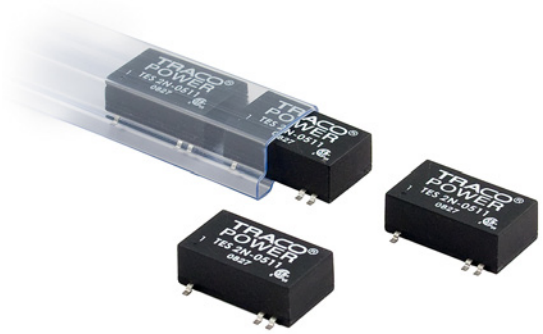
# TES 2N Series

**DC/DC CONVERTER 2W,** SMD-Package

## Features

- Small Footprint:
  24.0 x 18.1 mm (0.94 x 0.71 inches)
- Wide 2:1 Input Range
- Fully regulated Output
- Operating Temp. Range –40°C to +85°C
- Short Circuit Protection
- I/O-isolation 1500 VDC
- Input Filter meets EN55022,class A and FCC, level A
- Qualified for lead-free reflow solder process according IPC/JEDEC J-STD-020D
- 3 Years Product Warranty



## Applications

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

## General Description

The TRACO TES 2N series is a range of isolated 2W DC/DC converter modules featuring fully regulated output voltages and wide 2:1 input voltage ranges. The products come in a compact SMD package with a small footprint and low package height of just 8.0 mm (0.31 inch). All models are qualified for lead free reflow solder processes according IPC J-STD-020D standard.
An excellent efficiency allows an operating temperature range of–40°C to +85°C. The compact dimensions of these DC/DC converters make them an ideal solution for many space critical applications in battery-powered equipment and instrumentation.

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| Absolute Maximum Rating | | | | |
|---|---|---|---|---|
| **Parameter** | **Model** | **Min** | **Max** | **Unit** |
| Input Voltage<br>Input Surge Voltage ( 1 sec. ) | 5VDC Input Models<br>12VDC Input Models<br>24VDC Input Models<br>48VDC Input Models | -0.7<br>-0.7<br>-0.7<br>-0.7 | 11<br>25<br>50<br>100 | VDC |
| Operating Ambient Temperature<br>Without Derating<br>With Derating | All | -40<br>-40 | +70<br>+85 | ℃ |
| Operating Case Temperature | All | --- | +90 | ℃ |
| Storage Temperature | All | -50 | +125 | ℃ |

| Output Specification | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Model** | **Min** | **Nominal** | **Max** | **Unit** |
| Output Voltage<br>($V_{in}$=$V_{in\ nom}$; Full Load; $T_A$=25℃) | TES 2N-xx10 | 3.234 | 3.3 | 3.366 | VDC |
| | TES 2N-xx11 | 4.9 | 5 | 5.1 | |
| | TES 2N-xx12 | 11.76 | 12 | 12.24 | |
| | TES 2N-xx13 | 14.7 | 15 | 15.3 | |
| | TES 2N-xx21 | ±4.9 | ±5 | ±5.1 | |
| | TES 2N-xx22 | ±11.76 | ±12 | ±12.24 | |
| | TES 2N-xx23 | ±14.7 | ±15 | ±15.3 | |
| Output Regulation<br>Line ($V_{in\ min}$ to $V_{in\ max}$ at Full Load) | | --- | ±0.3 | ±0.5 | % |
| Output Regulation<br>Load (25% to 100% of Full Load) | | --- | ±0.5 | ±0.75 | % |
| Output Ripple & Noise<br>Peak-to-Peak (20MHz bandwidth) | | --- | 30 | 50 | mV pk-pk |
| Temperature Coefficient | All | --- | ±0.01 | ±0.02 | %/℃ |
| Dynamic Load Response<br>($V_{in}$ = $V_{in\ nom}$ ; TA=25℃ Load step change form 75% to 100% or 100% to 75% of full Load) | All | | | | |
| Peak Deviation | | --- | ±3 | ±5 | % |
| Recovery Time ($V_{out}$ < 10% peak deviation) | | --- | 100 | 300 | µS |
| Output Current | TES 2N-xx10 | 125 | --- | 500 | mA |
| | TES 2N-xx11 | 100 | --- | 400 | |
| | TES 2N-xx12 | 42 | --- | 167 | |
| | TES 2N-xx13 | 33 | --- | 134 | |
| | TES 2N-xx21 | ±50 | --- | ±200 | |
| | TES 2N-xx22 | ±21 | --- | ±83 | |
| | TES 2N-xx23 | ±17 | --- | ±67 | |
| Output Short Circuit Protection | All | Continuous | | | |

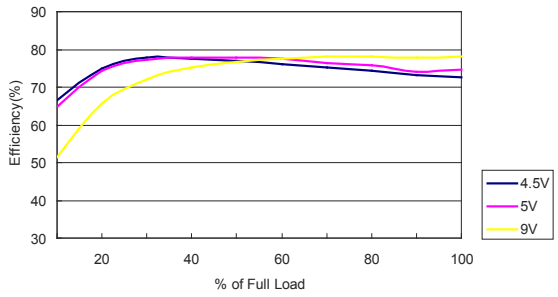
| Input Specification | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Model** | **Min** | **Nominal** | **Max** | **Unit** |
| Operating Input Voltage | 5V Input Models | 4.5 | 5 | 9 | VDC |
| | 12V Input Models | 9 | 12 | 18 | |
| | 24V Input Models | 18 | 24 | 36 | |
| | 48V Input Models | 36 | 48 | 75 | |
| Under Voltage Lockout Turn-on Threshold | 5V Input Models | 3.5 | 4 | 4.5 | VDC |
| | 12V Input Models | 4.5 | 7 | 9 | |
| | 24V Input Models | 8 | 12 | 18 | |
| | 48V Input Models | 16 | 24 | 36 | |
| Under Voltage Lockout Turn-off Threshold | 5V Input Models | --- | 3.5 | 4 | VDC |
| | 12V Input Models | --- | 6.5 | 8.5 | |
| | 24V Input Models | --- | 11 | 17 | |
| | 48V Input Models | --- | 22 | 34 | |
| Input reflected ripple current (20MHz bandwidth) (Measured with a inductor 4.7µH and Capacitance 220uF,ESR<1.0 ohm at 100KHz to simulated source) impedance | 5V Input Models | --- | 100 | --- | mA pk-pk |
| | 12V Input Models | --- | 25 | --- | |
| | 24V Input Models | --- | 15 | --- | |
| | 48V Input Models | --- | 10 | --- | |
| Input Current ($V_{in}$= $V_{in\ nom}$;Full Load) | TES 2N-0510 | --- | 471 | --- | mA |
| | TES 2N-0511 | --- | 548 | --- | |
| | TES 2N-0512 | --- | 534 | --- | |
| | TES 2N-0513 | --- | 582 | --- | |
| | TES 2N-0521 | --- | 667 | --- | |
| | TES 2N-0522 | --- | 615 | --- | |
| | TES 2N-0523 | --- | 598 | --- | |
| | TES 2N-1210 | --- | 184 | --- | |
| | TES 2N-1211 | --- | 217 | --- | |
| | TES 2N-1212 | --- | 209 | --- | |
| | TES 2N-1213 | --- | 220 | --- | |
| | TES 2N-1221 | --- | 242 | --- | |
| | TES 2N-1222 | --- | 224 | --- | |
| | TES 2N-1223 | --- | 226 | --- | |
| | TES 2N-2410 | --- | 96 | --- | |
| | TES 2N-2411 | --- | 109 | --- | |
| | TES 2N-2412 | --- | 109 | --- | |
| | TES 2N-2413 | --- | 108 | --- | |
| | TES 2N-2421 | --- | 119 | --- | |
| | TES 2N-2422 | --- | 112 | --- | |
| | TES 2N-2423 | --- | 110 | --- | |
| | TES 2N-4810 | --- | 49 | --- | |
| | TES 2N-4811 | --- | 57 | --- | |
| | TES 2N-4812 | --- | 53 | --- | |
| | TES 2N-4813 | --- | 55 | --- | |
| | TES 2N-4821 | --- | 62 | --- | |
| | TES 2N-4822 | --- | 57 | --- | |
| | TES 2N-4823 | --- | 57 | --- | |

| Input Specification | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Model** | **Min** | **Nominal** | **Max** | **Unit** |
| Input Standby Current (Typical value at $V_{in}$ = $V_{in\ nom}$; No Load) | TES 2N-0510 | --- | 40 | --- | mA |
| | TES 2N-0511 | --- | | --- | |
| | TES 2N-0512 | --- | | --- | |
| | TES 2N-0513 | --- | | --- | |
| | TES 2N-0521 | --- | | --- | |
| | TES 2N-0522 | --- | | --- | |
| | TES 2N-0523 | --- | | --- | |
| | TES 2N-1210 | --- | 20 | --- | |
| | TES 2N-1211 | --- | | --- | |
| | TES 2N-1212 | --- | | --- | |
| | TES 2N-1213 | --- | | --- | |
| | TES 2N-1221 | --- | | --- | |
| | TES 2N-1222 | --- | | --- | |
| | TES 2N-1223 | --- | | --- | |
| | TES 2N-2410 | --- | 10 | --- | |
| | TES 2N-2411 | --- | | --- | |
| | TES 2N-2412 | --- | | --- | |
| | TES 2N-2413 | --- | | --- | |
| | TES 2N-2421 | --- | | --- | |
| | TES 2N-2422 | --- | | --- | |
| | TES 2N-2423 | --- | | --- | |
| | TES 2N-4810 | --- | 8 | --- | |
| | TES 2N-4811 | --- | | --- | |
| | TES 2N-4812 | --- | | --- | |
| | TES 2N-4813 | --- | | --- | |
| | TES 2N-4821 | --- | | --- | |
| | TES 2N-4822 | --- | | --- | |
| | TES 2N-4823 | --- | | --- | |

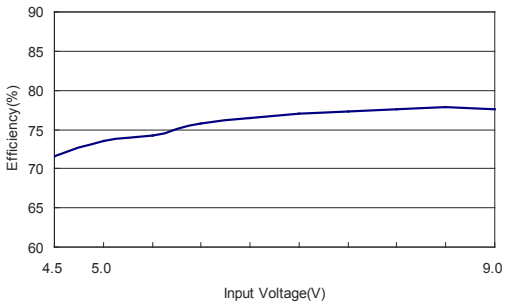
| General Specification | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Model** | **Min** | **Nominal** | **Max** | **Unit** |
| Efficiency ($V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$ =25°C) | TES 2N-0510 | --- | 70 | --- | % |
| | TES 2N-0511 | --- | 73 | --- | |
| | TES 2N-0512 | --- | 75 | --- | |
| | TES 2N-0513 | --- | 73 | --- | |
| | TES 2N-0521 | --- | 64 | --- | |
| | TES 2N-0522 | --- | 69 | --- | |
| | TES 2N-0523 | --- | 71 | --- | |
| | TES 2N-1210 | --- | 73 | --- | |
| | TES 2N-1211 | --- | 77 | --- | |
| | TES 2N-1212 | --- | 80 | --- | |
| | TES 2N-1213 | --- | 80 | --- | |
| | TES 2N-1221 | --- | 73 | --- | |
| | TES 2N-1222 | --- | 78 | --- | |
| | TES 2N-1223 | --- | 78 | --- | |
| | TES 2N-2410 | --- | 72 | --- | |
| | TES 2N-2411 | --- | 77 | --- | |
| | TES 2N-2412 | --- | 80 | --- | |
| | TES 2N-2413 | --- | 81 | --- | |
| | TES 2N-2421 | --- | 74 | --- | |
| | TES 2N-2422 | --- | 78 | --- | |
| | TES 2N-2423 | --- | 80 | --- | |
| | TES 2N-4810 | --- | 71 | --- | |
| | TES 2N-4811 | --- | 73 | --- | |
| | TES 2N-4812 | --- | 79 | --- | |
| | TES 2N-4813 | --- | 79 | --- | |
| | TES 2N-4821 | --- | 71 | --- | |
| | TES 2N-4822 | --- | 77 | --- | |
| | TES 2N-4823 | --- | 77 | --- | |
| Isolation Voltage<br>Input to Output (for 60 seconds) | | 1500 | --- | --- | VDC |
| Isolation Resistance | All | 1000 | --- | --- | MΩ |
| Isolation Capacitance | | --- | 250 | 420 | pF |
| Switching Frequency | | --- | 300 | --- | KHz |
| MTBF<br>MIL-STD-217F, TC=25°C | | 1,000,000 | --- | --- | Hours |

## Characteristic Curves

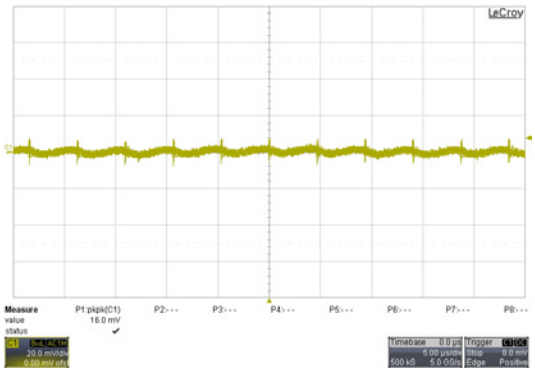
All test conditions are at 25°C The figures are identical for TES 2N-0510




Efficiency Versus Output Current

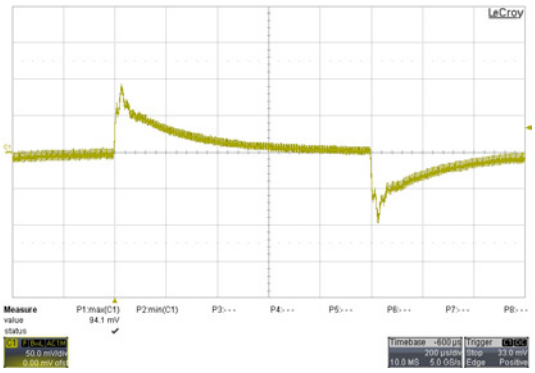



Efficiency Versus Input Voltage. Full Load

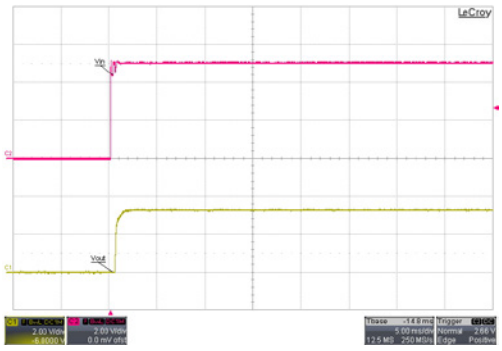


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

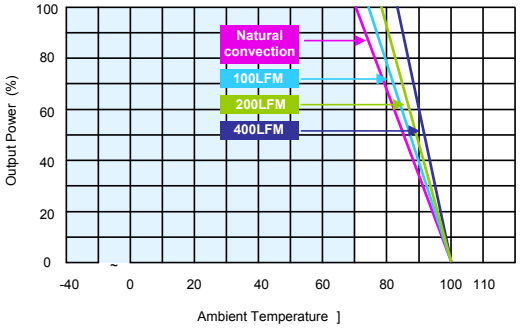


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



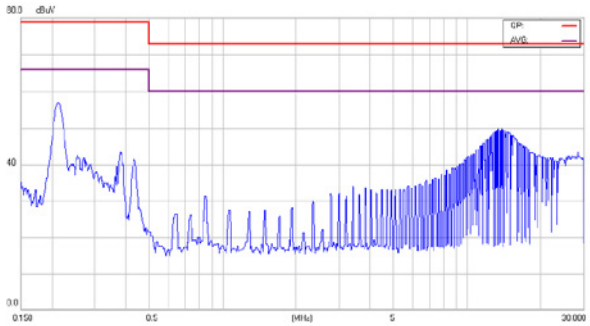
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



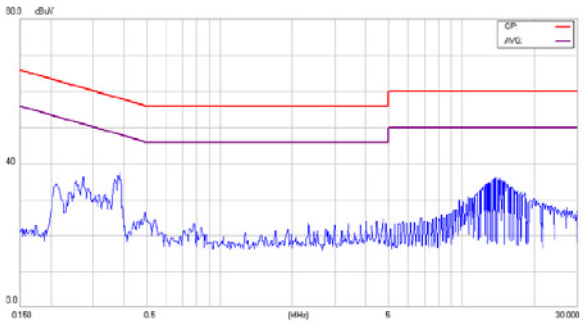

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

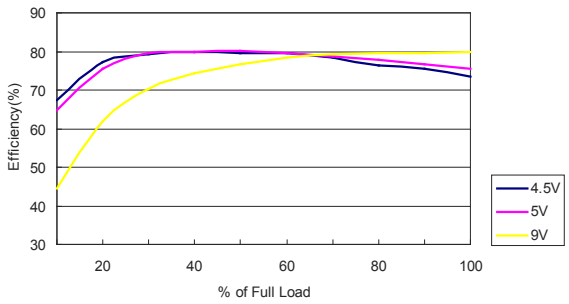


Conduction Emission of EN55022 Class B

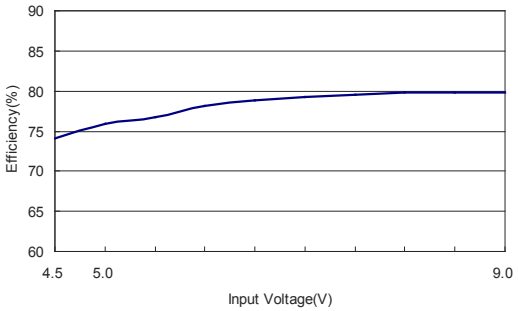
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

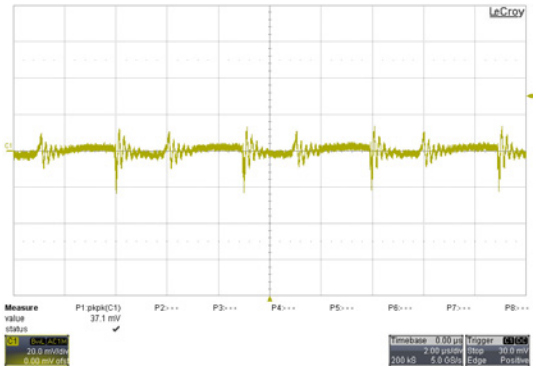
All test conditions are at 25°C The figures are identical for TES 2N-0511




Efficiency Versus Output Current

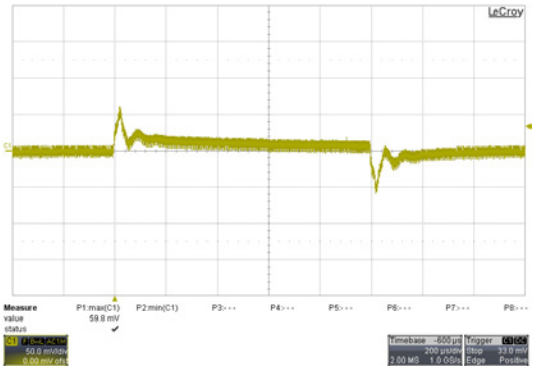



Efficiency Versus Input Voltage. Full Load

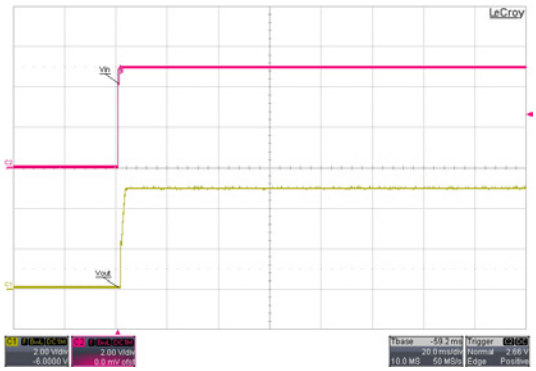


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

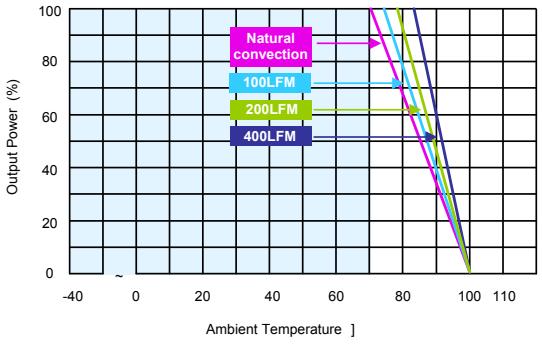


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



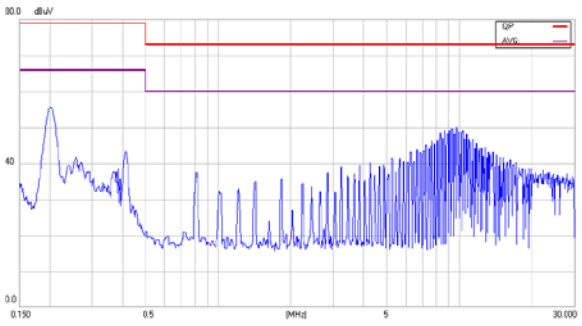
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



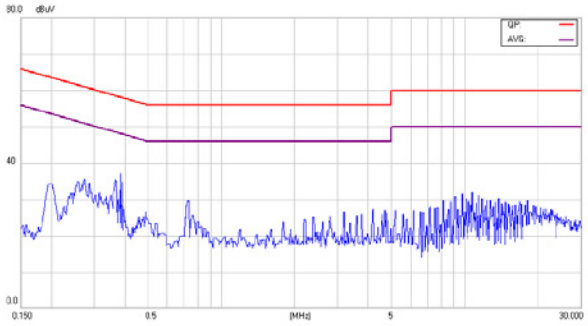

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

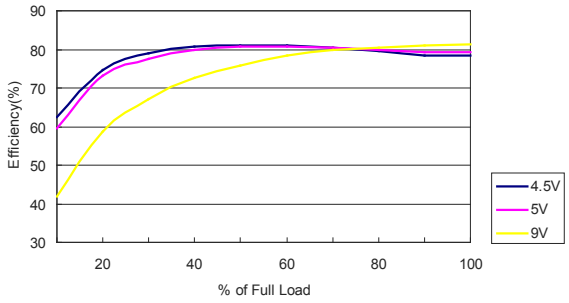


Conduction Emission of EN55022 Class B

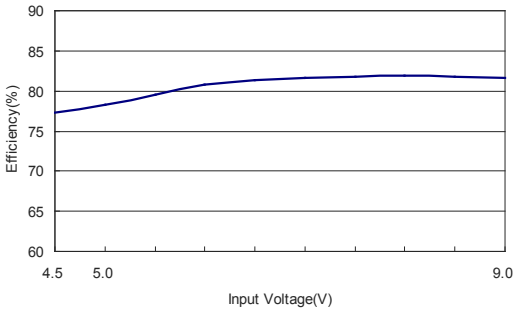
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

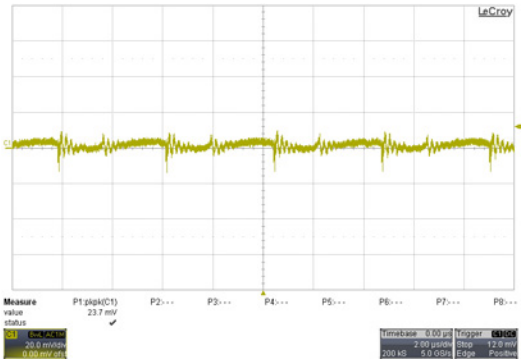
All test conditions are at 25°C The figures are identical for TES 2N-0512




Efficiency Versus Output Current

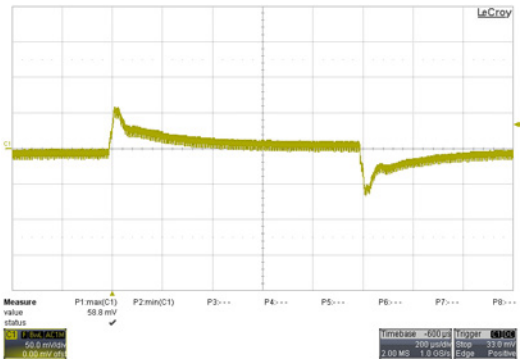



Efficiency Versus Input Voltage. Full Load



Typical Output Ripple and Noise.

