171930601

MagI³C Power Module

WPME-VDMM - Variable Step Down MicroModule

3.5V - 36V / 300mA / 1V - 6V Output

DESCRIPTION

The VDMM 171930601 MagI³C MicroModule provides a fully integrated DC-DC power supply including the switching regulator with integrated MOSFETs, controller and compensation, as well as the shielded inductor in one package.

The 171930601 offers high efficiency and delivers up to 300mA of output current. It operates with an input voltage from 3.5V to 36V and is designed for a small solution size.

The MicroModule maintains high efficiency throughout the output current range by automatically transitioning between operation modes based on the load demands.

The 171930601 is available in an LGA-8EP package (5 x 2.5 x 1.8mm).

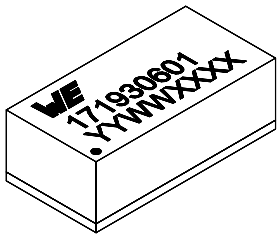
This module has integrated protection circuitry that guards against thermal overstress with thermal shutdown and protects against electrical damage using overcurrent, short circuit and undervoltage protections.

TYPICAL APPLICATIONS

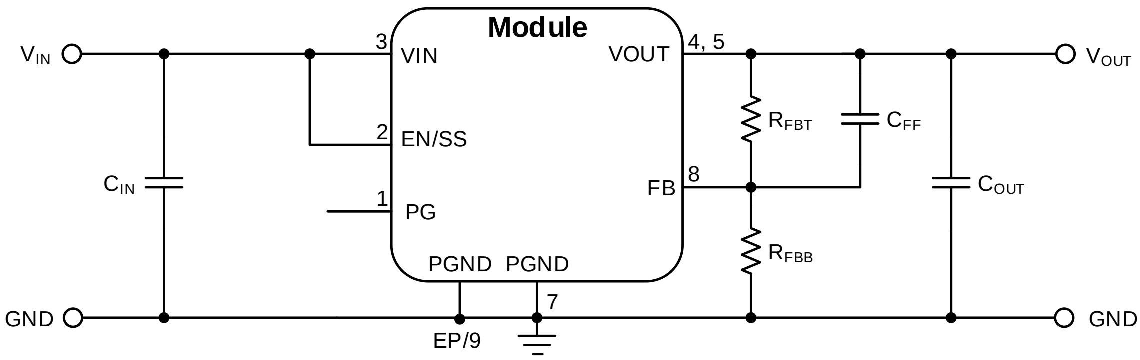
- Test and measurement
- Industrial control
- HVAC and building control
- Sensors

FEATURES

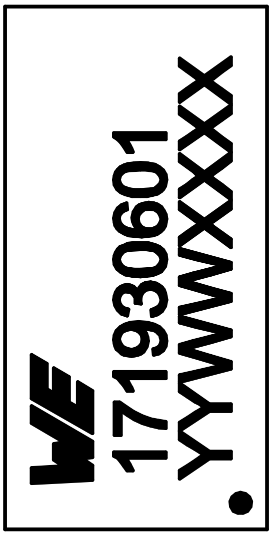
- Peak efficiency up to 87%
- Current capability up to 300mA
- Input voltage range: 3.5V to 36V
- Output voltage range: 1V to 6V
- 12.5µA typical quiescent current
- Integrated shielded inductor
- Fixed switching frequency: 1.2MHz
- Current mode control
- Synchronous operation
- Undervoltage lockout
- Embedded soft-start
- Adjustable soft-start
- Power good indicator
- Thermal shutdown
- Short circuit protection
- Cycle-by-cycle current limit
- RoHS und REACh compliant
- Operating ambient temp. range: -40C to 105°C
- No output current derating up to 85°C ambient temperature
- Operating junction temp. range: -40°C to 125°C
- Complies with EN55032 class B radiated emissions standard



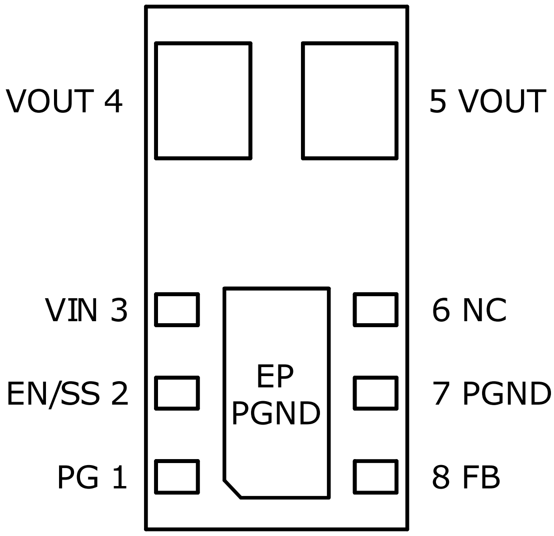
TYPICAL CIRCUIT DIAGRAM



Pinout



Top View



Bottom View

SYMBOL	NUMBER	TYPE	DESCRIPTION
PG	1	Output	Power good flag pin. This open drain output asserts low if the output voltage is lower than 90% or higher than 110% of the set value. A pull-up resistor of 100kΩ is recommended if this function is used.
EN/SS	2	Input	Enable pin. Setting this pin high enables the device, while setting this pin low shuts down the device. This pin must not be left floating. An internal soft-start of 2ms has already been implemented in the MicroModule. For an external soft-start function, an external resistor (R_{SS}) and capacitor (C_{SS}) should be used.
VIN	3	Input	Input voltage. Place the input capacitor as close as possible.
VOUT	4, 5	Power	Output voltage. Place output capacitors as close as possible. For thermal performance, use copper plane(s) at this pin.
NC	6		Pin is not internally electrically connected.
PGND	7	Power	Power Ground. It must be connected to the ground plane and to the thermal pad using thermal vias for the best thermal performance
FB	8	Input	Feedback pin. This pin must be connected to the external resistor divider (between VOUT and PGND) to adjust the output voltage. The trace between VOUT, FB and through the external resistor divider should be kept as short and near to the module as possible.
PGND	EP	Exposed Pad	Exposed Pad. This pin is electrically connected internally to PGND. It is recommended to connect it to the ground plane for device heat dissipation.

ORDERING INFORMATION

ORDER CODE	SPECIFICATIONS	PACKAGE	PACKAGING UNIT
171930601	300mA / 1V-6V Vout version	LGA-8EP	7" Reel (1000 pieces)
178930601	300mA / 1V-6V Vout version	Eval Board	1 piece

SALES INFORMATION

SALES CONTACT
Würth Elektronik eiSos GmbH & Co. KG EMC and Inductive Solutions Max-Eyth-Str. 1 74638 Waldenburg Germany Tel. +49 (0) 7942 945 0 www.we-online.com/powermodules Technical support: powermodules@we-online.com

ABSOLUTE MAXIMUM RATINGS

Caution:
Exceeding the listed absolute maximum ratings may affect the device negatively and may cause permanent damage.

SYMBOL	PARAMETER	LIMIT		UNIT
		MIN(1)	MAX(1)	
VIN	Input Voltage	-0.3	40	V
VOUT	Output Voltage	-0.3	40	V
FB	Feedback	-0.3	6.2	V
EN	Enable	-0.3	40	V
PG	Power Good	-0.3	6.2	V
I_{PG}	Power Good Pin Current	-	8	mA
$T_{storage}$	Assembled, non-operating storage temperature	-55	125	°C

OPERATING CONDITIONS

Operating conditions are conditions under which the device is intended to be functional. All values are referenced to GND. MIN and MAX limits are valid for the recommended ambient temperature range of **-40°C to 105°C**.

SYMBOL	PARAMETER	MIN	TYP(3)	MAX	UNIT
V_{IN}	Input Voltage	3.5	-	36	V
V_{OUT}	Output Voltage	1	-	6	V
T_A	Ambient temperature range	-40	-	105	°C
T_{jop}	Junction temperature range	-40	-	125	°C
I_{OUT}	Output current	-	-	300	mA

THERMAL SPECIFICATIONS

Caution:
Typical values represents statistically the utmost probable values at the following conditions: VIN = 24V, VOUT = 5V, CIN = 4.7µF ceramic, COUT = 47µF ceramic, T_A = 25°C unless otherwise noted.

SYMBOL	PARAMETER	TYP(3)	UNIT
Θ_{JA}	Junction-to-ambient thermal resistance(4)	55	K/W
Θ_{JC}	Junction-to-case (top) thermal resistance(4)	40	K/W
T_{SD}	Thermal shutdown, rising	155	°C
	Thermal shutdown, hysteresis	25	°C

ELECTRICAL SPECIFICATIONS

MIN and MAX limits are valid for the recommended ambient temperature range of **-40°C to 105°C**. Typical values represents statistically the utmost probable values at the following conditions: VIN = 24V, VOUT = 5V, CIN = 4.7µF ceramic, COUT = 47µF ceramic, T_A = 25°C unless otherwise noted.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN(1)	TYP(3)	MAX(1)	UNIT
Output Voltage						
V_{REF}	Reference voltage		0.739	0.75	0.761	V
I_{FB}	Feedback input bias current		-0.1	0	0.1	µA
V_{OUT}	Line regulation	V_{IN} = 8V to 36V, I_{OUT} = 300mA	-	0.06	-	%
	Load regulation	30mA ≤ I_{LOAD} ≤ 300mA	-	1.35	-	%
	Output voltage ripple	I_{OUT} = 300mA, 20MHz BWL	-	7	-	mV_{pp}
		I_{OUT} = 30mA, 20MHz BWL	-	10	-	mV_{pp}
Current						
I_{out}	Output current		-	-	300	mA
I_{CL-HS}	High side switch current limit		1	1.3	-	A
Switching Frequency						
f_{SW}	Switching frequency		-	1.2	-	MHz
Enable and Undervoltage Lockout						
V_{UVLO}	V_{IN} undervoltage threshold	V_{IN} increasing	2.7	2.8	2.9	V
		V_{IN} decreasing	2.6	2.7	2.8	V
$V_{EN/SS}$	EN/SS threshold	Enable logic high voltage	2.5	-	36	V
		Enable logic low voltage	-	-	0.3	V
$I_{EN/SS}$	EN/SS pin input current	V_{IN} = 36V, Enable = high	-	0.1	0.3	µA
		V_{IN} = 36V, Enable = low	-0.1	-	0.1	µA
C_{OUT}	Output capacitor	These values are absolute. Practical capacitor values need to have derating aspects considered.	20	47	150	µF
Soft-Start						
t_{SS}	Soft-start time	Rising edge to 95% of V_{OUT}	-	2	-	ms
Efficiency						
η	Efficiency	V_{IN} = 5V, V_{OUT} = 3.3V, I_{OUT} = 300mA	-	87	-	%
		V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 300mA	-	87	-	%
		V_{IN} = 24V, V_{OUT} = 5V, I_{OUT} = 300mA	-	83	-	%
Input Quiescent, No Load and Shutdown Current						
I_Q	Quiescent current	V_{EN} = high, V_{IN} = 12V	-	12.5	-	µA
		V_{EN} = high, V_{IN} = 24V	-	13.5	-	µA
I_{IN-NL}	No load input current	Vout = 3.3V	-	15.3	-	µA
I_{SD}	Shutdown current	V_{EN} = low, V_{IN} = 12V	-	1.7	-	µA
		V_{EN} = low, V_{IN} = 24V	-	2.8	-	µA

RoHS, REACh

RoHS directive	COMPLIANT RoHS&REACh WÜRTH ELEKTRONIK	Directive 2011/65/EU of the European Parliament and the Council of June 8th, 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
REACh directive		Directive 1907/2006/EU of the European Parliament and the Council of June 1st, 2007 regarding the Registration, Evaluation, Authorization and Restriction of Chemicals (REACh).

PACKAGE SPECIFICATIONS

ITEM	PARAMETER	TYP(3)	UNIT
Mold Compound	UL94V-0	-	-
Weight	-	0.04341	g

NOTES

(1) Min and Max limits are 100% production tested at 25°C. Limits over the operating temperature range are guaranteed through correlation using Statistical Quality Control (SQC) methods.

(2) Depending on heat sink design, number of PCB layers, copper thickness and air flow.

(3) Typical numbers are valid at 25°C ambient temperature and represent statistically the utmost probable values assuming a Gaussian distribution.

(4) Measured on the 178930601 evaluation board, a 40 x 40mm two layer board, with 35 µm (1 ounce) copper.

TYPICAL PERFORMANCE CURVES

If not otherwise specified, the following conditions apply: V_{IN} = 24V; C_{IN} = 4.7µF X7R 50V ceramic (885012209048); C_{OUT} = 47µF X5R ceramic; C_{FF} = 220pF; T_A = 25°C.

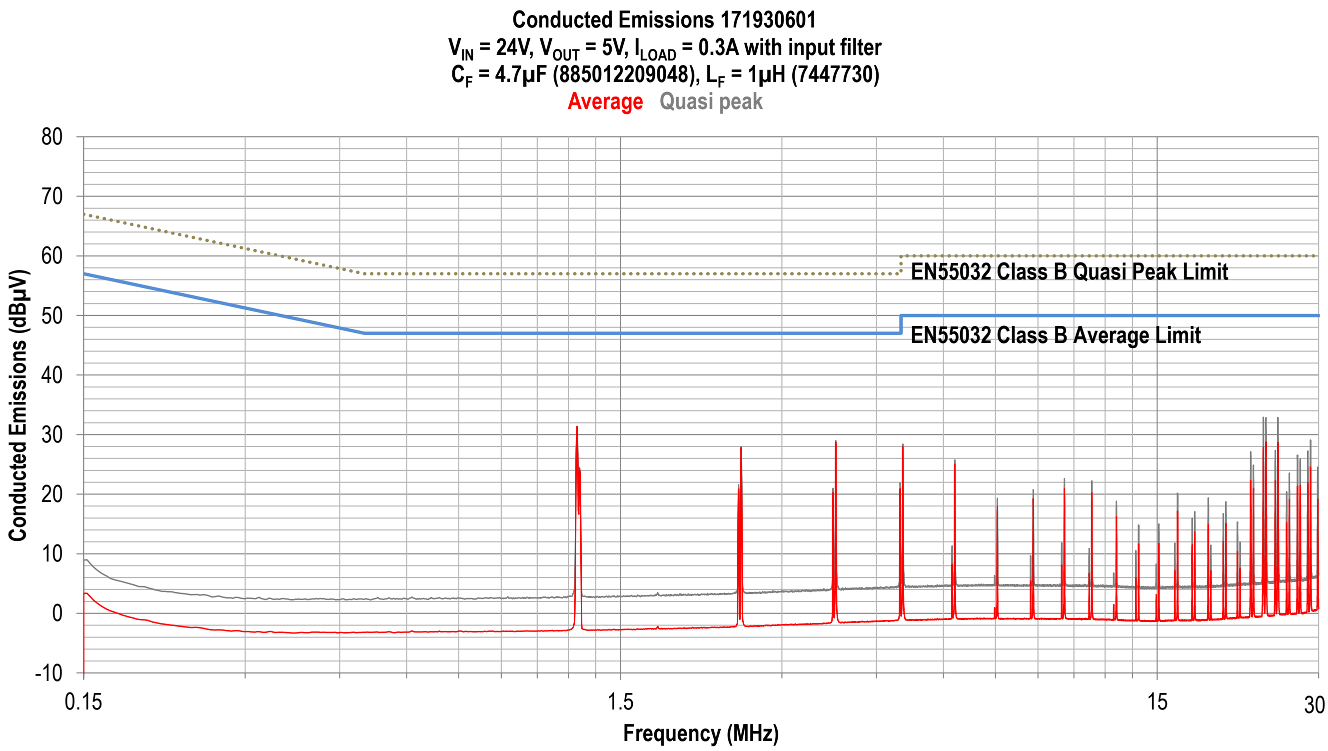
RADIATED EMISSIONS EN55032 (CISPR-32) CLASS B COMPLIANT TEST SETUP

- Measured with module on an Evaluation Board 178930601 in a Fully Anechoic Room (FAR) at 3m antenna distance.
- Measurement input wire length: 160cm (80cm horizontal + 80cm vertical)
- Output wire length: 1m

