3 -0.3	5.8 15.0	Vdc
Operating Ambient Temperature [T_A]	All	-40	85	°C
Storage Temperature	All	-55	125	°C

OUTPUT SPECIFICATIONS					
Parameter	Device	Min	Typ	Max	Unit
Operating Output Voltage Range (Selected via an external resistor)	TOS xx-05 TOS xx-12	0.75 0.75		3.3 5.0	Vdc
Voltage Accuracy ($V_{IN} = V_{IN\,nom}$; $I_{out} = I_{out\,max}$; $T_A = 25°C$)	All	-2		+2	% Vout set
Output Regulation Line (**VIN min** to **VIN max** at Full Load) Load (0% to 100% of Full Load)	 All All		 0.3 0.4		 % Vout set % Vout set
Output Ripple & Noise ($V_{IN} = V_{IN\,nom}$; $I_{out} = I_{out\,max}$; $T_A = 25°C$) Cout = 1µF Ceramic // 10µF Tantalum capacitor RMS (5Hz to 20MHz bandwidth) Peak-to-Peak (5Hz to 20MHz bandwidth)	 TOS 10-12 and TOS 16-12			 30 75	 mV rms mV pk-pk
RMS (5Hz to 20MHz bandwidth) Peak-to-Peak (5Hz to 20MHz bandwidth)	All other TOS xx-xx			20 50	mV rms mV pk-pk
Temperature Coefficient	All		0.4		% Vout set
Output Voltage Overshoot (V_{IN} = 2.4 ~ 5.5V; $I_{out} = I_{out\,max}$; $T_A = 25°C$) (V_{IN} = 8.3 ~ 14.0V; $I_{out} = I_{out\,max}$; $T_A = 25°C$)	 TOS xx-05 TOS xx-12			 1	 % Vout set
External Capacitance ESR ≧ 1mΩ ESR ≧ 10mΩ	TOS 06-05			 1000 3000	 µF µF
ESR ≧ 1mΩ ESR ≧ 10mΩ	All other TOS xx-xx			1000 5000	µF µF
Output Current	TOS 06-xx TOS 10-xx TOS 16-xx	0 0 0		6 10 16	Adc
Output Over Current Protection (Hiccup Mode)	TOS 06-05 TOS xx-12 TOS 16-05 TOS 16-12		220 200 180 180		% Iout
Output Short-Circuit Current (Vout ≦ 250mV) (Hiccup Mode)	TOS 06-xx TOS 10-xx TOS 16-xx		2.0 3.0 3.5		Adc
Dynamic Load Response (∆Iout / ∆t = 2.5A/µs; $V_{IN} = V_{IN\,nom}$; $T_A = 25°C$) Load change from 50% to 100% or 100% to 50% of $I_{out\,max}$ Cout = 1µF Ceramic // 10µF Tantalum capacitor Peak Deviation Setting Time (Vout < 10% peak deviation)	 TOS 06-05 TOS 06-05		 130 25		 mV µs
(∆Iout / ∆t = 2.5A/µs; $V_{IN} = V_{IN\,nom}$; $T_A = 25°C$) Load change from 50% to 100% or 100% to 50% of $I_{out\,max}$ Cout = 1µF Ceramic // 10µF Tantalum capacitor Peak Deviation Setting Time (Vout < 10% peak deviation)	TOS 16-05 TOS 16-05		300 25		mV µs
(∆Iout / ∆t = 2.5A/µs; $V_{IN} = V_{IN\,nom}$; $T_A = 25°C$) Load change from 50% to 100% or 100% to 50% of $I_{out\,max}$ Cout = 1µF Ceramic // 10µF Tantalum capacitor Peak Deviation Setting Time (Vout < 10% peak deviation)	All other TOS xx-xx All other TOS xx-xx		200 25		mV µs

OUTPUT SPECIFICATIONS					
Parameter	Device	Min	Typ	Max	Unit
Dynamic Load Response (ΔIout / Δt = 2.5A/µs; $V_{IN} = V_{IN\,nom}$; T_A = 25°C) Load change from 50% to 100% or 100% to 50% of $I_{out\,max}$ Cout = 2 x 150µF polymer capacitors Peak Deviation	TOS 06-xx		50		mV
Setting Time (Vo < 10% peak deviation)	TOS 06-xx		50		µs
(ΔIout / Δt = 2.5A/µs; $V_{IN} = V_{IN\,nom}$; T_A = 25°C) Load change from 50% to 100% or 100% to 50% of $I_{out\,max}$ Cout = 2 x 150µF polymer capacitors Peak Deviation	TOS 10-xx		100		mV
Setting Time (Vo < 10% peak deviation)	TOS 10-xx		50		µs
(ΔIout / Δt = 2.5A/µs; $V_{IN} = V_{IN\,nom}$; T_A = 25°C) Load change from 50% to 100% or 100% to 50% of $I_{out\,max}$ Cout = 2 x 150µF polymer capacitors Peak Deviation	TOS 16-xx		150		mV
Setting Time (Vo < 10% peak deviation)	TOS 16-xx		50		µs

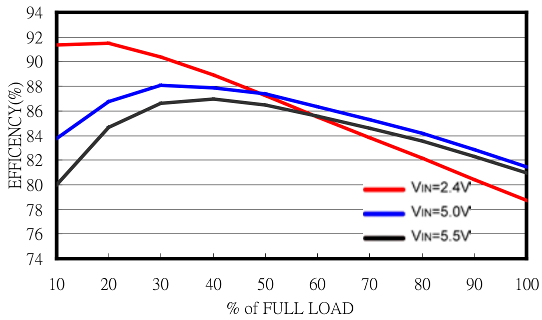
INPUT SPECIFICATIONS					
Parameter	Device	Min	Typ	Max	Unit
Operating Input Voltage	$V_{out\,set} < V_{IN} - 0.5V$	2.4	5	5.5	Vdc
Maximum Input Current ($V_{IN} = V_{IN\,min}$; $V_{out\,set}$ = 3.3V; $I_{out} = I_{out\,max}$)				6	Adc
Input No Load Current (V_{IN} = 5V; I_{out} = 0A; module enabled)	V_{out} = 0.75V V_{out} = 3.3V		20 45		mA mA
Input No Load Current (V_{IN} = 5V; I_{out} = 0A; module disabled)	All		0.6		mA
Under Voltage Lockout Turn-on Threshold			2.2		Vdc
Under Voltage Lockout Turn-off Threshold			2.0		Vdc
Input reflected ripple current (5 to 20MHz, 1µH source impedance)	All		35		mA pk-pk

GENERAL SPECIFICATIONS					
Parameter	Device	Min	Typ	Max	Unit
Efficiency (Vin nom; Iout max; Vout max; T_A = 25°C)	TOS 06-05 TOS 06-12 TOS 10-05 TOS 10-12 TOS 16-05 TOS 16-12		94.0 92.0 95.0 95.0 95.0 94.0		% % % % % %
Switching Frequency	All		300		KHz
Weight	TOS 05-xx All other TOS-xx-xx		2.8 6.0		g
MTBF	TOS 06-05 TOS 06-12 TOS 10-05 TOS 10-12 TOS 16-05 TOS 16-12		2.1×10^7 2.0×10^7 1.4×10^7 1.4×10^7 1.4×10^7 1.4×10^7		hours

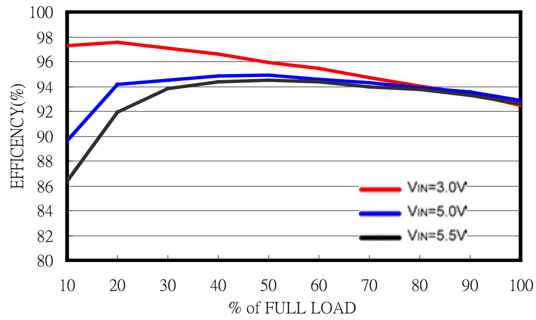
FEATURE SPECIFICATIONS					
Parameter	Device	Min	Typ	Max	Unit
On/Off Signal interface Device code with no Suffix – Positive logic (On/Off is open collector/drain logic input; Signal referenced to GND)					
Input High Voltage (Module ON)	All			$V_{IN\ max}$	Vdc
Input High Current	All			10	µA
Input Low Voltage (Module OFF)	All	-0.2		0.3	Vdc
Input Low Current	All		0.2	1	mA
On/Off Signal interface Device code with Suffix "-N" – Negative logic (On/Off is open collector/drain logic input with external pull-up resistor; signal referenced to GND)					
Input High Voltage (Module OFF)	TOS xx-05	1.5		$V_{IN\ max}$	Vdc
Input High Current	TOS xx-05		0.2	1	mA
Input Low Voltage (Module ON)	TOS xx-05	-0.2		0.3	Vdc
Input Low Current	TOS xx-05			10	µA
On/Off Signal interface Device code with Suffix "-N" – Negative logic (On/Off is open collector/drain logic input with external pull-up resistor; signal referenced to GND)					
Input High Voltage (Module OFF)	TOS xx-12	2.5		$V_{IN\ max}$	Vdc
Input High Current	TOS xx-12		0.2	1	mA
Input Low Voltage (Module ON)	TOS xx-12	-0.2		0.3	Vdc
Input Low Current	TOS xx-12			10	µA
Turn-On Delay and Rise Times ($V_{IN} = V_{IN\ nom}$; $I_{out} = I_{out\ max}$; $T_A = 25°C$)					
CASE 1: On/Off input is set to logic Low (Module ON) and then input power is applied (delay from instant at which $V_{IN} = V_{IN\ min}$ until $V_{out} = 10\%$ of $V_{out\ set}$)	TOS xx-05 TOS xx-12		1 3		ms ms
CASE 2: Input power is applied for at least one second and then the On/Off input is set to Logic Low (delay from instant at which Von/off = 0.3V until $V_{out} = 10\%$ of $V_{out\ set}$)	TOS xx-05 TOS xx-12		1 3		ms ms
Output Voltage Rise Time (time for Vo to rise from 10% of $V_{out\ set}$ to 90% of $V_{out\ set}$)	TOS xx-05 TOS xx-12		3 4	6 6	ms ms
Remote Sense Range	TOS 10-xx and TOS 16-xx only			0.5	V
Over Temperature Protection	TOS 06-05 TOS 06-12 All other TOS xx-xx		135 140 125		°C

Characteristic Curves

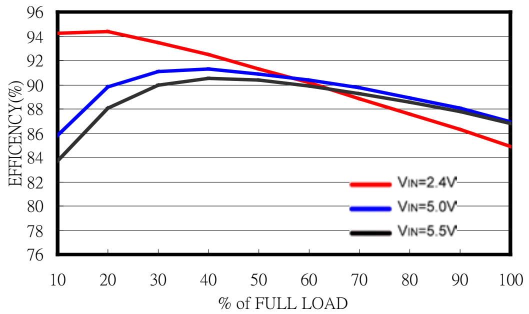
All test conditions are at 25°C.The figures are identical for either TOS 06-05SM and TOS 06-05SIL



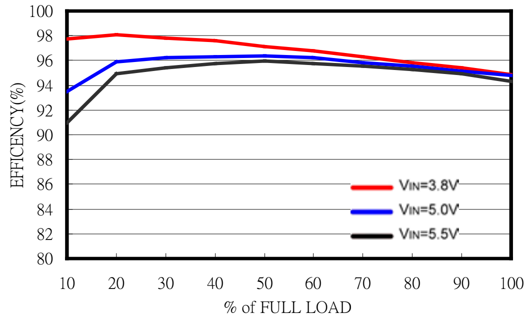
Efficiency versus Load
Vout = 0.75Vdc



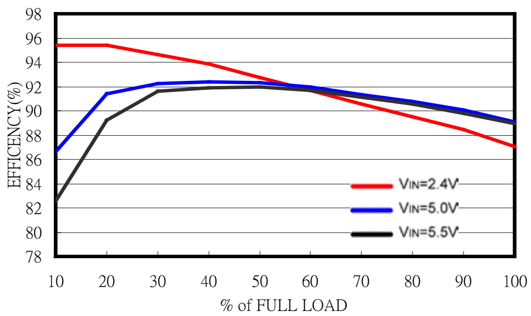
Efficiency versus Load
Vout = 2.5Vdc



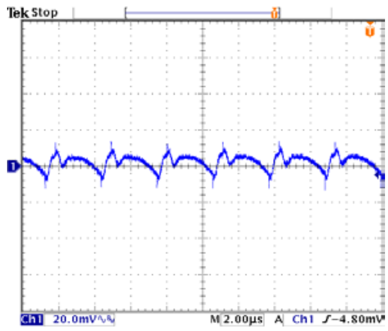
Efficiency versus Load
Vout = 1.2Vdc



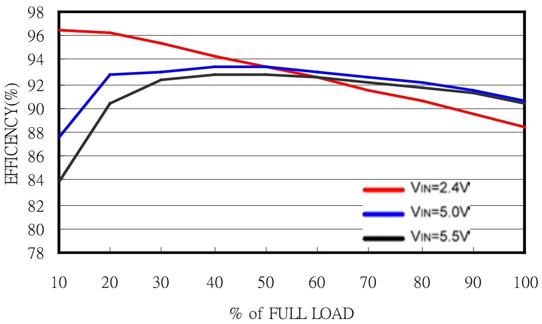
Efficiency versus Load
Vout = 3.3Vdc



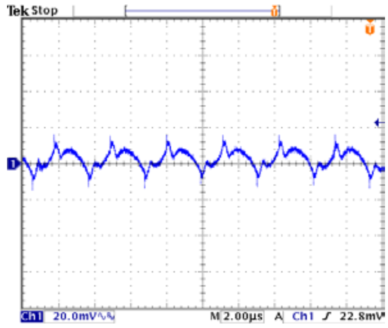
Efficiency versus Load
Vout = 1.5Vdc



Output Ripple and Noise
VIN = 5Vdc; Vout = 0.75Vdc; Iout = 6A



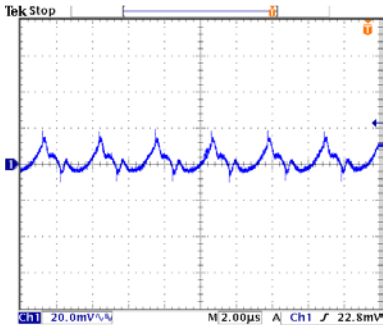
Efficiency versus Load
Vout = 1.8Vdc



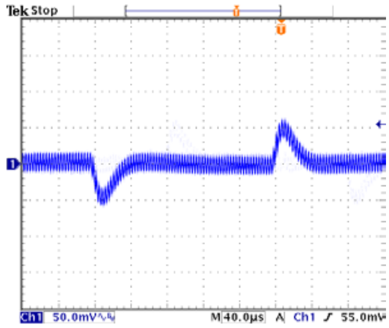
Output Ripple and Noise
VIN = 5Vdc; Vout = 1.8Vdc; Iout = 6A

Characteristic Curves

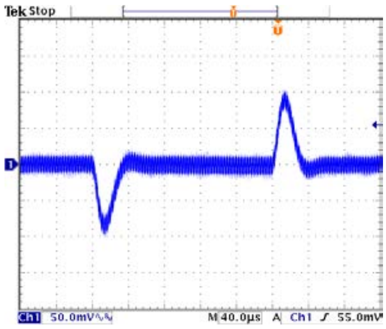
All test conditions are at 25°C.The figures are identical for either TOS 06-05SM or TOS 06-05SIL