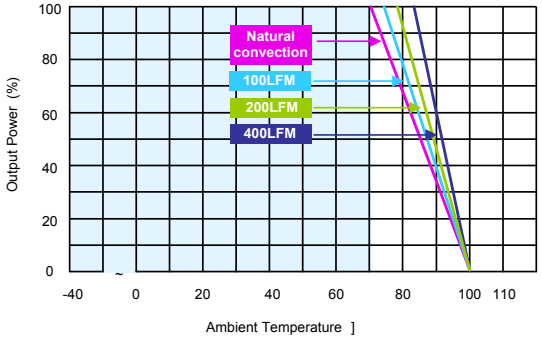
$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$



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

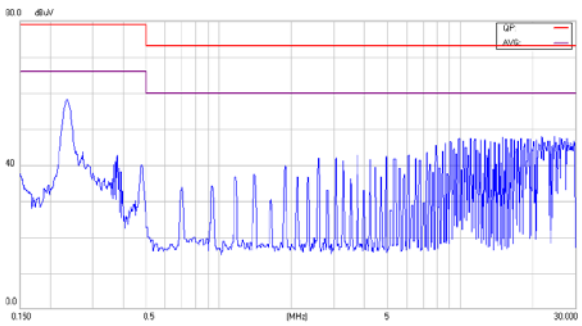
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



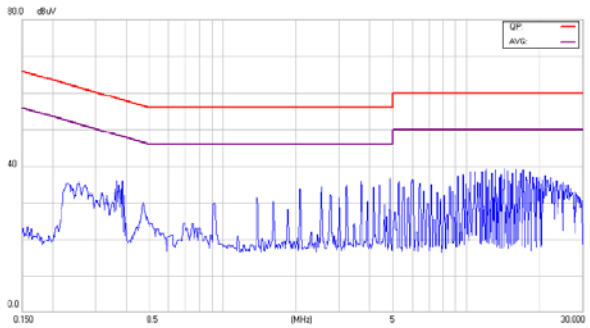

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

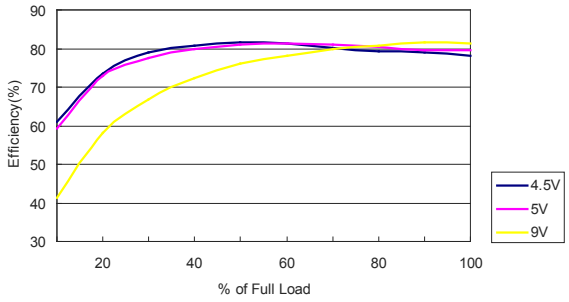


Conduction Emission of EN55022 Class B

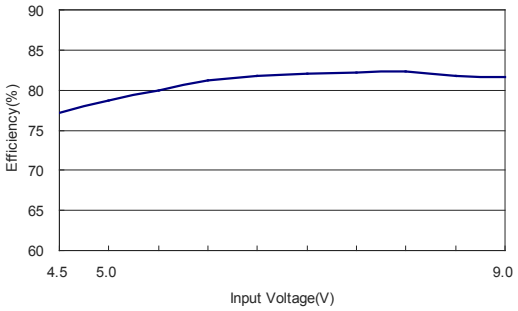
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

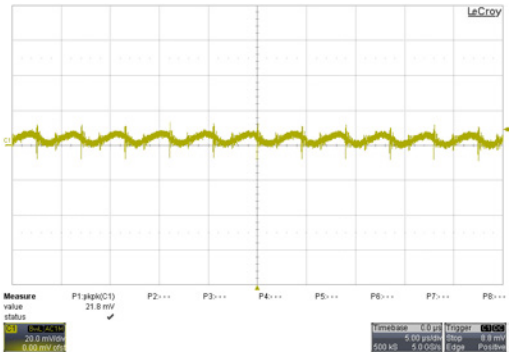
All test conditions are at 25°C The figures are identical for TES 2N-0513




Efficiency Versus Output Current

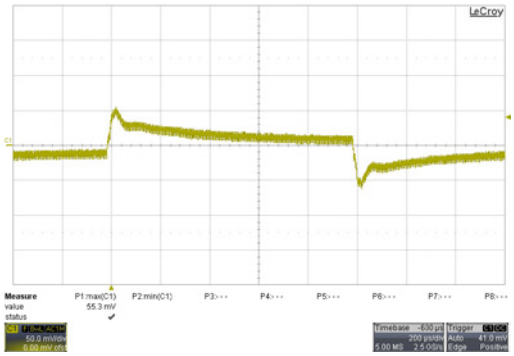



Efficiency Versus Input Voltage. Full Load

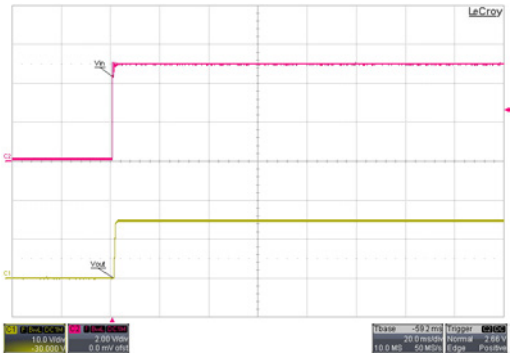


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

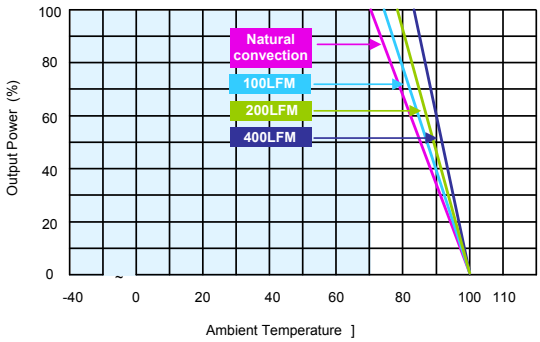


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



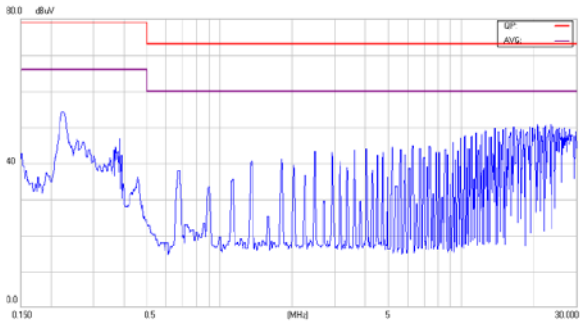
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



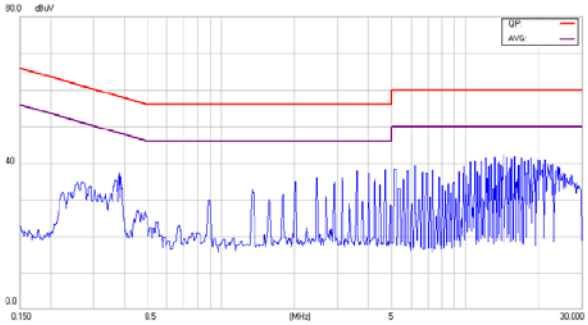

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

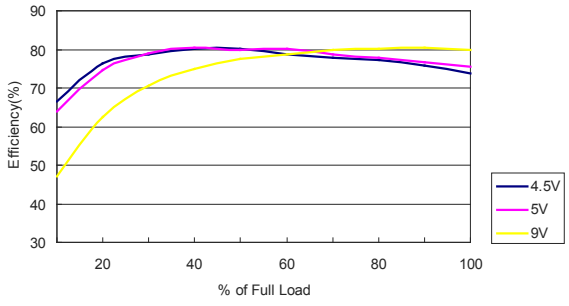


Conduction Emission of EN55022 Class B

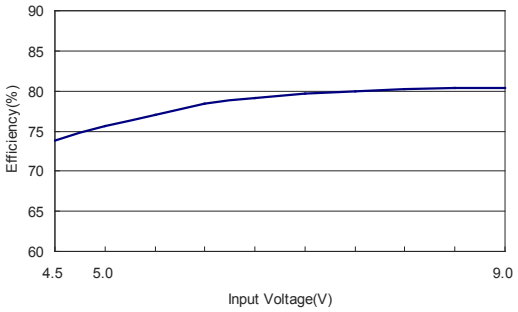
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

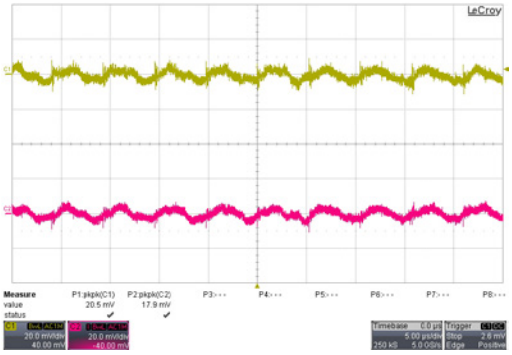
All test conditions are at 25°C The figures are identical for TES 2N-0521




Efficiency Versus Output Current

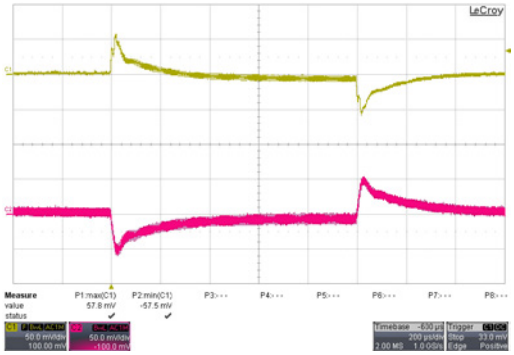



Efficiency Versus Input Voltage. Full Load

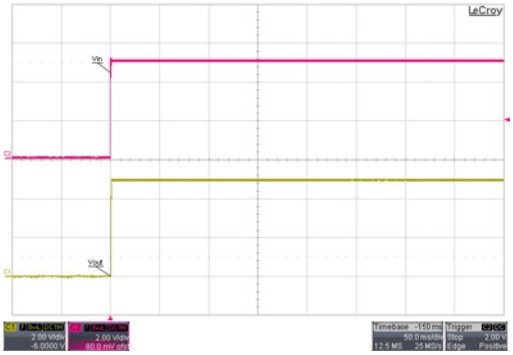


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

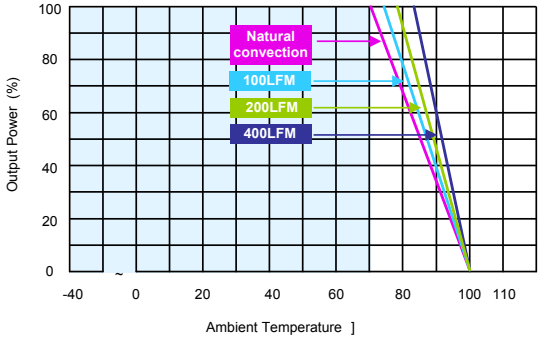


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



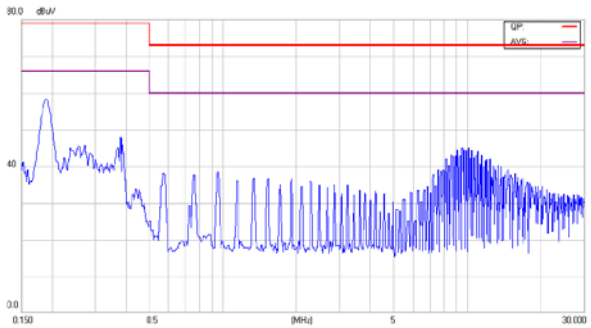
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



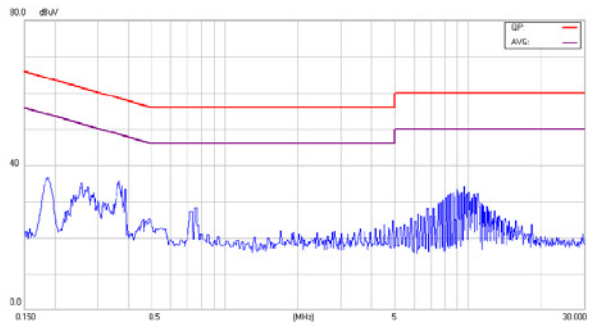

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

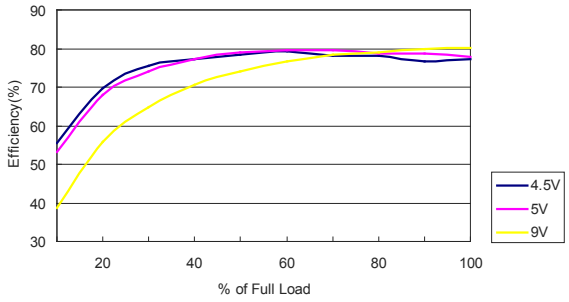


Conduction Emission of EN55022 Class B

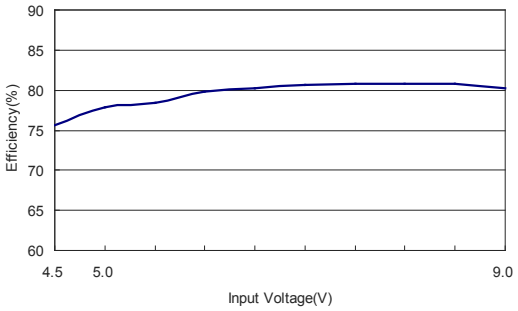
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

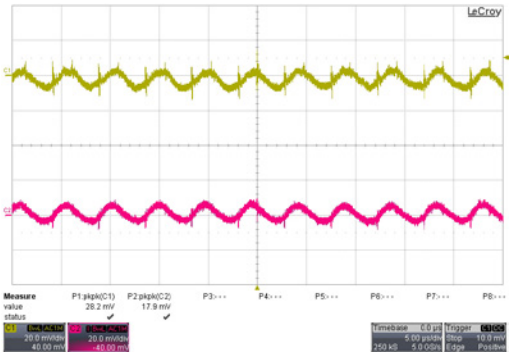
All test conditions are at 25°C The figures are identical for TES 2N-0522




Efficiency Versus Output Current

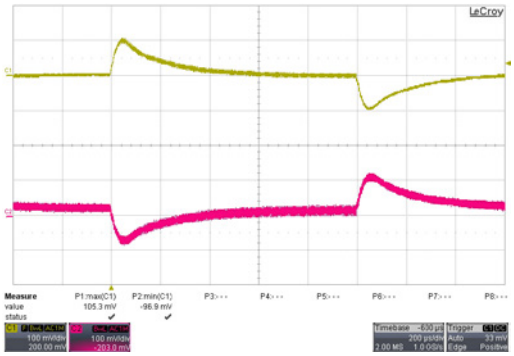



Efficiency Versus Input Voltage. Full Load

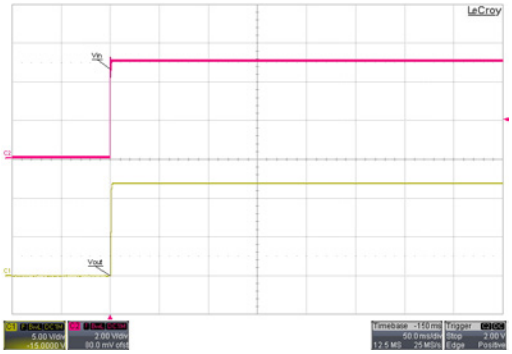


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

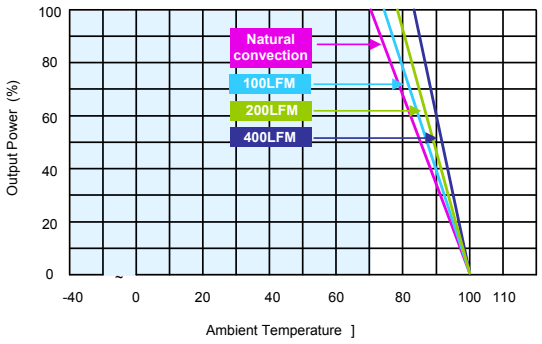


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



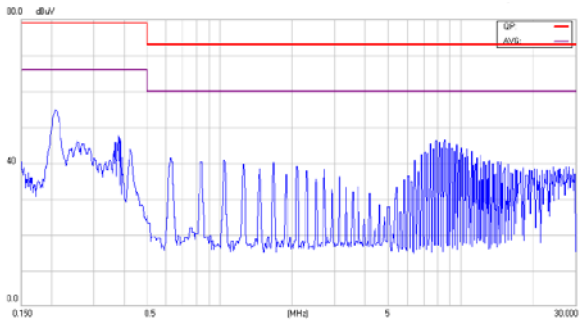
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



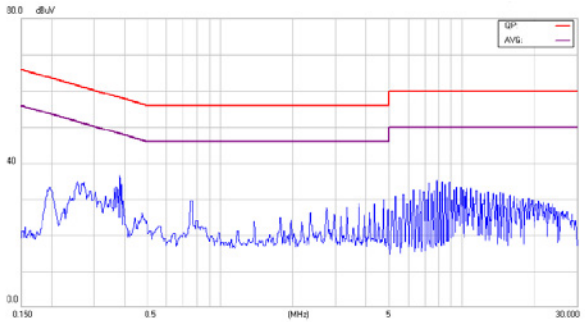

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

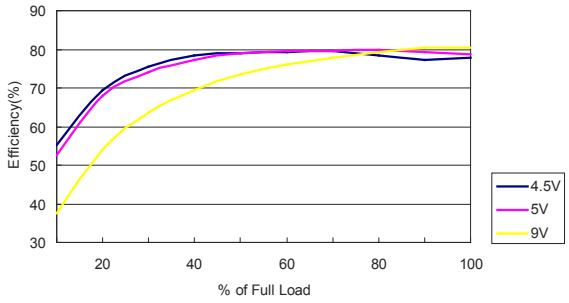


Conduction Emission of EN55022 Class B

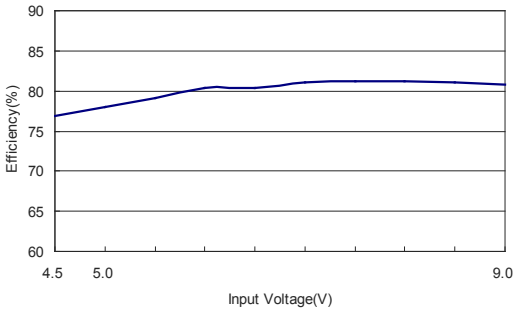
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

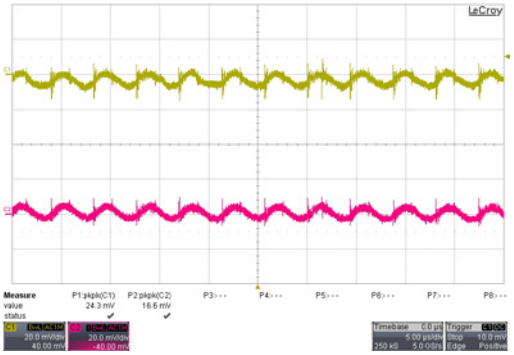
All test conditions are at 25°C The figures are identical for TES 2N-0523