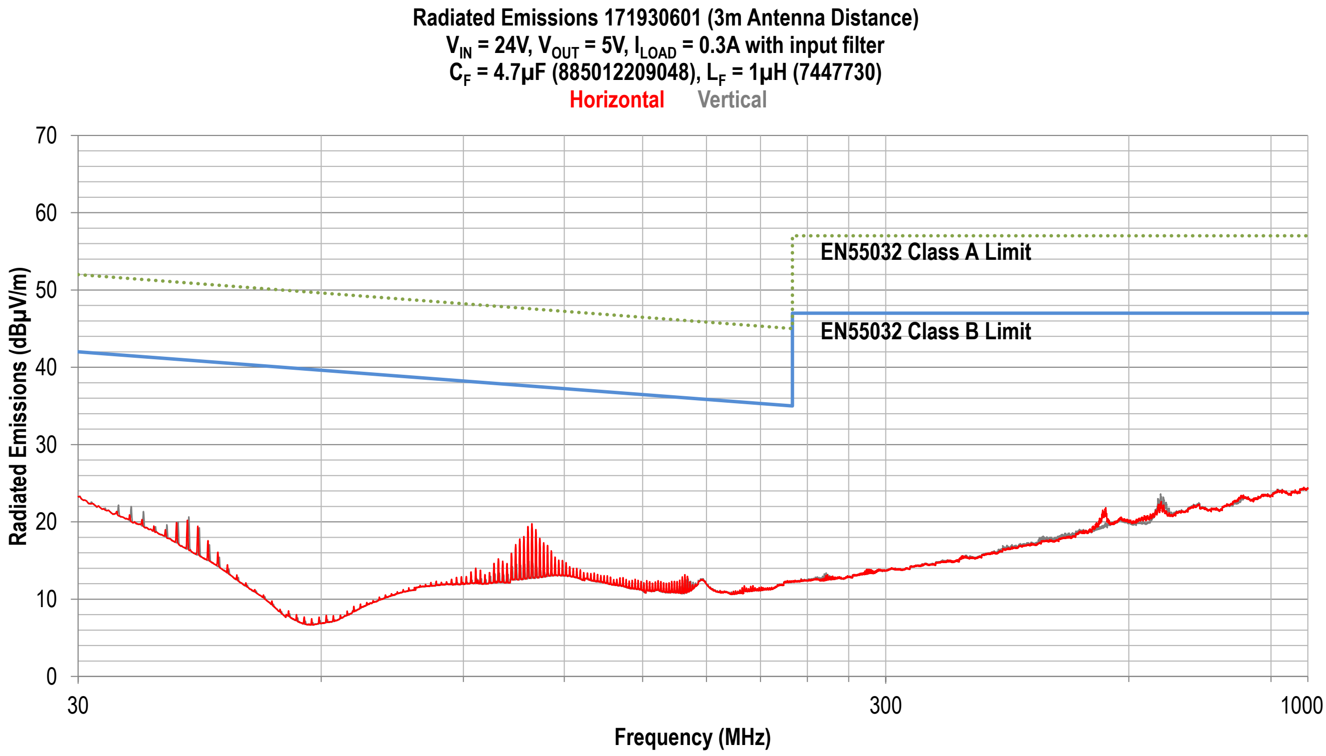
CONDUCTED EMISSIONS EN55032 (CISPR-32) CLASS B COMPLIANT TEST SETUP

- Measurement input wire length: 80cm
- Output wire length: 1m

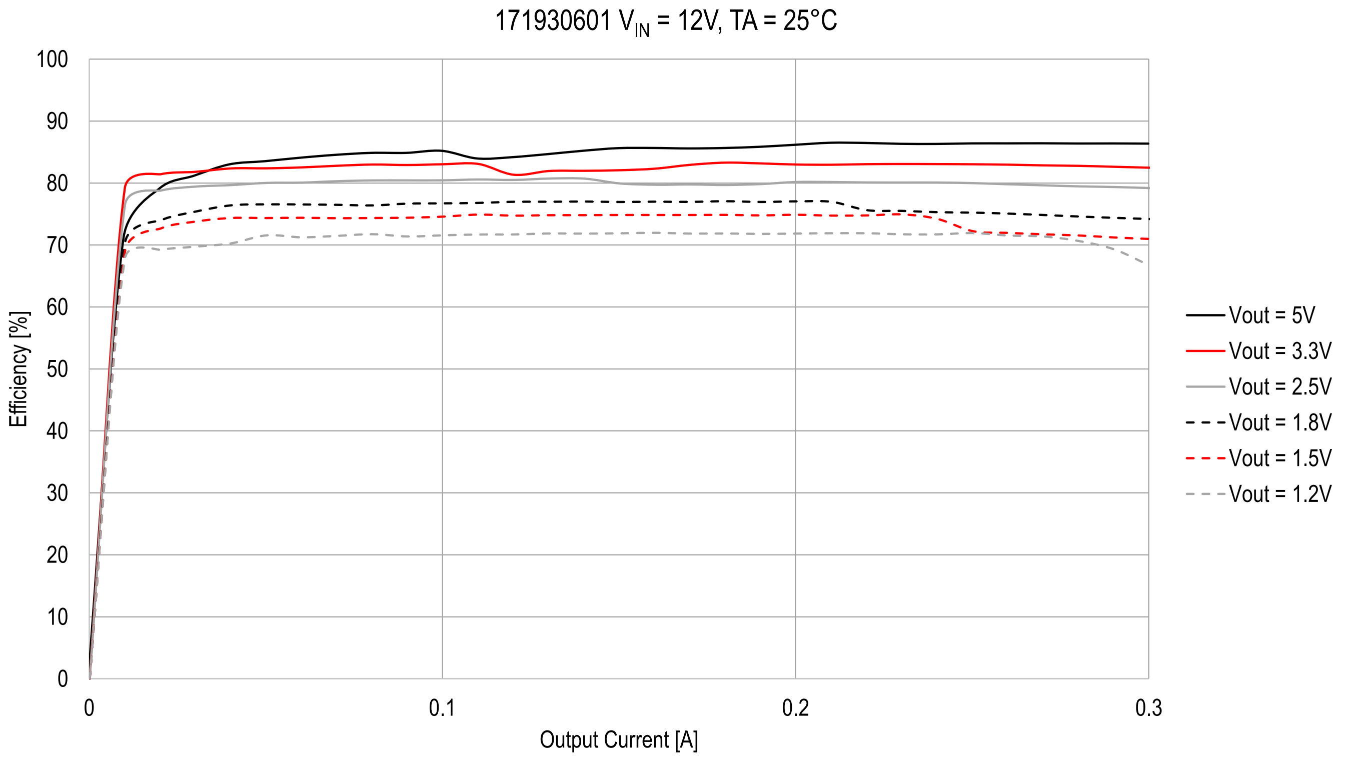
CONDUCTED EMISSIONS

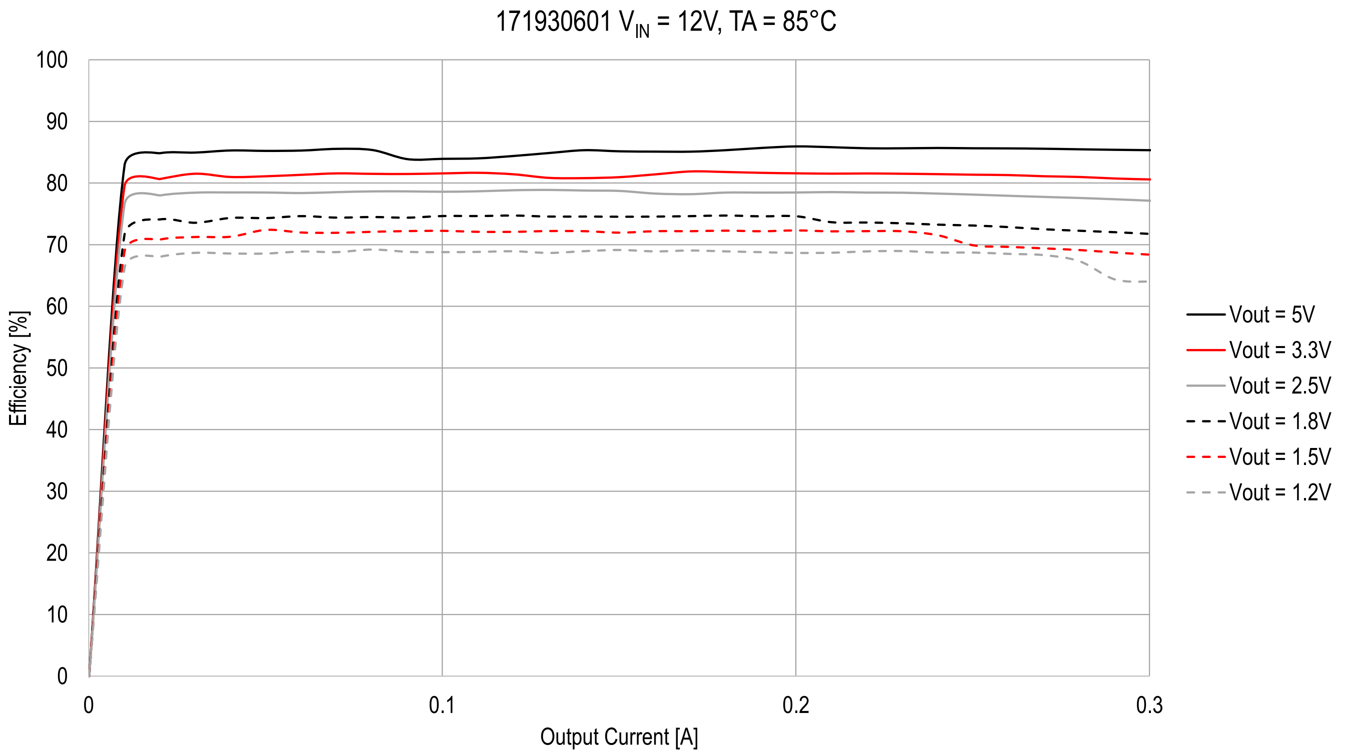


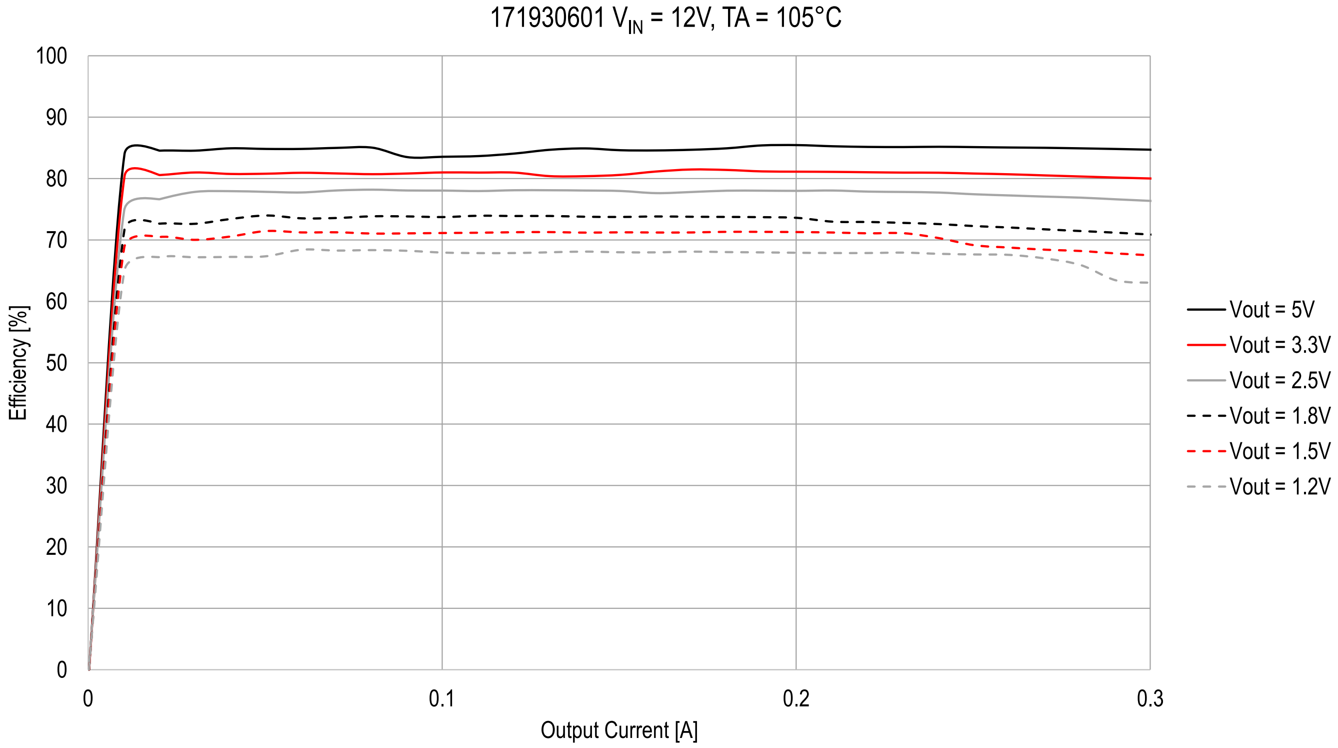
RADIATED EMISSIONS



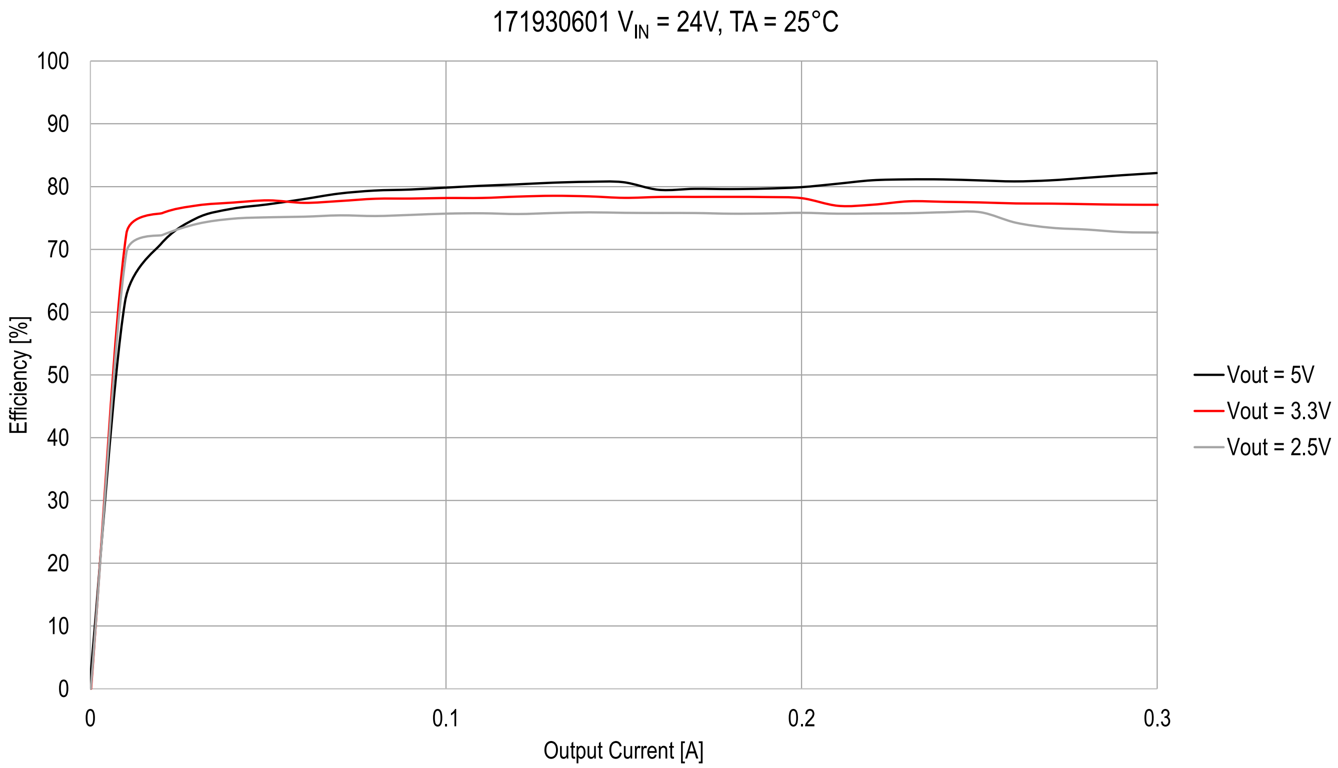
EFFICIENCY 12Vin

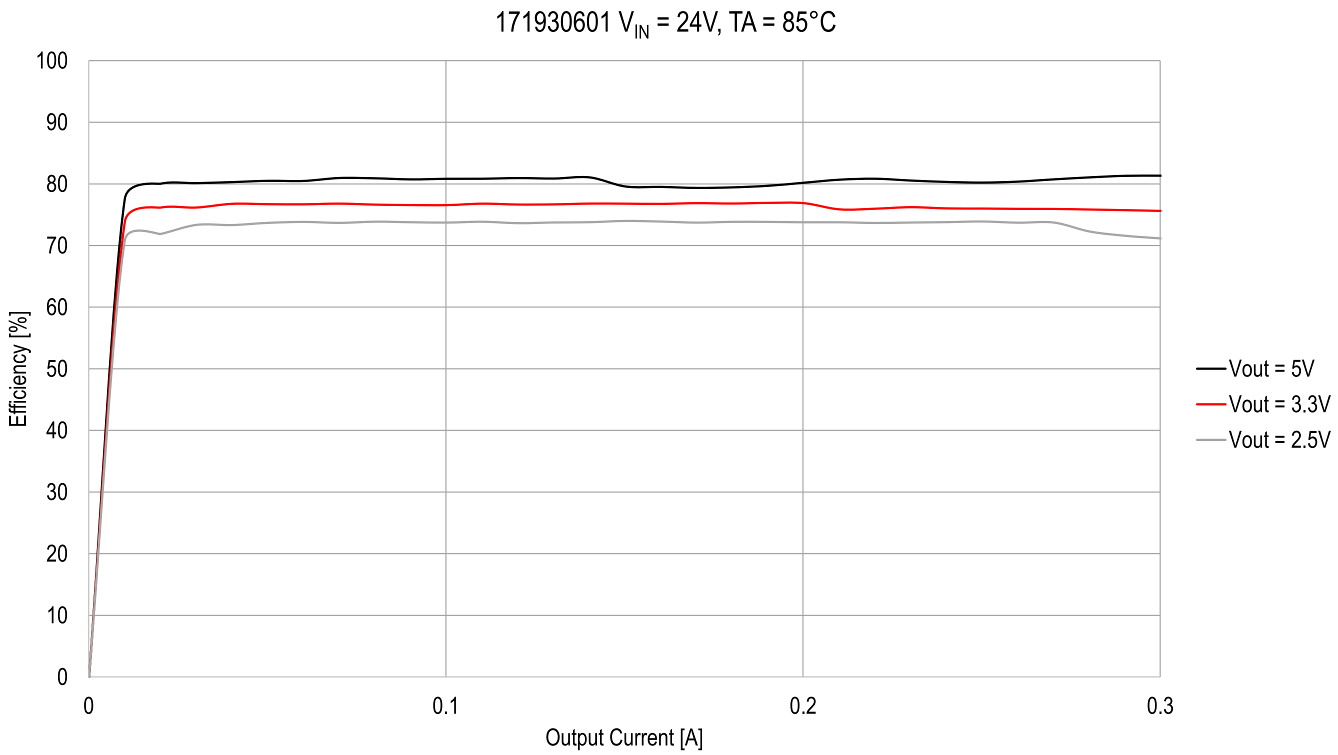