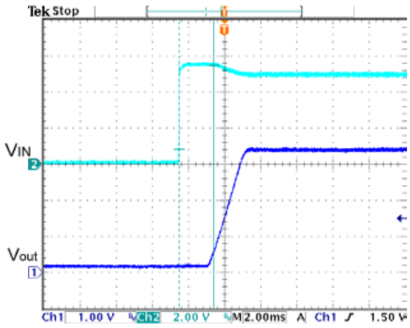
Output Ripple and Noise
VIN = 5Vdc; Vout = 3.3Vdc; Iout = 6A



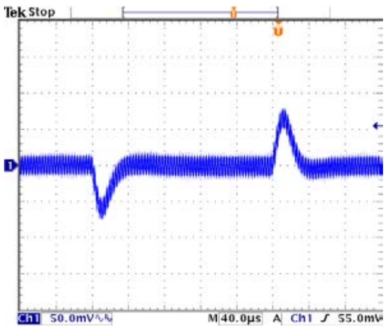
Dynamic Load 50% of Full Load Step Change
VIN = 5Vdc; Vout = 3.3Vdc;
Cout = 2 × 150µF polymer capacitors



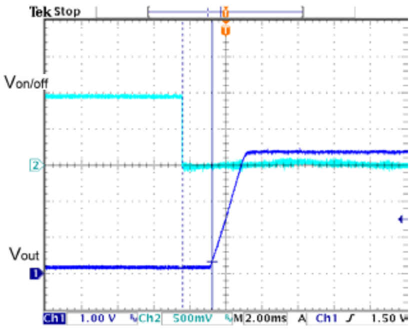
Dynamic Load 50% of Full Load Step Change
VIN = 5Vdc; Vout = 1.8Vdc



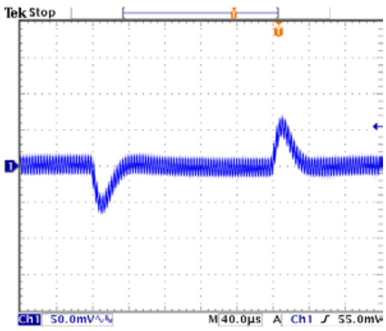
Input and Output Start-Up
VIN = 5Vdc; Vout = 3.3Vdc; Iout = 6A



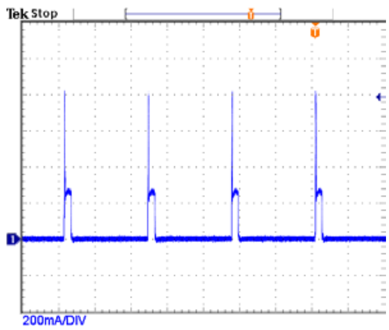
Dynamic Load 50% of Full Load Step Change
VIN = 5Vdc; Vout = 2.5Vdc



Start-Up Using Remote On/Off
VIN = 5Vdc; Vout = 3.3Vdc; Iout = 6A



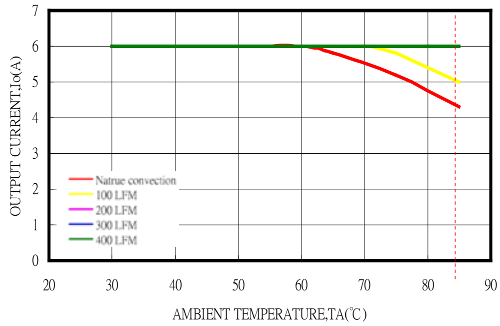
Dynamic Load 50% of Full Load Step Change
VIN = 5Vdc; Vout = 3.3Vdc



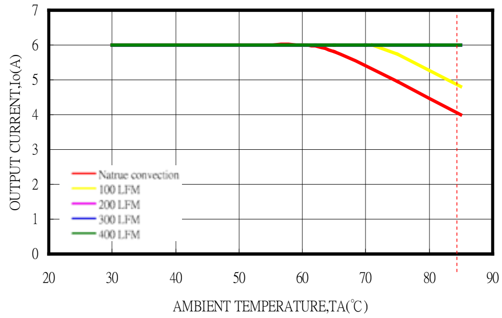
Output Short Circuit, Input Current
VIN = 5Vdc; Vout = 3.3Vdc

Characteristic Curves

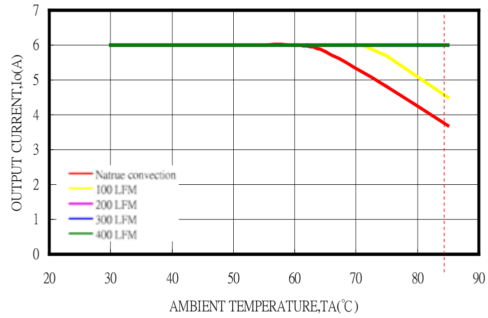
All test conditions are at 25°C.The figures are identical for either TOS 06-05SM and TOS 06-05SIL



Derating Output Current versus Ambient Temperature and Airflow
VIN = 5Vdc; Vout = 0.75Vdc



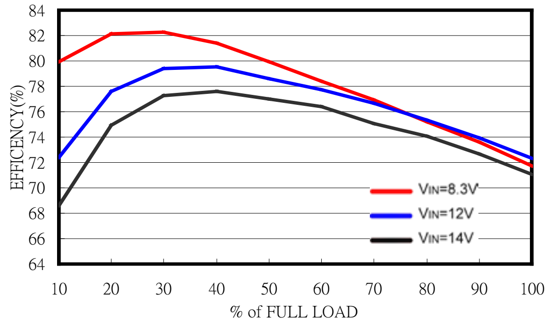
Derating Output Current versus Ambient Temperature and Airflow
VIN = 5Vdc; Vout = 1.8Vdc



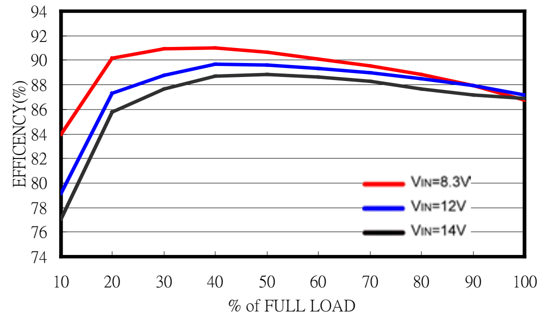
Derating Output Current versus Ambient Temperature and Airflow
VIN = 5Vdc; Vout = 3.3Vdc

Characteristic Curves

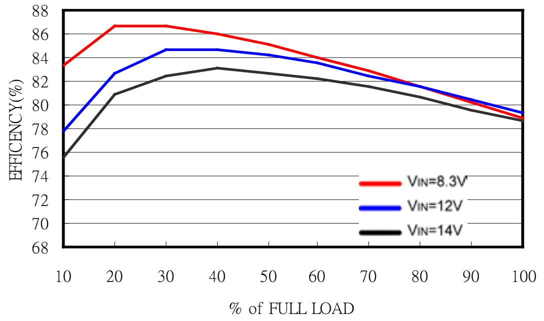
All test conditions are at 25°C.The figures are identical for either TOS 06-12SM and TOS 06-12SIL



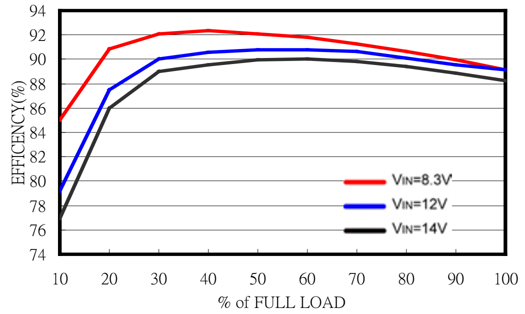
Efficiency versus Load
Vout = 0.75Vdc



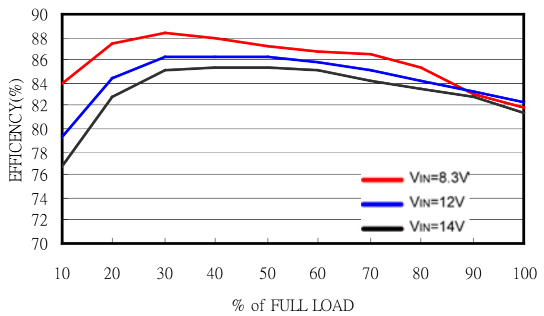
Efficiency versus Load
Vout = 2.5Vdc



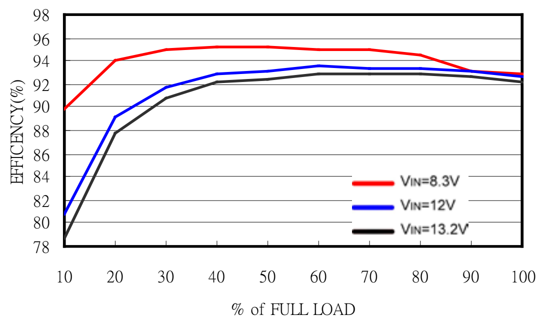
Efficiency versus Load
Vout = 1.2Vdc



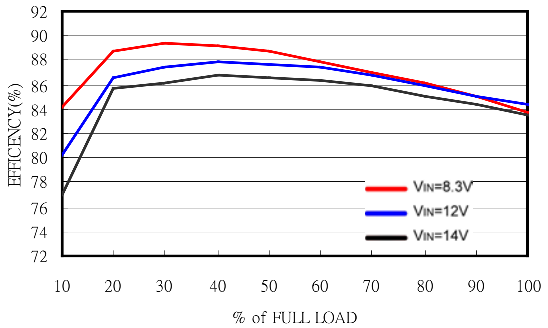
Efficiency versus Load
Vout = 3.3Vdc



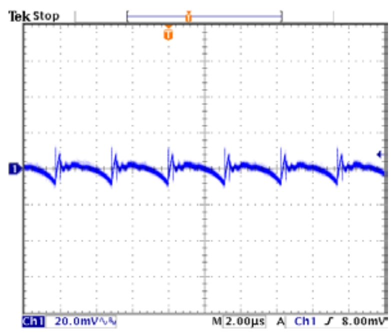
Efficiency versus Load
Vout = 1.5Vdc



Efficiency versus Load
Vout = 5Vdc



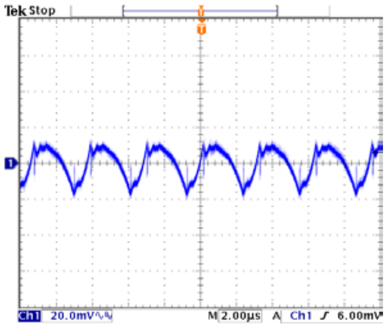
Efficiency versus Load
Vout = 1.8Vdc



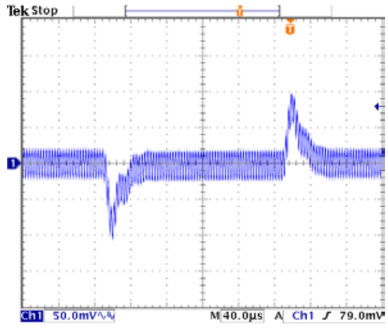
Output Ripple and Noise
VIN = 12Vdc; Vout = 0.75Vdc; Iout = 6A

Characteristic Curves

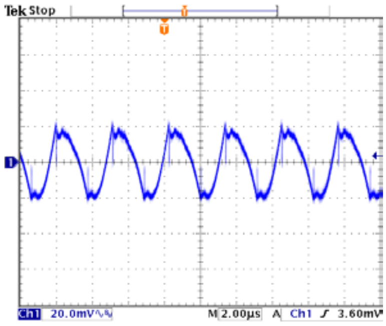
All test conditions are at 25°C. The figures are identical for either TOS 06-12SM and TOS 06-12SIL



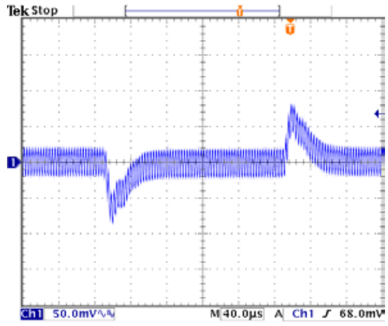
Output Ripple and Noise
VIN = 12Vdc; Vout = 3.3Vdc; Iout = 6A



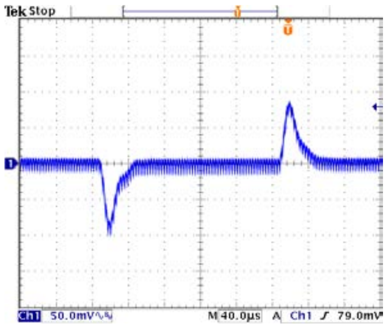
Dynamic Load 50% of Full Load Step Change
VIN = 12Vdc; Vout = 5.0Vdc



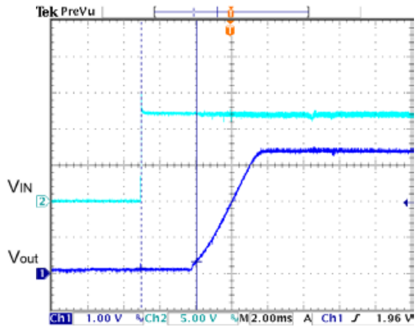
Output Ripple and Noise
VIN = 12Vdc; Vout = 5.0Vdc; Iout = 6A



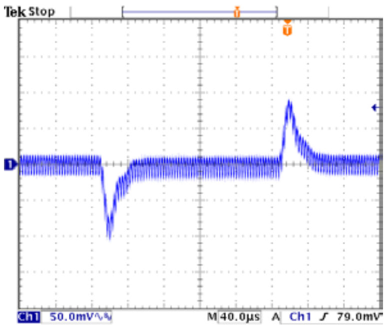
Dynamic Load 50% of Full Load Step Change
VIN =12Vdc; Vout = 5.0Vdc; Cout = 2x150µF polymer capacitors



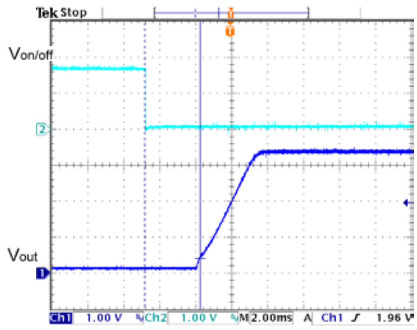
Dynamic Load 50% of Full Load Step Change
VIN = 12Vdc; Vout = 1.8Vdc



Input and Output Start-Up
VIN = 12Vdc; Vout = 3.3Vdc; Iout = 6A



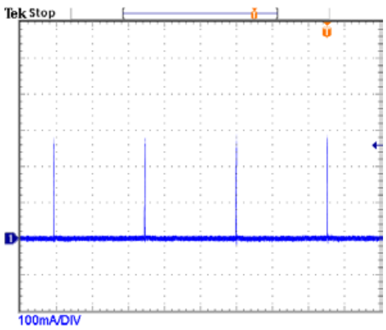
Dynamic Load 50% of Full Load Step Change
VIN = 12Vdc; Vout = 3.3Vdc