Efficiency Versus Output Current

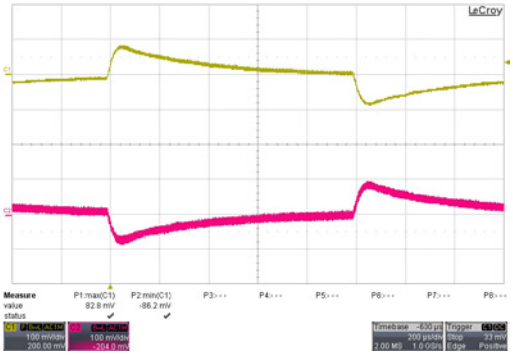



Efficiency Versus Input Voltage. Full Load

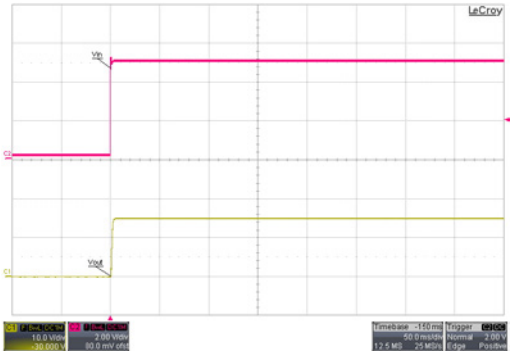


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

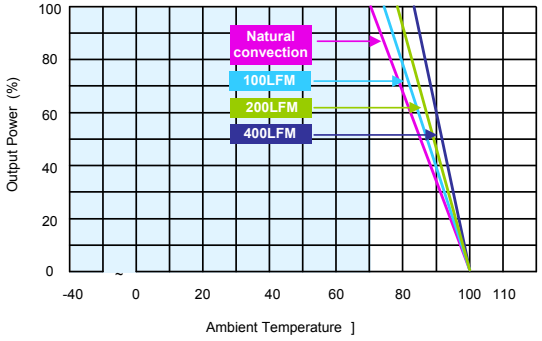


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



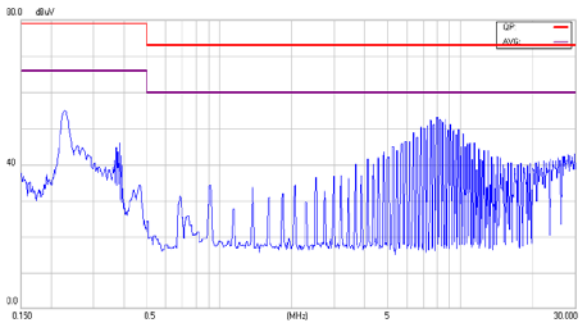
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



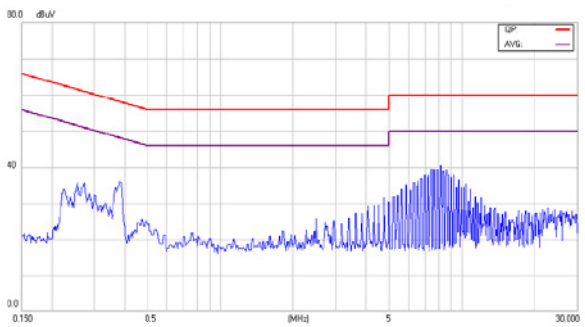

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

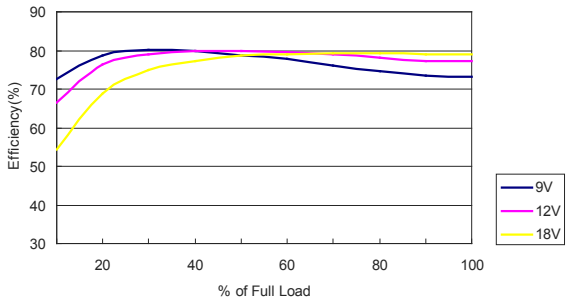


Conduction Emission of EN55022 Class B

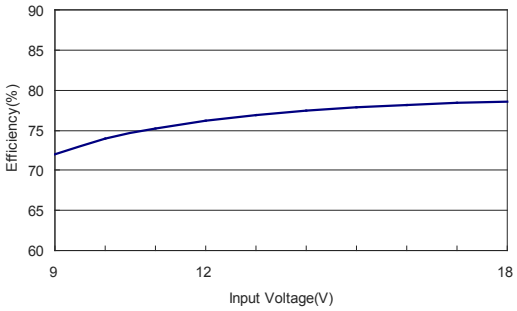
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

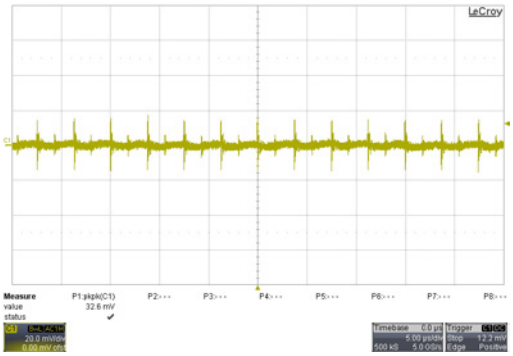
All test conditions are at 25°C The figures are identical for TES 2N-1210




Efficiency Versus Output Current

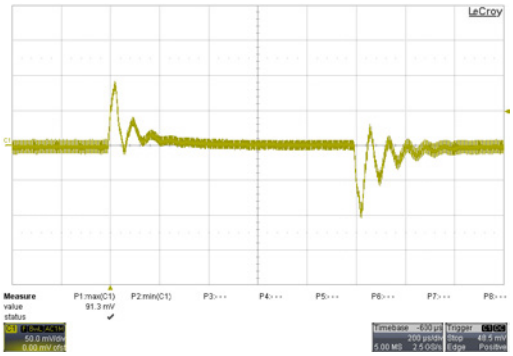



Efficiency Versus Input Voltage. Full Load

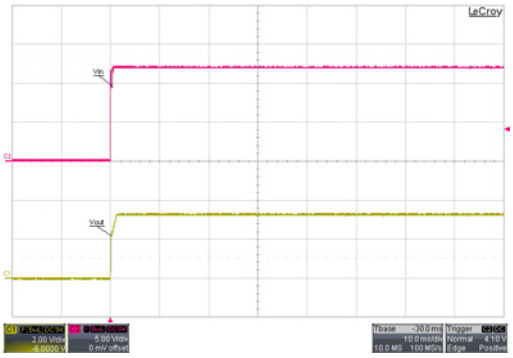


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

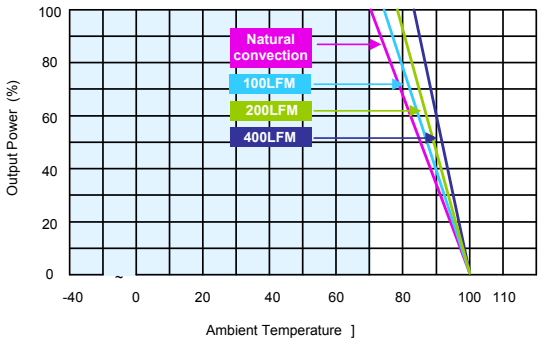


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



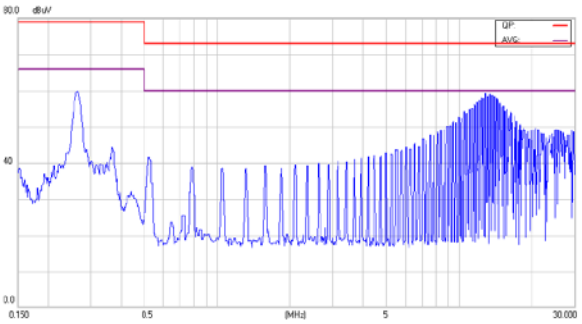
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



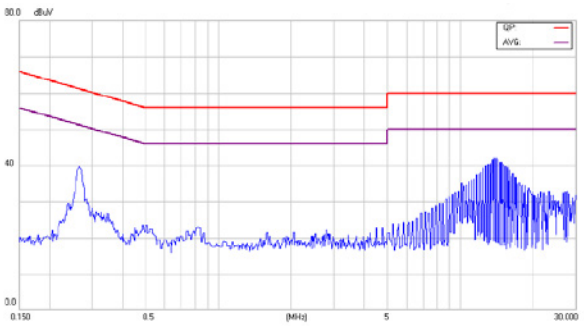

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

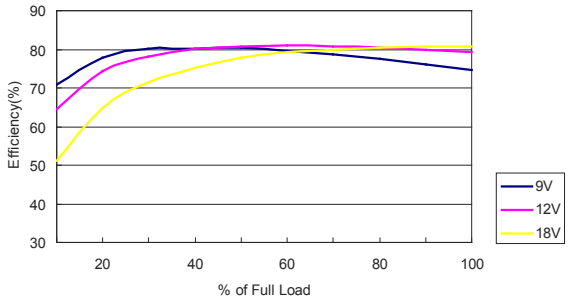


Conduction Emission of EN55022 Class B

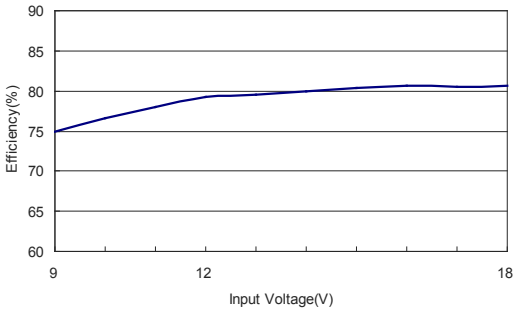
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

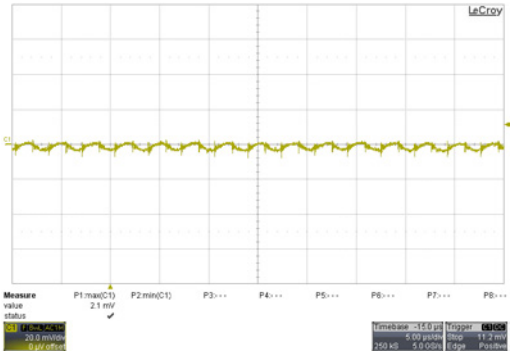
All test conditions are at 25°C The figures are identical for TES 2N-1211




Efficiency Versus Output Current

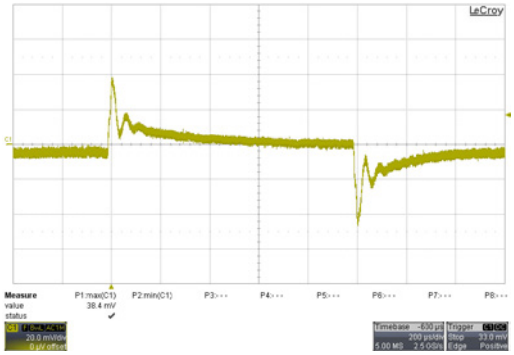



Efficiency Versus Input Voltage. Full Load

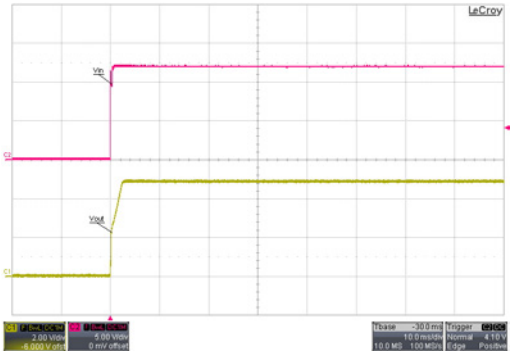


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

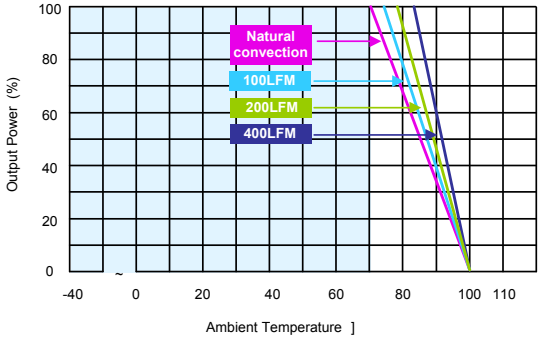


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



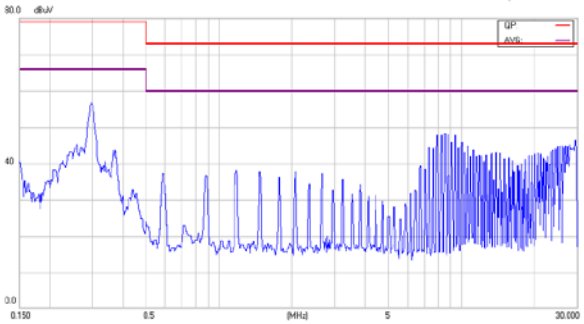
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



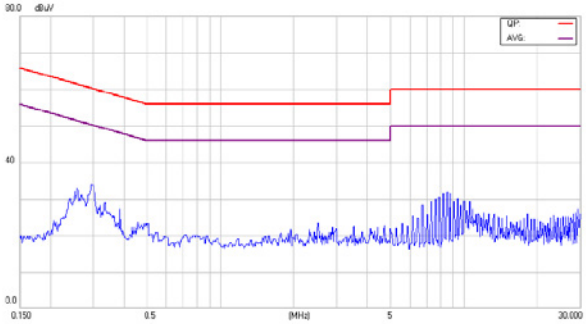

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

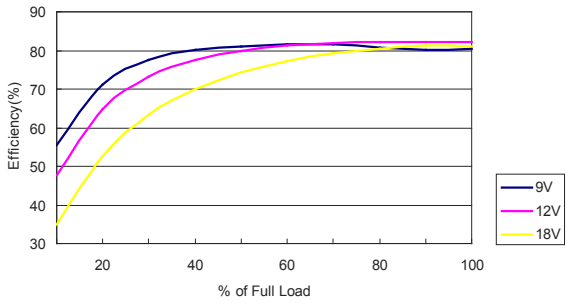


Conduction Emission of EN55022 Class B

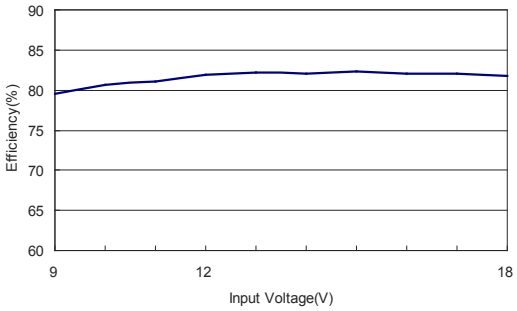
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

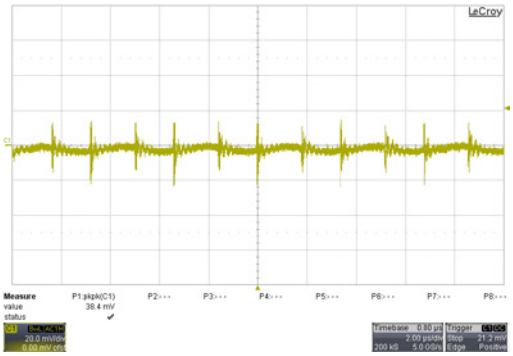
All test conditions are at 25°C The figures are identical for TES 2N-1212




Efficiency Versus Output Current

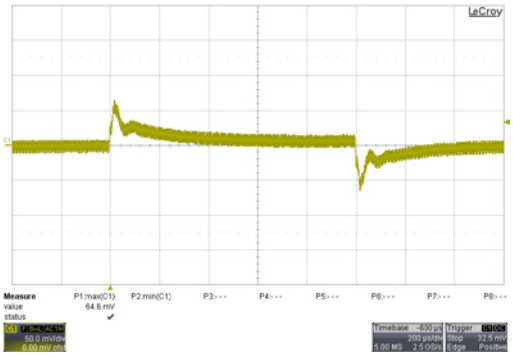



Efficiency Versus Input Voltage. Full Load

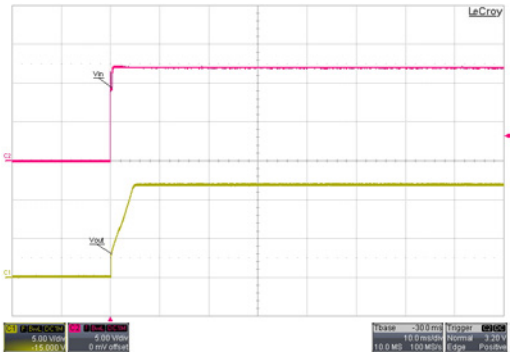


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

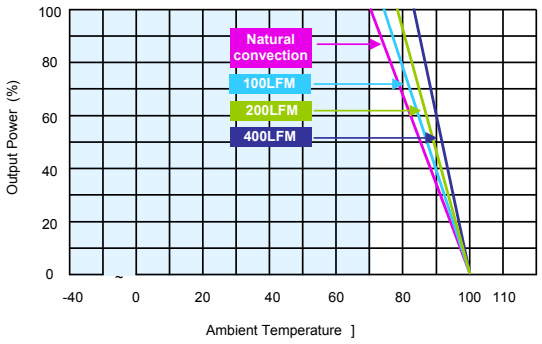


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



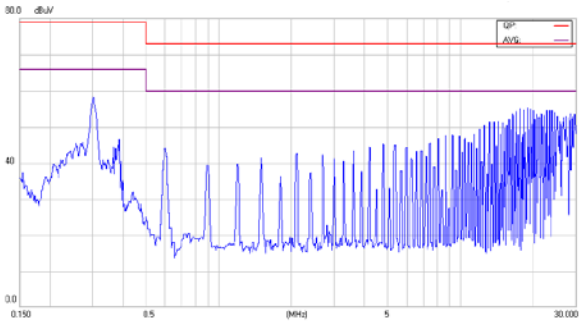
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



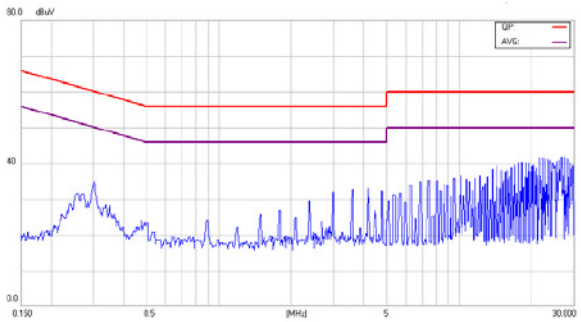

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

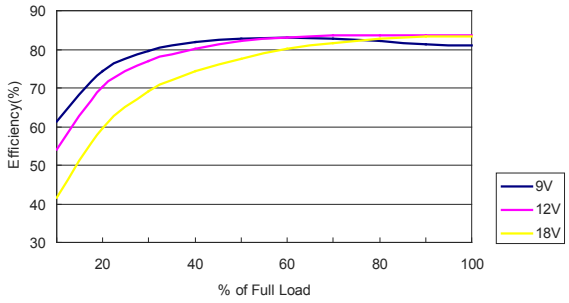


Conduction Emission of EN55022 Class B

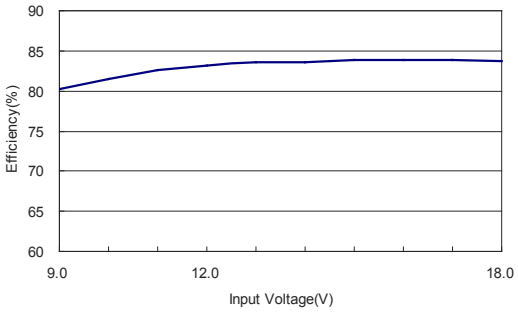
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

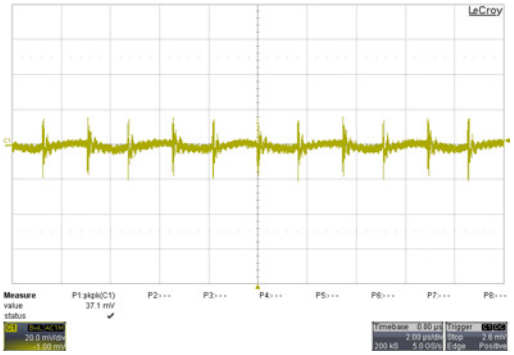
All test conditions are at 25°C The figures are identical for TES 2N-1213