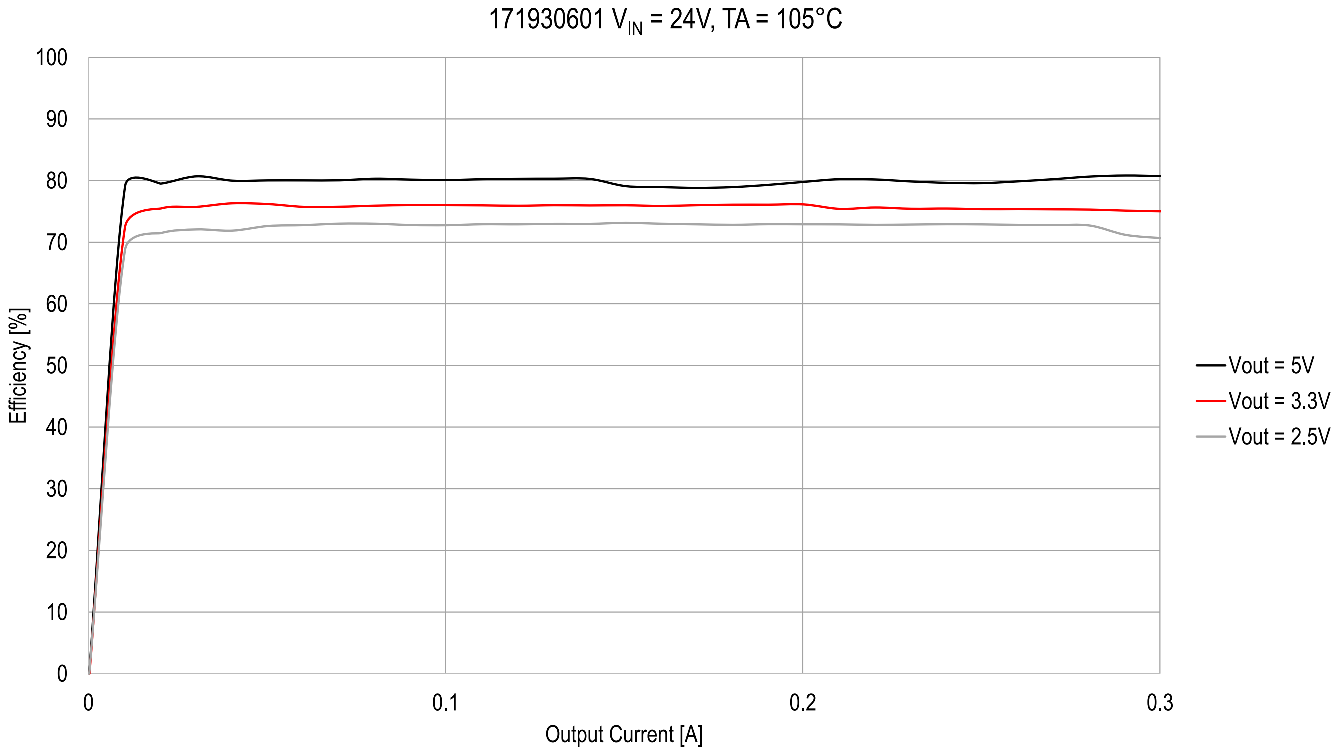




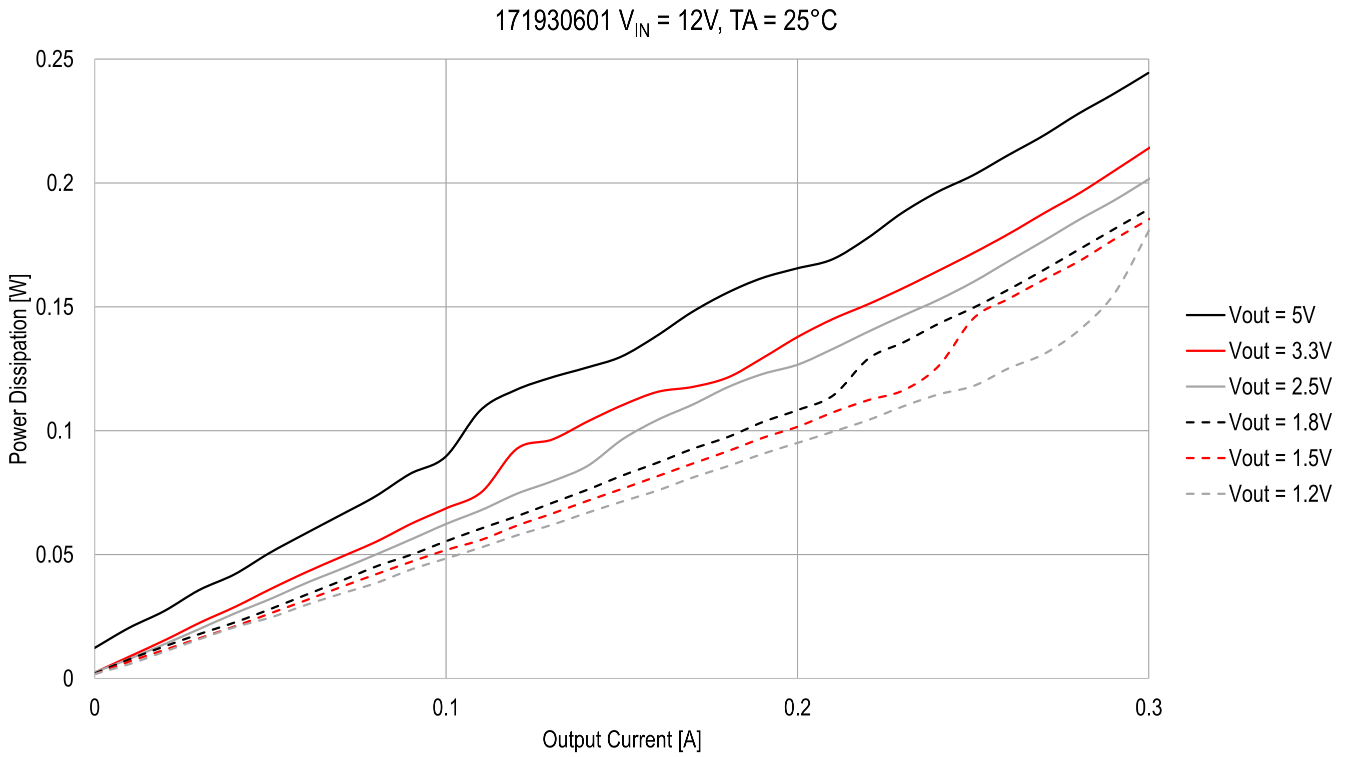
EFFICIENCY 24Vin

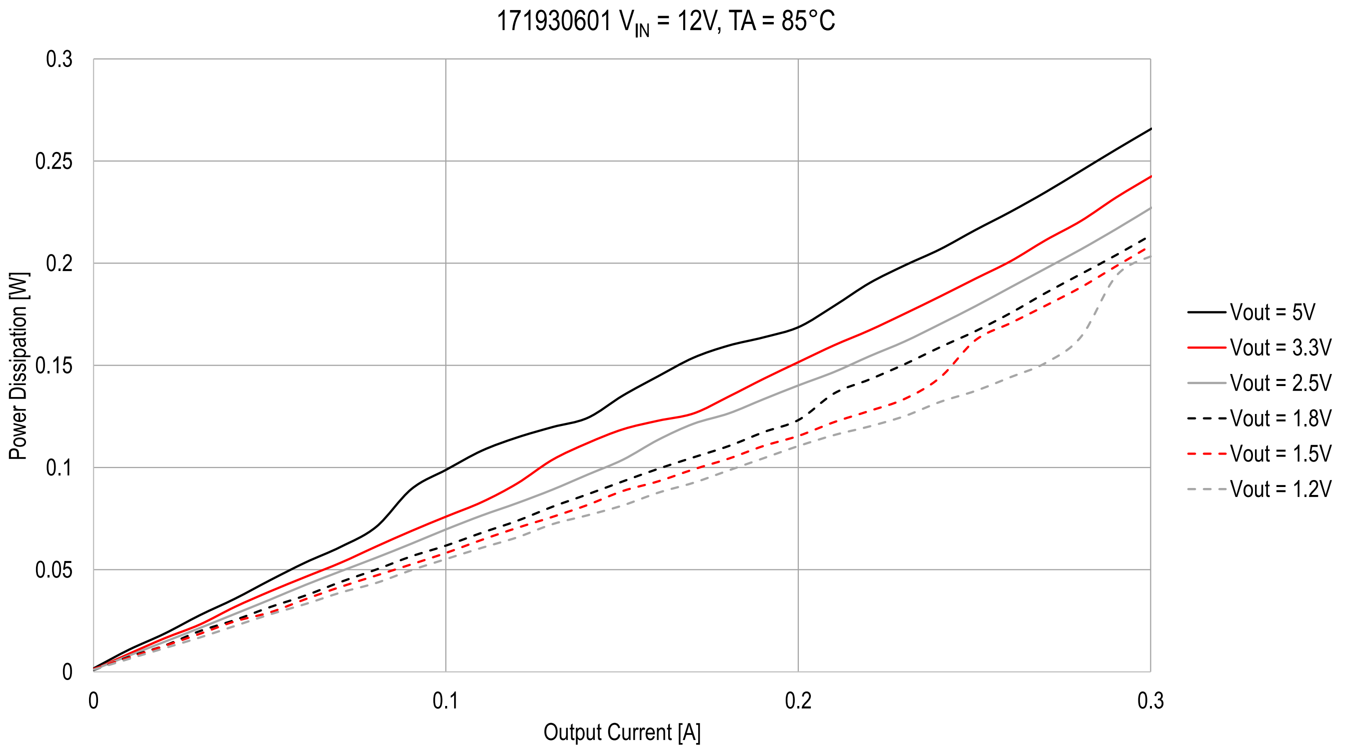


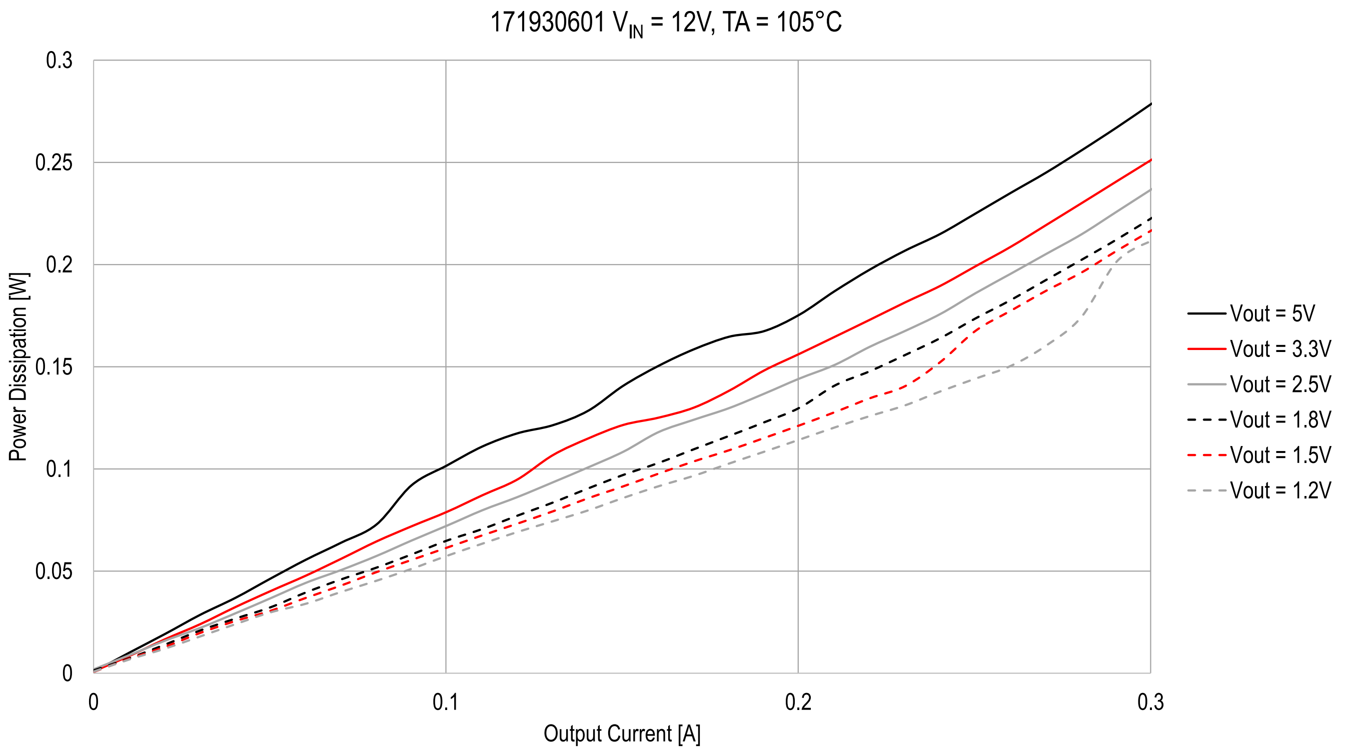

171930601 VIN = 24V, TA = 85°C
Efficiency [%]
100
90
80
70
60
50
40
30
20
10
0
0
0.1
0.2
0.3
Output Current [A]
Vout = 5V
Vout = 3.3V
Vout = 2.5V


171930601 VIN = 24V, TA = 105°C
Efficiency [%]
100
90
80
70
60
50
40
30
20
10
0
0
0.1
0.2
0.3
Output Current [A]
Vout = 5V
Vout = 3.3V
Vout = 2.5V