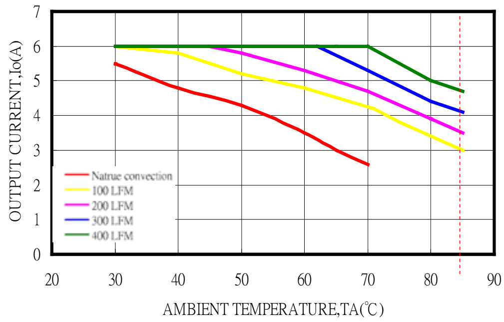
Start-Up Using Remote On/Off
VIN = 12Vdc; Vout = 3.3Vdc; Iout = 6A

Characteristic Curves

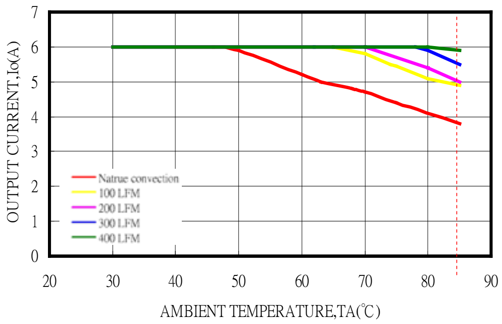
All test conditions are at 25°C.The figures are identical for either TOS 06-12SM and TOS 06-12SIL



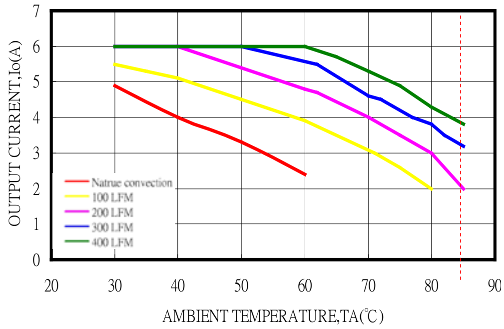
Output Short Circuit, Input Current
VIN = 5Vdc; Vout = 3.3Vdc



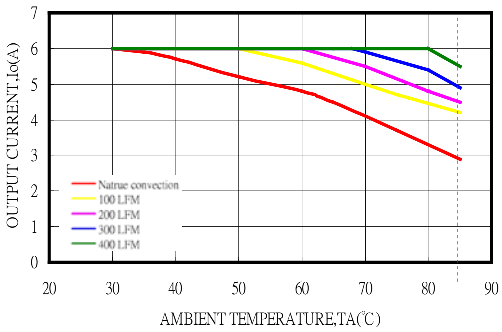
Derating Output Current versus Ambient Temperature and Airflow
VIN = 12Vdc; Vout = 3.3Vdc



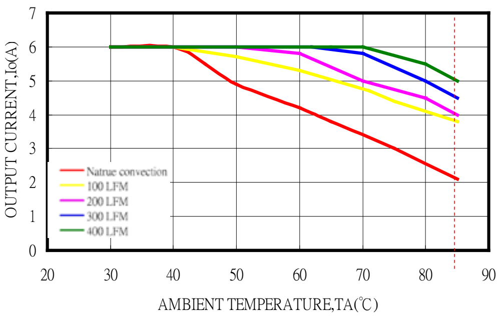
Derating Output Current versus Ambient Temperature and Airflow
VIN = 12Vdc; Vout = 0.75Vdc



Derating Output Current versus Ambient Temperature and Airflow
VIN = 12Vdc; Vout = 5Vdc



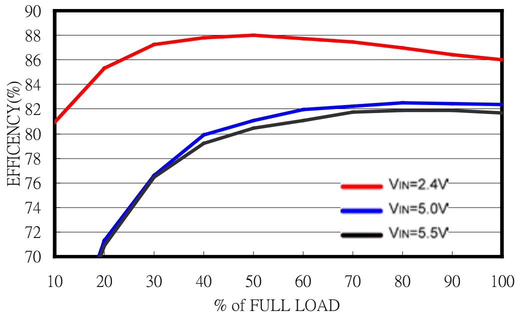
Derating Output Current versus Ambient Temperature and Airflow
VIN = 12Vdc; Vout = 1.8Vdc



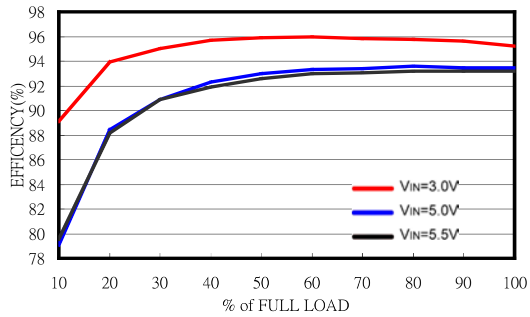
Derating Output Current versus Ambient Temperature and Airflow
VIN = 12Vdc; Vout = 2.5Vdc

Characteristic Curves

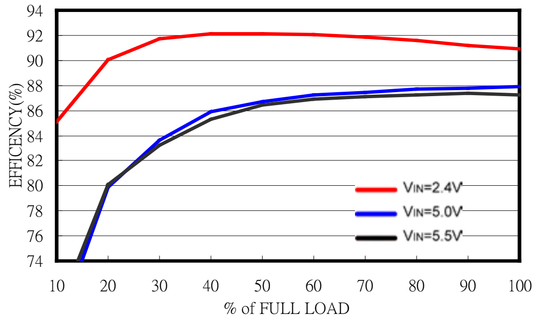
All test conditions are at 25°C.The figures are identical for either TOS 10-05SM and TOS 10-05SIL



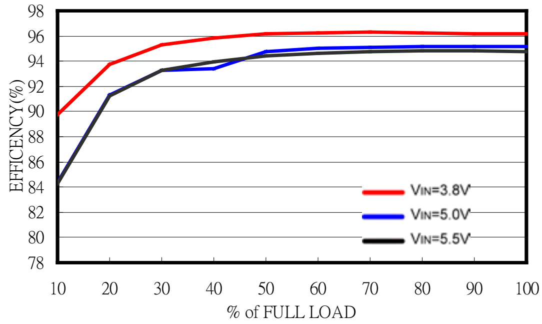
Efficiency versus Load
Vout = 0.75Vdc



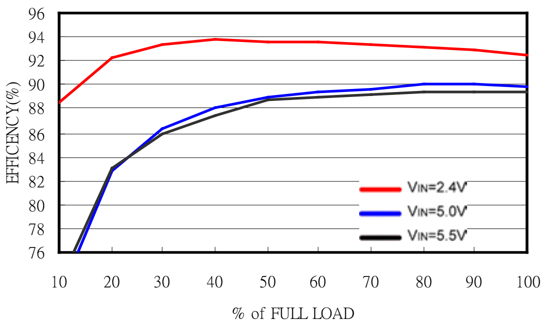
Efficiency versus Load
Vout = 2.5Vdc



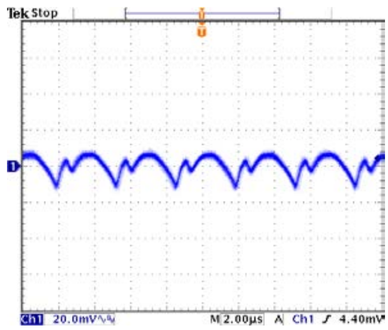
Efficiency versus Load
Vout = 1.2Vdc



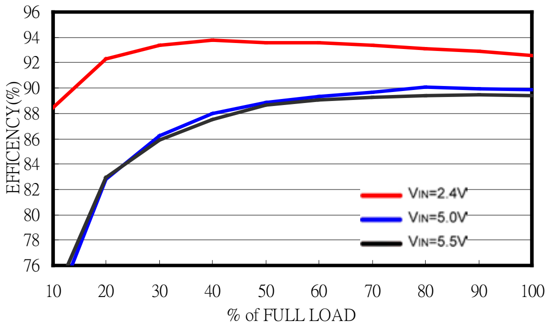
Efficiency versus Load
Vout = 3.3Vdc



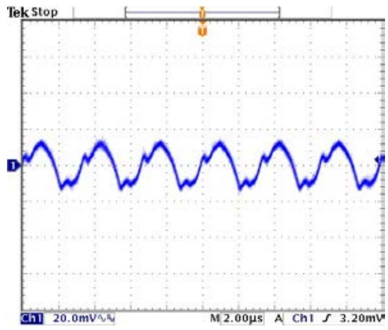
Efficiency versus Load
Vout = 1.5Vdc



Output Ripple and Noise
VIN = 5Vdc; Vout = 0.75Vdc; Iout = 10A



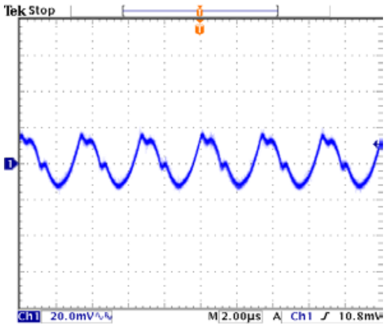
Efficiency versus Load
Vout = 1.8Vdc



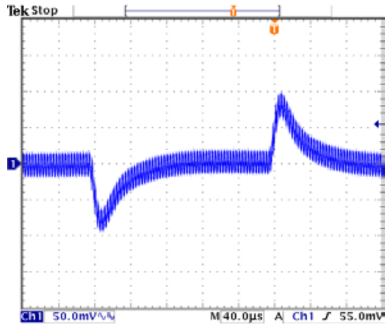
Output Ripple and Noise
VIN = 5Vdc; Vout = 1.8Vdc; Iout = 10A

Characteristic Curves

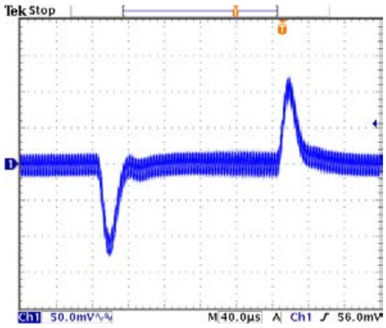
All test conditions are at 25°C.The figures are identical for either TOS 10-05SM and TOS 10-05SIL



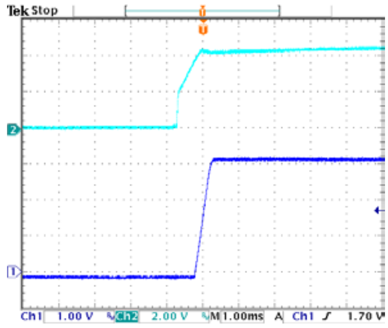
Output Ripple and Noise
VIN = 5Vdc; Vout = 3.3Vdc; Iout = 10A



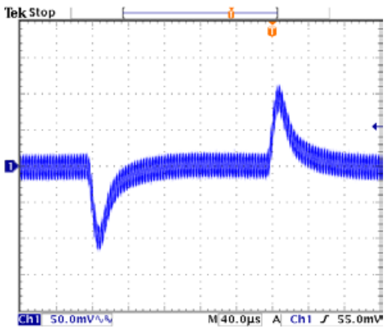
Dynamic Load 50% of Full Load Step Change
VIN = 5Vdc; Vout = 3.3Vdc; Cout = 2x150µF polymer capacitors



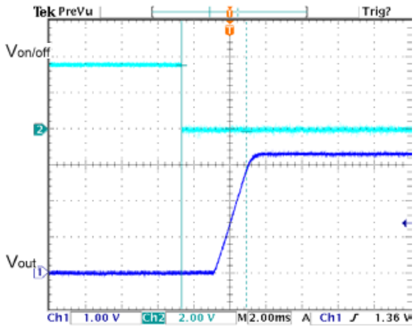
Dynamic Load 50% of Full Load Step Change
VIN = 5Vdc; Vout = 1.8Vdc



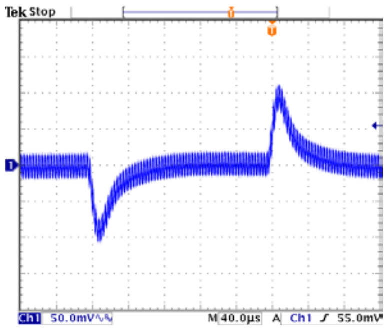
Input and Output Start-Up
VIN = 5Vdc; Vout = 3.3Vdc; Iout = 10A



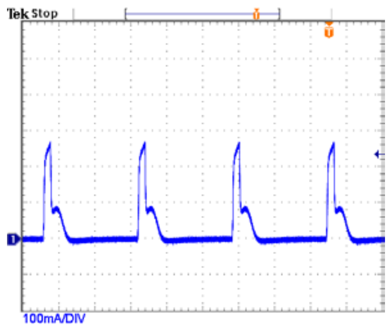
Dynamic Load 50% of Full Load Step Change
VIN = 5Vdc; Vout = 2.5Vdc



Start-Up Using Remote On/Off
VIN = 5Vdc; Vout = 3.3Vdc; Iout = 10A



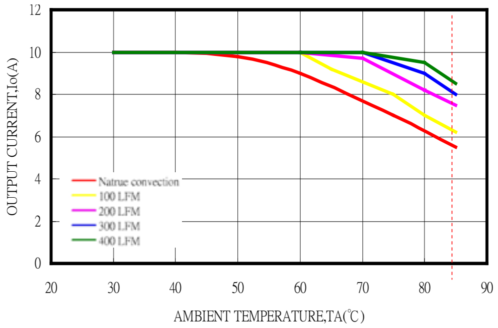
Dynamic Load 50% of Full Load Step Change
VIN = 5Vdc; Vout = 3.3Vdc



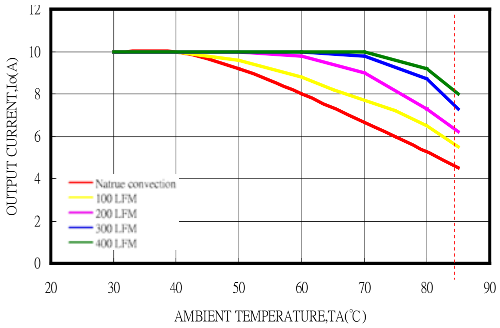
Output Short Circuit, Input Current
VIN = 5Vdc; Vout = 3.3Vdc

Characteristic Curves

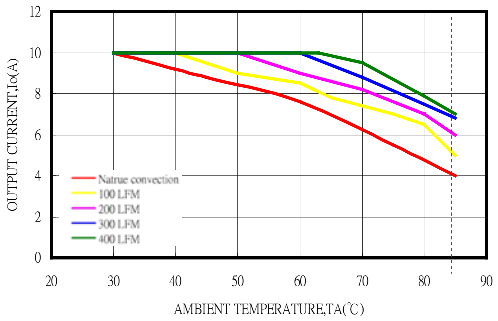
All test conditions are at 25°C.The figures are identical for either TOS 10-05SM and TOS 10-05SIL



Derating Output Current versus Ambient Temperature and Airflow
VIN = 5Vdc; Vout = 0.75Vdc