Efficiency Versus Output Current

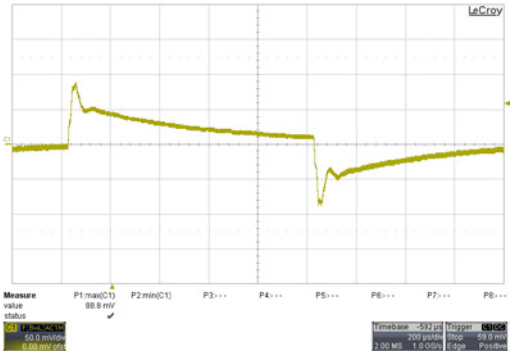



Efficiency Versus Input Voltage. Full Load

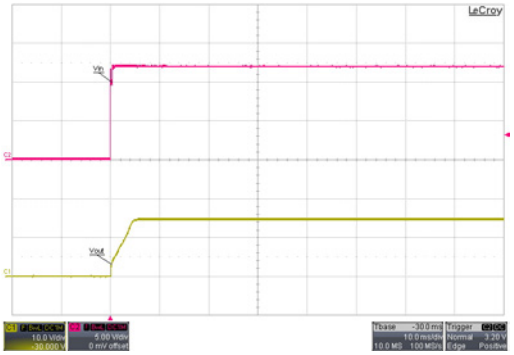


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

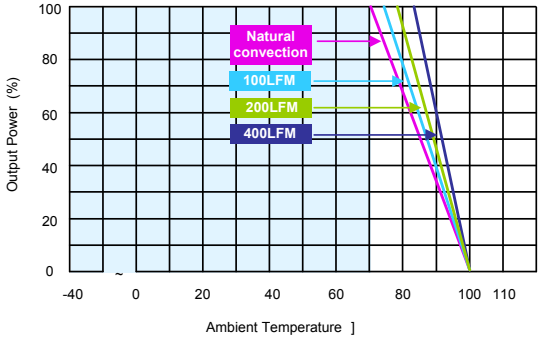


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



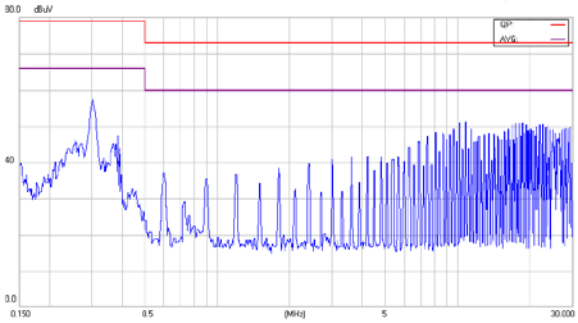
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



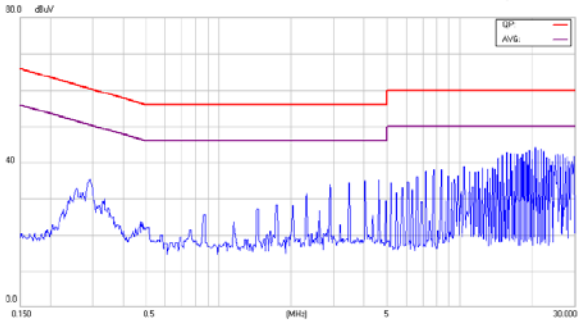

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

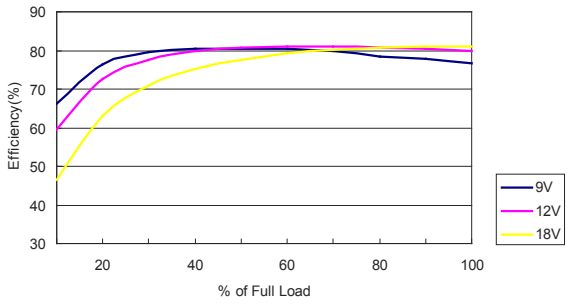


Conduction Emission of EN55022 Class B

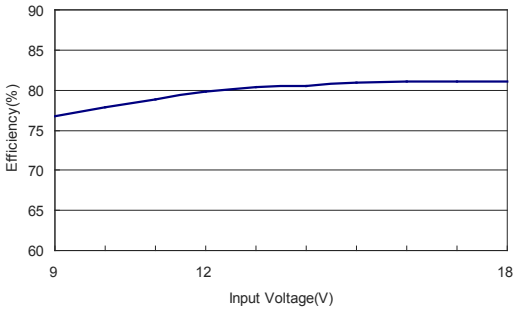
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

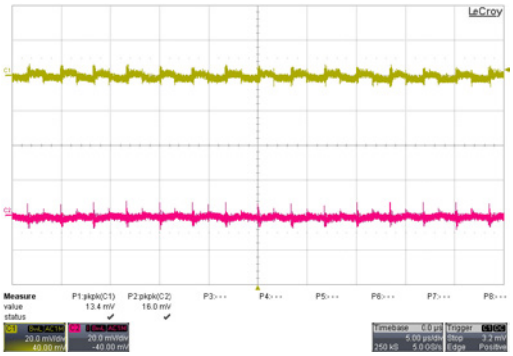
All test conditions are at 25°C The figures are identical for TES 2N-1221




Efficiency Versus Output Current

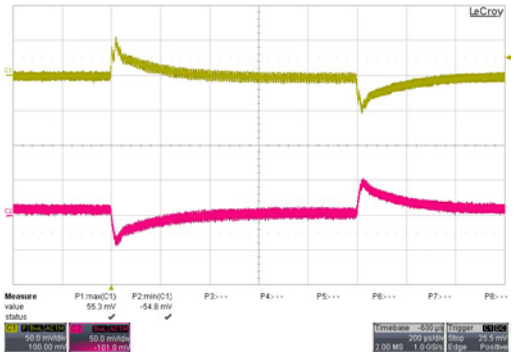



Efficiency Versus Input Voltage. Full Load



Typical Output Ripple and Noise.

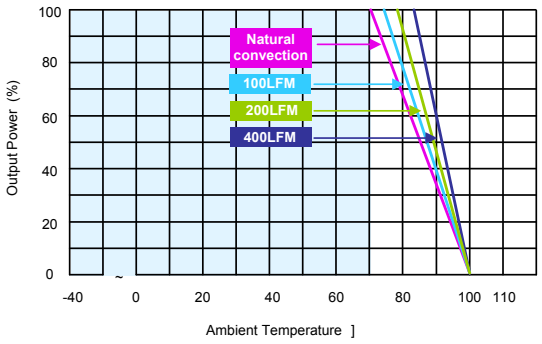
$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$



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

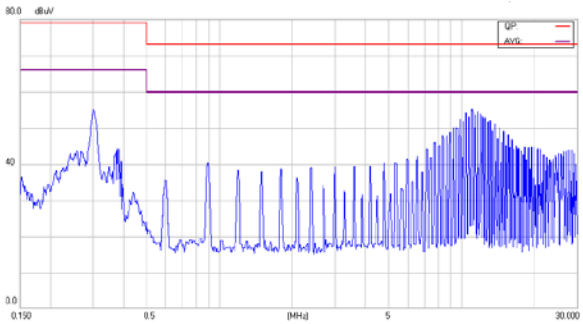
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



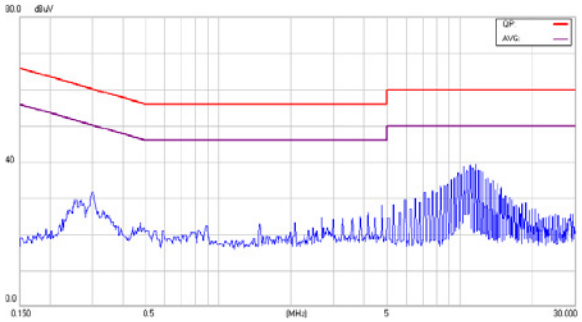

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

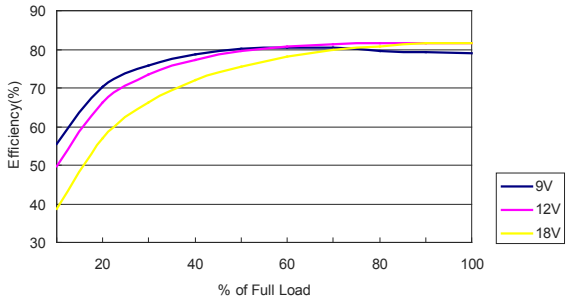


Conduction Emission of EN55022 Class B

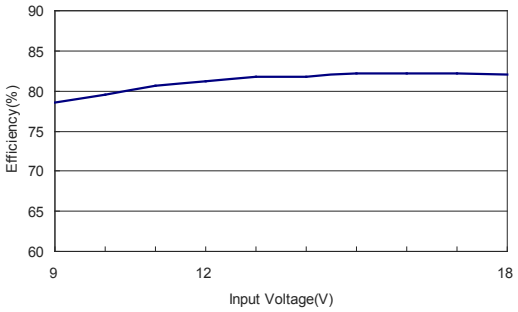
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

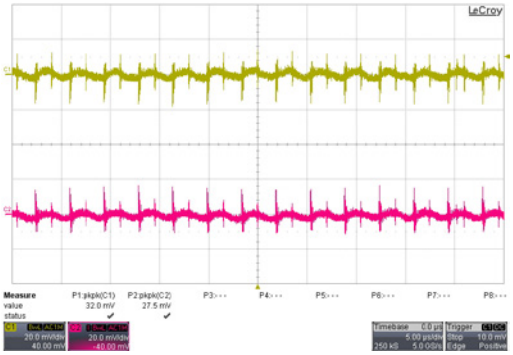
All test conditions are at 25°C The figures are identical for TES 2N-1222




Efficiency Versus Output Current

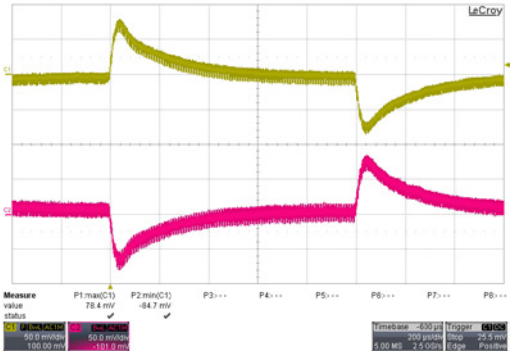



Efficiency Versus Input Voltage. Full Load

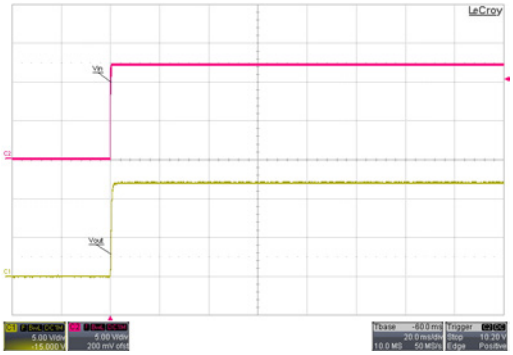


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

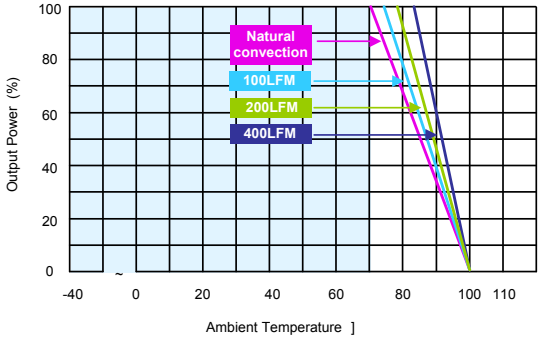


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



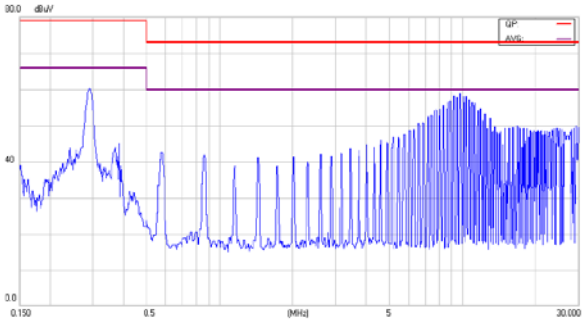
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



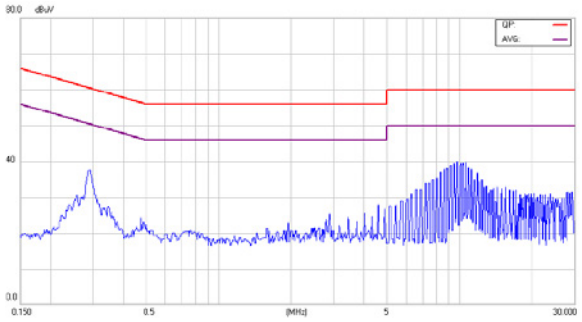

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

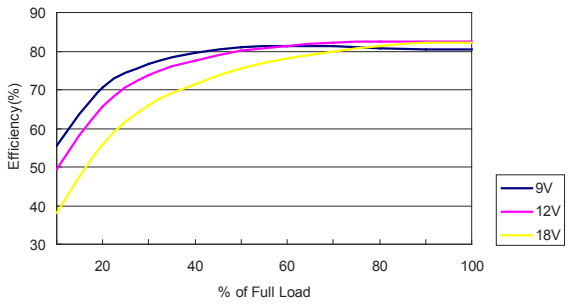


Conduction Emission of EN55022 Class B

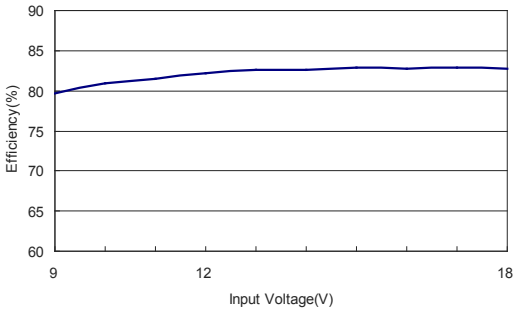
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

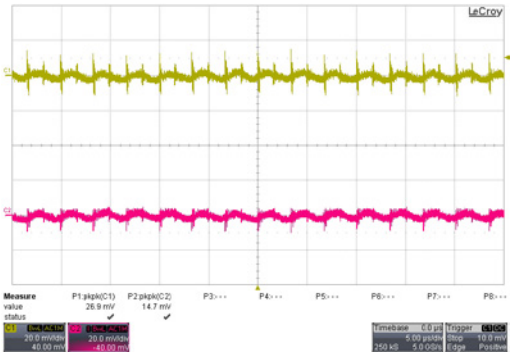
All test conditions are at 25°C The figures are identical for TES 2N-1223




Efficiency Versus Output Current

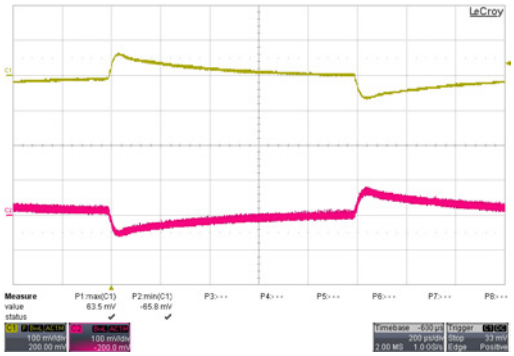



Efficiency Versus Input Voltage. Full Load

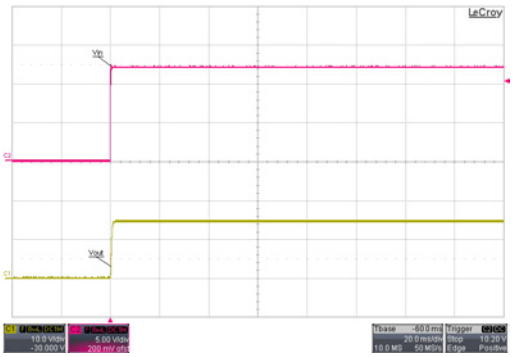


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

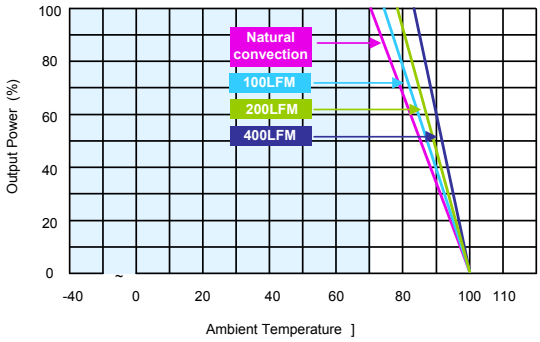


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



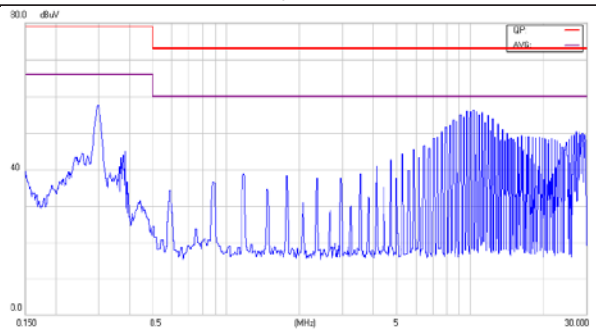
Typical Input Start-Up and Output Rise Characteristic

$V_{in=}$ =$V_{in\ nom}$ ; Full Load



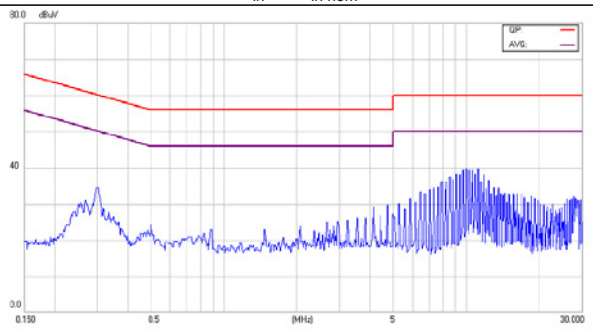

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in=}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in=}$ =$V_{in\ nom}$ ; Full Load

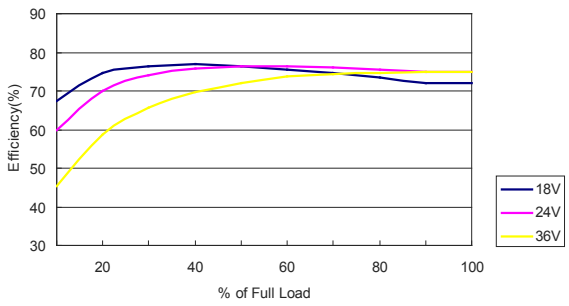


Conduction Emission of EN55022 Class B

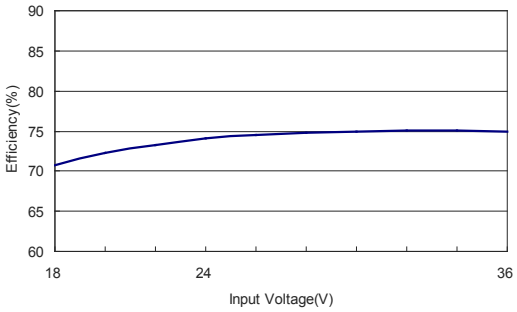
$V_{in=}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

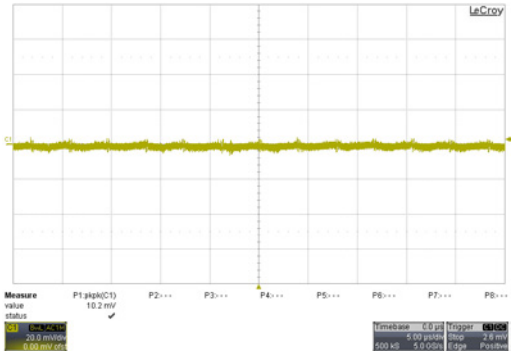
All test conditions are at 25°C The figures are identical for TES 2N-2410




Efficiency Versus Output Current

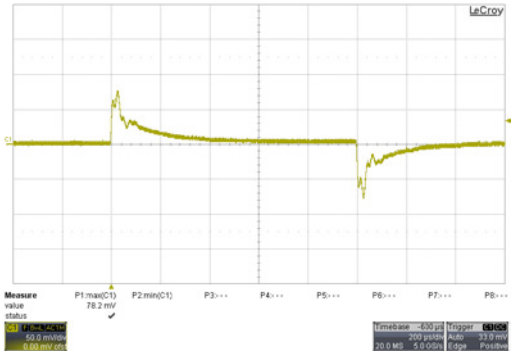



Efficiency Versus Input Voltage. Full Load

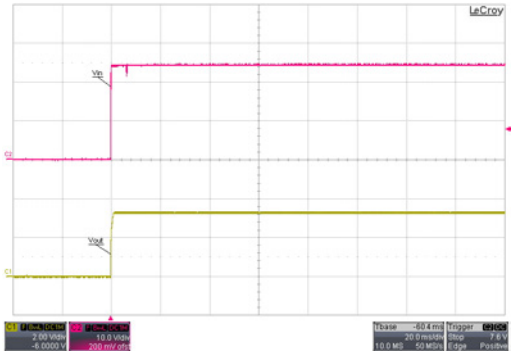


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

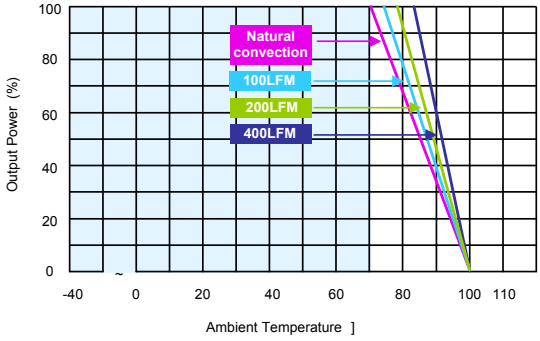


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



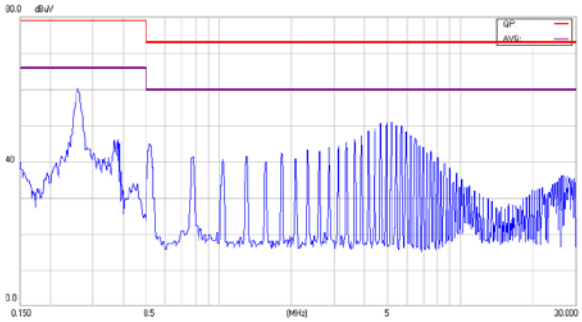
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