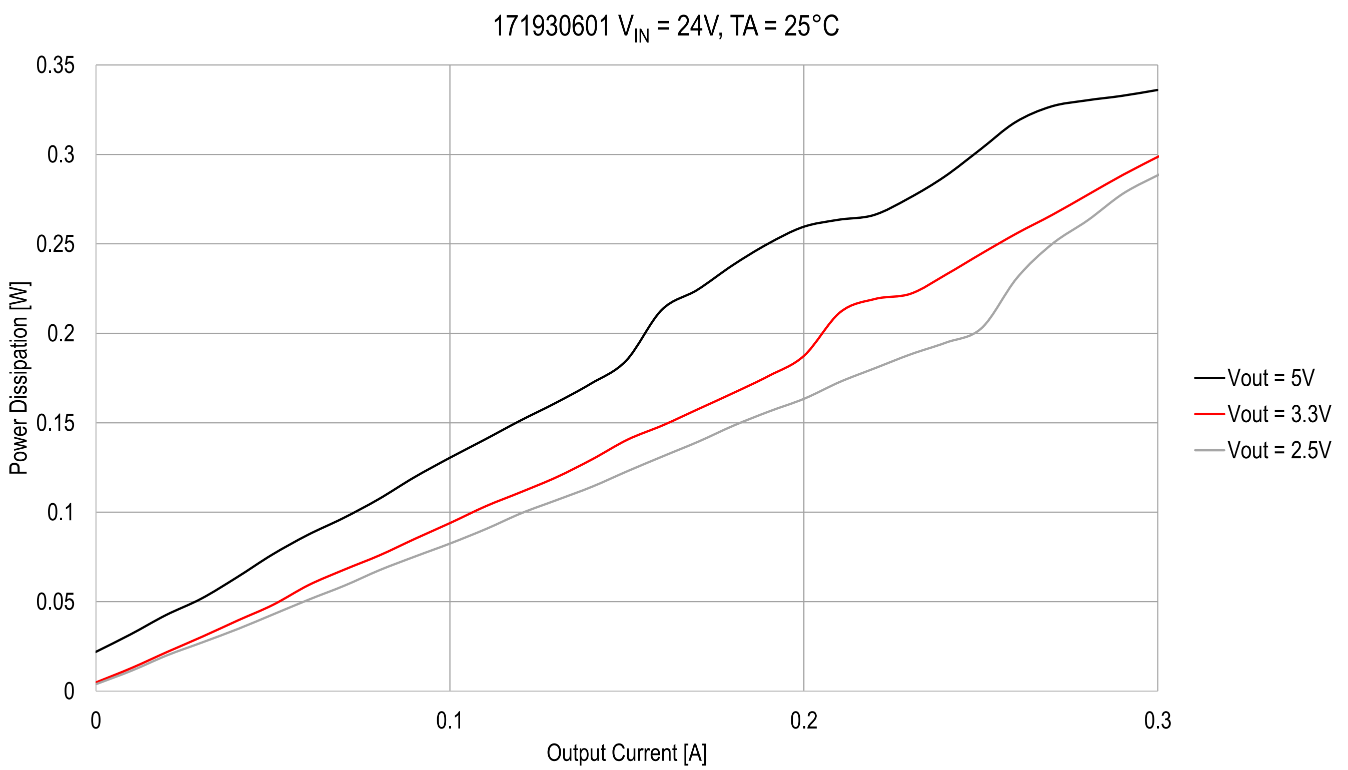
POWER DISSIPATION 12Vin

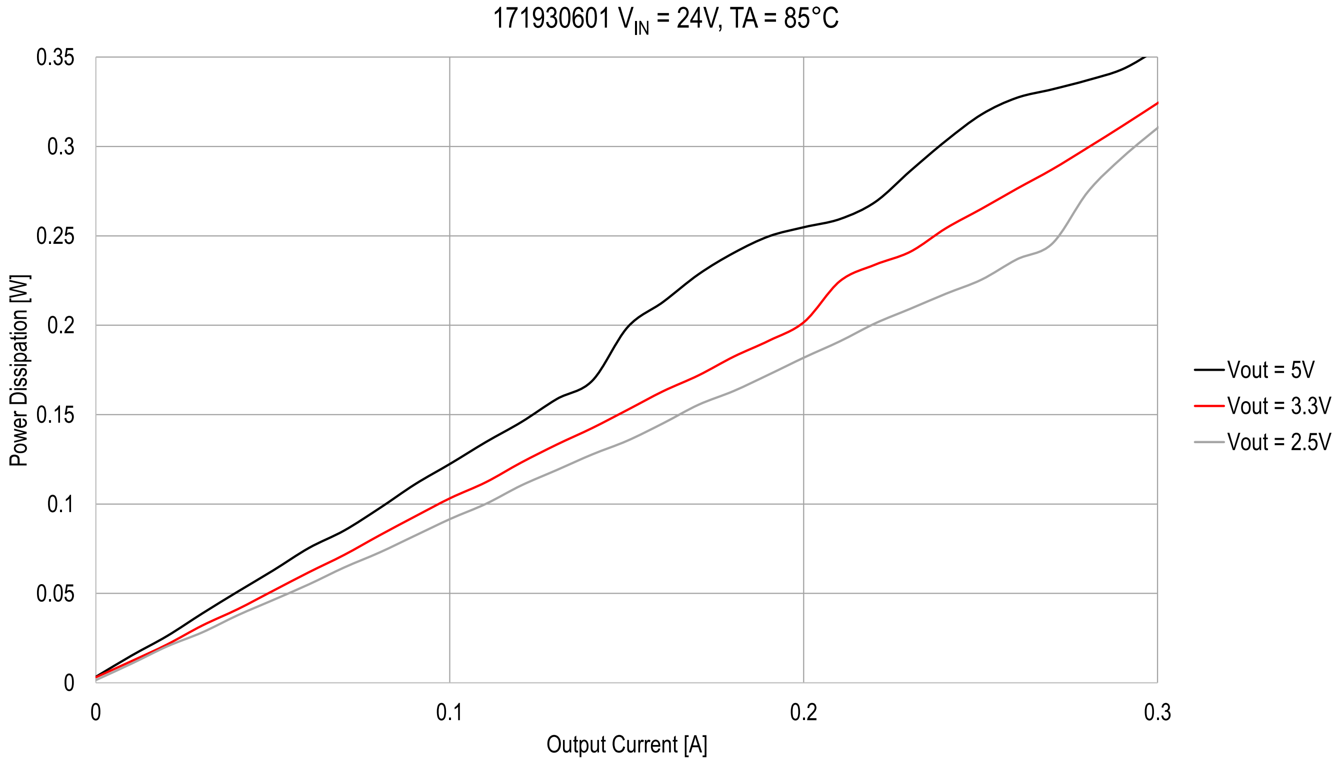


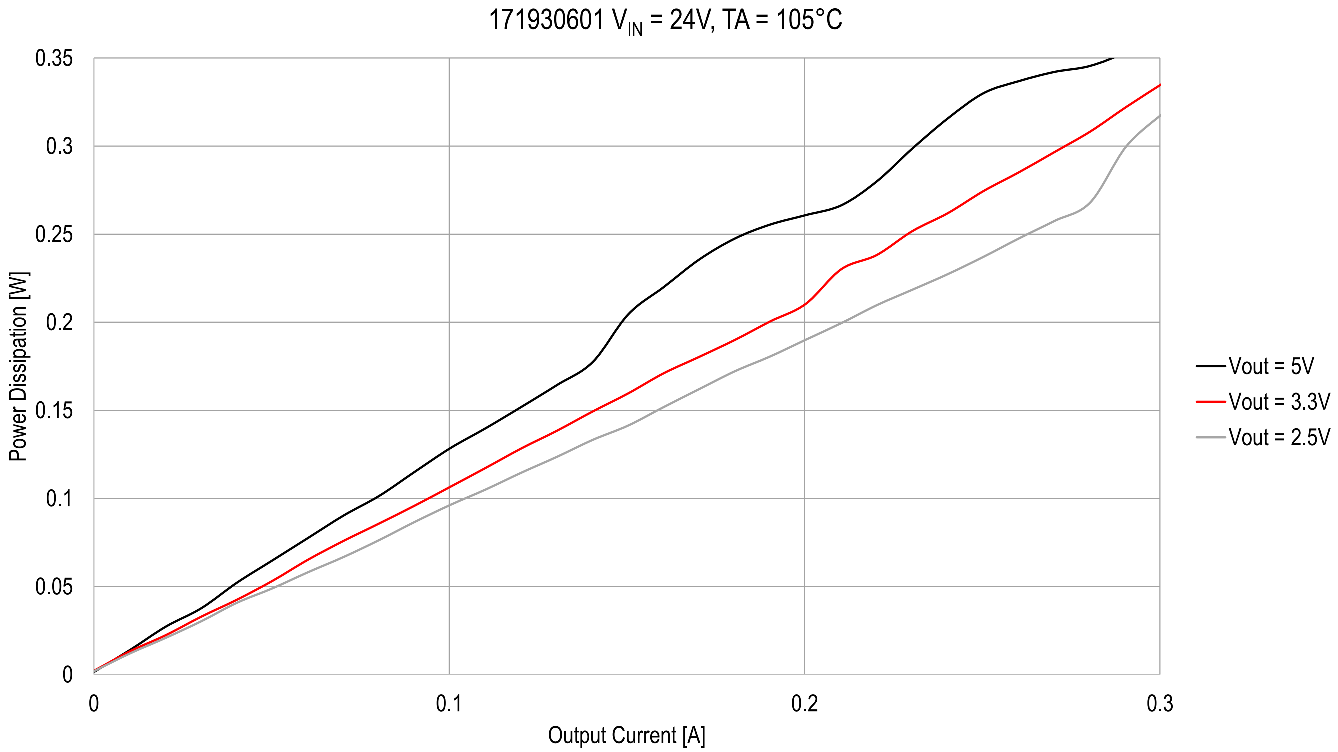




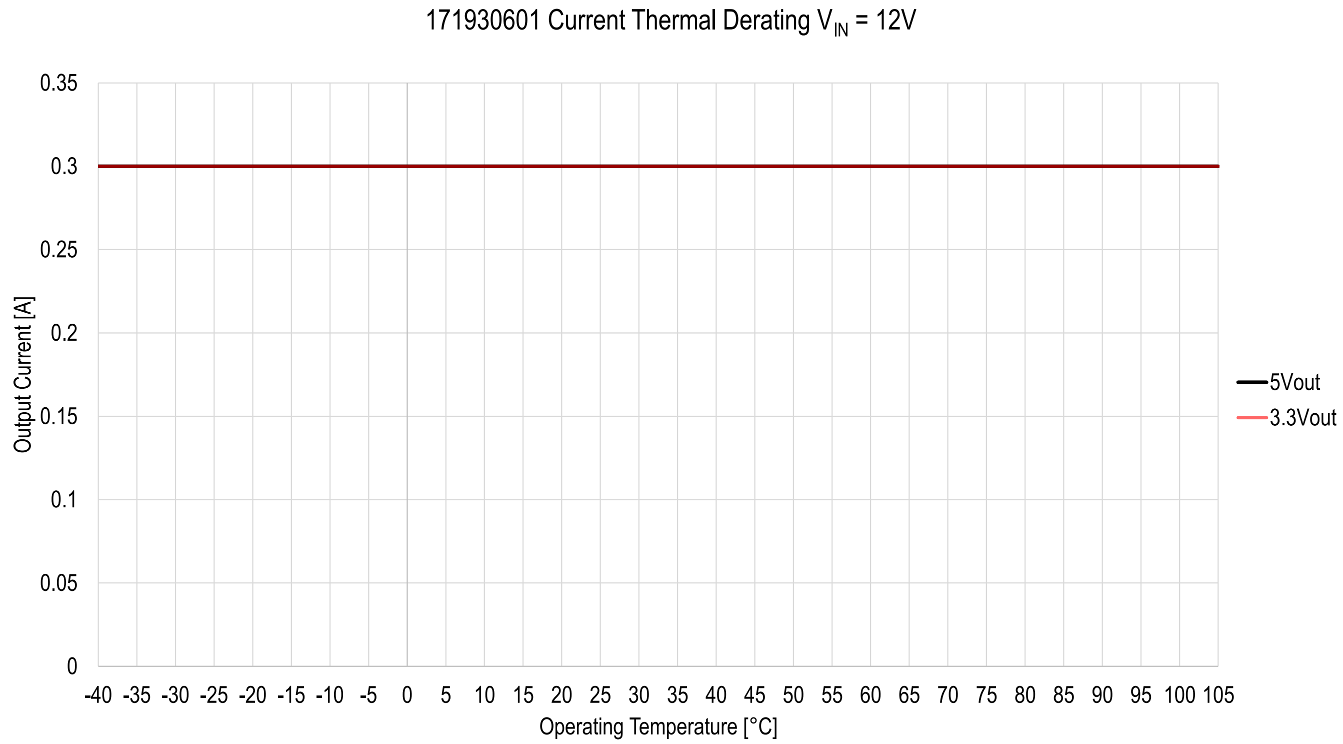
POWER DISSIPATION 24Vin

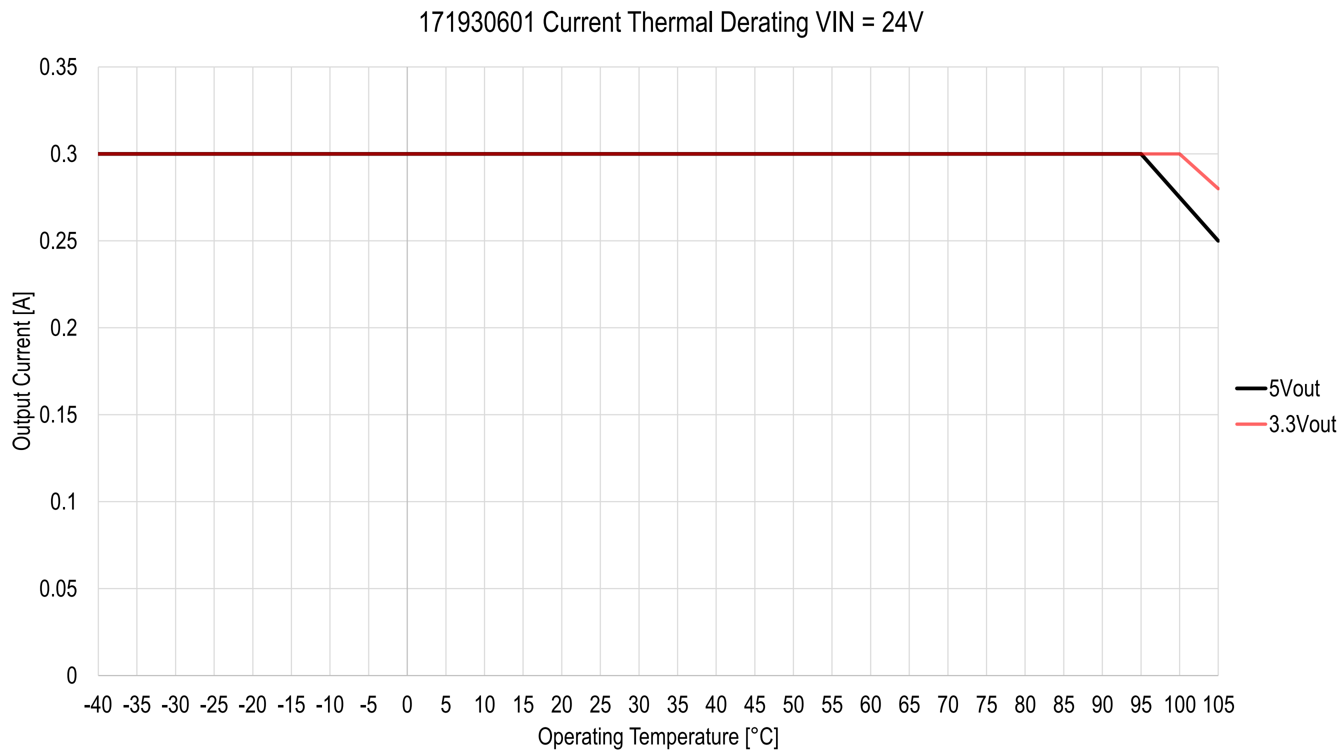



171930601 V_IN = 24V, TA = 85°C
Power Dissipation [W]
Output Current [A]
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.1
0.2
0.3
Vout = 5V
Vout = 3.3V
Vout = 2.5V


171930601 V_IN = 24V, TA = 105°C
Power Dissipation [W]
Output Current [A]
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.1
0.2
0.3
Vout = 5V
Vout = 3.3V
Vout = 2.5V