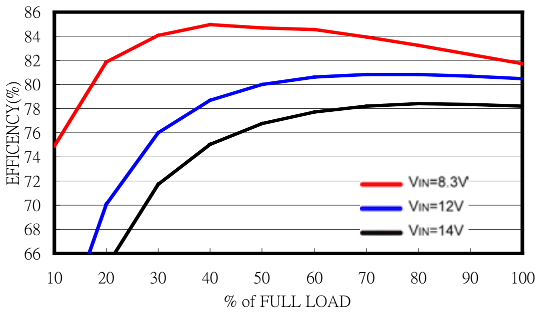
Derating Output Current versus Ambient Temperature and Airflow
VIN = 5Vdc; Vout = 1.8Vdc



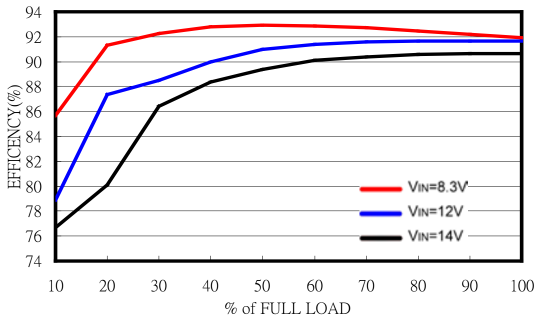
Derating Output Current versus Ambient Temperature and Airflow
VIN = 5Vdc; Vout = 3.3Vdc

Characteristic Curves

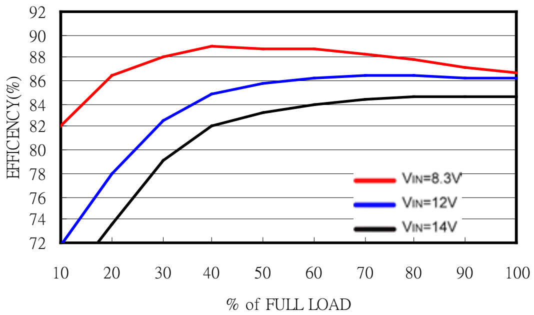
All test conditions are at 25°C.The figures are identical for either TOS 10-12SM and TOS 10-12SIL



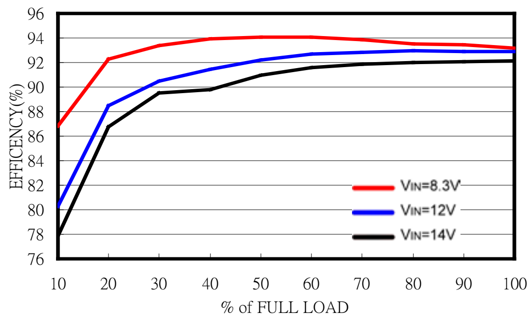
Efficiency versus Load
Vout = 0.75Vdc



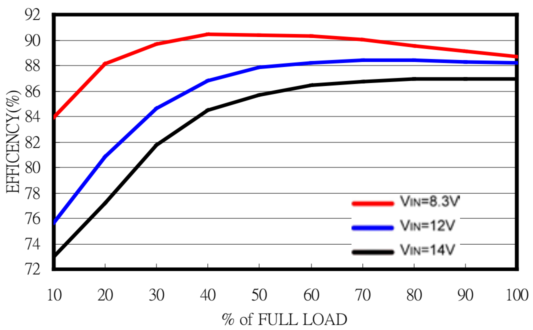
Efficiency versus Load
Vout = 2.5Vdc



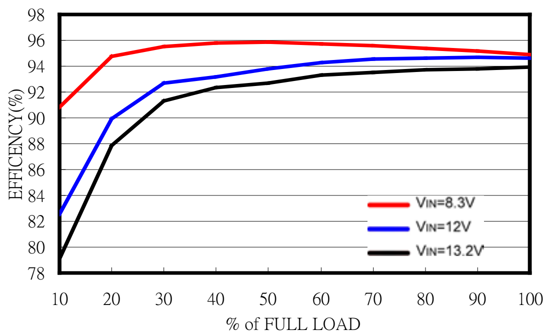
Efficiency versus Load
Vout = 1.2Vdc



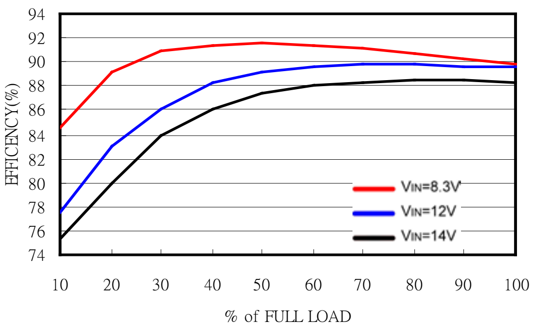
Efficiency versus Load
Vout = 3.3Vdc



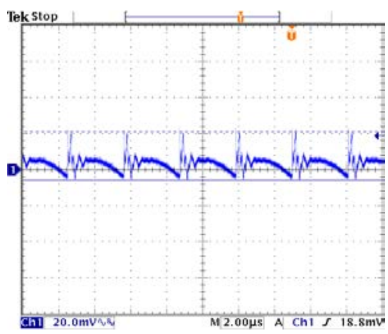
Efficiency versus Load
Vout = 1.5Vdc



Efficiency versus Load
Vout = 5Vdc



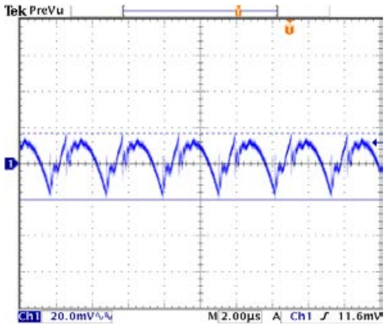
Efficiency versus Load
Vout = 1.8Vdc



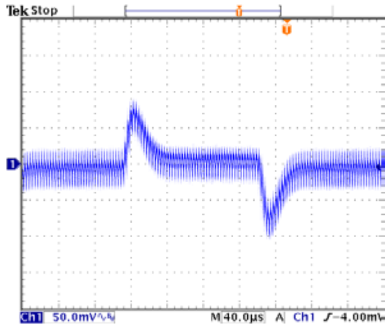
Output Ripple and Noise
VIN = 12Vdc; Vout = 0.75Vdc; Iout = 10A

Characteristic Curves

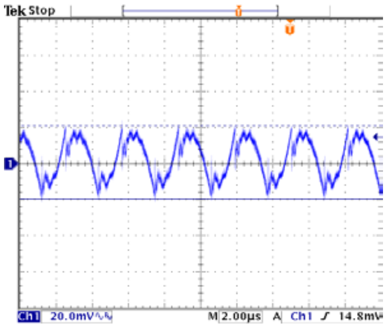
All test conditions are at 25°C.The figures are identical for either TOS 10-12SM and TOS 10-12SIL



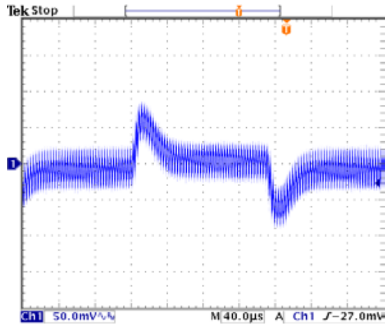
Output Ripple and Noise
VIN = 12Vdc; Vout = 3.3Vdc; Iout = 10A



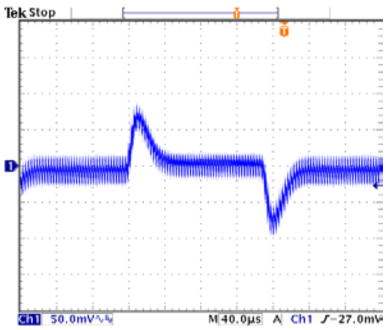
Dynamic Load 50% of Full Load Step Change
VIN = 12Vdc; Vout = 5.0Vdc



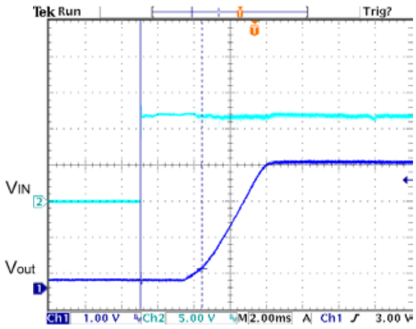
Output Ripple and Noise
VIN = 12Vdc; Vout = 5.0Vdc; Iout = 10A



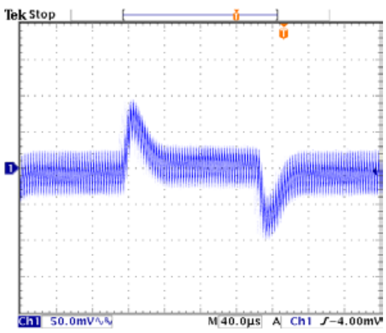
Dynamic Load 50% of Full Load Step Change
VIN =12Vdc; Vout = 5.0Vdc; Cout = 2x150µF polymer capacitors



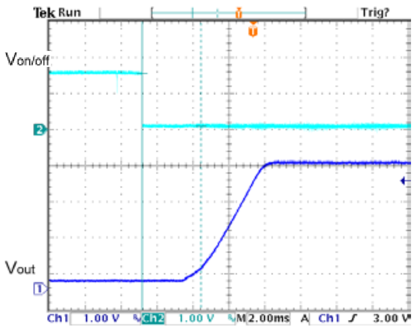
Dynamic Load 50% of Full Load Step Change
VIN = 12Vdc; Vout = 1.8Vdc



Input and Output Start-Up
VIN = 12Vdc; Vout = 3.3Vdc; Iout = 10A



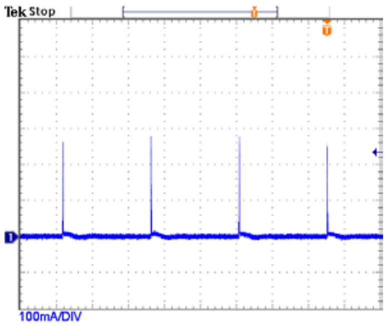
Dynamic Load 50% of Full Load Step Change
VIN = 12Vdc; Vout = 3.3Vdc



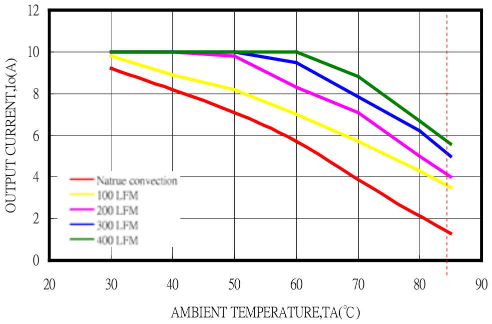
Start-Up Using Remote On/Off
VIN = 12Vdc; Vout = 3.3Vdc; Iout = 10A

Characteristic Curves

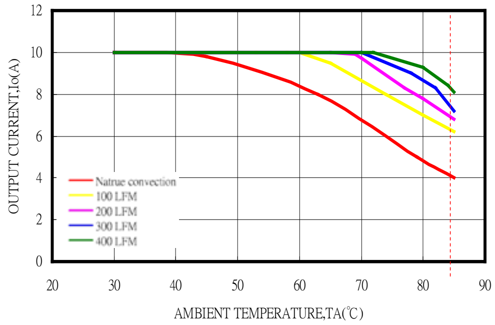
All test conditions are at 25°C.The figures are identical for either TOS 10-12SM and TOS 10-12SIL



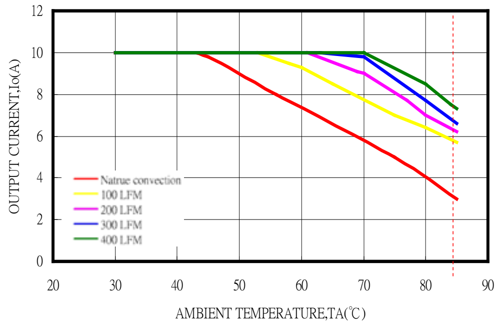
Output Short Circuit, Input Current
VIN = 5Vdc; Vout = 3.3Vdc



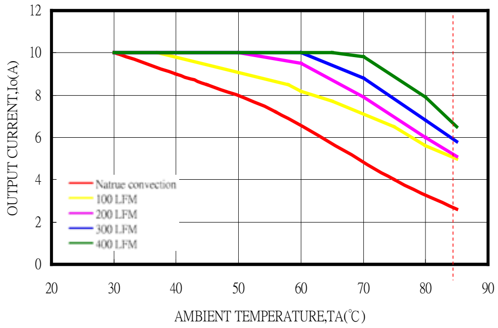
Derating Output Current versus Ambient Temperature and Airflow
VIN = 12Vdc; Vout = 5Vdc



Derating Output Current versus Ambient Temperature and Airflow
VIN = 12Vdc; Vout = 0.75Vdc



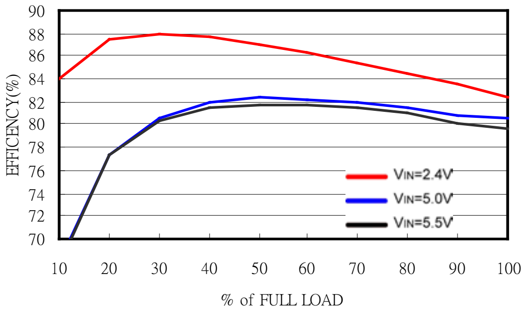
Derating Output Current versus Ambient Temperature and Airflow
VIN = 12Vdc; Vout = 1.8Vdc



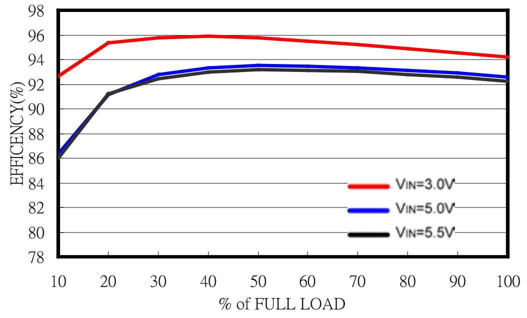
Derating Output Current versus Ambient Temperature and Airflow
VIN = 12Vdc; Vout = 3.3Vdc

Characteristic Curves

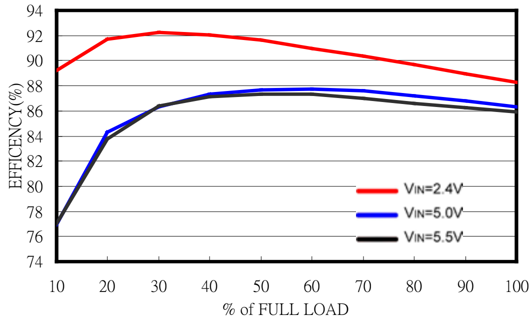
All test conditions are at 25°C.The figures are identical for either TOS 16-05SM and TOS 16-05SIL



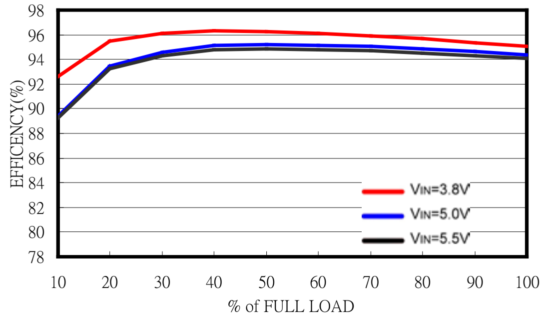
Efficiency versus Output Current
Vout = 0.75Vdc