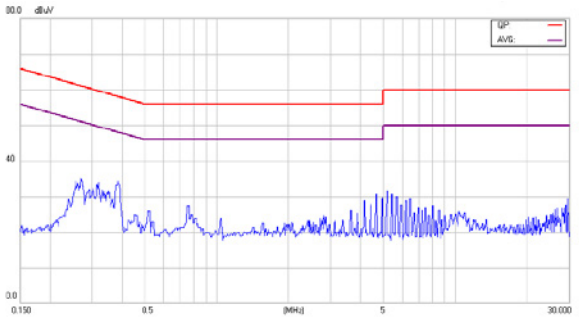

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

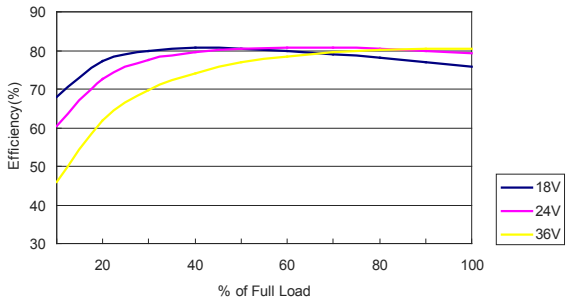


Conduction Emission of EN55022 Class B

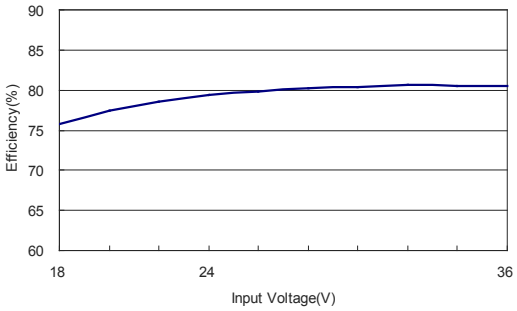
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

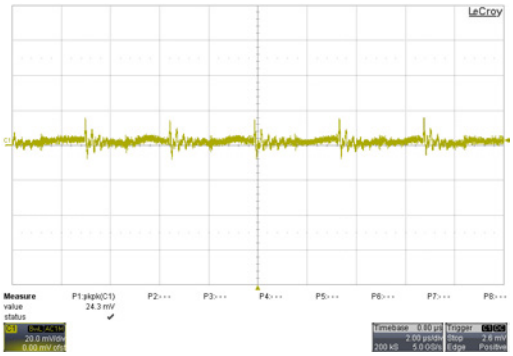
All test conditions are at 25°C The figures are identical for TES 2N-2411




Efficiency Versus Output Current

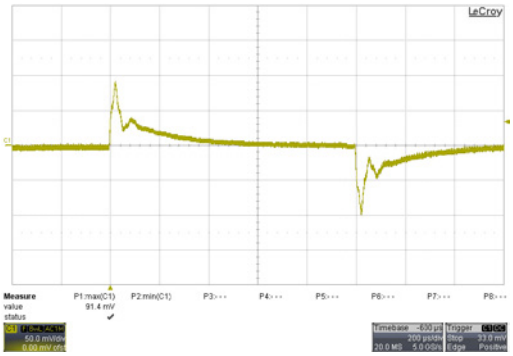



Efficiency Versus Input Voltage. Full Load

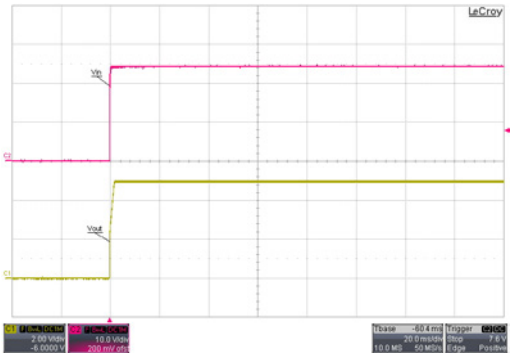


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

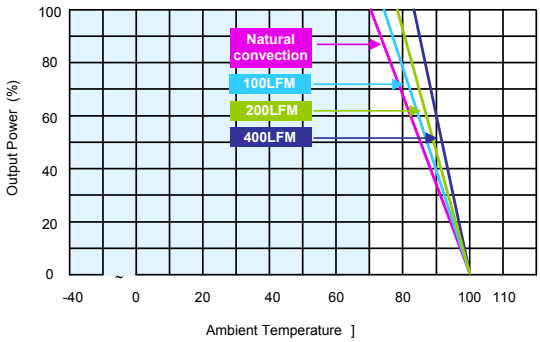


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



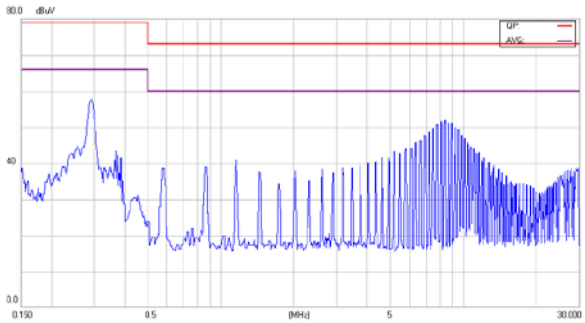
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



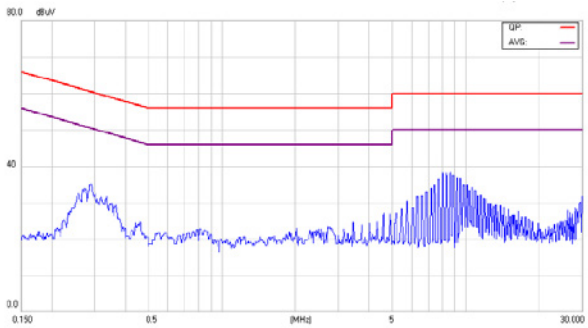

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

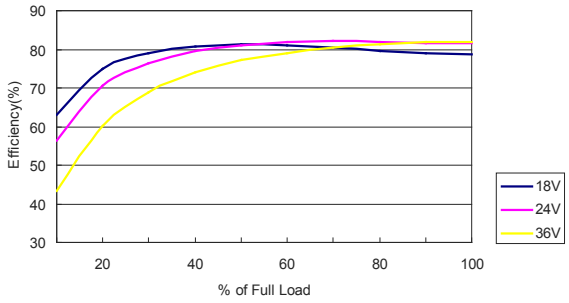


Conduction Emission of EN55022 Class B

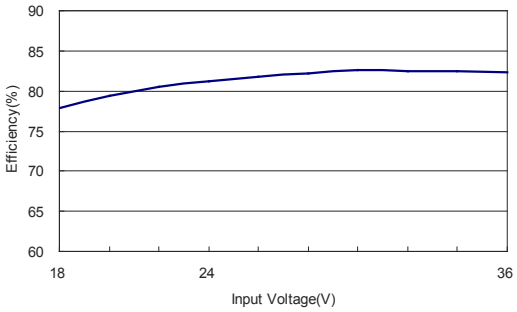
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

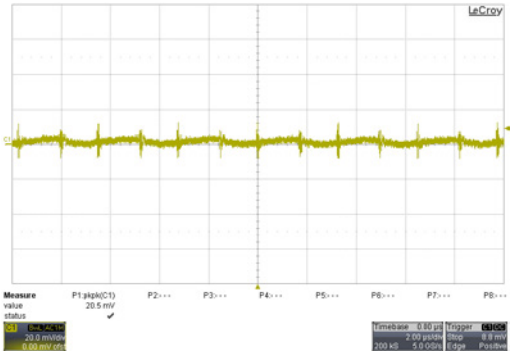
All test conditions are at 25°C The figures are identical for TES 2N-2412




Efficiency Versus Output Current

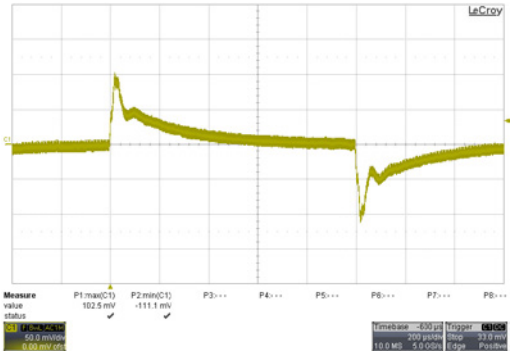



Efficiency Versus Input Voltage. Full Load

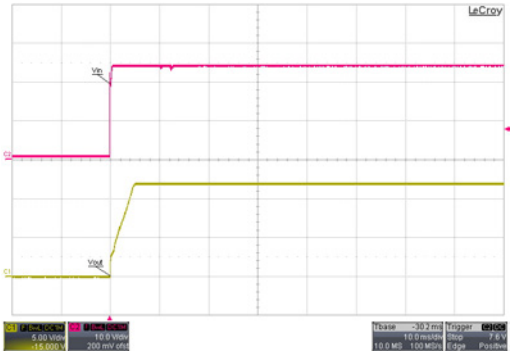


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

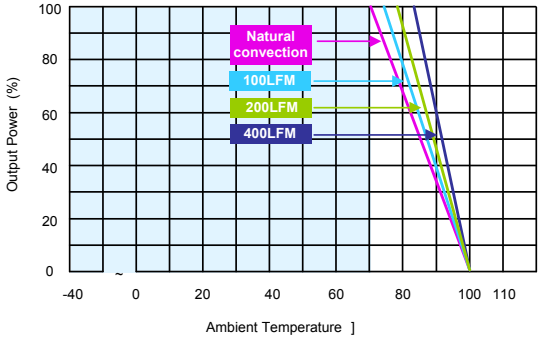


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



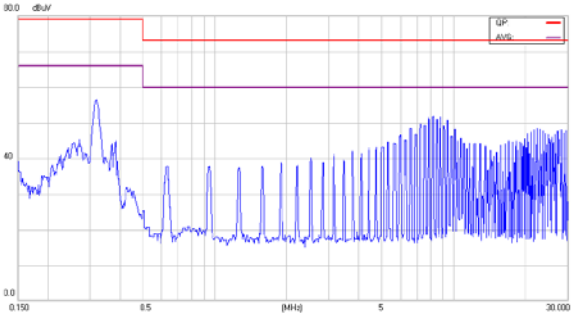
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



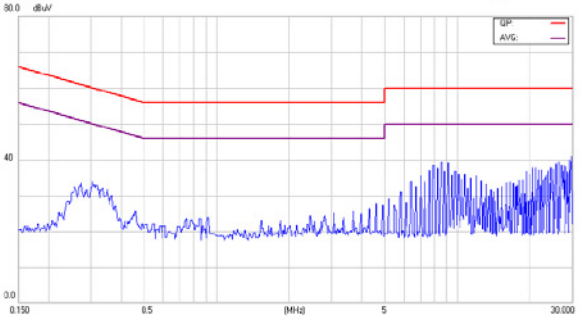

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

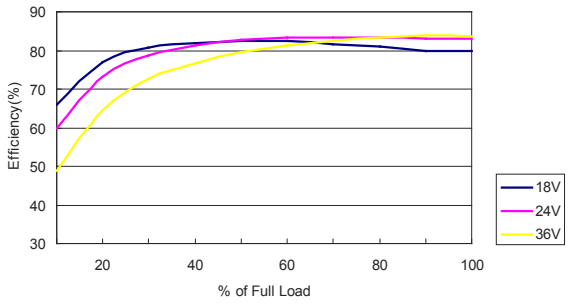


Conduction Emission of EN55022 Class B

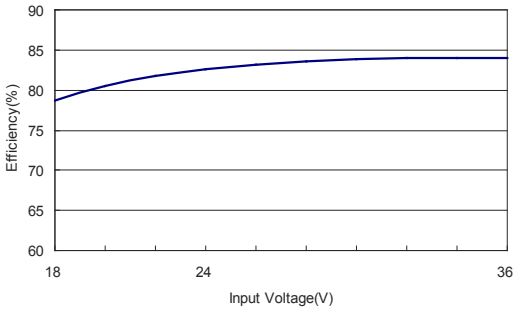
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

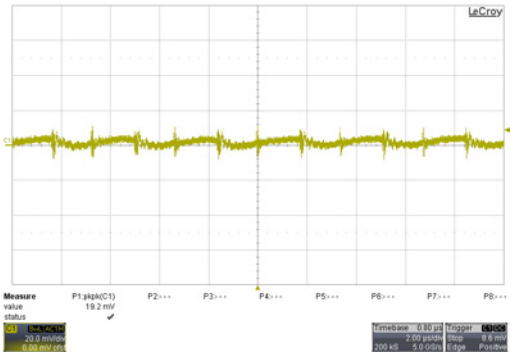
All test conditions are at 25°C The figures are identical for TES 2N-2413




Efficiency Versus Output Current

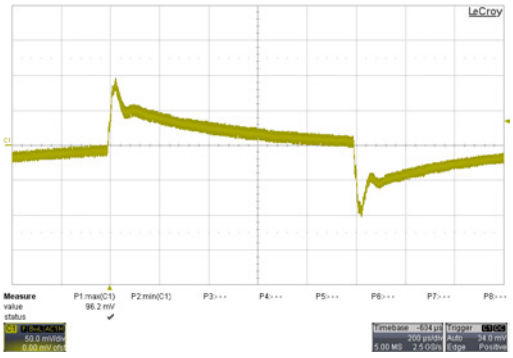



Efficiency Versus Input Voltage. Full Load

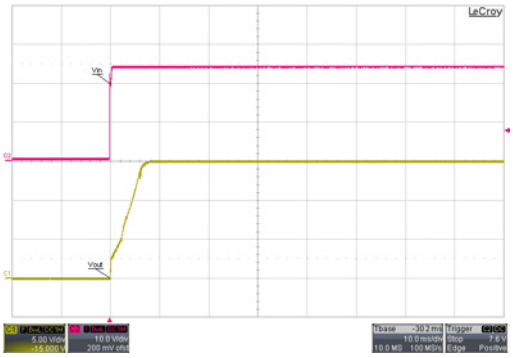


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

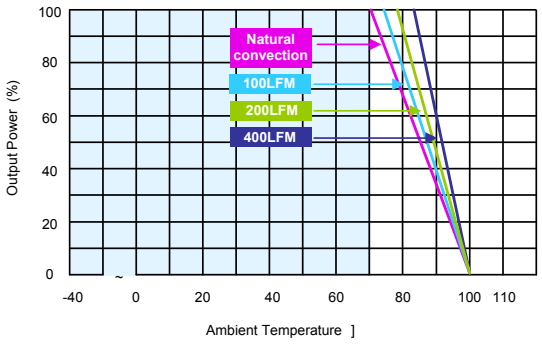


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



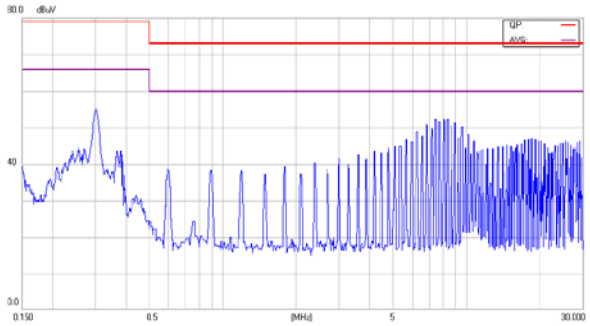
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



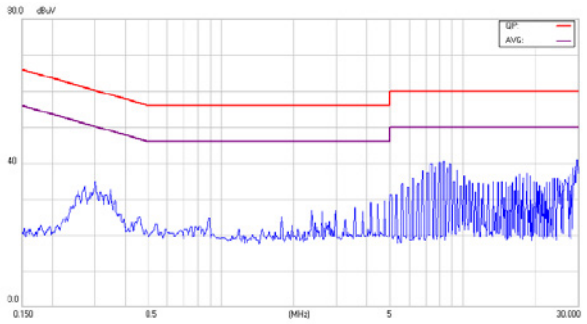

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

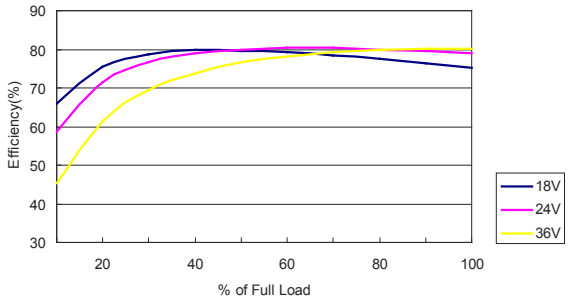


Conduction Emission of EN55022 Class B

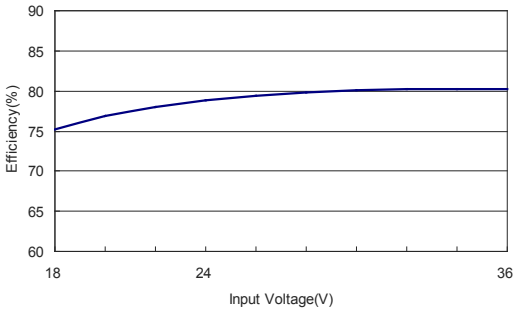
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

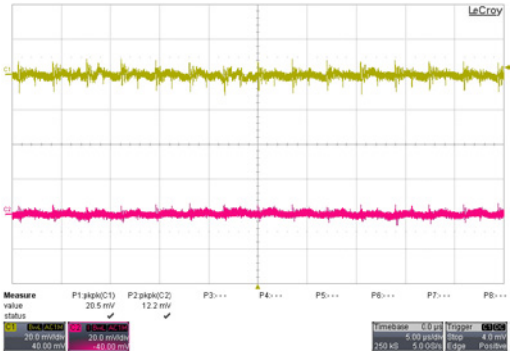
All test conditions are at 25°C The figures are identical for TES 2N-2421




Efficiency Versus Output Current

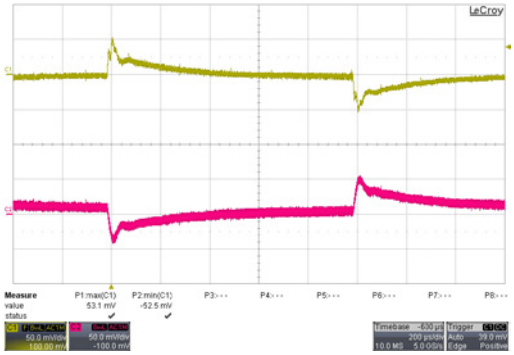



Efficiency Versus Input Voltage. Full Load

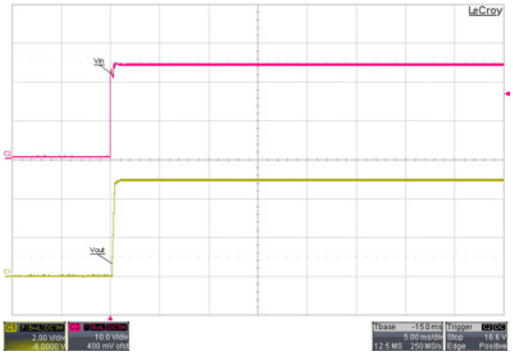


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

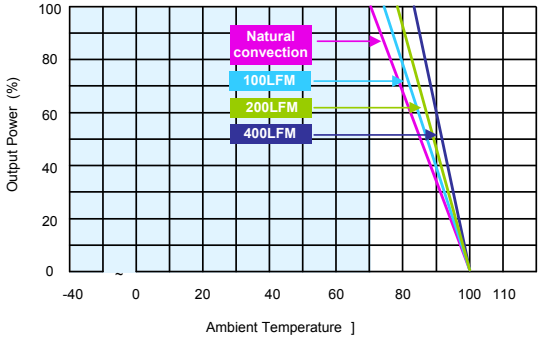


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



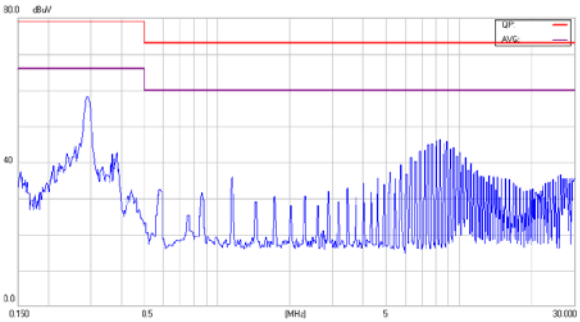
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



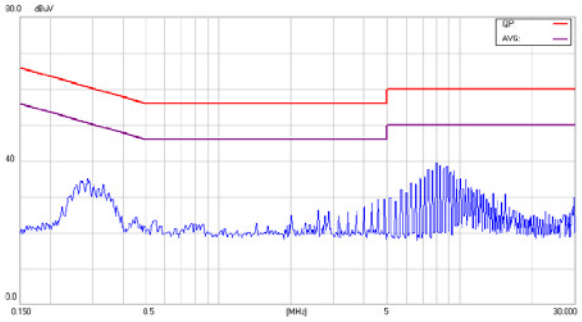

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

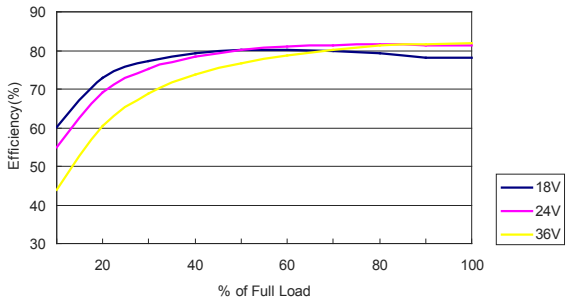


Conduction Emission of EN55022 Class B

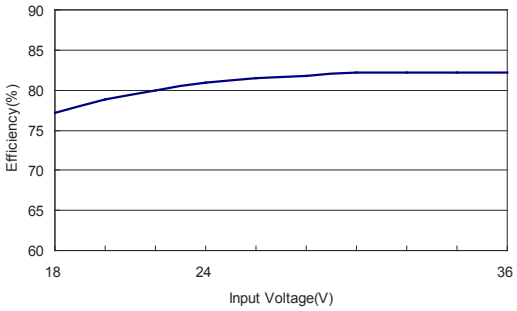
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