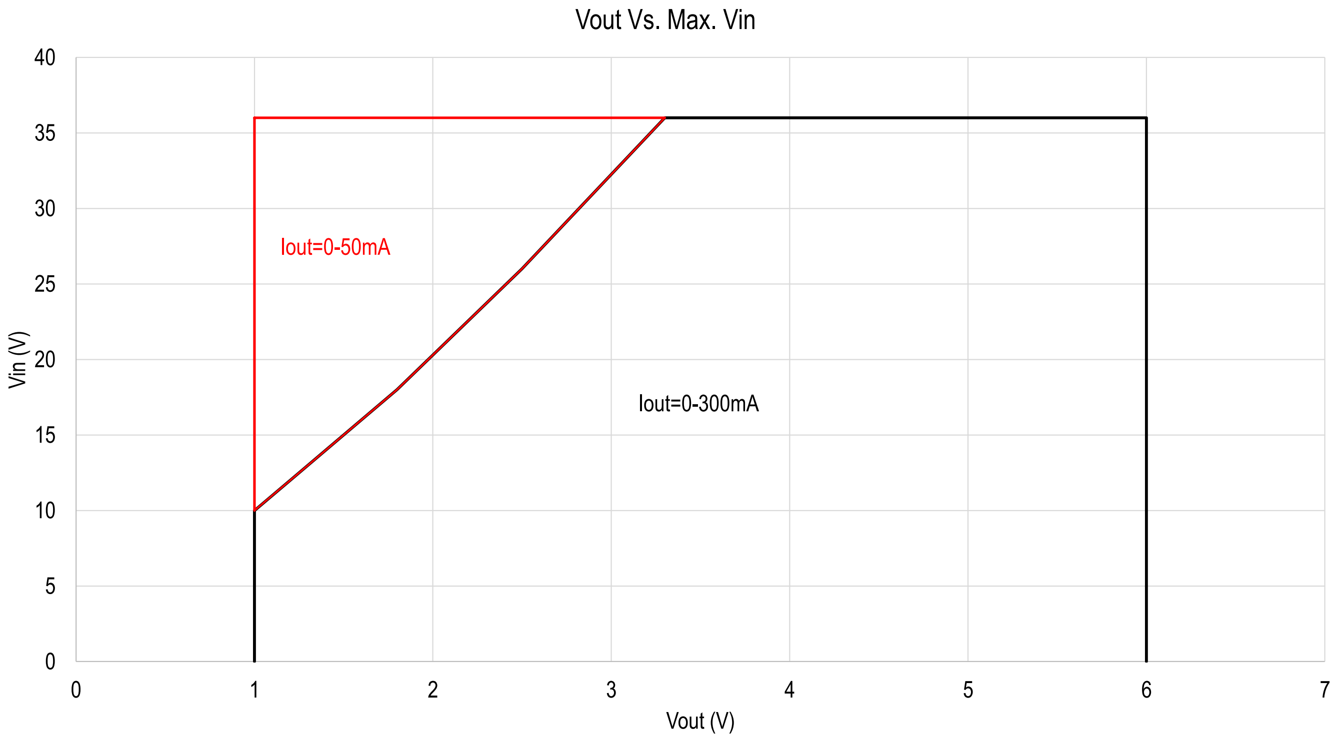
THERMAL DERATING



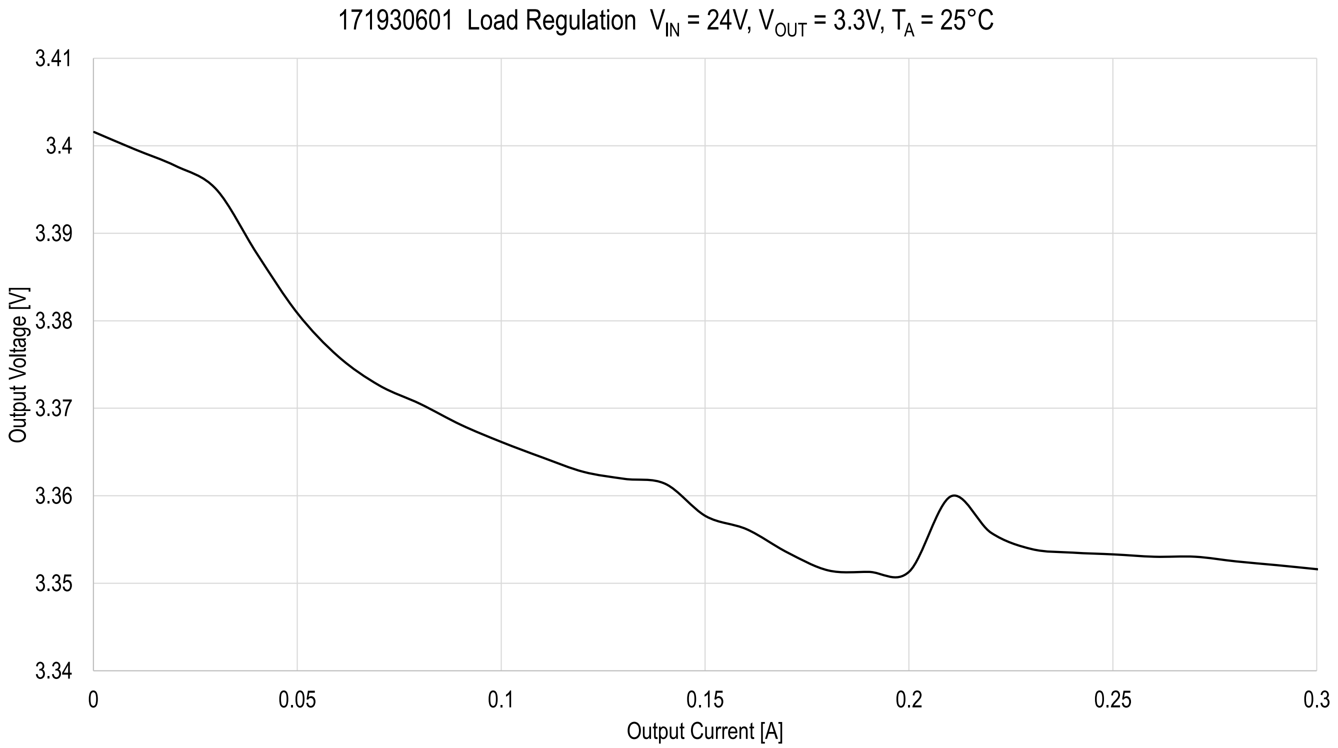


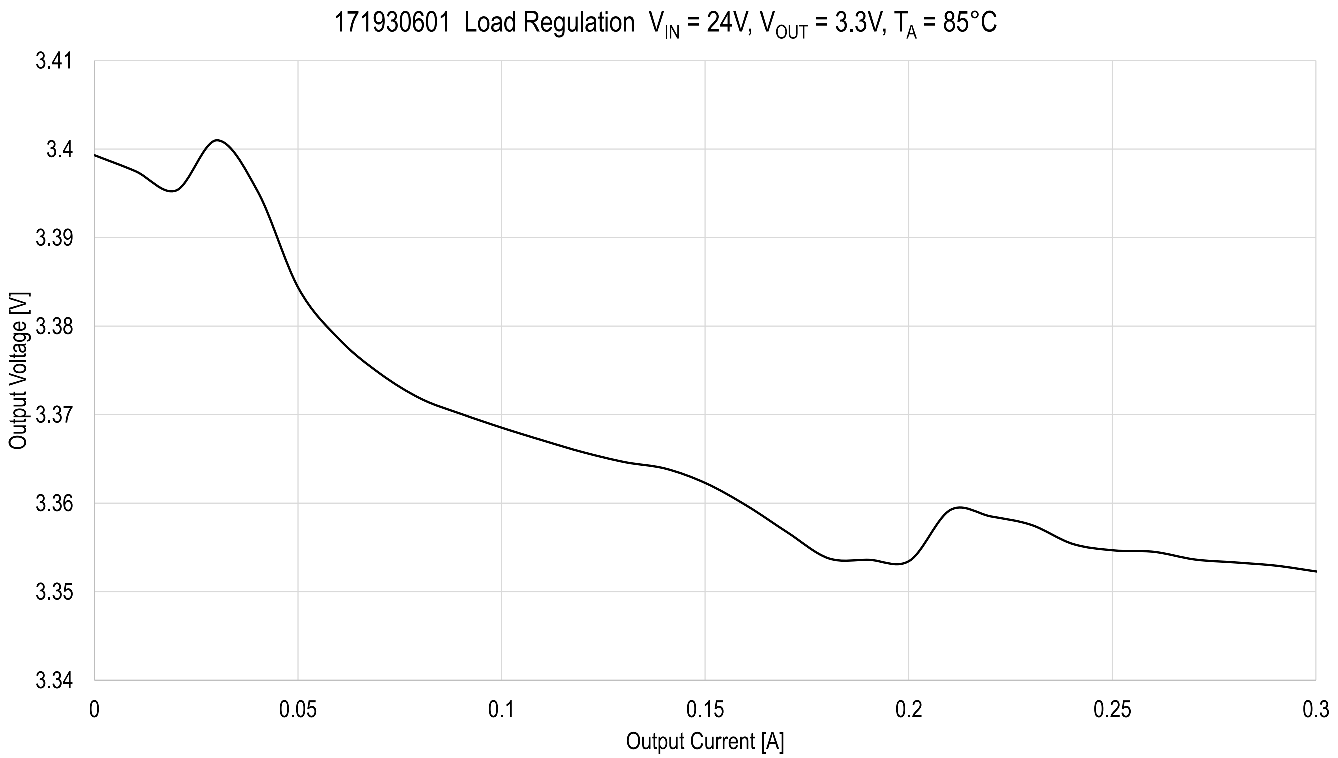
Note: Both thermal derating graphs were measured on the 178930601 Evaluation Board (40 x 40 mm, two layers, 35 µm copper thickness). Please see T_A limits in Operating Conditions on page 4.