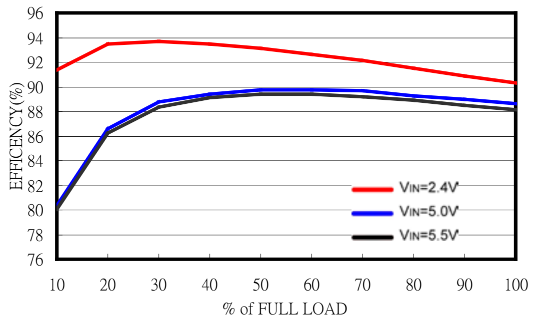
Efficiency versus Output Current
Vout = 2.5Vdc



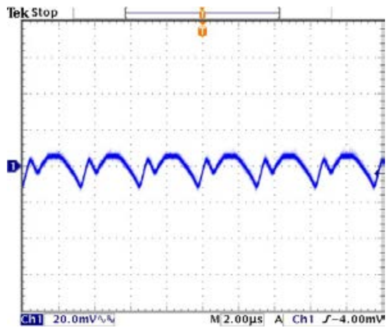
Efficiency versus Output Current
Vout = 1.2Vdc



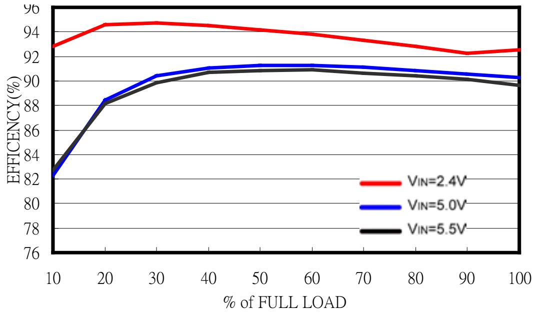
Efficiency versus Output Current
Vout = 3.3Vdc



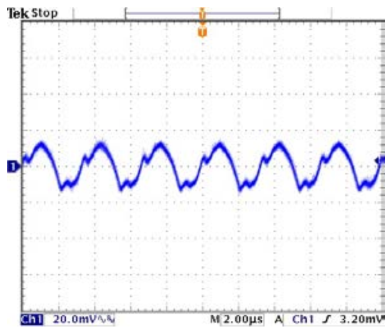
Efficiency versus Output Current
Vout = 1.5Vdc



Output Ripple and Noise
VIN = 5Vdc; Vout = 0.75Vdc; Iout = 16A



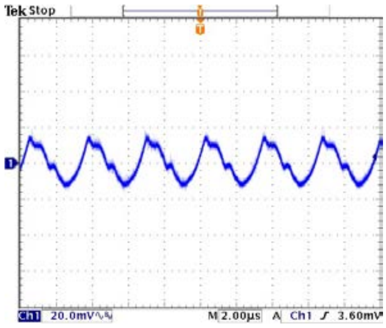
Efficiency versus Output Current
Vout = 1.8Vdc



Output Ripple and Noise
VIN = 5Vdc; Vout = 1.8Vdc; Iout = 16A

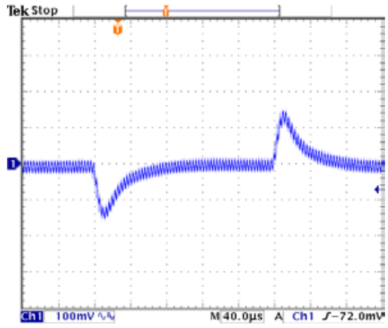
Characteristic Curves

All test conditions are at 25°C.The figures are identical for either TOS 16-05SM and TOS 16-05SIL



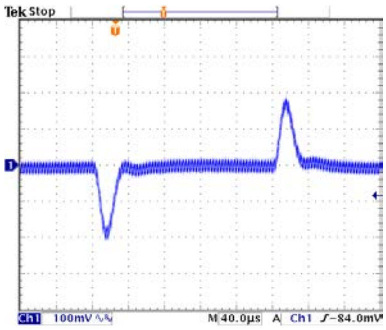
Output Ripple and Noise

VIN = 5Vdc; Vout = 3.3Vdc; Iout = 16A



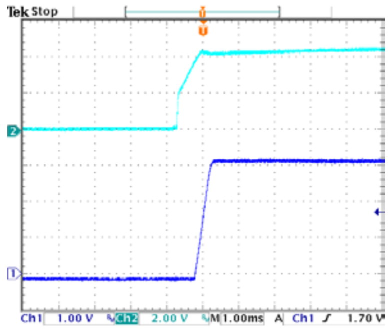
Dynamic Load 50% of Full Load Step Change

VIN = 5Vdc; Vout = 3.3Vdc; Cout = 2x150µF polymer capacitors



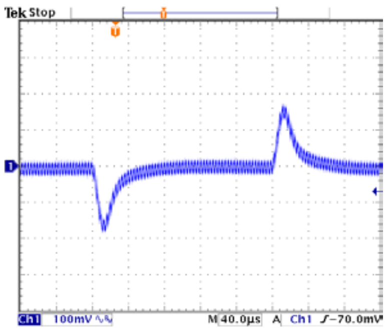
Dynamic Load 50% of Full Load Step Change

VIN = 5Vdc; Vout = 1.8Vdc



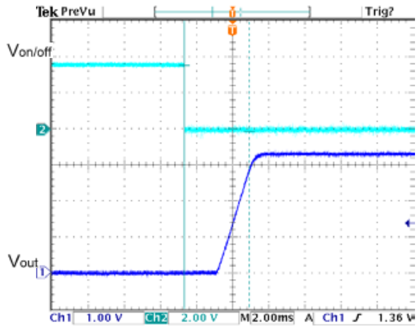
Input and Output Start-Up

VIN = 5Vdc; Vout = 3.3Vdc; Iout = 16A



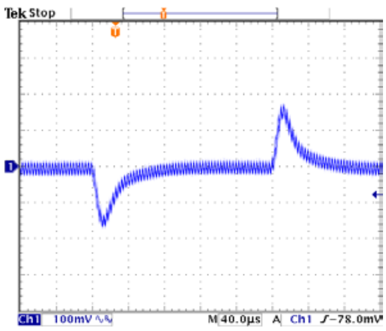
Dynamic Load 50% of Full Load Step Change

VIN = 5Vdc; Vout = 2.5Vdc



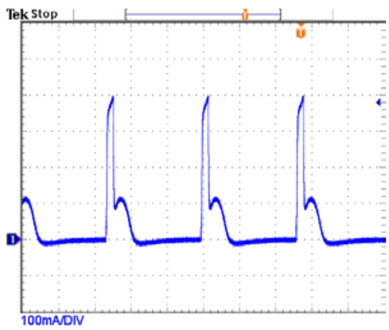
Start-Up Using Remote On/Off

VIN = 5Vdc; Vout = 3.3Vdc; Iout = 16A



Dynamic Load 50% of Full Load Step Change

VIN = 5Vdc; Vout = 3.3Vdc

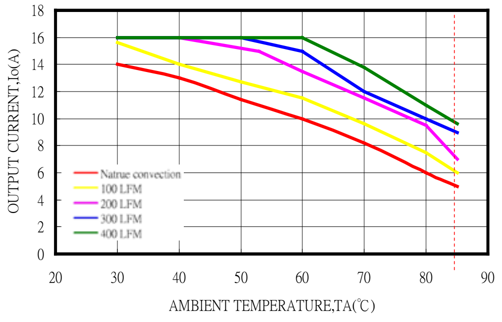


Output Short Circuit, Input Current

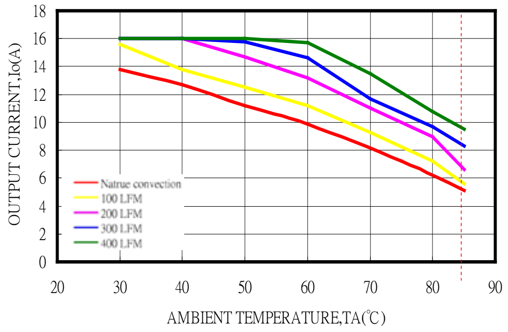
VIN = 5Vdc; Vout = 3.3Vdc

Characteristic Curves

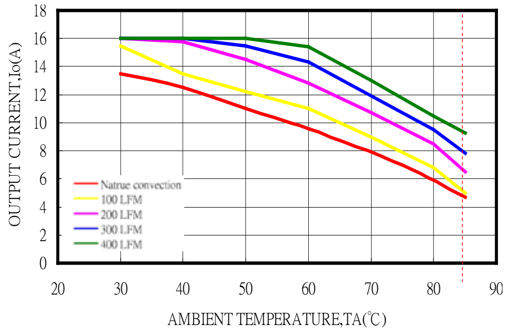
All test conditions are at 25°C.The figures are identical for either TOS 16-05SM and TOS 16-05SIL



Derating Output Current versus Ambient Temperature and Airflow
VIN = 5Vdc; Vout = 0.75Vdc



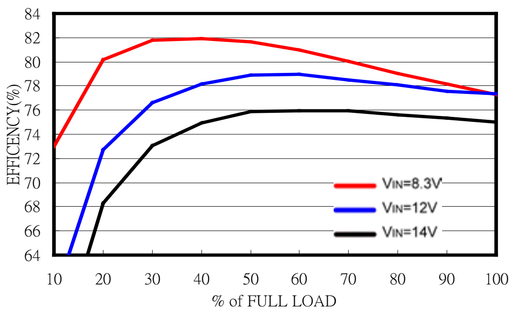
Derating Output Current versus Ambient Temperature and Airflow
VIN = 5Vdc; Vout = 1.8Vdc



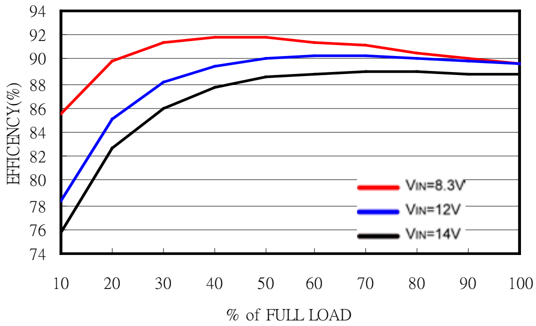
Derating Output Current versus Ambient Temperature and Airflow
VIN = 5Vdc; Vout = 3.3Vdc

Characteristic Curves

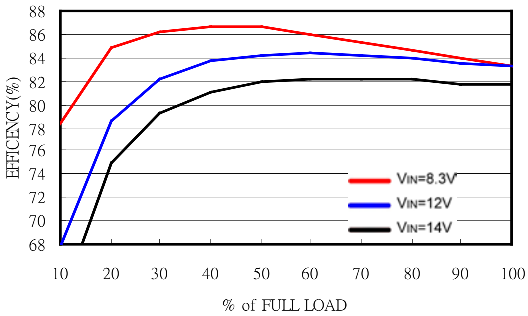
All test conditions are at 25°C.The figures are identical for either TOS 16-12SM and TOS 16-12SIL



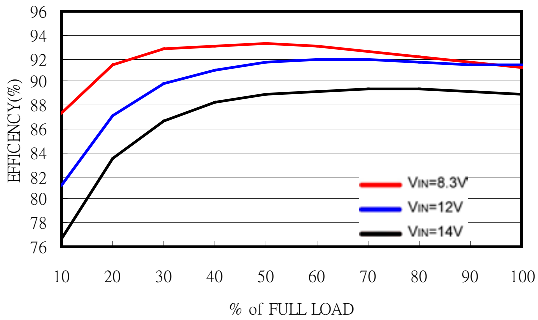
Efficiency versus Load
Vout = 0.75Vdc



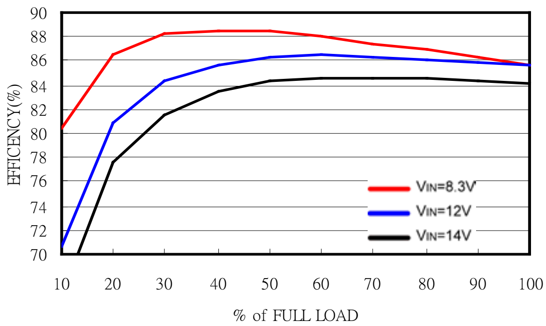
Efficiency versus Load
Vout = 2.5Vdc



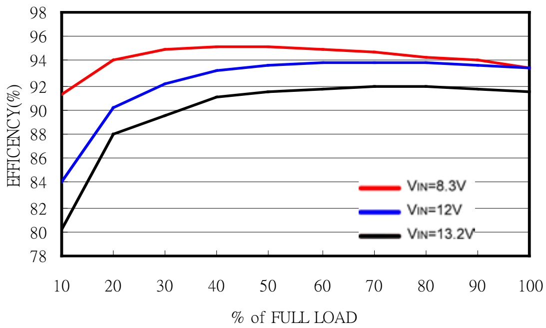
Efficiency versus Load
Vout = 1.2Vdc



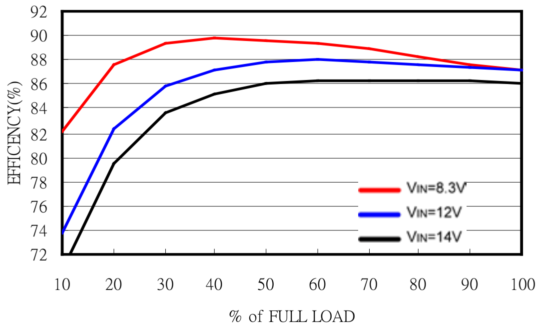
Efficiency versus Load
Vout = 3.3Vdc



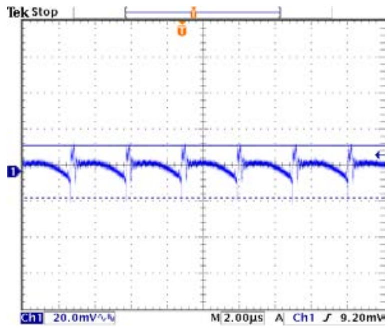
Efficiency versus Load
Vout = 1.5Vdc



Efficiency versus Load
Vout = 5Vdc



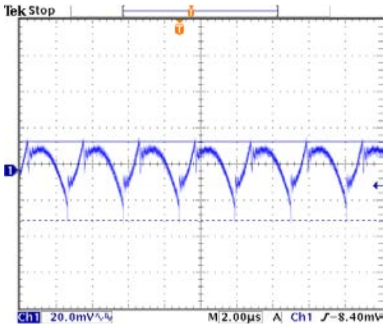
Efficiency versus Load
Vout = 1.8Vdc



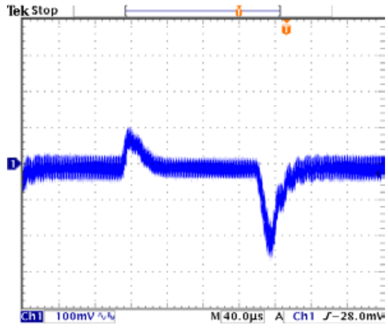
Output Ripple and Noise
VIN = 12Vdc; Vout = 0.75Vdc; Iout = 16A