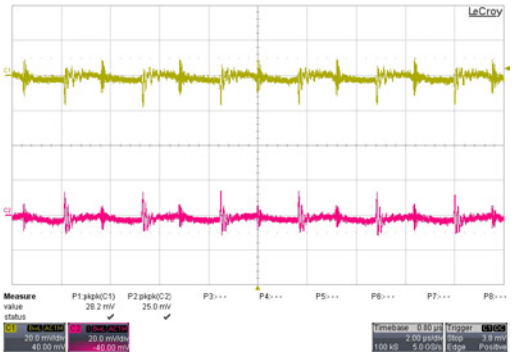
All test conditions are at 25°C The figures are identical for TES 2N-2422




Efficiency Versus Output Current

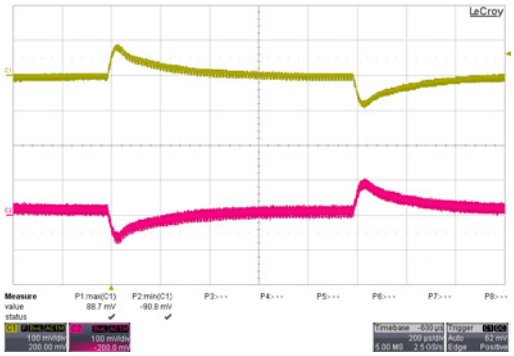



Efficiency Versus Input Voltage. Full Load

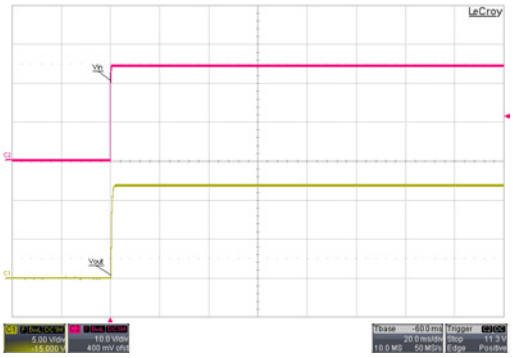


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

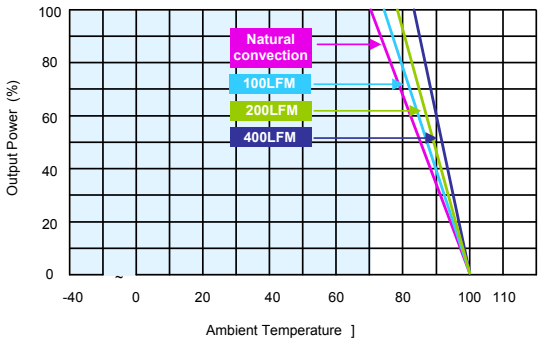


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



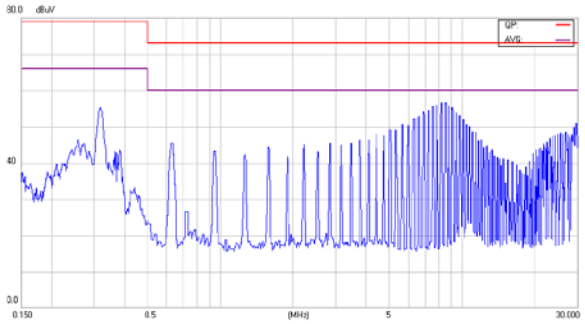
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



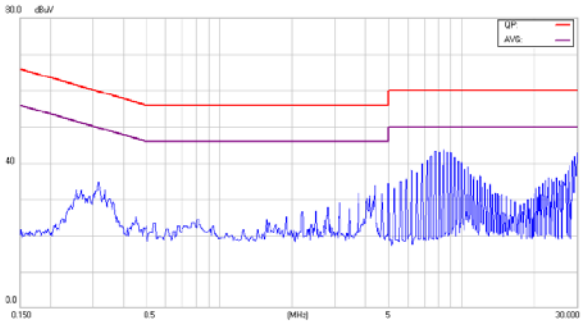

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

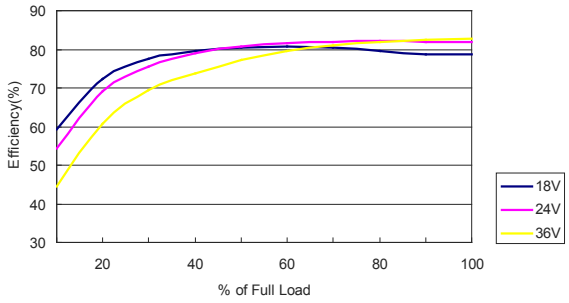


Conduction Emission of EN55022 Class B

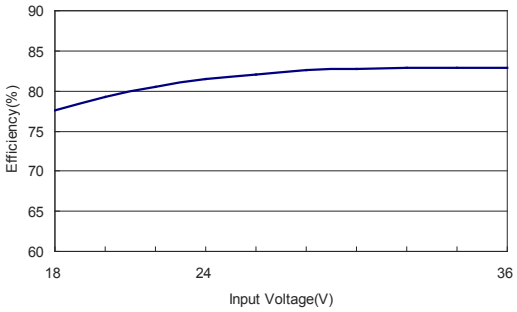
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

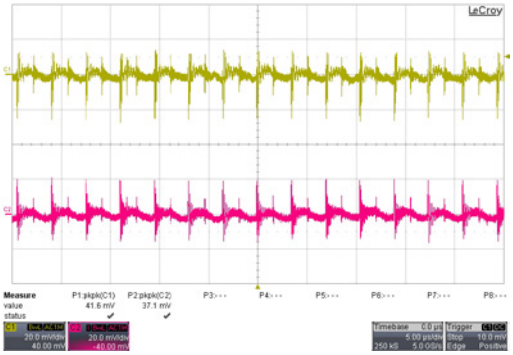
All test conditions are at 25°C The figures are identical for TES 2N-2423




Efficiency Versus Output Current

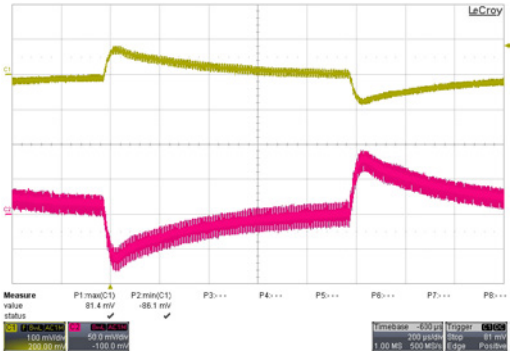



Efficiency Versus Input Voltage. Full Load

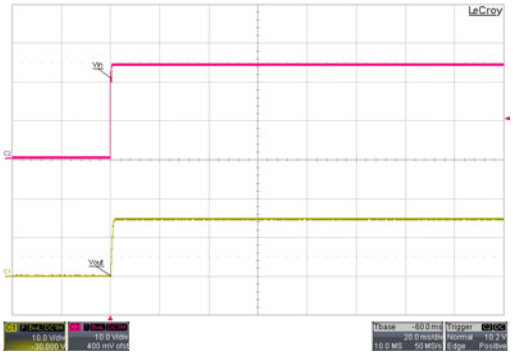


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

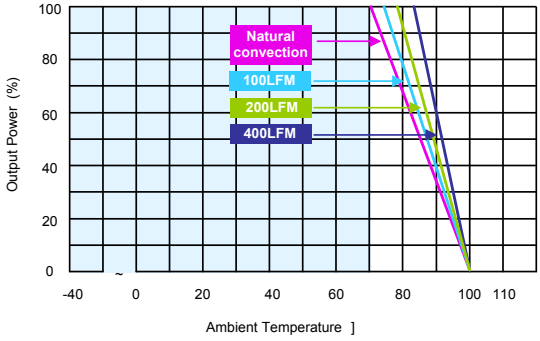


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



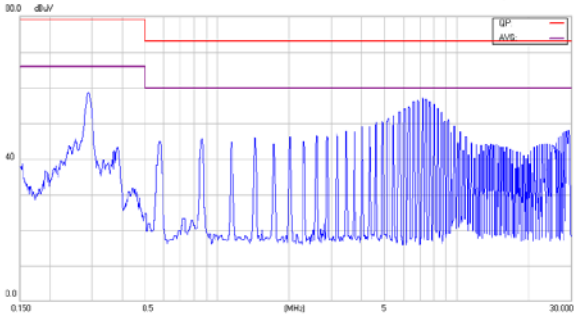
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



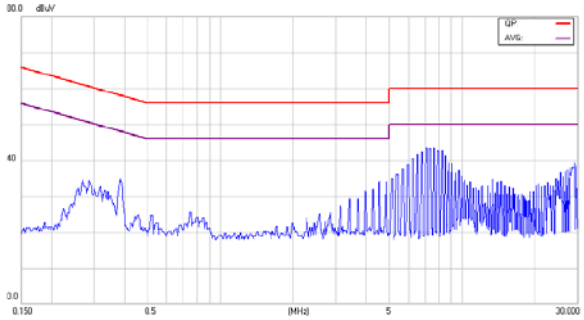

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

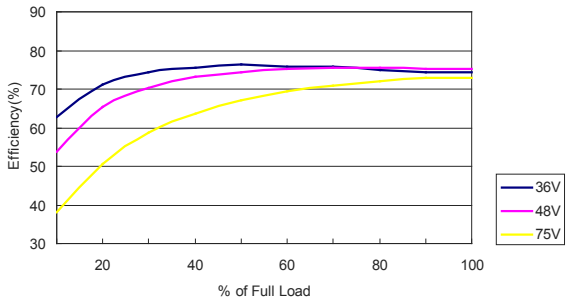


Conduction Emission of EN55022 Class B

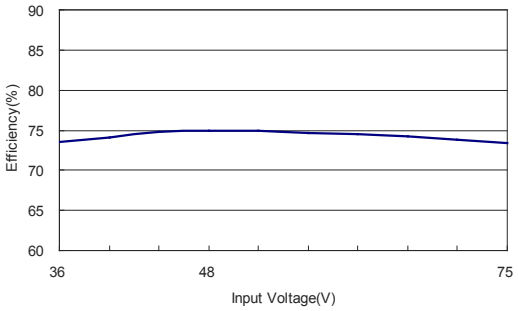
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

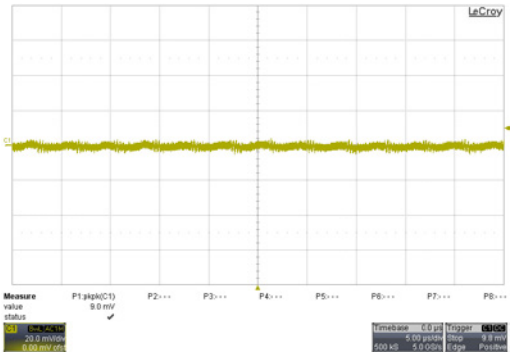
All test conditions are at 25°C The figures are identical for TES 2N-4810




Efficiency Versus Output Current

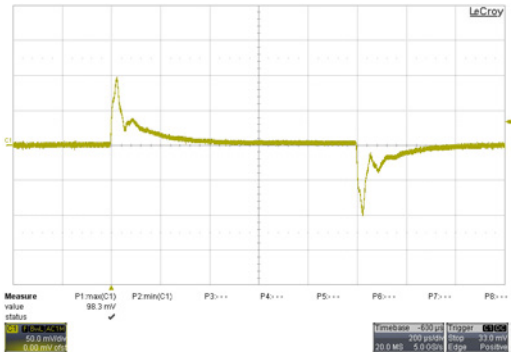



Efficiency Versus Input Voltage. Full Load



Typical Output Ripple and Noise.

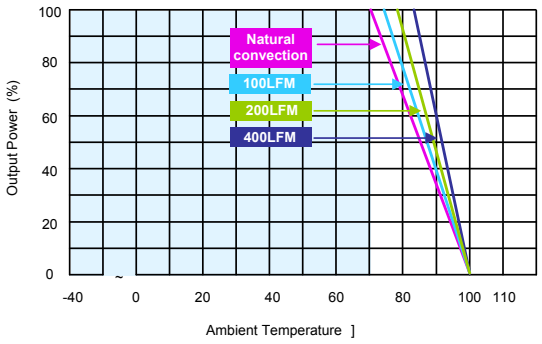
$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$



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

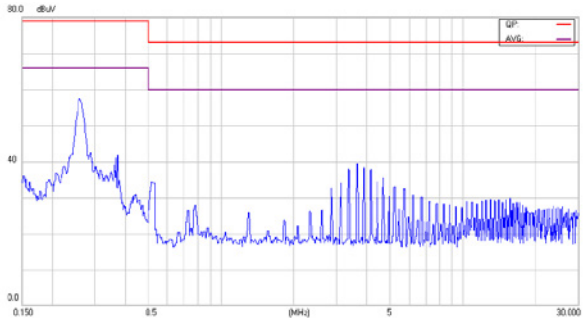
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



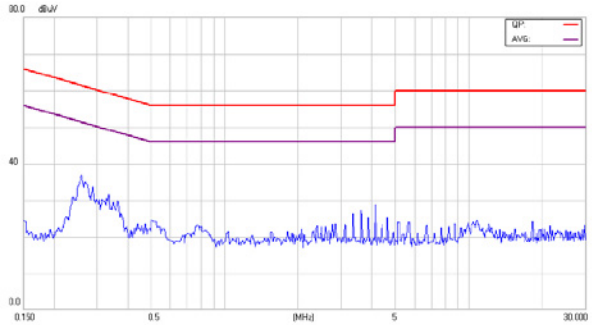

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

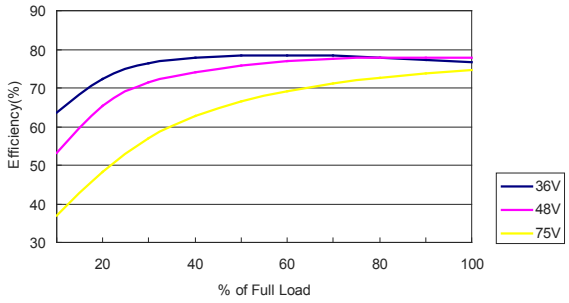


Conduction Emission of EN55022 Class B

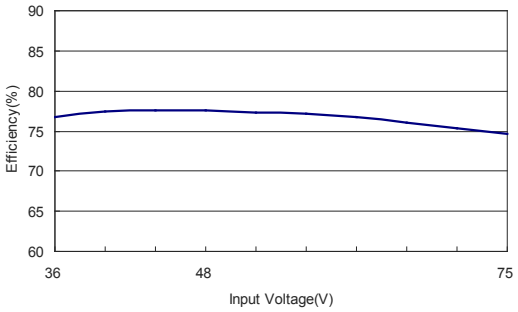
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

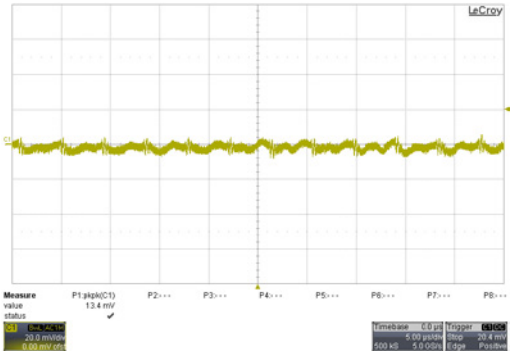
All test conditions are at 25°C The figures are identical for TES 2N-4811




Efficiency Versus Output Current

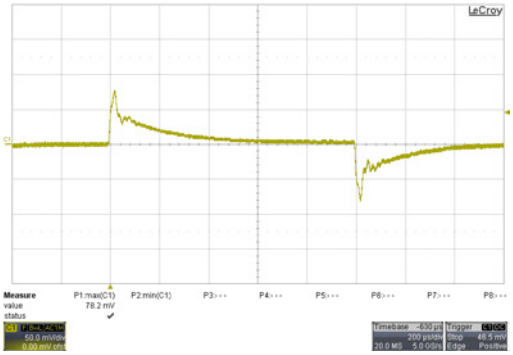



Efficiency Versus Input Voltage. Full Load



Typical Output Ripple and Noise.

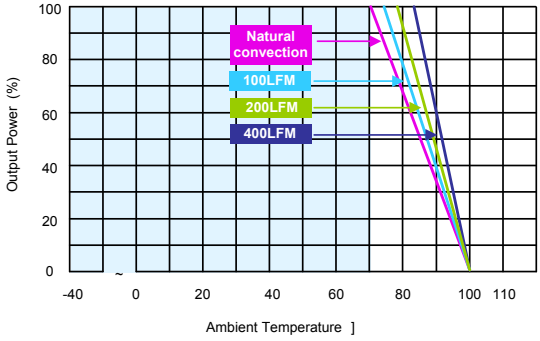
$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$



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

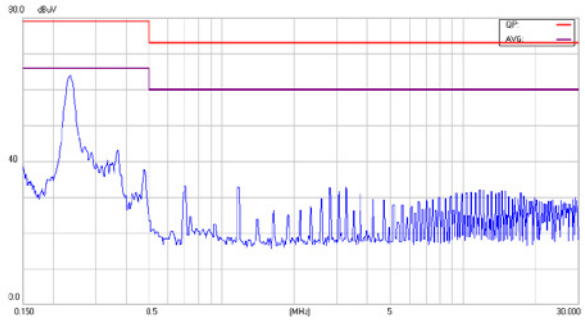
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



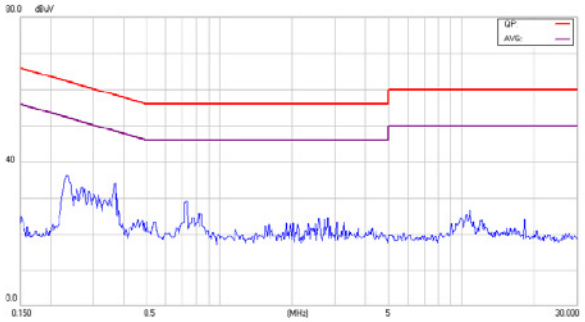

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

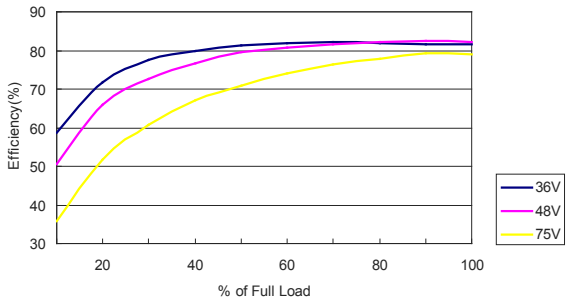


Conduction Emission of EN55022 Class B

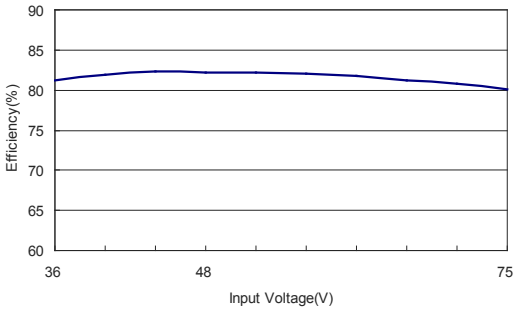
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

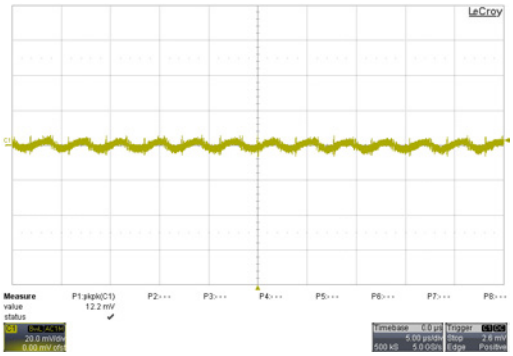
All test conditions are at 25°C The figures are identical for TES 2N-4812




Efficiency Versus Output Current

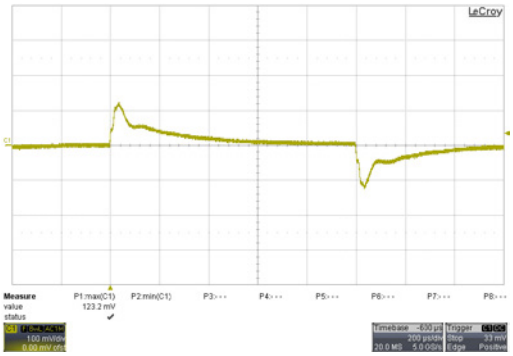



Efficiency Versus Input Voltage. Full Load

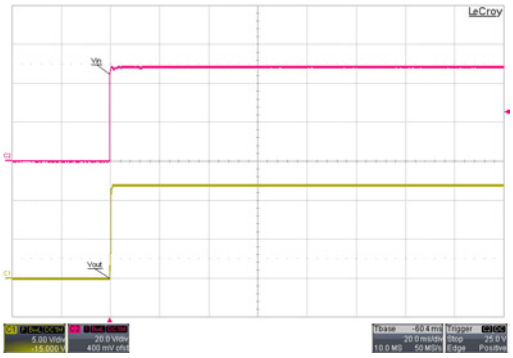


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

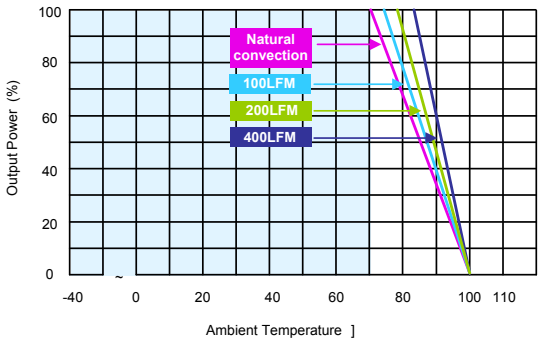


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



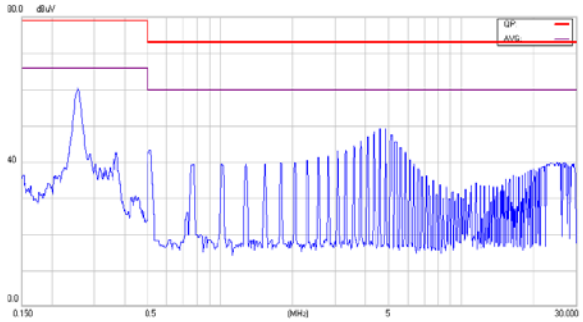
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