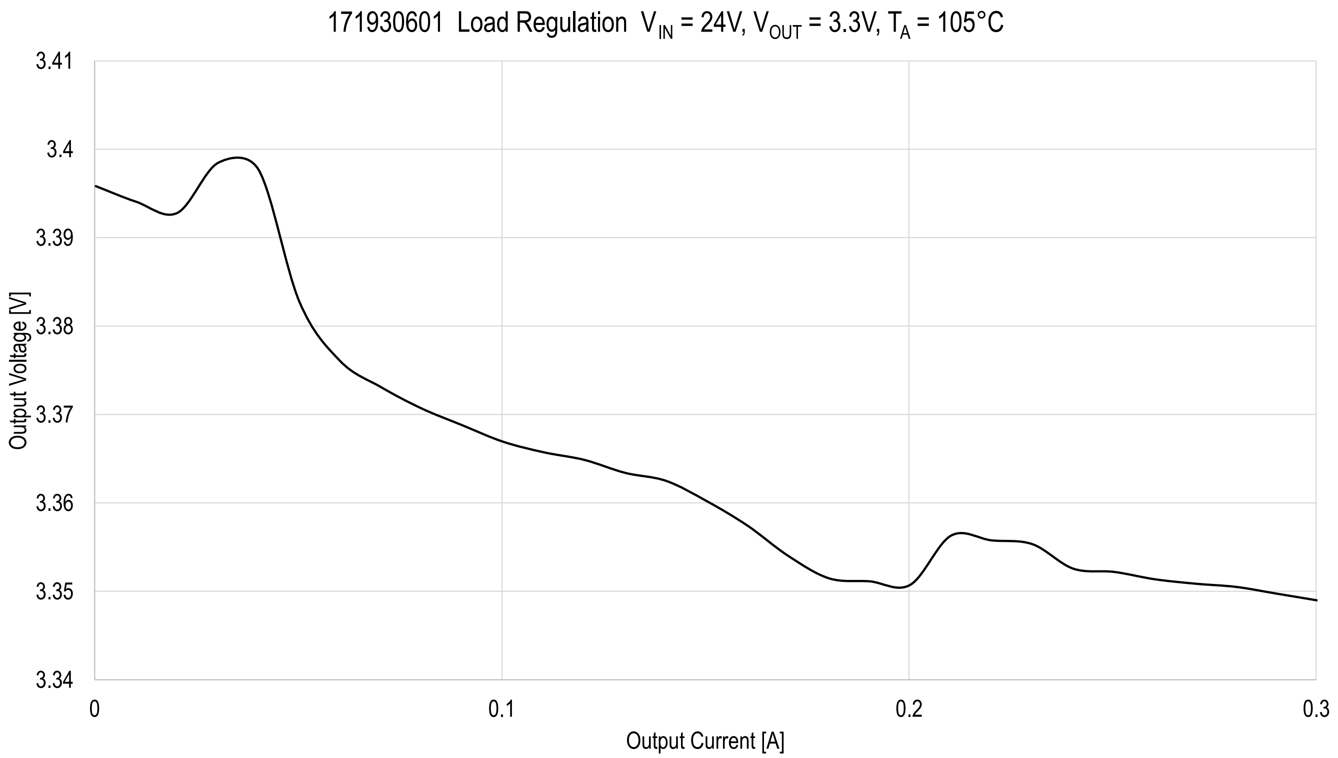
OPERATING RANGE



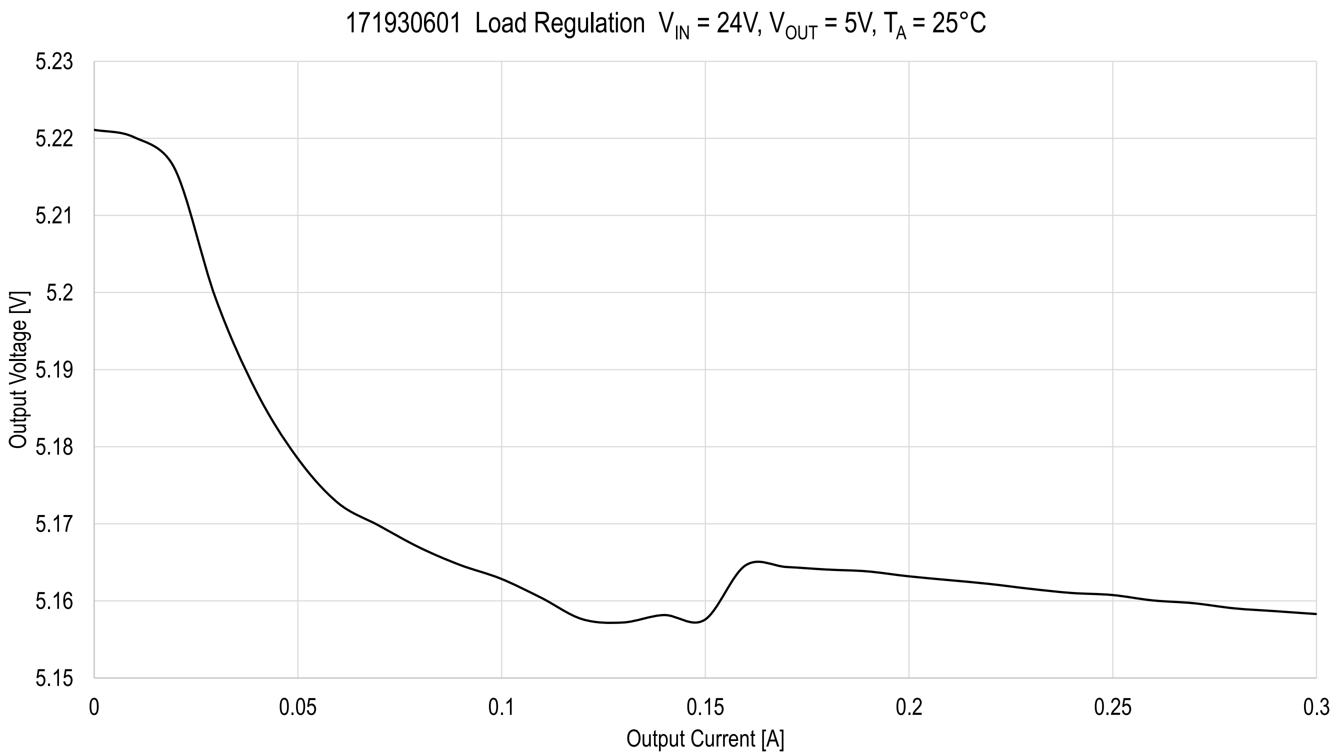
LOAD REGULATION 3.3Vout

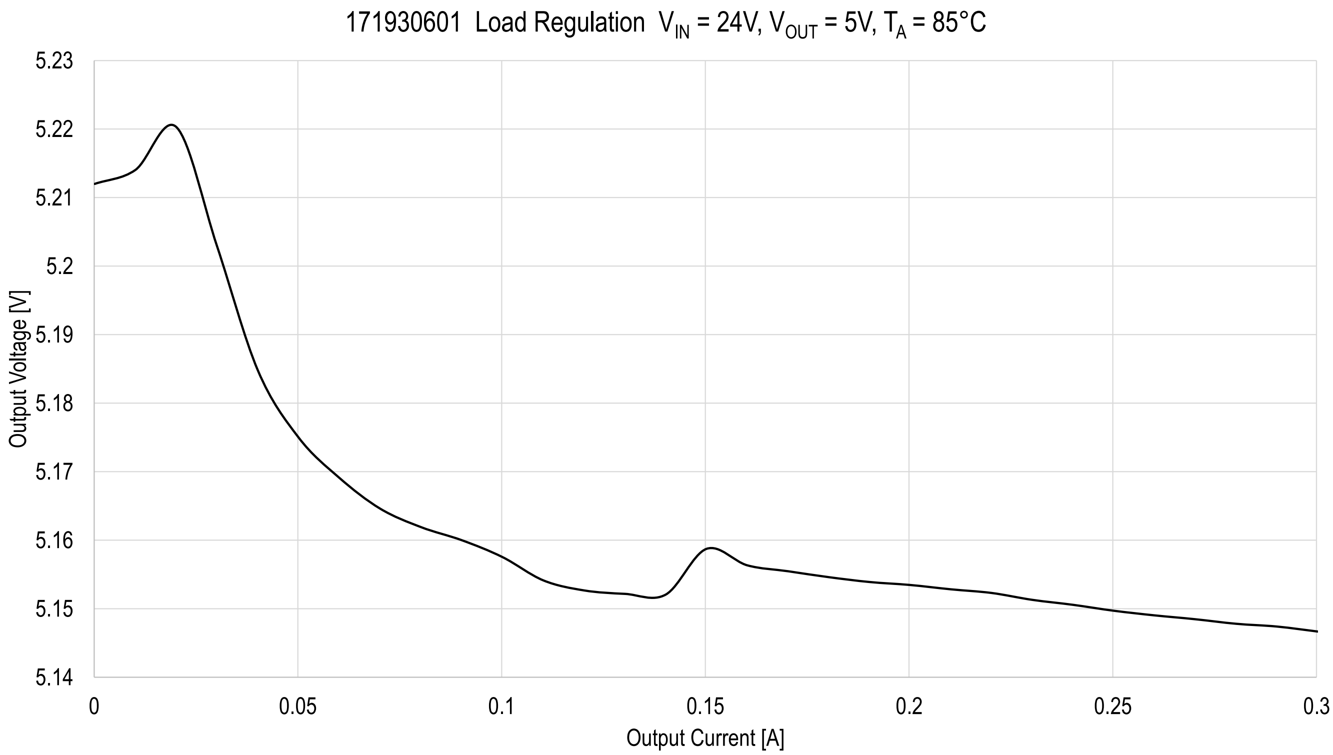


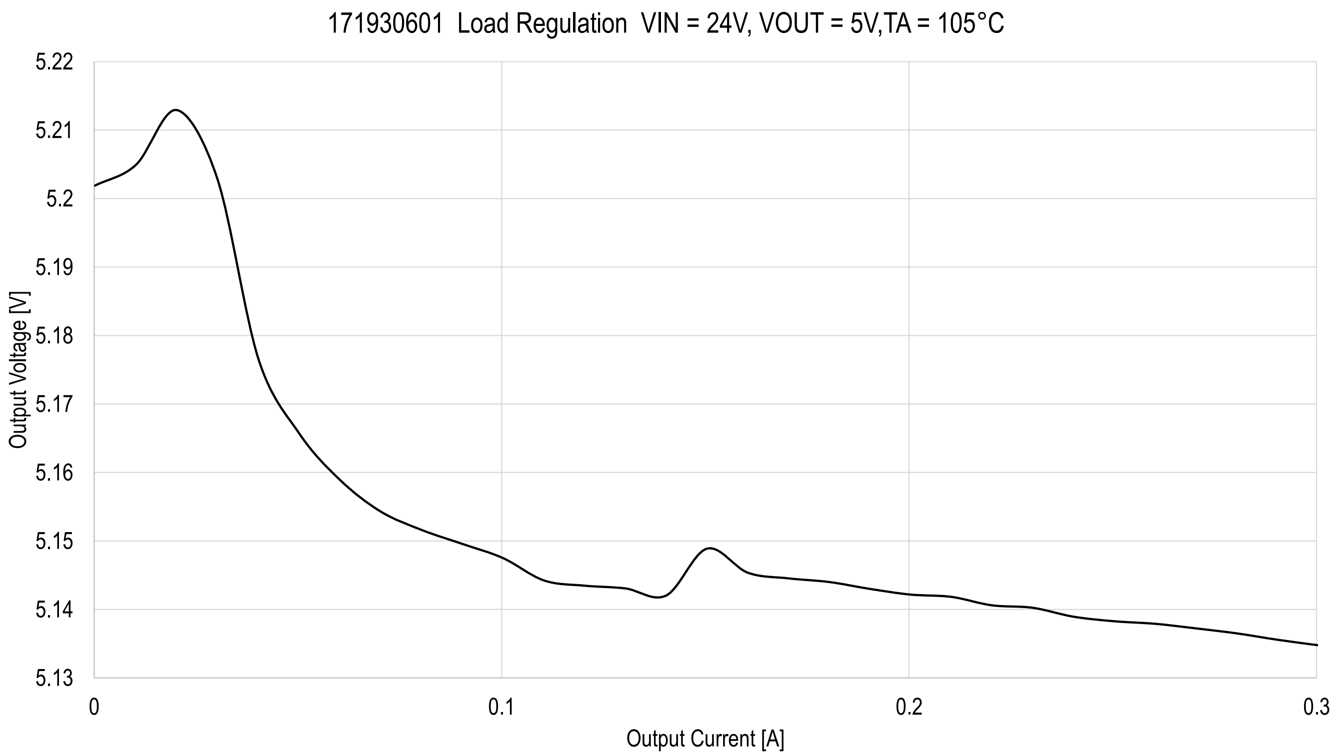




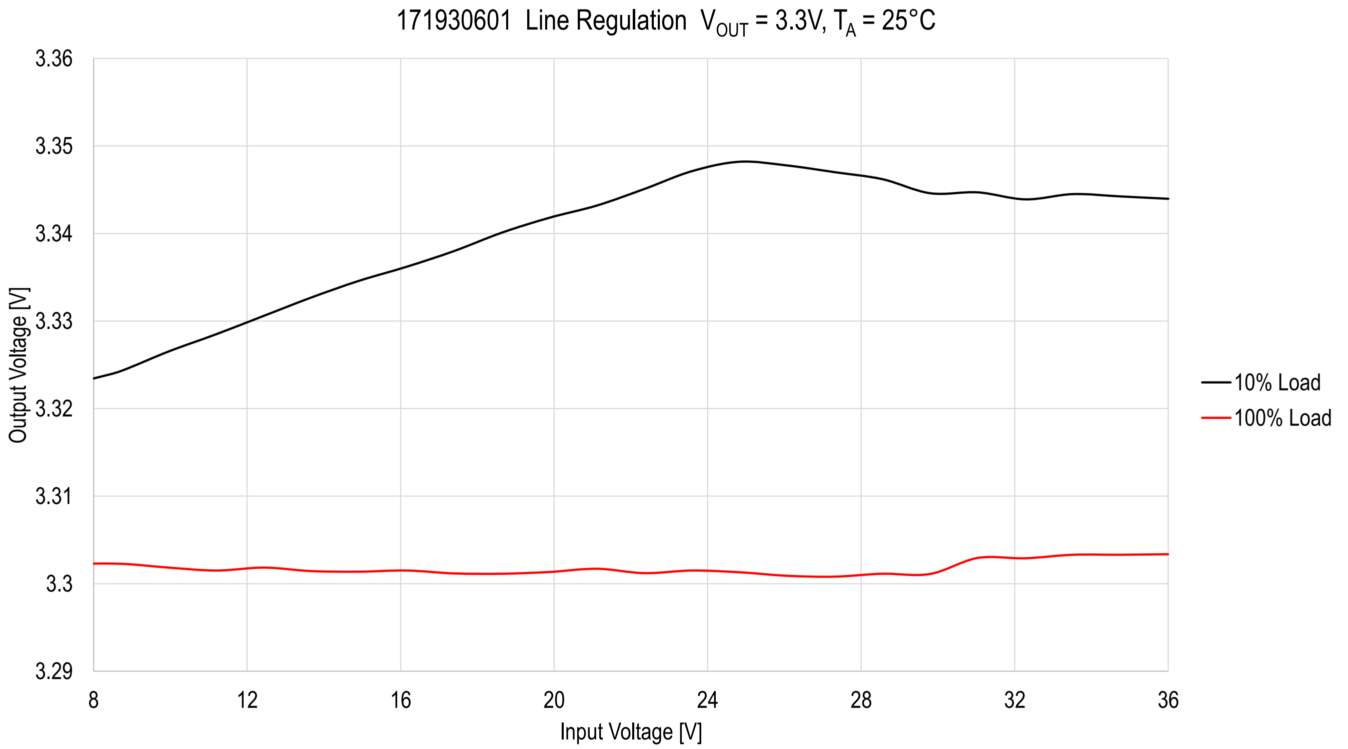
LOAD REGULATION 5Vout

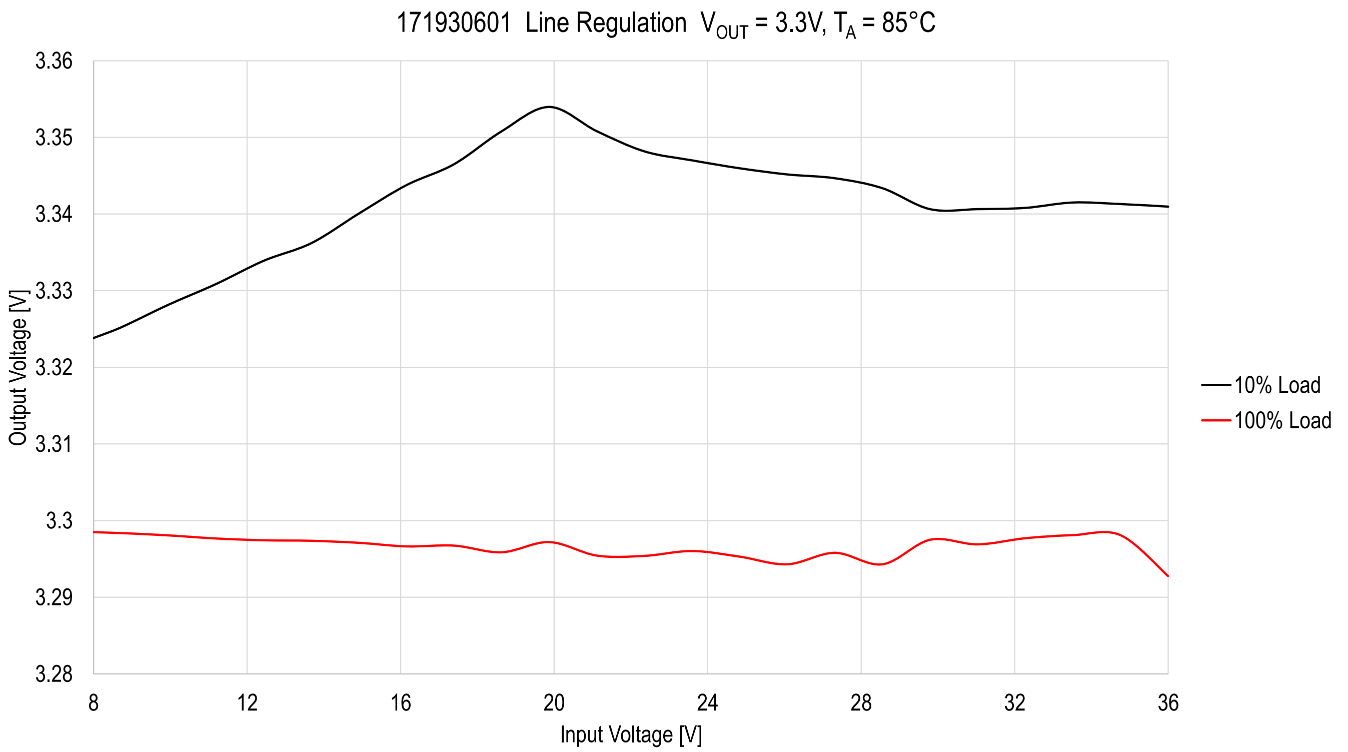


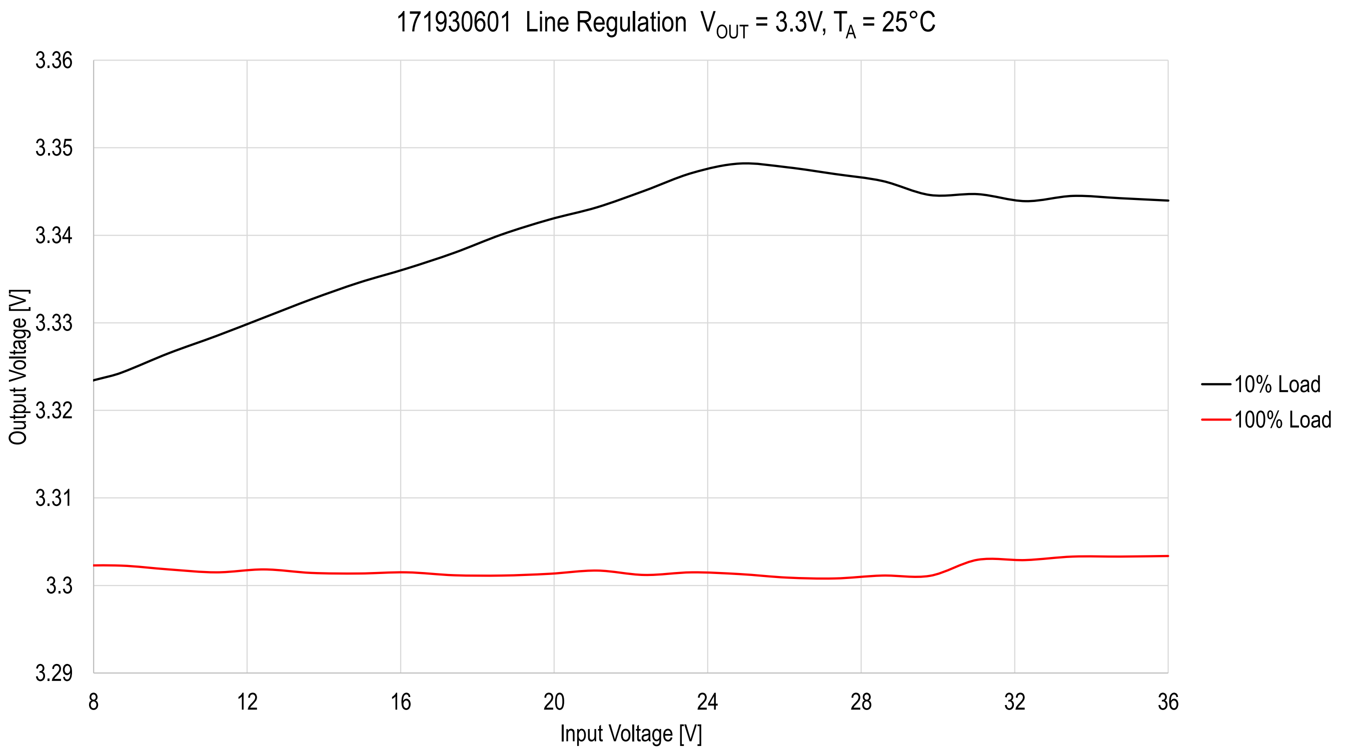

171930601 Load Regulation V_{IN} = 24V, V_{OUT} = 5V, T_A = 85°C
Output Voltage [V]
Output Current [A]
5.23
5.22
5.21
5.2
5.19
5.18
5.17
5.16
5.15
5.14
0
0.05
0.1
0.15
0.2
0.25
0.3


171930601 Load Regulation VIN = 24V, VOUT = 5V,TA = 105°C
Output Voltage [V]
Output Current [A]
5.22
5.21
5.2
5.19
5.18
5.17
5.16
5.15
5.14
5.13
0
0.1
0.2
0.3