Characteristic Curves

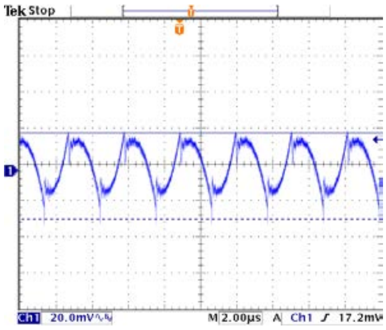
All test conditions are at 25°C.The figures are identical for either TOS 16-12SM and TOS 16-12SIL



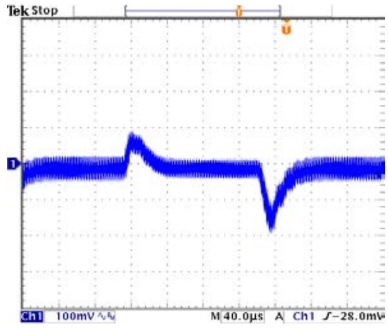
Output Ripple and Noise
VIN = 12Vdc; Vout = 3.3Vdc; Iout = 16A



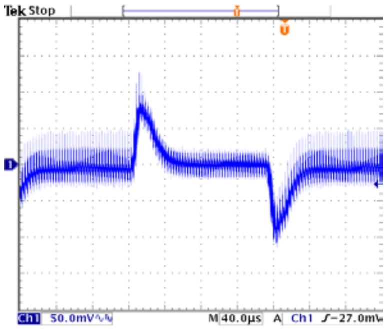
Dynamic Load 50% of Full Load Step Change
VIN = 12Vdc; Vout = 5Vdc



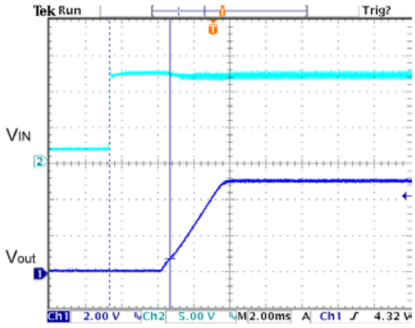
Output Ripple and Noise
VIN = 12Vdc; Vout = 5.0Vdc; Iout = 16A



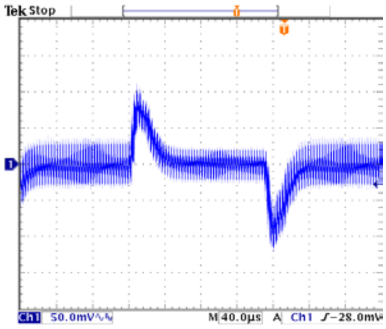
Dynamic Load 50% of Full Load Step Change
VIN =12Vdc; Vout = 5.0Vdc; Cout = 2x150µF polymer capacitors



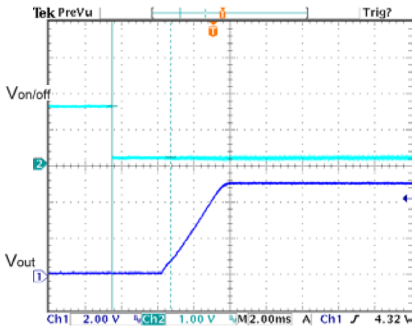
Dynamic Load 50% of Full Load Step Change
VIN = 12Vdc; Vout = 1.8Vdc



Input and Output Start-Up
VIN = 12Vdc; Vout = 3.3Vdc; Iout = 16A



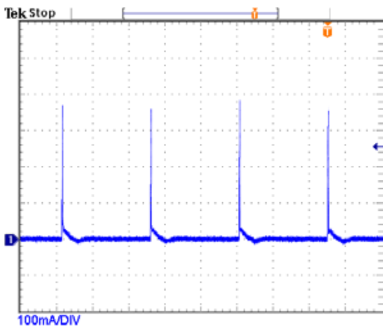
Dynamic Load 50% of Full Load Step Change
VIN = 12Vdc; Vout = 3.3Vdc



Start-Up Using Remote On/Off
VIN = 12Vdc; Vout = 3.3Vdc; Iout = 16A

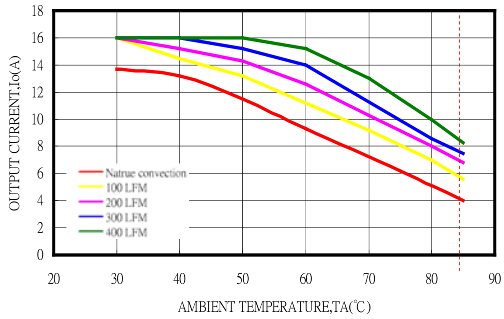
Characteristic Curves

All test conditions are at 25°C.The figures are identical for either TOS 16-12SM and TOS 16-12SIL



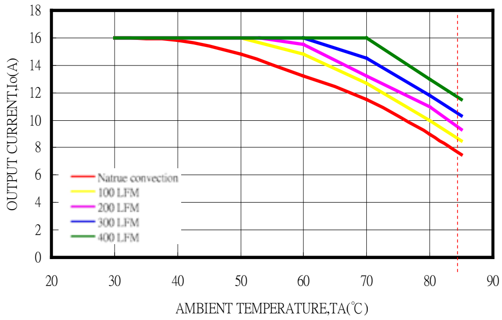
Output Short Circuit, Input Current

VIN = 5Vdc; Vout = 3.3Vdc



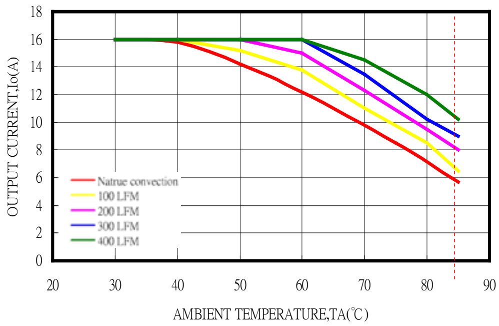
Derating Output Current versus Ambient Temperature and Airflow

VIN = 12Vdc; Vout = 5Vdc



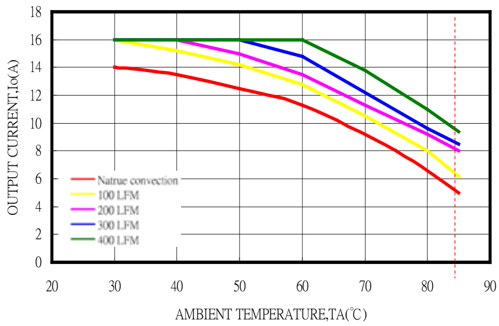
Derating Output Current versus Ambient Temperature and Airflow

VIN = 12Vdc; Vout = 0.75Vdc



Derating Output Current versus Ambient Temperature and Airflow

VIN = 12Vdc; Vout = 1.8Vdc



Derating Output Current versus Ambient Temperature and Airflow

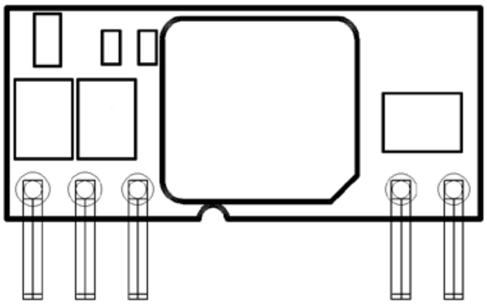
VIN = 12Vdc; Vout = 3.3Vdc

Thermal Consideration of TOS 06-05yyy

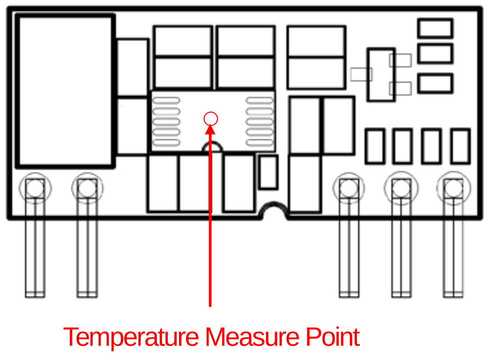
The power module operates in a variety of thermal environments; however, sufficient cooling should be provided to help ensure reliable operation of the unit. Heat is removed by conduction, convention, and radiation to the surrounding Environment. Proper cooling can be verified by measuring the point as the figure below. The temperature at this location should not exceed 125°C (TOS 06-xxyyy) or 115°C (all other TOS converters). When Operating, adequate cooling must be provided to maintain the test point temperature at or below 125°C (TOS 06-xxyyy) or 115°C (all other TOS converters). Although the maximum point Temperature of the power modules is 125°C (TOS 06-xxyyy) or 115°C (all other TOS converters), you can limit this Temperature to a lower value for extremely high reliability.

The unit will shutdown if the thermal reference point exceeds 135°C typ. (TOS 06-xxyyy) or 125°C (all other TOS converters) but the thermal shutdown is not intended as a guarantee that the unit will survive temperature beyond its rating. The module will automatically restarts after it cools down.

TOS 06-05SIL

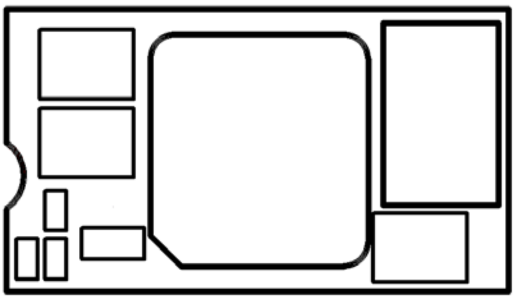


Top View

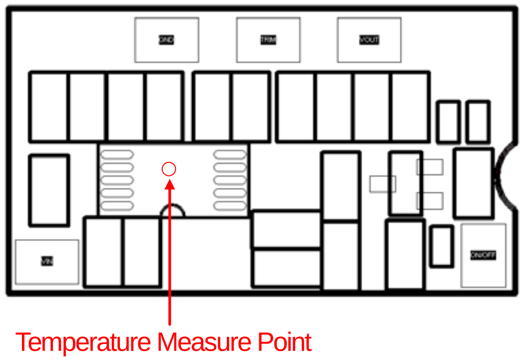


Bottom View

TOS 06-05SM

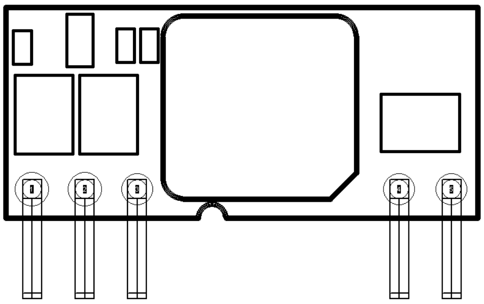


Top View

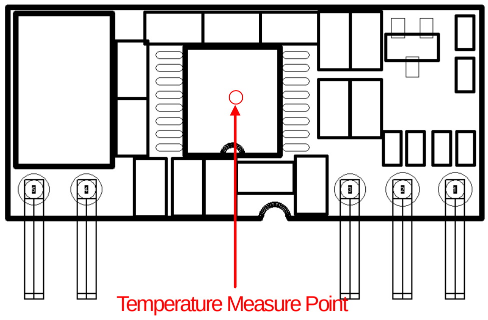


Bottom View

TOS 06-12SIL

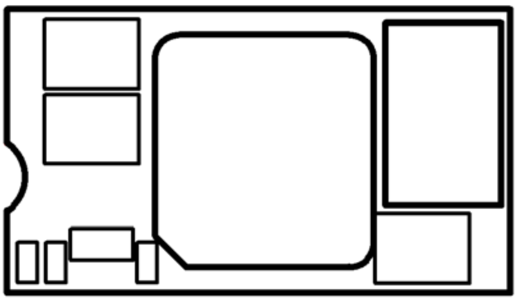


Top View

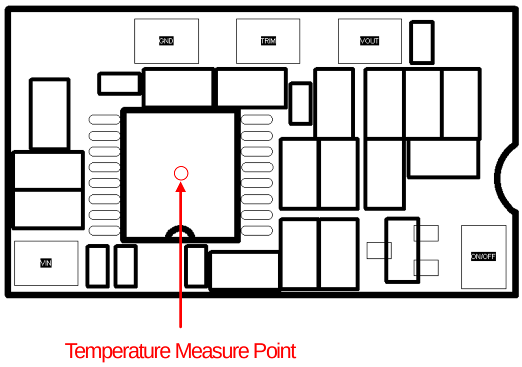


Bottom View

TOS 06-12SM

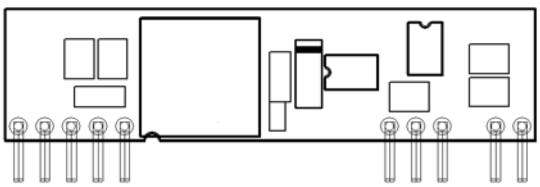


Top View

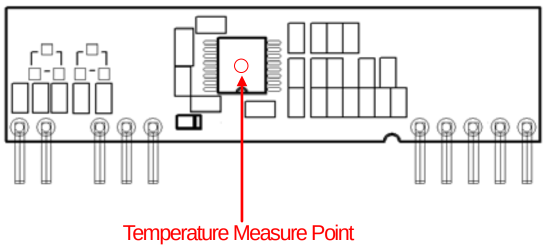


Bottom View

TOS 10-05SIL, TOS 10-12SIL, TOS 16-05SIL and TOS 16-12SIL

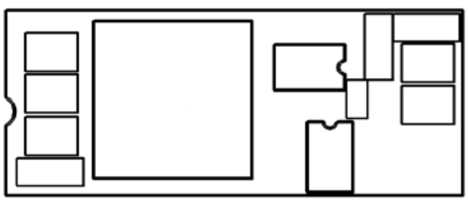


Top View

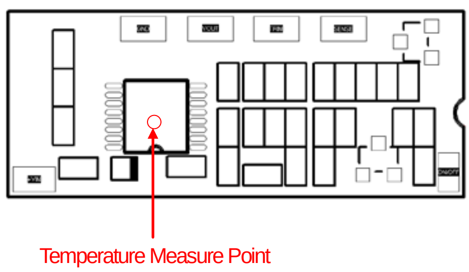


Bottom View

TOS 10-05SM, TOS 10-12SM, TOS 16-05SM and TOS 16-12SM



Top View



Bottom View

Short Circuity Protection

Continuous, hiccup and auto-recovery mode.
During short circuit, converter still shut down. The average current during this condition will be very low and the device can be safety in this condition.

Output over current protection

To provide protection in an over output current condition, the unit is equipped with internal current-limiting circuitry and can endure current limiting continuously. When the fault condition occurs, the unit enters hiccup mode.
Hiccup-mode is a method of operation in a power supply whose purpose is to protect the power supply from being damaged during an over-current fault condition. It also enables the power supply to restart when the fault is removed.
The typical average output current during hiccup is 2A (TOS 06), 3A (TOS 10) and 3.5A (TOS 16).