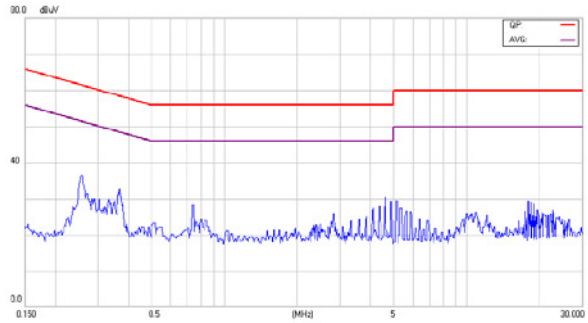

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

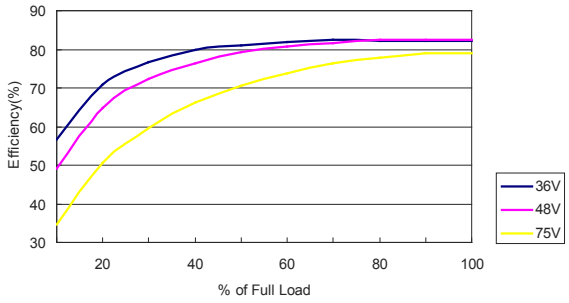


Conduction Emission of EN55022 Class B

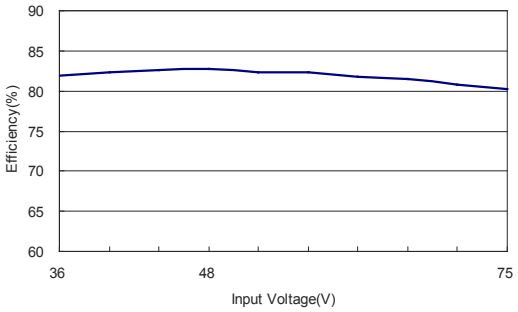
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

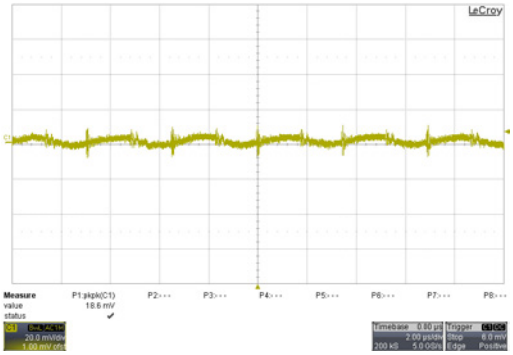
All test conditions are at 25°C The figures are identical for TES 2N-4813




Efficiency Versus Output Current

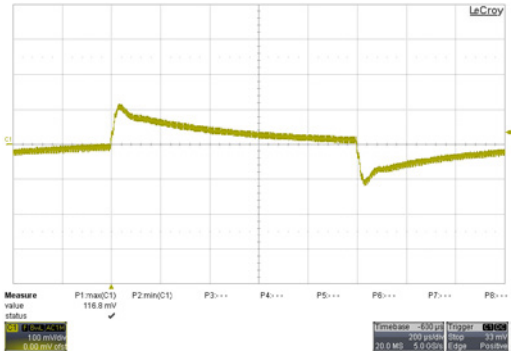



Efficiency Versus Input Voltage. Full Load

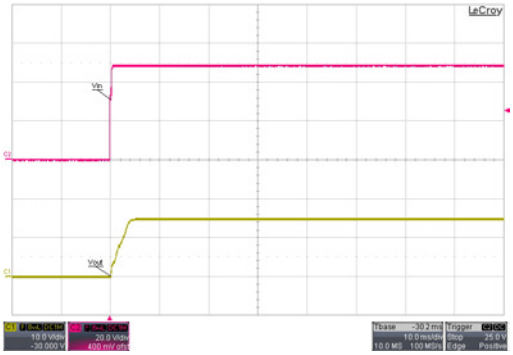


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

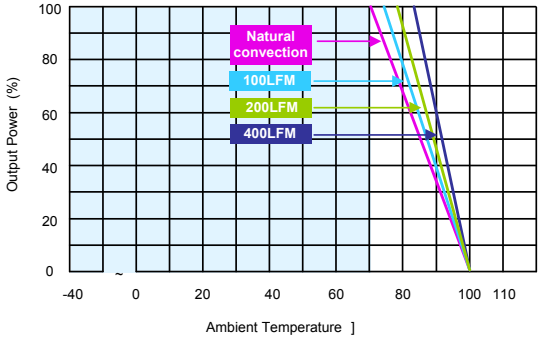


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



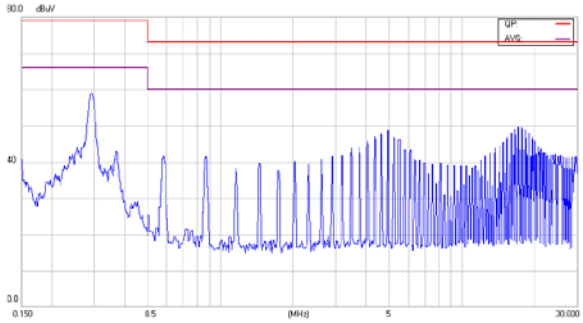
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



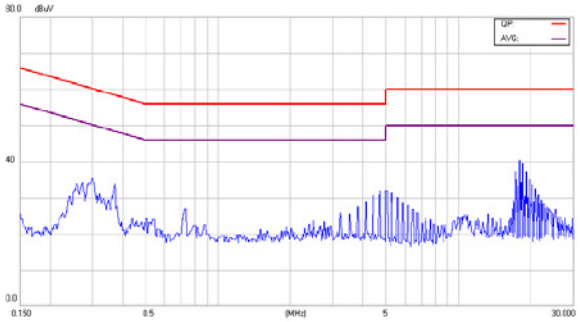

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

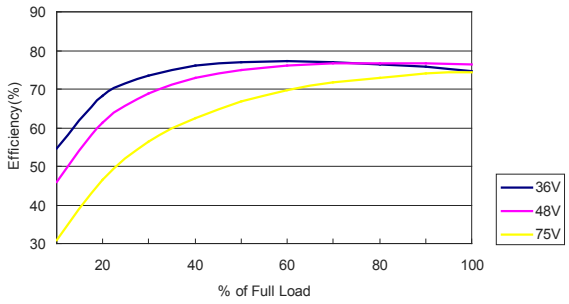


Conduction Emission of EN55022 Class B

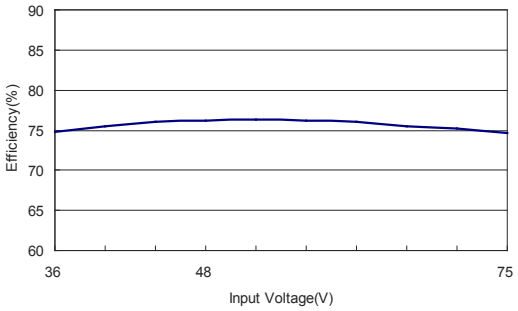
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

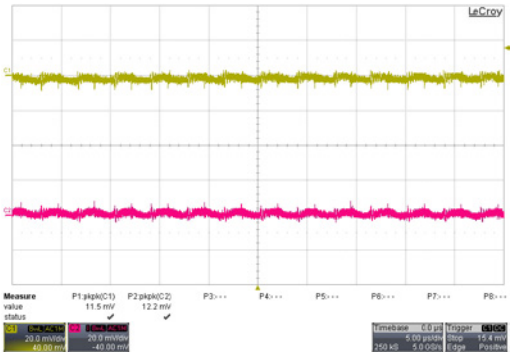
All test conditions are at 25°C The figures are identical for TES 2N-4821




Efficiency Versus Output Current

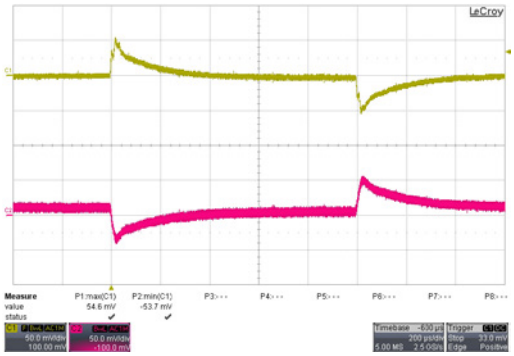



Efficiency Versus Input Voltage. Full Load

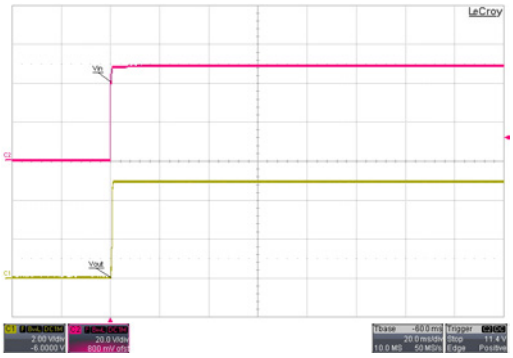


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

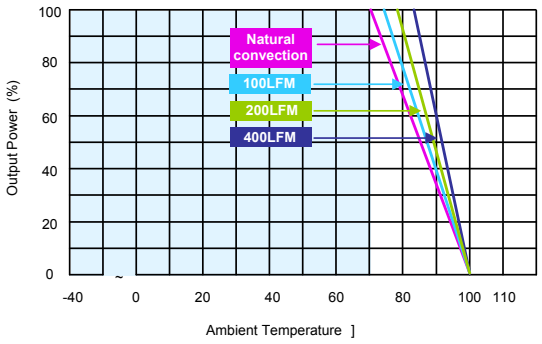


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



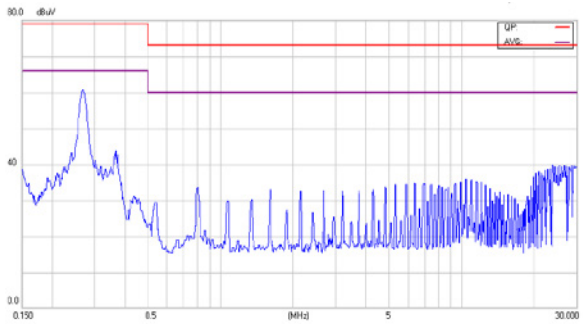
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



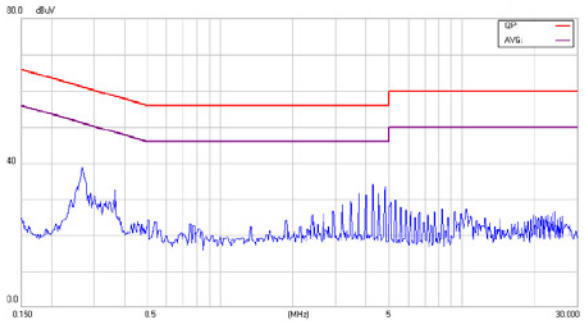

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

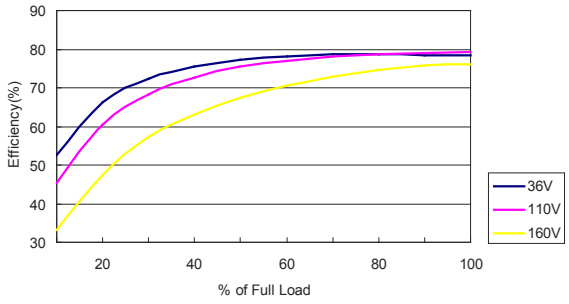


Conduction Emission of EN55022 Class B

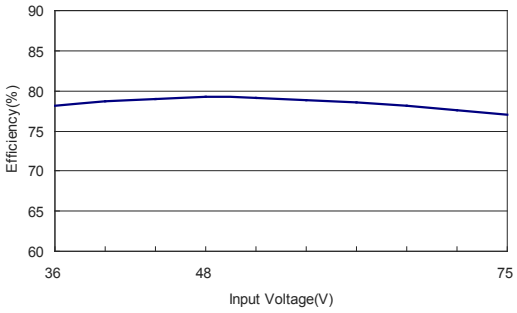
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

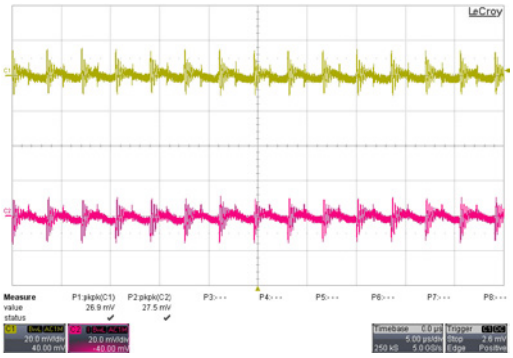
All test conditions are at 25°C The figures are identical for TES 2N-4822




Efficiency Versus Output Current

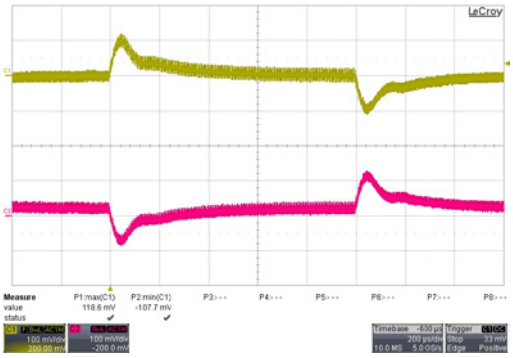



Efficiency Versus Input Voltage. Full Load



Typical Output Ripple and Noise.

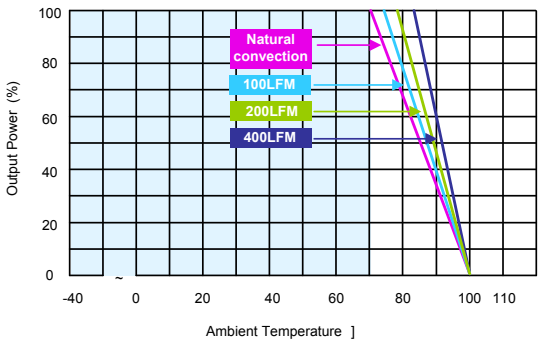
$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$



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

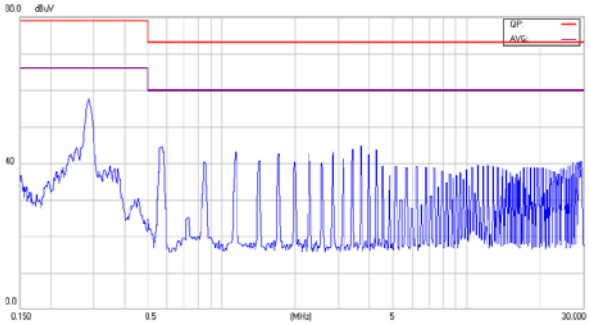
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



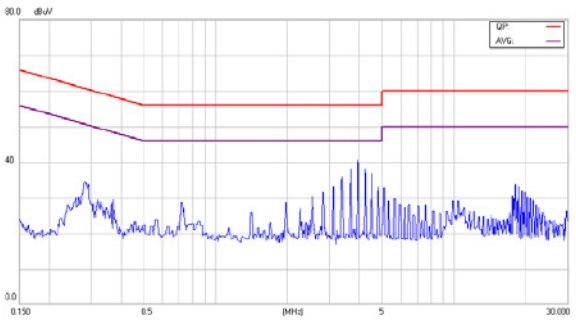

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

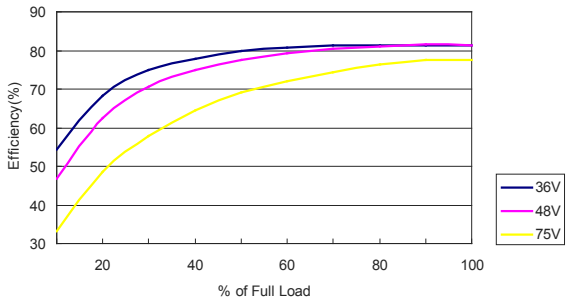


Conduction Emission of EN55022 Class B

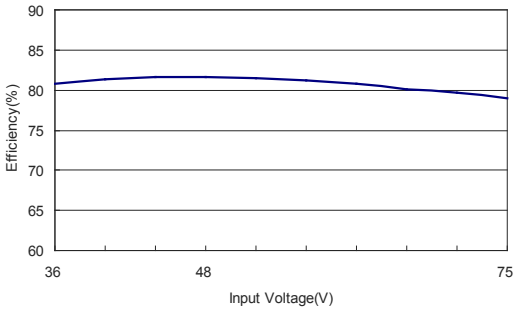
$V_{in}$ =$V_{in\ nom}$ ; Full Load

## Characteristic Curves

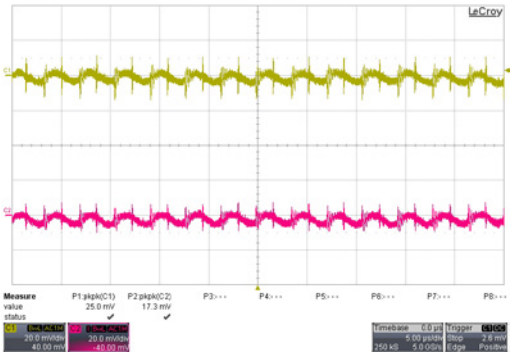
All test conditions are at 25°C The figures are identical for TES 2N-4823




Efficiency Versus Output Current

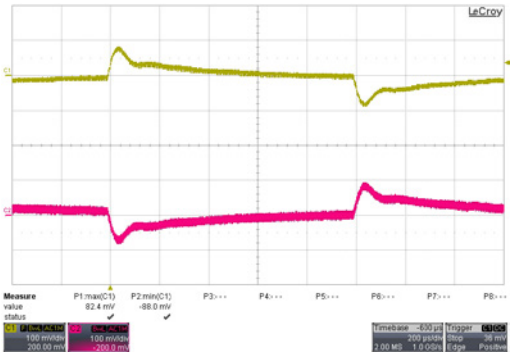



Efficiency Versus Input Voltage. Full Load

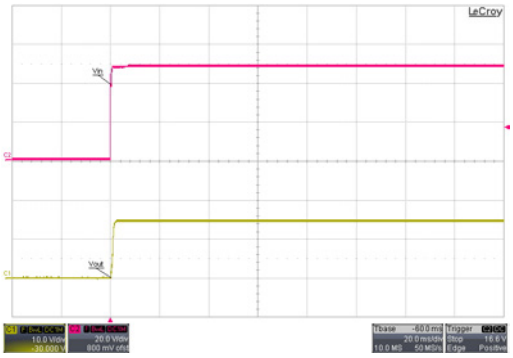


Typical Output Ripple and Noise.