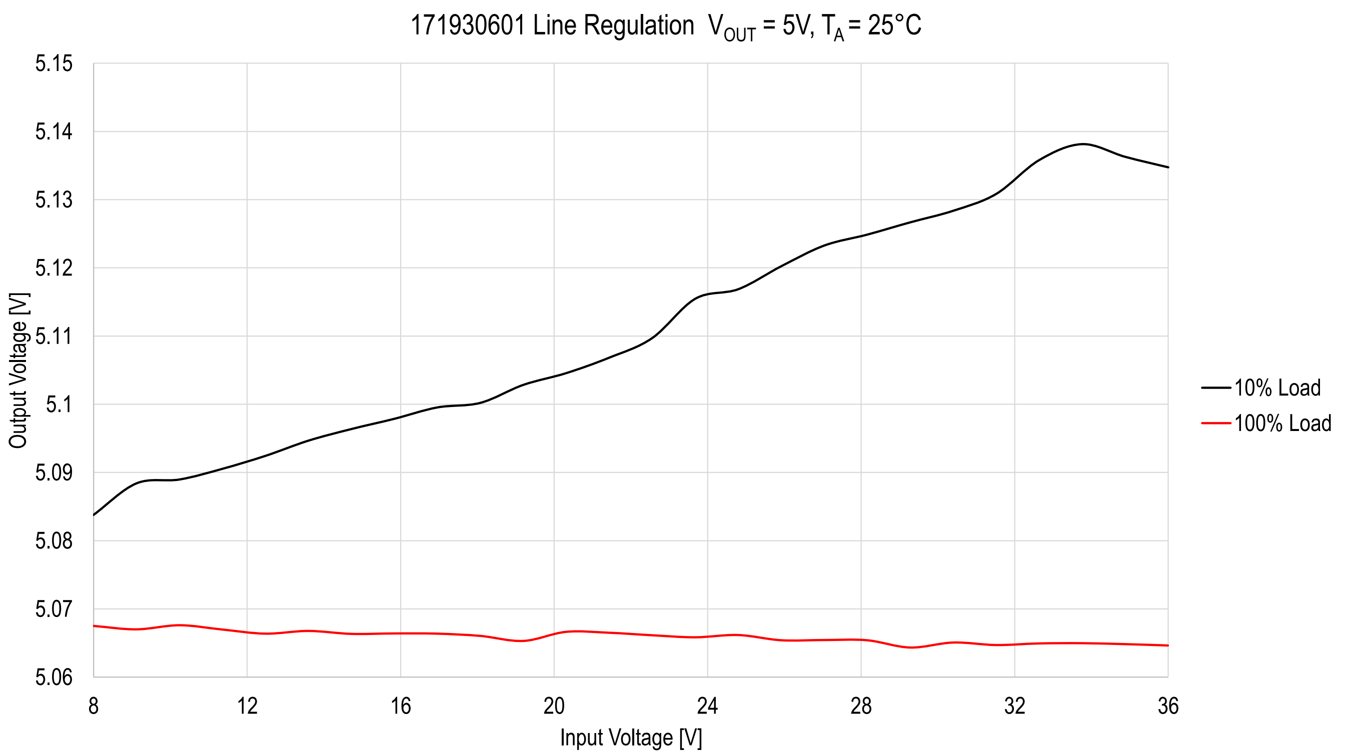
LINE REGULATION 3.3Vout

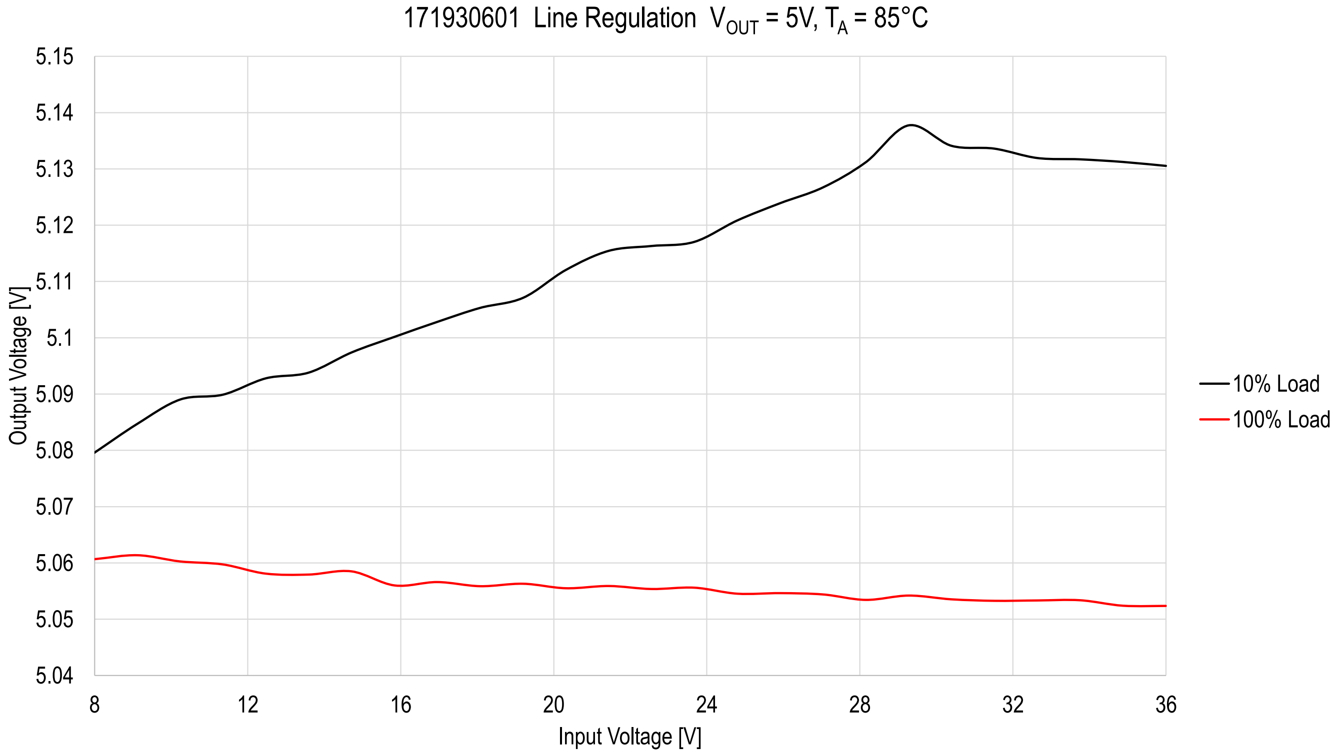


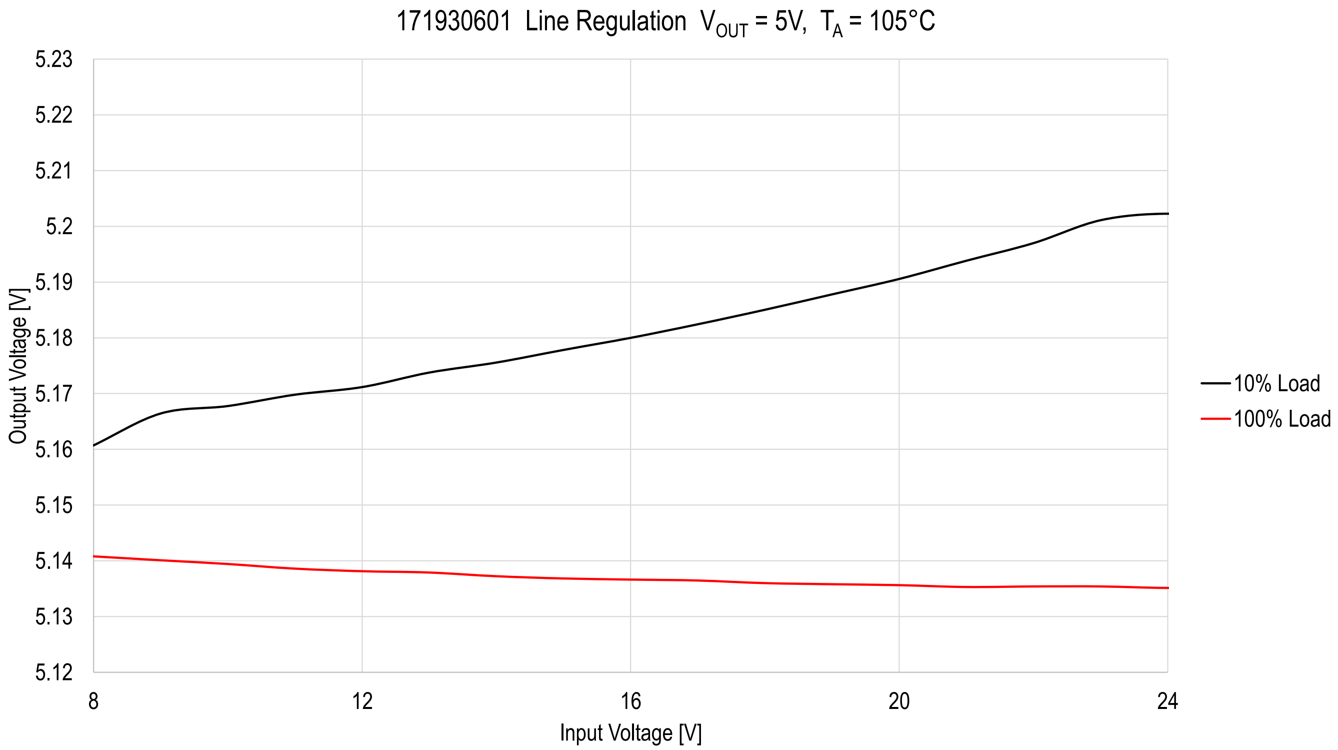




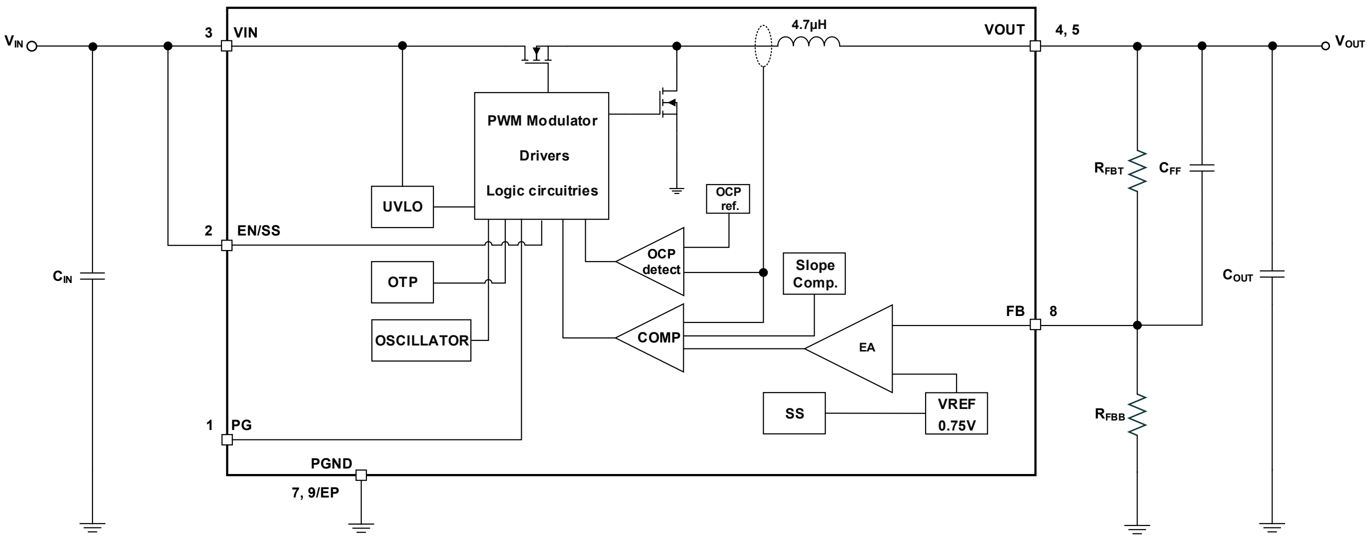
LINE REGULATION 5Vout




171930601 Line Regulation VOUT = 5V, TA = 85°C
Output Voltage [V]
5.15
5.14
5.13
5.12
5.11
5.1
5.09
5.08
5.07
5.06
5.05
5.04
8
12
16
20
24
28
32
36
Input Voltage [V]
10% Load
100% Load


171930601 Line Regulation VOUT = 5V, TA = 105°C
Output Voltage [V]
5.23
5.22
5.21
5.2
5.19
5.18
5.17
5.16
5.15
5.14
5.13
5.12
8
12
16
20
24
Input Voltage [V]
10% Load
100% Load

BLOCK DIAGRAM



CIRCUIT DESCRIPTION

The VDMM 171930601 MagI³C MicroModule is a fully integrated DC-DC power supply including the switching regulator with integrated MOSFETs, controller and compensation, as well as the shielded inductor in one package. The control scheme is based on a current mode (CM) regulation loop.

The V_{OUT} of the regulator is divided by the feedback resistor network R_{FBT} and R_{FBB} and fed into the FB pin. The error amplifier compares this signal with the internal 0.75V reference. The error signal is amplified and controls the on-time of a fixed frequency pulse width generator. This signal drives the power MOSFETs.

The current mode architecture features a constant frequency during load steps. Only the on-time is modulated. It is internally compensated and stable with low ESR output capacitors and requires no external compensation network.

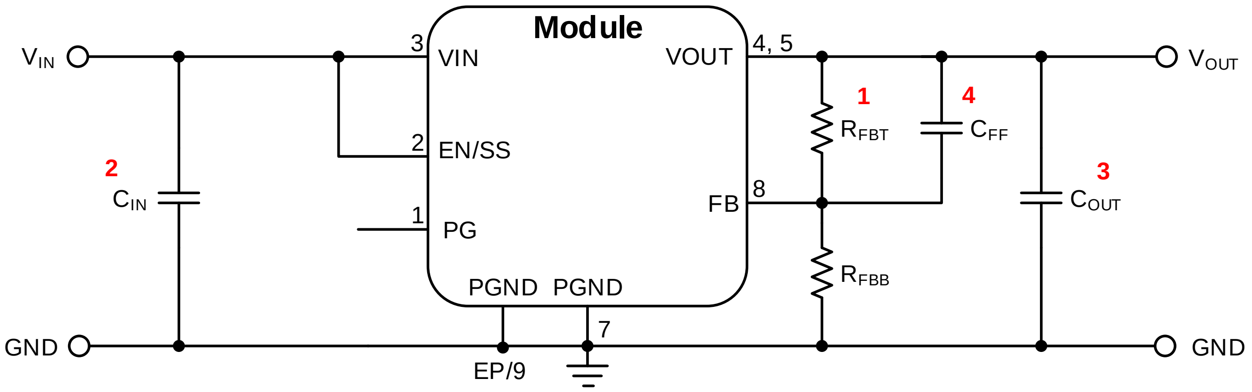
This architecture supports fast transient response and very small output voltage ripples ($<10mV_{p-p}$) are achieved.

DESIGN FLOW

The next four simple steps will show how to select the external components to design the 171930601 into an application.

Essential Steps

1. Set output voltage
2. Select input capacitor
3. Select output capacitor
4. Select feed-forward capacitor



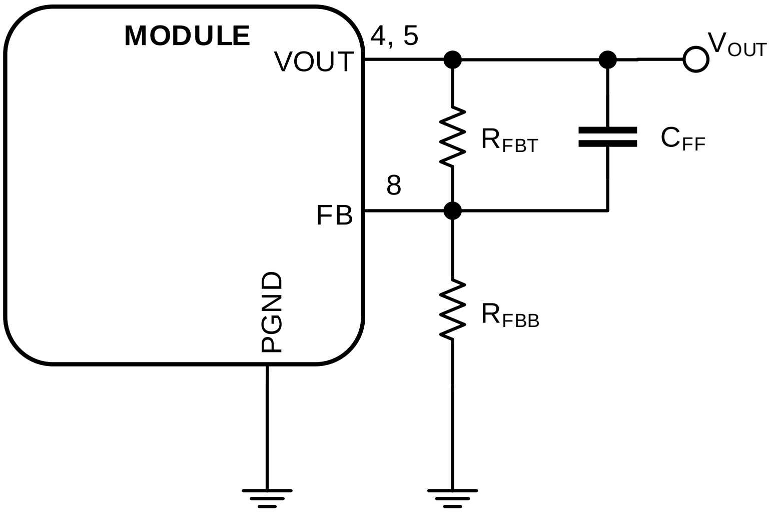
STEP 1 Setting the Output Voltage (V_{OUT})

The output voltage is selected with an external resistor divider between V_{OUT} and GND (see circuit below). The voltage across the lower resistor of the divider is provided to the FB pin and compared with a reference voltage of 0.75V (V_{REF}). The output voltage adjustment range is from 1V to 6V. The output voltage can be calculated according to the following formula:

$$V_{\text{OUT}} = V_{\text{REF}} \cdot (\frac{R_{\text{FBT}}}{R_{\text{FBB}}} + 1) \tag{1}$$

One resistor must be chosen and then the other resistor can be calculated. For example, if $R_{FBT} = 64.9\text{k}\Omega$ then the resistance value of the lower resistor in the feedback network is indicated in the table below for common output voltages.