Output Voltage Programming

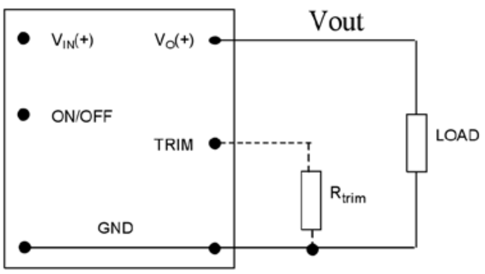
Output voltage can be adjusted from 0.75Vdc to 3.3Vdc (TOS xx-05yyy) or 0.75Vdc to 5.0Vdc (TOS xx-12yyy) by connecting an external resistor between Trim and GND pins. Without this external resistor, the output voltage will be 0.75Vdc. Using the following equation to calculate the value of external resistor for desired output voltage.

- **Trim equation**

$$TOSxx-05yyy \Rightarrow Rtrim = \left[\frac{21070}{Vout-0.7525} - 5110\right] = \Omega$$

$$TOSxx-12yyy \Rightarrow Rtrim = \left[\frac{10500}{Vo-0.7525} - 1000\right] = \Omega$$

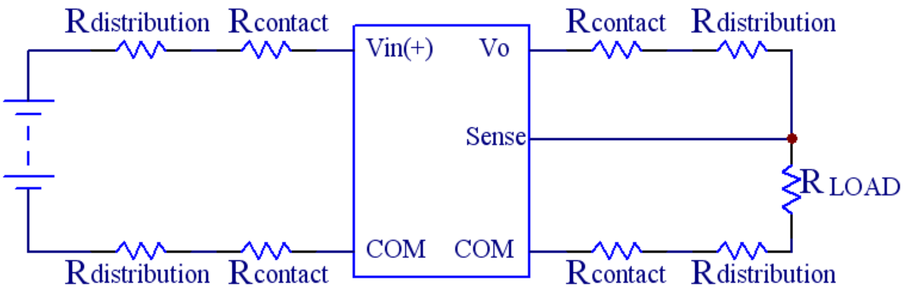
TOS xx-05yyy	
Vout set (V)	Rtrim (KΩ)
0.7525	Open
1.2	41.973
1.5	23.077
1.8	15.004
2.5	6.974
3.3	3.160



TOS xx-12yyy	
Vout set (V)	Rtrim (KΩ)
0.7525	Open
1.2	22.460
1.5	13.050
1.8	9.024
2.5	5.009
3.3	3.122
5.0	1.472

Remote Sense

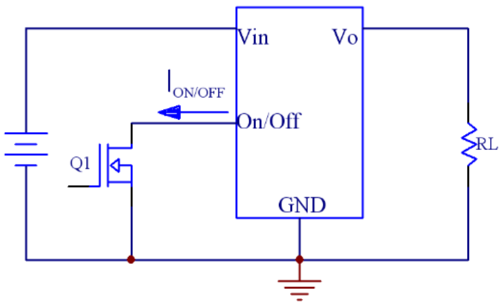
To minimum the effects of distribution losses by regulating the voltage at the Remote Sense pin. The voltage between the Sense pin and Vo pin must not exceed 0.5V.
When using Remote Sense, the output voltage of the module can increase, which if the same output current is maintained, the output power of the module increase, too. Make sure that the output power of the module at or below the maximum rated power. When the Remote Sense feature is not being used, leave the Remote Sense pin unconnected.



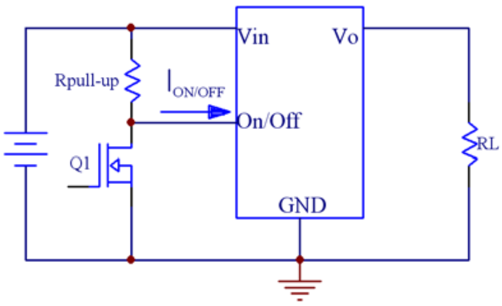
Remote Sense circuit configuration

Remote ON/OFF Control

Two remote ON/OFF control logic are available for TOS xx-xxSM and TOS xx-xxSIL. The positive logic On/Off signal, on the standard TOS device with no device code suffix, turns the module ON during logic High on the On/Off pin and turns OFF during a logic Low. Optionally there is the negative logic On/Off signal available, device code suffix "-N", turns the module OFF during a logic High on the On/Off pin and turns ON during a logic Low.
The On/Off pin is an open collector/drain logic input signal (Von/off) that referenced to GND.



Circuit configuration for using Positive logic



Circuit configuration for using Negative logic

Input Filtering

TOS 06-05SM / TOS 06-05SIL module should be connected to a low impedance DC source. A highly inductive source can affect the stability of the module. To make sure the module is stable, input capacitor is necessary that minimize input ripple voltage of the module.

TOS 06-05yyy: To minimize input voltage ripple, 2 × 150μF low-ESR polymer capacitors in parallel with 2 × 47μF ceramic capacitors are recommended at the input of the module.

TOS 06-12yyy: To minimize input voltage ripple, 2 × 47μF low-ESR tantalum capacitors in parallel with 2 × 22μF very low-ESR ceramic capacitors are recommended at the input of the module.

TOS 10-05yyy: To minimize input voltage ripple, 3 × 150μF low-ESR polymer capacitors in parallel with 2 × 47μF ceramic capacitors are recommended at the input of the module.

TOS 10-12yyy: To minimize input voltage ripple, 4 × 47μF low-ESR tantalum capacitors in parallel with 4 × 22μF very low-ESR ceramic capacitors are recommended at the input of the module.

TOS 16-05yyy: To minimize input voltage ripple, 4 × 150μF low-ESR polymer capacitors in parallel with 4 × 47μF ceramic capacitors are recommended at the input of the module.

TOS 16-12yyy: To minimize input voltage ripple, 6 × 47μF low-ESR tantalum capacitors in parallel with 6 × 22μF very low-ESR ceramic capacitors are recommended at the input of the module.

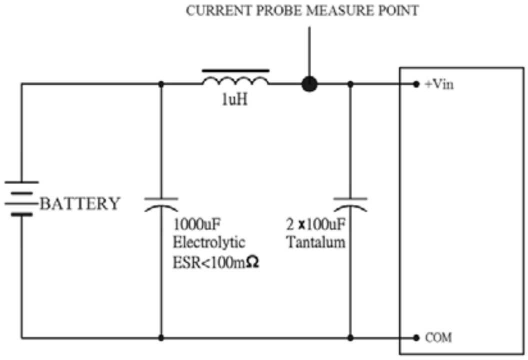
Output Filtering

For low output ripple voltage, output capacitor with 1μF ceramic and 10μF tantalum capacitors are needed to comply with the published ripple and noise specifications.

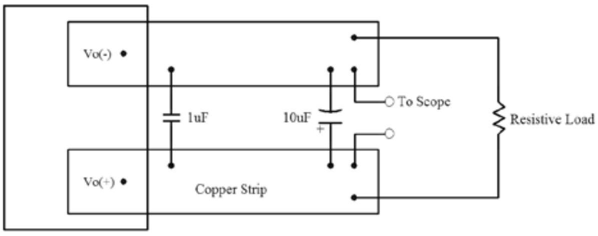
To reduce the output ripple and improve the dynamic response to a step load change, additional capacitance at the output can be used. Low ESR polymer and ceramic capacitors are recommended to improve the dynamic response of the module. For stable operation of the module, limit the capacitance to less than the maximum output capacitance as specified in the output specification table.

Testing Configurations

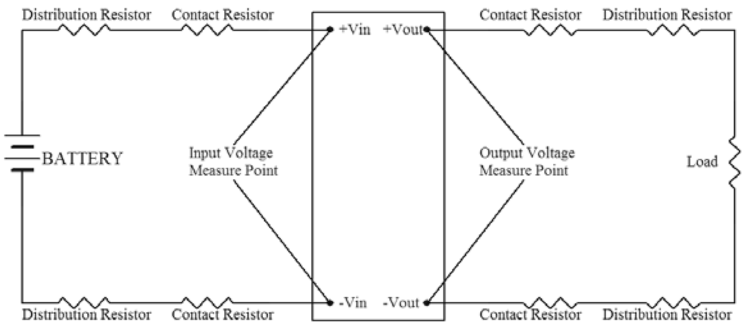
Input reflected-ripple current measurement test up



Peak-to-peak output ripple & noise measurement test up



Output voltage and efficiency measurement test up

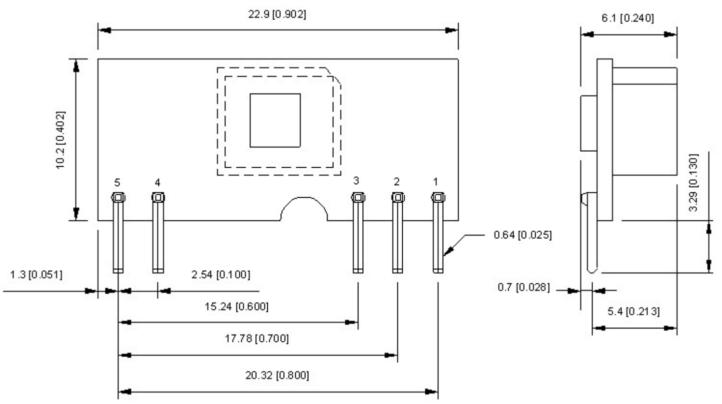


Note: All measurements are taken at the module terminals.

$$Efficiency = \left(\frac{Vout \times Iout}{Vin \times Iin} \right) \times 100\%$$

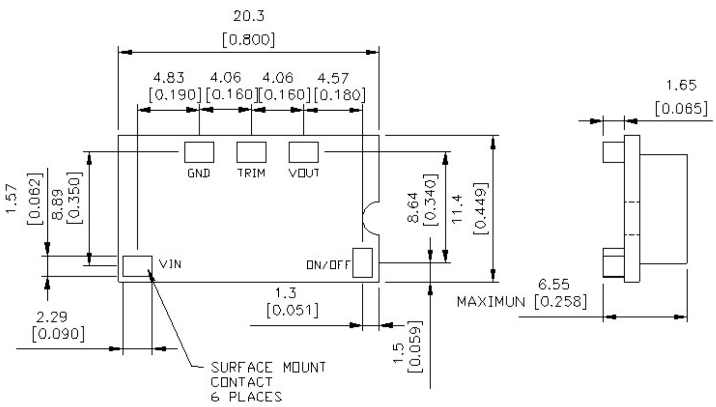
Mechanical Data

TOS 06-xxSIL



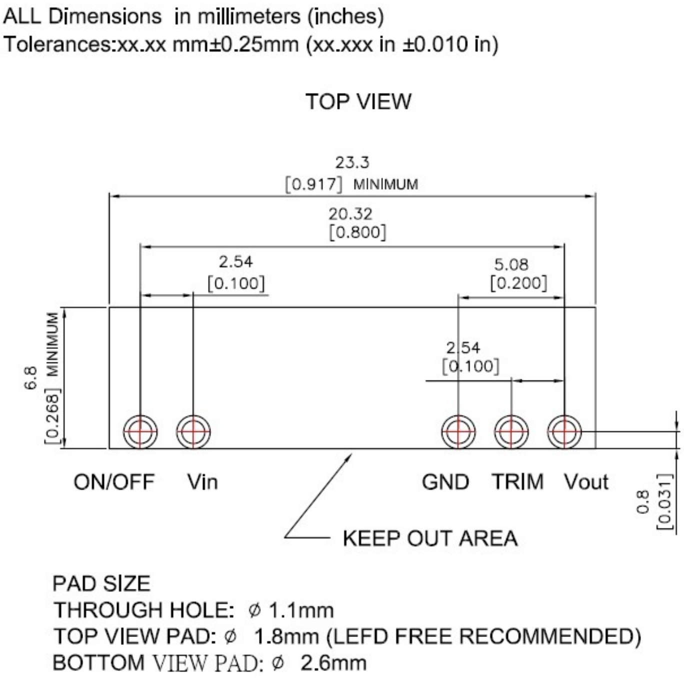
DOH06-05T	
PIN	FUNCTION
1	VOUT
2	TRIM
3	GND
4	VIN
5	ON/OFF