$V_{in}$ =$V_{in\ nom}$; Full Load; $T_A$

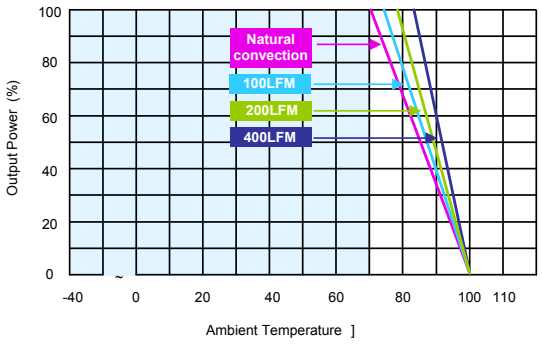


Transient Response to Dynamic Load Change from 100% to 75% of Full Load ; $V_{in}$ =$V_{in\ nom}$



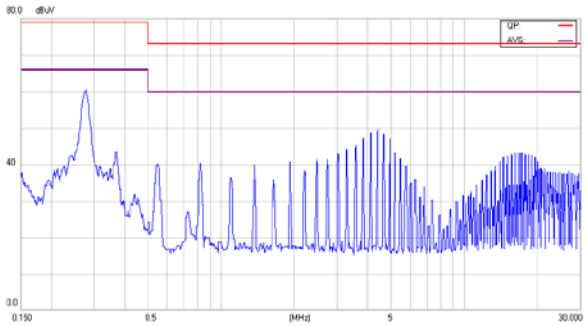
Typical Input Start-Up and Output Rise Characteristic

$V_{in}$ =$V_{in\ nom}$ ; Full Load



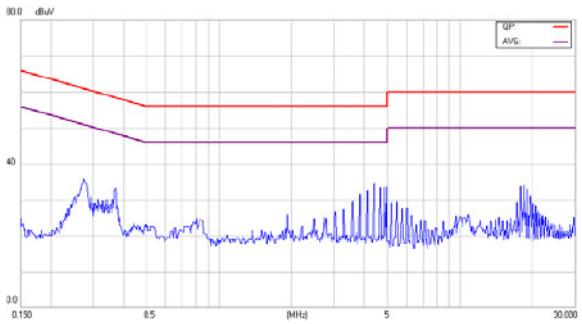

Derating Output Current Versus Ambient Temperature and Airflow

$V_{in}$ =$V_{in\ nom}$



Conduction Emission of EN55022 Class A

$V_{in}$ =$V_{in\ nom}$ ; Full Load

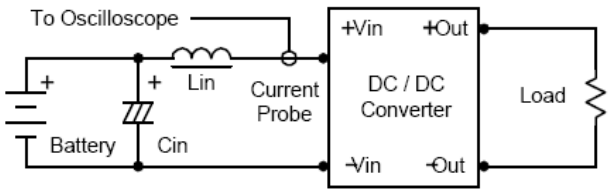


Conduction Emission of EN55022 Class B

$V_{in}$ =$V_{in\ nom}$ ; Full Load

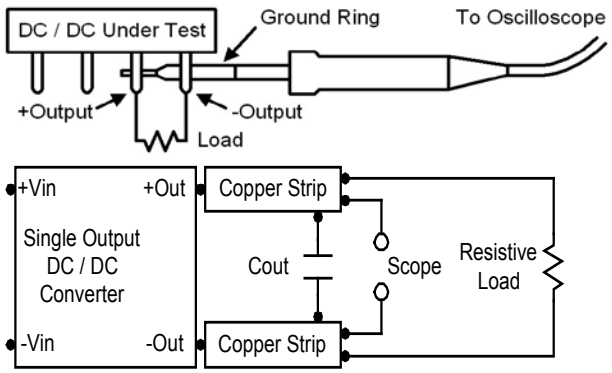
## Testing Configurations

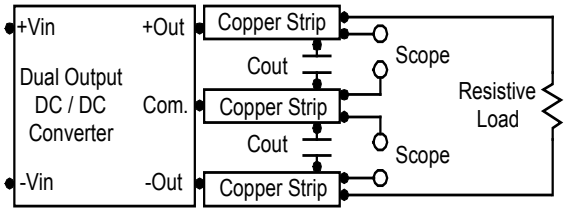
### Input reflected-ripple current measurement test up




| Component | Value | Reference |
|---|---|---|
| L | 4.7µH | ----- |
| C | 220µF (ESR<1.0Ω at 100KHz) | Aluminum Electrolytic Capacitor |

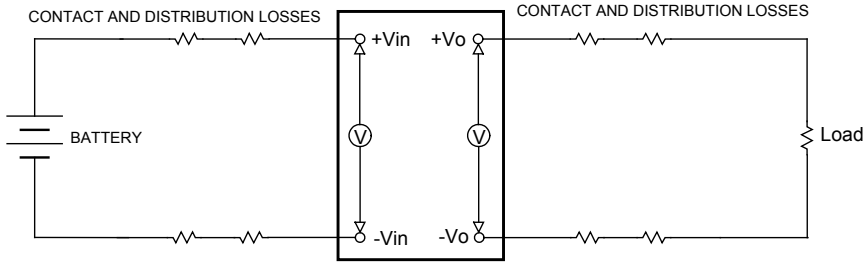
### Peak-to-peak output ripple & noise measurement test up



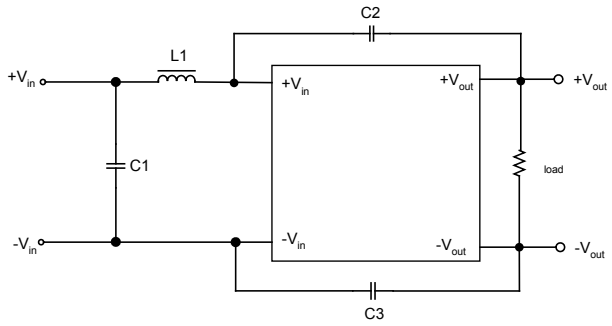




### Output voltage and efficiency measurement test up

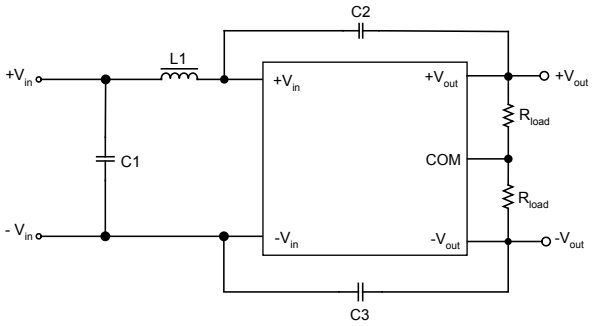
$$Efficiency = \left( \frac{V_{out} \times I_{out}}{V_{in} \times I_{in}} \right) \times 100\% = [\%]$$



## EMC considerations

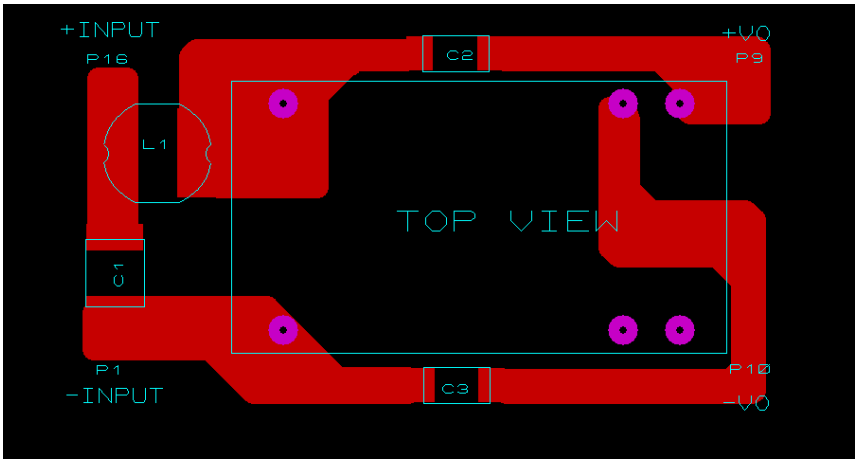



Single Output




Dual Output

Recommended circuit to comply EN55022 Class B Limits




Recommended PCB Layout with Input Filter

To: comply with EN55022 CLASS B following components are needed:

| Model | Component | Value |
|---|---|---|
| TES 2N-05xx | C1 | 2.2µF/16V 1206 X7R |
| | C2 | 100pF/2KV 1808 X7R |
| | L1 | 4.7µH SR0302/1.2A |
| TES 2N-12xx | C1 | 1µF/25V 1206 X7R |
| | C2 | 100pF/2KV 1808 X7R |
| | C3 | 220pF/2KV 1808 X7R |
| | L1 | 6.8µH SR0302/1A |
| TES 2N-24xx | C1 | 1µF/50V 1206 X7R |
| | C2 | 100pF/2KV 1808 X7R |
| | C3 | 220pF/2KV 1808 X7R |
| | L1 | 47µH SR0302/0.36A |
| TES 2N-48xx | C1 | 0.47µF/100V 1206 X7R |
| | C2,C3 | 470pF/2KV 1808 X7R |
| | L1 | 47µH SR0302/0.36A |

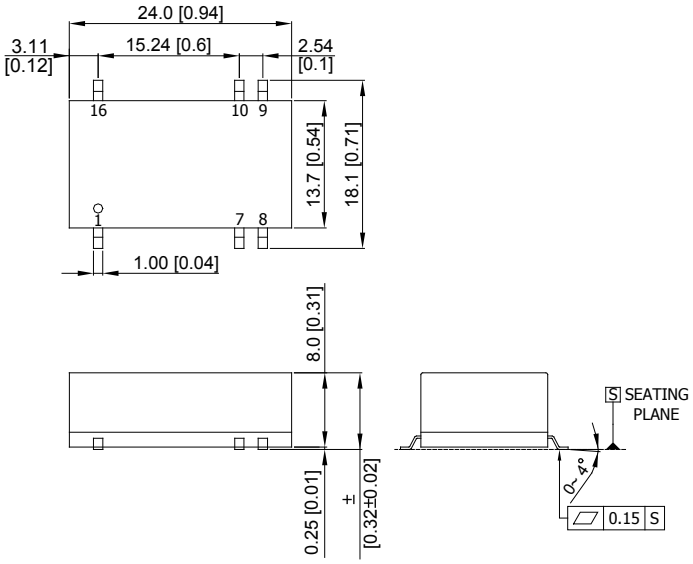
## Input Source Impedance

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 on the input to insure startup.
By using a good quality low Equivalent Series Resistance (ESR < 1.0Ω at 100 kHz) capacitor of a 8.2µF for the 5V input devices, a 3.3µF for the 12V input devices and a 1.5µF for the 24V and 48V devices, capacitor mounted close to the power module helps ensure stability of the unit.

## Output Over Current Protection

To provide protection in a fault (output overload) condition, the unit is equipped with internal current limiting circuitry and can endure current limiting for an unlimited duration. At the point of current-limit inception, the unit shifts from voltage control to current control. The unit operates normally once the output current is brought back into its specified range.

## Mechanical Dimensions

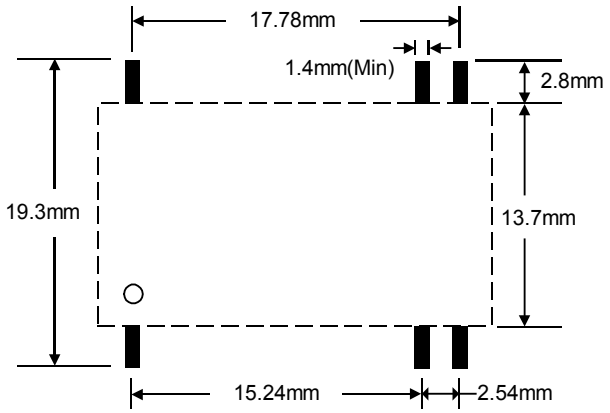



Weight:5.1g

| Pin Connections | | |
|---|---|---|
| Pin | Single Output | Dual Output |
| 1 | -Vin | -Vin |
| 7 | NC | NC |
| 8 | NC | Common |
| 9 | +Vout | +Vout |
| 10 | -Vout | -Vout |
| 16 | +Vin | +Vin |

1. All dimensions in mm (inches)
Tolerance: X.X±0.25 (X.XX±0.01")
X.XX±0.13 (X.XXX±0.005")
2. Pins ±0.05 (±0.002")

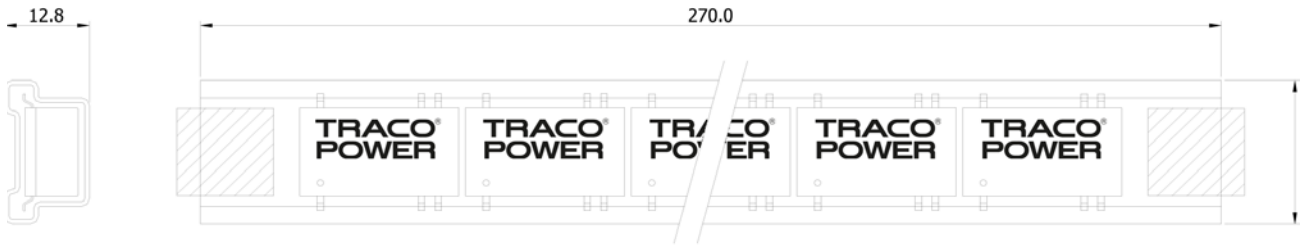
## Recommended Pad Layout for Single & Dual Output Converter




1.All dimensions in mm (Inches)
Tolerance: x.x±0.25mm (x.xx ±0.01")
x.xx±0.13mm (x.xxx ±0.005")
2. Pins ±0.05 (±0.002")

## Packaging Information

TUBE




unit : mm

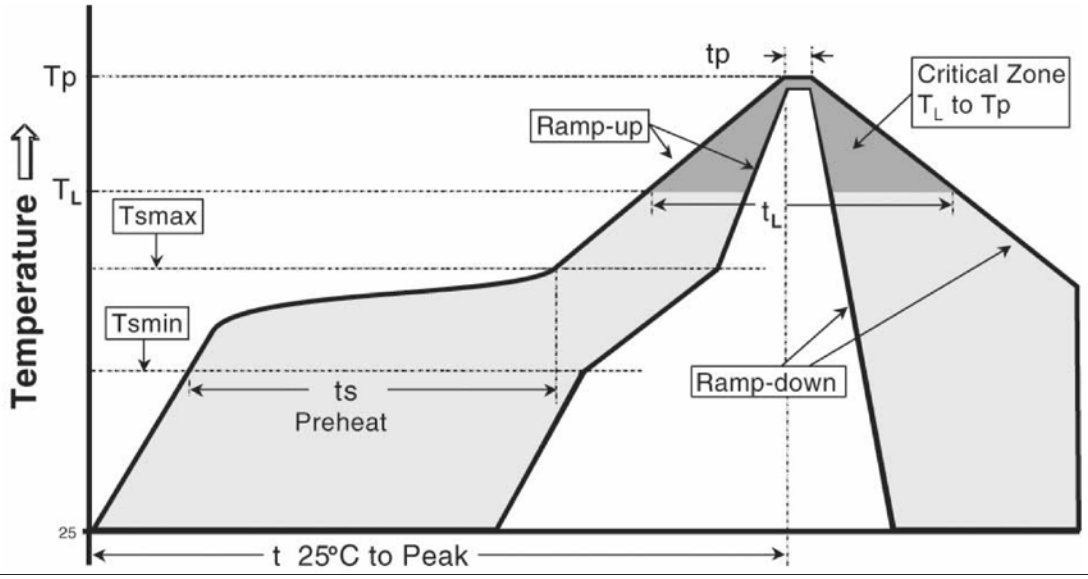
10 PCS per TUBE

## Soldering and Reflow Considerations

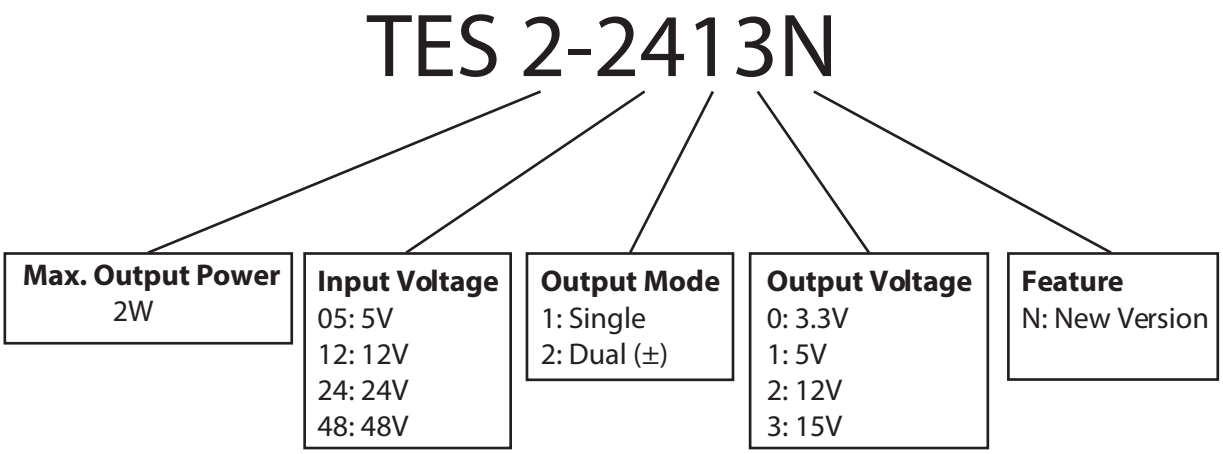
Lead free wave solder profile for TES 2N Series

| Profile Feature | Sn-Pb Eutectic Assembly | Pb-Free Assembly |
|---|---|---|
| Average ramp-up rate (Tsmax to Tp) | 3° C/second max. | 3° C/second max. |
| **Preheat**<br>- Temperature Min ($Ts_{min}$)<br>- Temperature Max ($Ts_{max}$)<br>- Time ($Ts_{min}$ to $Ts_{max}$) (ts) | <br>100 °C<br>150 °C<br>60-120 seconds | <br>150 °C<br>200 °C<br>60-180 seconds |
| Time maintained above:<br>- Temperature ($T_L$)<br>- Time ($t_L$) | <br>183 °C<br>60-150 seconds | <br>217 °C<br>60-150 seconds |
| Peak Temperature (Tp) | See Table 4.1 | See Table 4.2 |
| Time within 5°C of actual Peak Temperature (tp)[2] | 10-30 seconds | 20-40 seconds |
| Ramp-down Rate | 6 °C/second max. | 6 °C/second max. |
| Time 25°C to Peak Temperature | 6 minutes max. | 8 minutes max. |

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



## Part Number Structure




| Model Number | Input Range (VDC) | Output Voltage (VDC) | Max. Output Current (mA) | Input Current at Full Load[1] (mA) | Efficiency[2] (%) |
|---|---|---|---|---|---|
| TES 2N-0510 | 4.5-9 | 3.3 | 500 | 471 | 70 |
| TES 2N-0511 | 4.5-9 | 5 | 400 | 548 | 73 |
| TES 2N-0512 | 4.5-9 | 12 | 167 | 534 | 75 |
| TES 2N-0513 | 4.5-9 | 15 | 134 | 582 | 73 |
| TES 2N-0521 | 4.5-9 | ±5 | ±200 | 667 | 64 |
| TES 2N-0522 | 4.5-9 | ±12 | ±83 | 615 | 69 |
| TES 2N-0523 | 4.5-9 | ±15 | ±67 | 598 | 71 |
| TES 2N-1210 | 9-18 | 3.3 | 500 | 184 | 73 |
| TES 2N-1211 | 9-18 | 5 | 400 | 217 | 77 |
| TES 2N-1212 | 9-18 | 12 | 167 | 209 | 80 |
| TES 2N-1213 | 9-18 | 15 | 134 | 220 | 80 |
| TES 2N-1221 | 9-18 | ±5 | ±200 | 242 | 73 |
| TES 2N-1222 | 9-18 | ±12 | ±83 | 224 | 78 |
| TES 2N-1223 | 9-18 | ±15 | ±67 | 226 | 78 |
| TES 2N-2410 | 18-36 | 3.3 | 500 | 96 | 72 |
| TES 2N-2411 | 18-36 | 5 | 400 | 109 | 77 |
| TES 2N-2412 | 18-36 | 12 | 167 | 109 | 80 |
| TES 2N-2413 | 18-36 | 15 | 134 | 108 | 81 |
| TES 2N-2421 | 18-36 | ±5 | ±200 | 119 | 74 |
| TES 2N-2422 | 18-36 | ±12 | ±83 | 112 | 78 |
| TES 2N-2423 | 18-36 | ±15 | ±67 | 110 | 80 |
| TES 2N-4810 | 36-75 | 3.3 | 500 | 49 | 71 |
| TES 2N-4811 | 36-75 | 5 | 400 | 57 | 73 |
| TES 2N-4812 | 36-75 | 12 | 167 | 53 | 79 |
| TES 2N-4813 | 36-75 | 15 | 134 | 55 | 79 |
| TES 2N-4821 | 36-75 | ±5 | ±200 | 62 | 71 |
| TES 2N-4822 | 36-75 | ±12 | ±83 | 57 | 77 |
| TES 2N-4823 | 36-75 | ±15 | ±67 | 57 | 77 |

Note 1. Maximum value at nominal input voltage and full load of standard type.
Note 2. Typical value at nominal input voltage and full load.

## 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 in 5Vin with maximum rating of 1A, in 12Vin with maximum rating of 500mA, in 24Vin with maximum rating of 250mA and in 48Vin with maximum rating of 120mA. 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 TES 2N series of DC/DC converters has been calculated using MIL-HDBK 217F NOTICE2, Operating Temperature 25°C, Ground Benign.

| Model | MTBF | Unit |
|---|---|---|
| TES 2N-0510 | 1,360,729 | Hours |
| TES 2N-0511 | 1,699,813 | |
| TES 2N-0512 | 1,389,082 | |
| TES 2N-0513 | 1,389,082 | |
| TES 2N-0521 | 1,340,123 | |
| TES 2N-0522 | 1,366,867 | |
| TES 2N-0523 | 1,366,867 | |
| TES 2N-1210 | 1,370,238 | |
| TES 2N-1211 | 1,370,238 | |
| TES 2N-1212 | 1,403,115 | |
| TES 2N-1213 | 1,403,115 | |
| TES 2N-1221 | 1,353,363 | |
| TES 2N-1222 | 1,380,643 | |
| TES 2N-1223 | 1,380,643 | |
| TES 2N-2410 | 1,365,934 | |
| TES 2N-2411 | 1,365,934 | |
| TES 2N-2412 | 1,407,856 | |
| TES 2N-2413 | 1,407,856 | |
| TES 2N-2421 | 1,347,709 | |
| TES 2N-2422 | 1,374,759 | |
| TES 2N-2423 | 1,374,759 | |
| TES 2N-4810 | 1,367,428 | |
| TES 2N-4811 | 1,367,428 | |
| TES 2N-4812 | 1,394,895 | |
| TES 2N-4813 | 1,394,895 | |
| TES 2N-4821 | 1,331,381 | |
| TES 2N-4822 | 1,357,773 | |
| TES 2N-4823 | 1,357,773 | |