TOS 06-xxSM

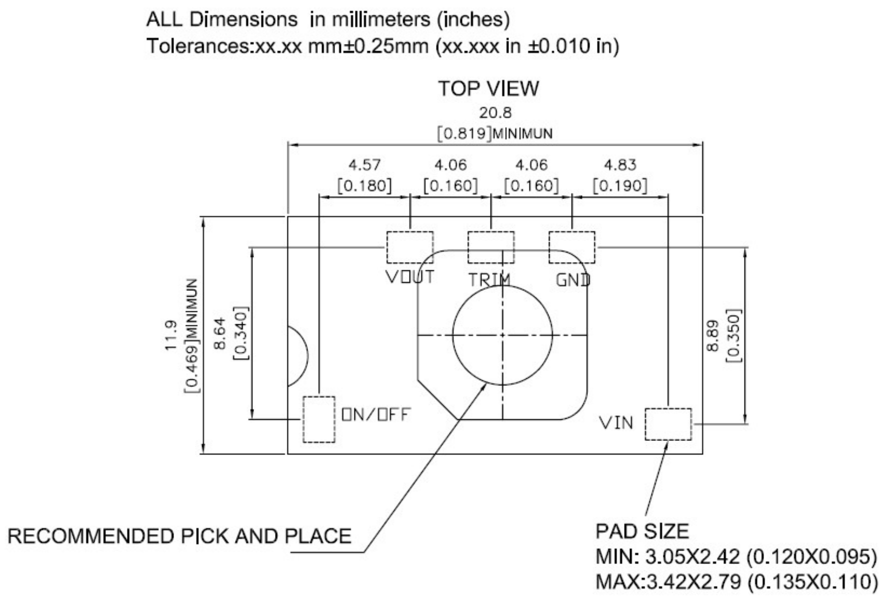


Recommended Pad Layout

Recommended pad layout for TOS 06-xxSIL

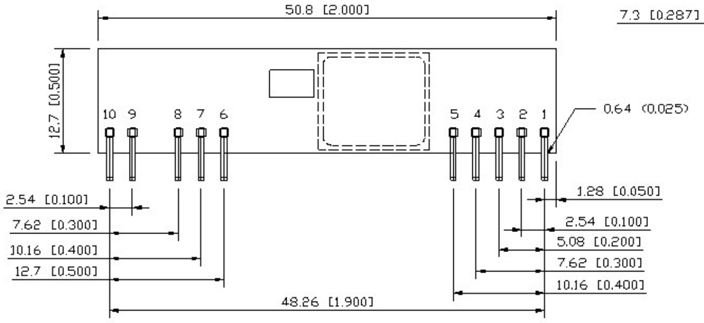


Recommended pad layout for TOS 06-xxSM

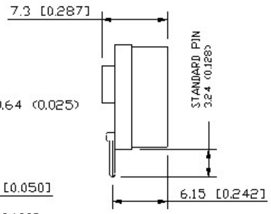


Mechanical Data

TOS 10-xxSIL and TOS 16-xxSIL



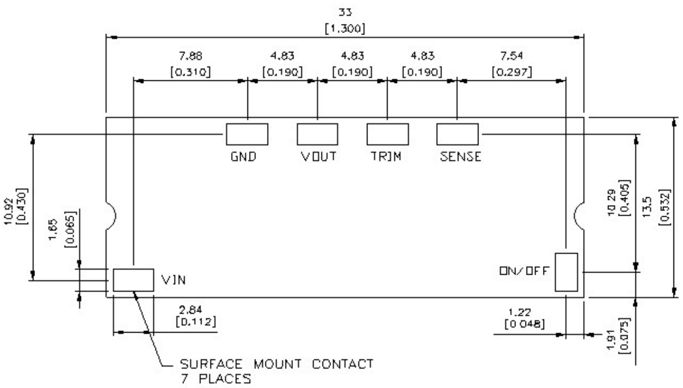
Bottom View



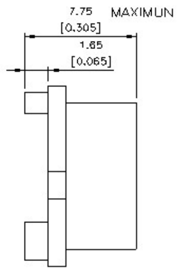
Side View

PIN	FUNCTION
1	Vo
2	Vo
3	+SENSE
4	Vo
5	GND
6	GND
7	Vin
8	Vin
9	Trim
10	ON/OFF

TOS 10-xxSM and TOS 16-xxSM



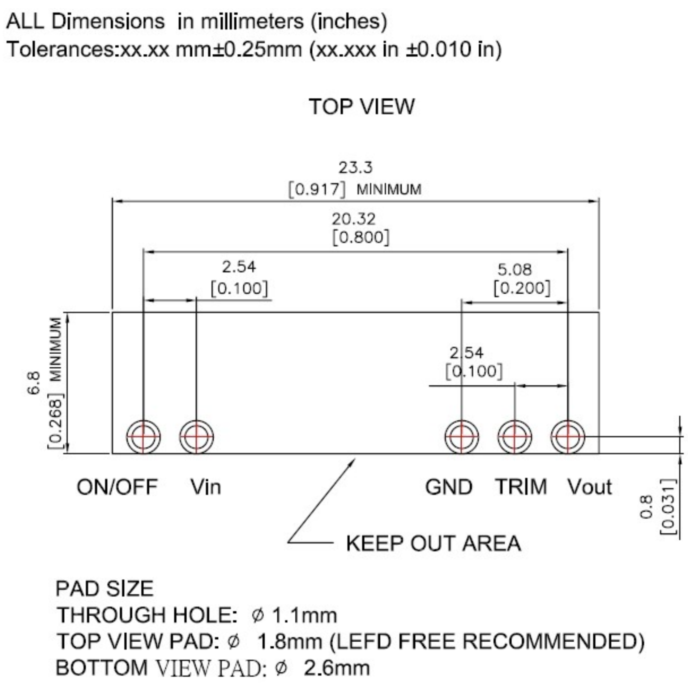
Bottom Vies



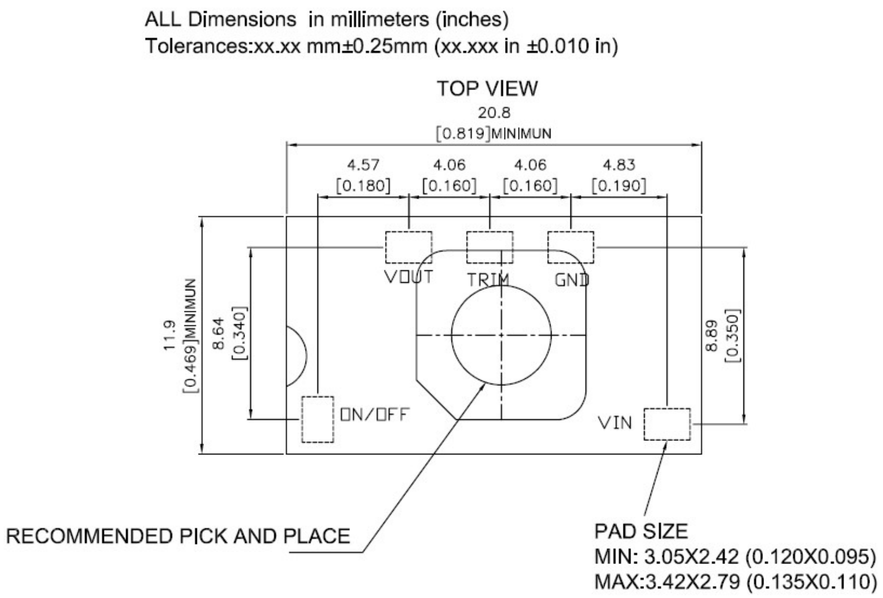
Side View

Recommended Pad Layout

Recommended pad layout for TOS 10-xxSIL and TOS 16-xxSIL

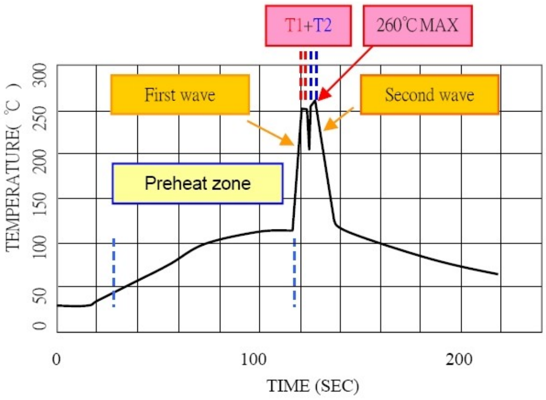


Recommended pad layout for TOS 10-xxSM and TOS 16-xxSM



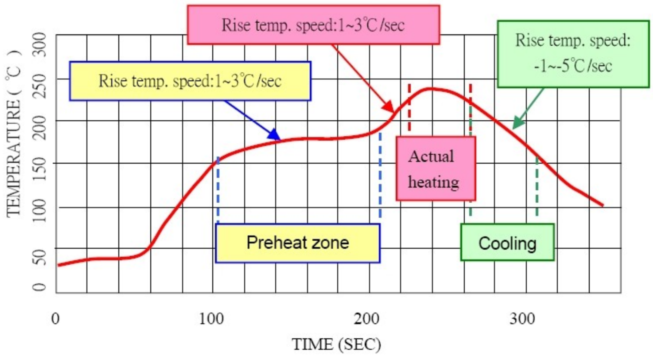
Soldering and Re-flow Considerations

Lead free wave solder profile for TOS xx-xxSIL



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

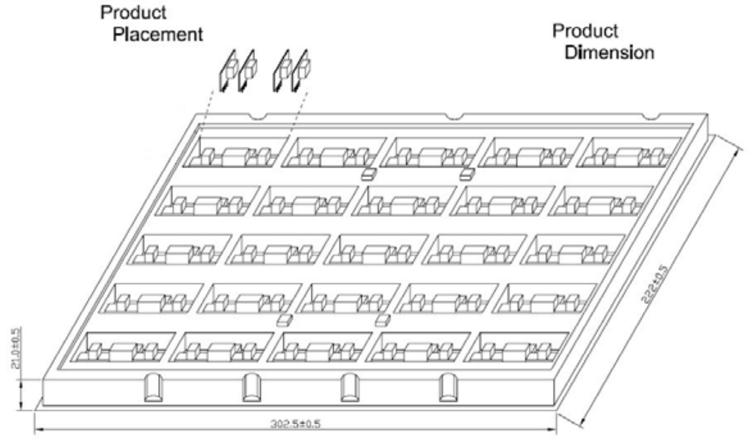
Lead free re-flow profile for TOS xx-xxSM



Zone	Reference Parameter.
Preheat zone	Rise temp. speed: 1~3°C/sec Preheat time: 60~90sec Preheat temp.: 155~185℃
Actual heating	Rise temp. speed: 1~3°C/sec Melting time: 20~40 sec Melting temp: 220°C Peak temp.: 230~240℃ Peak time: 10~20 sec
Cooling	Rise temp. speed: -1~-5°C/sec

Packaging Information

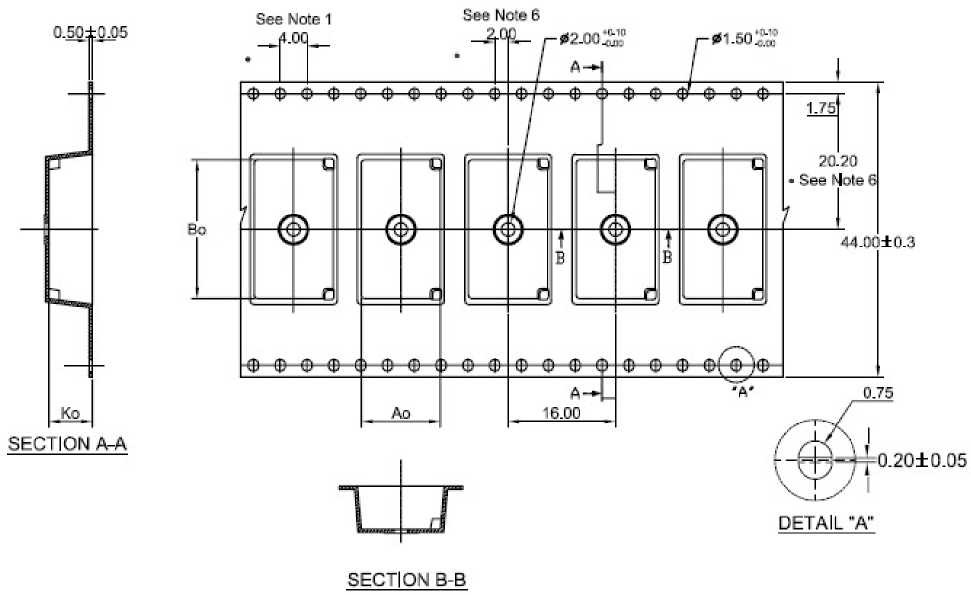
Packaging information for TOS 06-xxSIL



Notes:

1. Material: PS (thick = 1.2mm)

Packaging information for TOS 06-xxSM

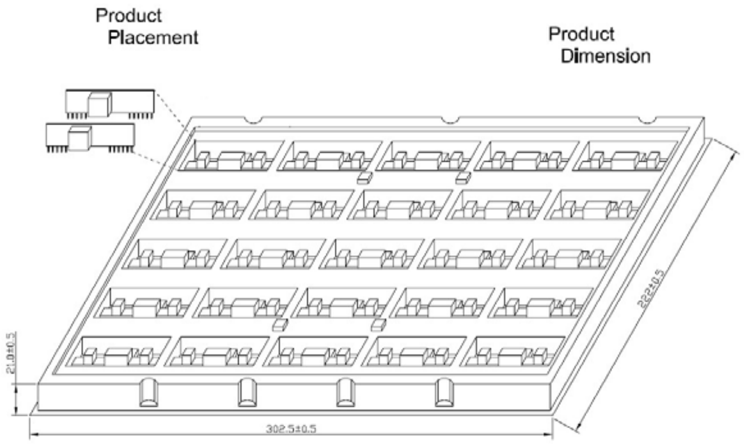


Notes:
1. 10 sprocket hole pitch cumulative tolerance ± 0.2
2. Camber not to exceed 1mm in 100mm.
3. Material: Black Polystyrene.
4. Ao and Bo measured on a plane 0.3mm above the bottom of the pocket.
5. Ko measured from a plane on the inside bottom of the pocket to the top surface of the carrier tape.
6. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.

Ao=11.80mm
Bo=20.70mm
Ko= 6.50mm

Packaging Information

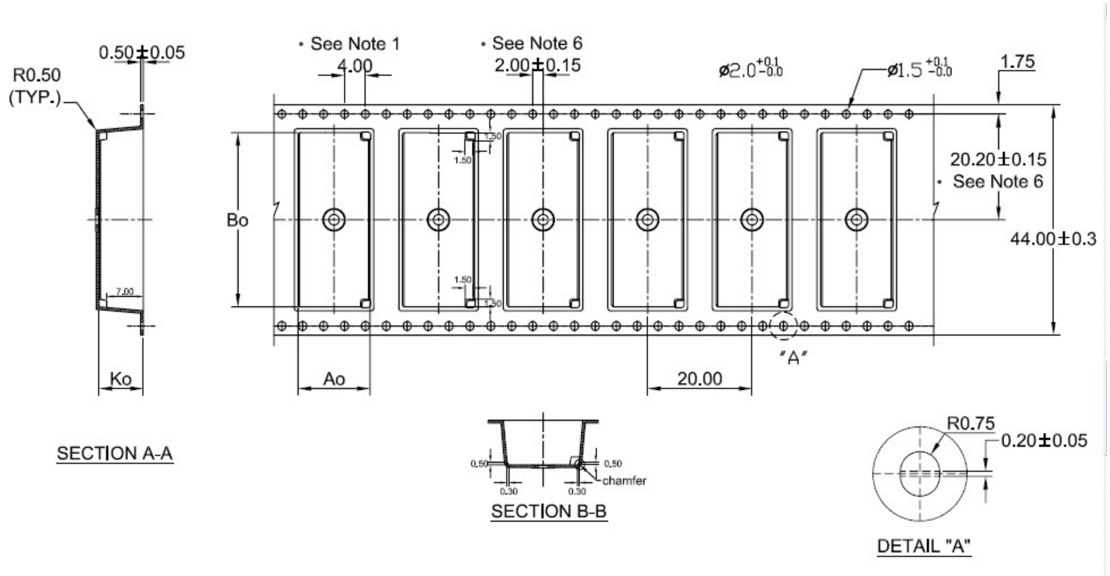
Packaging information for TOS 10-xxSIL and TOS 16-xxSIL



Notes:

1. Material: PS (thick = 1.2mm)

Packaging information for TOS 10-xxSM and TOS 16-xxSM



Notes:

1. 10 sprocket hole pitch cumulative tolerance ± 0.2
2. Camber not to exceed 1mm in 100mm.
3. Material: Black Advantek Polystyrene.
4. Ao and Bo measured on a plane 0.3mm above the bottom of the pocket.
5. Ko measured from a plane on the inside bottom of the pocket to the top surface of the carrier tape.
6. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.

Ao=13.80mm
Bo=33.30mm
Ko= 8.50mm

Safety and Installation Instruction

Fusing Consideration

Caution: This power module is not internally fused. An input line fuse must always be used.

This encapsulated power module can be used in a wide variety of applications, ranging from simple stand-alone operation to an integrated part of sophisticated power architecture. To maximum flexibility, internal fusing is not included; however, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require a normal-blow fuse with maximum rating of 6A (TOS 06), 15A (TOS 10) and 20A (TOS 16). Based on the information provided in this data sheet on Inrush energy and maximum dc input current; the same type of fuse with lower rating can be used. Refer to the fuse manufacturer's data for further information.

MTBF and Reliability

The MTBF of the TOS DC/DC converters has been calculated using Bellcore TR-NWT-000332 Case I: 50% stress, Operating Temperature at 40°C (Ground fixed and controlled environment)

TOS 06-xxSIL and TOS 06-xxSM:	MTBF = 2.133x10^7 hours = 21'330'000 hours
TOS 10-05SIL and TOS 10-05SM:	MTBF = 1,428x10^7 hours = 14'280'000 hours
TOS 10-12SIL and TOS 10-12SM:	MTBF = 1,409x10^7 hours = 14'090'000 hours
TOS 16-05SIL and TOS 16-05SM:	MTBF = 1,428x10^7 hours = 14'280'000 hours
TOS 16-12SIL and TOS 16-12SM:	MTBF = 1,409x10^7 hours = 14'090'000 hours