V_{OUT}	1.2V	1.5V	1.8V	2.5V	3.3V	5.0V	6.0V
R_{FBB} (E96)	107kΩ	64.9kΩ	46.4Ω	27.4kΩ	19.1kΩ	11.3kΩ	9.3kΩ



STEP 2 Select the Input Capacitor (C_{IN})

The energy at the input of the MicroModule is stored in the input capacitor. An input capacitor (4.7µF) is required externally to provide cycle-by-cycle switching current and to support load transients. The external input capacitor must be placed directly at the VIN pin. For this MagI³C MicroModule it is recommended to use a MLCC (multi-layer ceramic capacitor) of 4.7µF. Attention must be paid to the voltage, frequency and temperature deratings and thermal class of the selected capacitor.

STEP 3 Select the Output Capacitor (C_{OUT})

The output capacitor should be selected in order to minimize the output voltage ripple and to provide a stable voltage at the output. It also affects the loop stability. An external MLCC of 47µF is recommended for all application conditions. Attention must be paid to the voltage, frequency and temperature derating and thermal class of the selected capacitor.

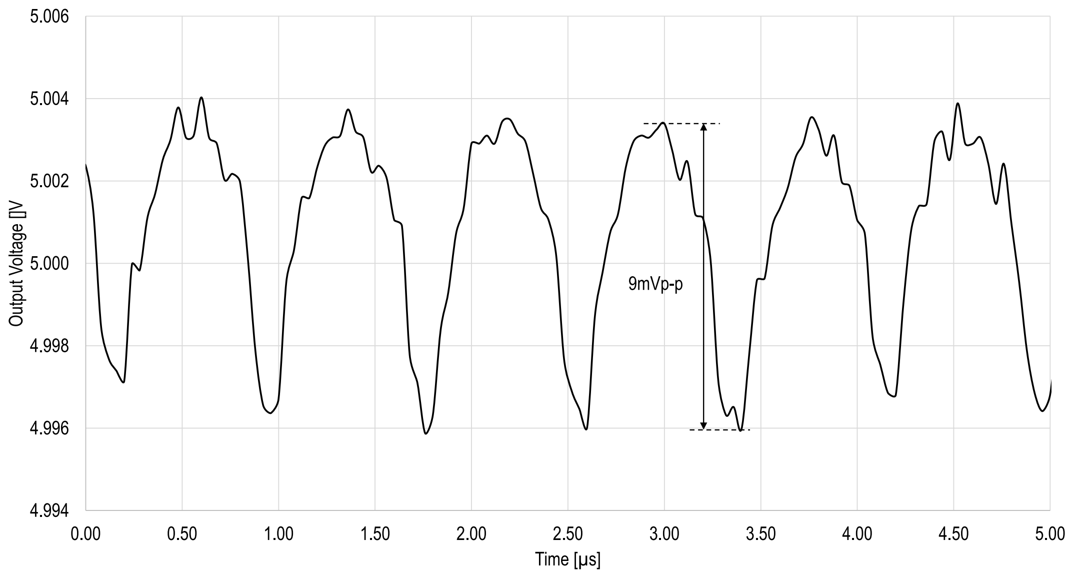
In general, the output voltage ripple can be calculated using the following equation:

$$V_{\text{OUT ripple}} = \Delta I_{\text{L}} \cdot ESR + \Delta I_{\text{L}} \cdot \left(\frac{1}{8 \cdot f_{\text{SW}} \cdot C_{\text{OUT}}}\right) \quad (2)$$

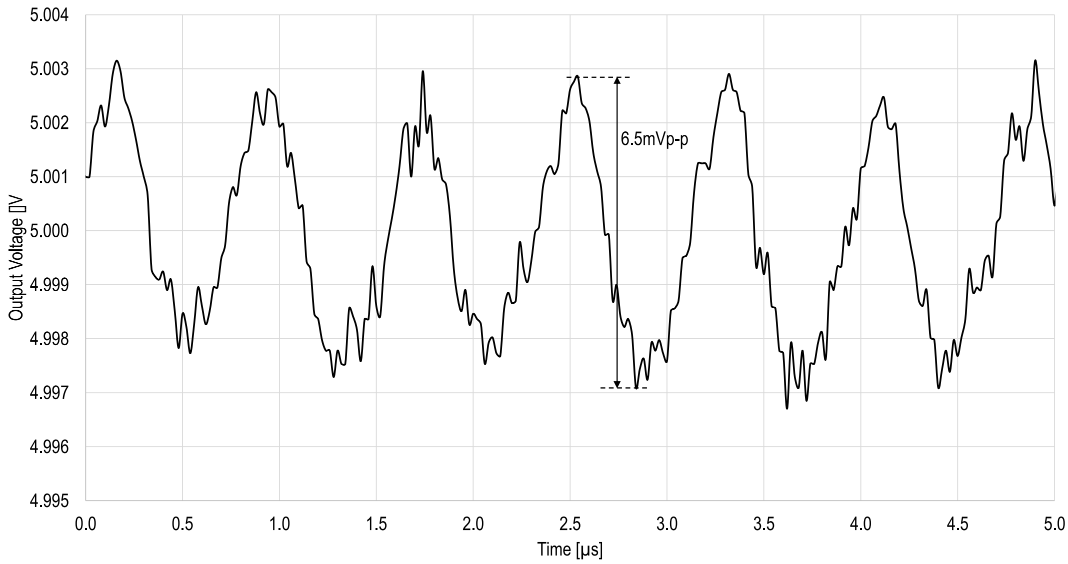
where ΔI_L is the inductor current ripple and can be calculated with the following equation:

$$\Delta I_{\text{L}} = \frac{V_{\text{OUT}} \cdot (V_{\text{IN}} - V_{\text{OUT}})}{f_{\text{SW}} \cdot L \cdot V_{\text{IN}}} \quad (3)$$

171930601 Output Voltage Ripple, V_{IN} = 24V, V_{OUT} = 5V, I_{OUT} = 300mA and C_{OUT} = 33µF



171930601 Output Voltage Ripple, V_{IN} = 24V, V_{OUT} = 5V, I_{OUT} = 300mA and C_{OUT} = 68µF

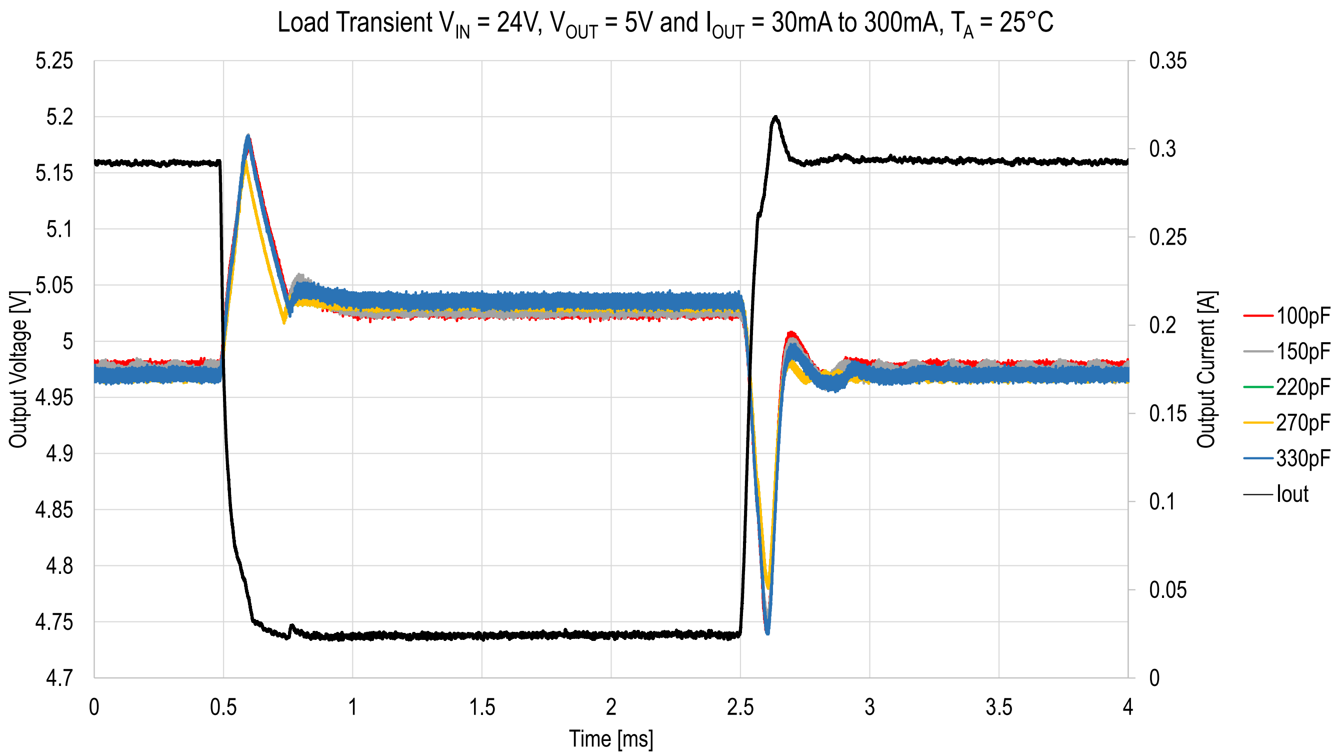


STEP 4 Select the Feed-Forward Capacitor (C_{FF})

The 171930601 MagI³C MicroModule allows for the selection of a feed forward capacitor, C_{FF}. To maintain the same transient response for different C_{FF} values, the top feedback resistor R_{FBT} should also be adjusted. The integrated inductor has a value of 4.7µH. The equation used to determine C_{FF} and R_{FBT} is as follows:

$$C_{FF} = \frac{\sqrt{C_{OUT} \cdot L}}{R_{FBT}} \tag{4}$$

A C_{FF} value of 220pF has been evaluated experimentally to provide suitable efficiency and transient characteristics for most applications.
The pictures below show the transient behavior of the 171930601 in response to a load transition from 30mA to 300mA using the recommended C_{FF} = 220pF, as well as other values of C_{FF}.



This behavior is valid only for this test under the specified conditions and must be verified in the real application. While the recommended C_{FF} value of 220pF will work for most applications.

MODES OF OPERATION

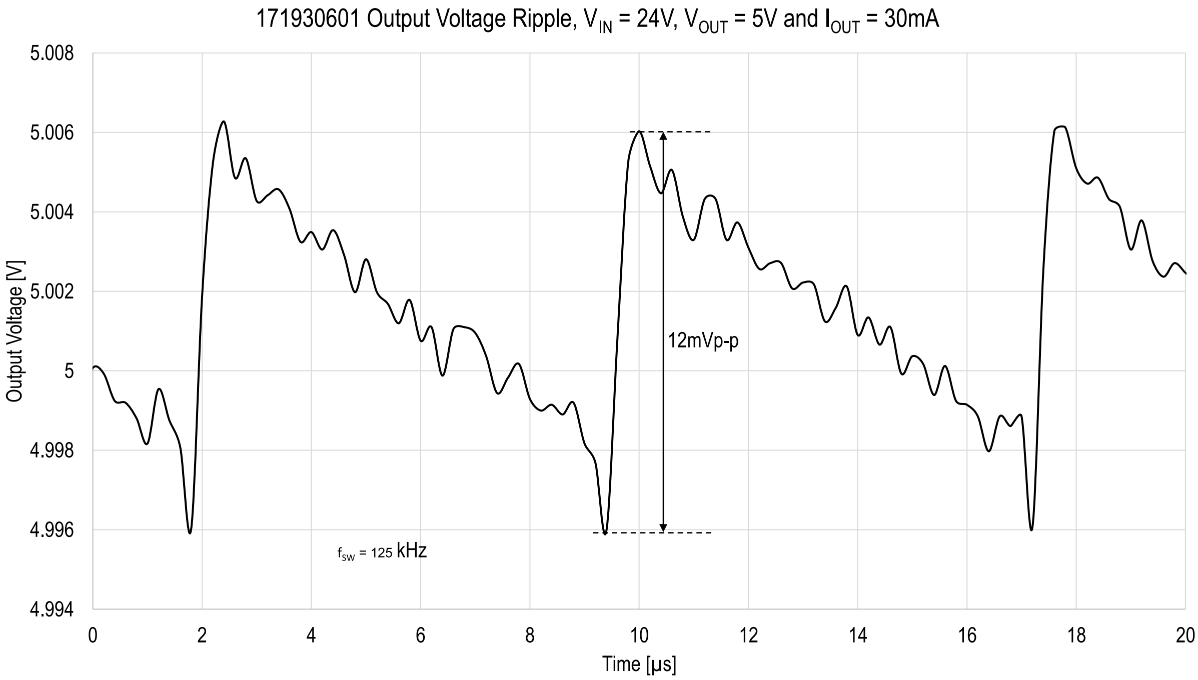
The 171930601 MicroModule has two different modes of operation and the transition takes place automatically depending on the load current value. Under light load conditions, the module operates in PFM mode where the MicroModule runs at a lower switching frequency to reduce the current consumption, which leads to achieving a higher efficiency. The PFM control is achieved by creating a single pulse to turn on the high side switch while monitoring the inductor current. The high side switch is kept on until the inductor current hits a preset value (I_{PFM}).

After reaching I_{PFM}, the high side switch is turned off and the low side switch turns on. The inductor current decreases until it reaches zero. When the inductor current reaches zero, both switches are turned off (idle time) and the output capacitor solely supplies the load with energy. While the energy is supplied to the load, the output voltage starts to drop. The MicroModule monitors the output voltage ripple value and when it hits a certain limit, while the two switches are off, another pulse is initiated and the cycle repeats. When the load current increases, the idle time decreases and the switching frequency increases until the nominal switching frequency is reached and the MicroModule goes to the PWM mode.

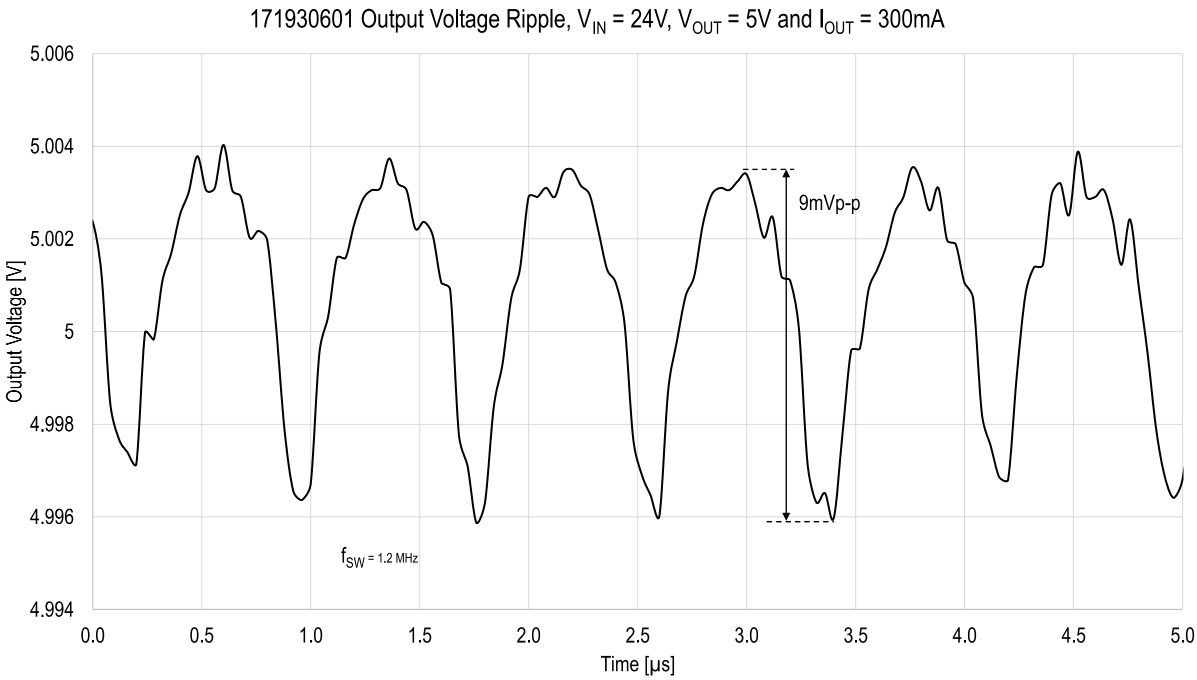
OUTPUT VOLTAGE RIPPLE

If the module is working in PWM mode, the ripple is very low and it always has the same frequency as the internal oscillator (1.2MHz). If the load current is low enough to be in the PFM mode of operation then the output voltage ripple will be higher and the frequency lower than the nominal switching frequency (see pictures below).

PFM Operation



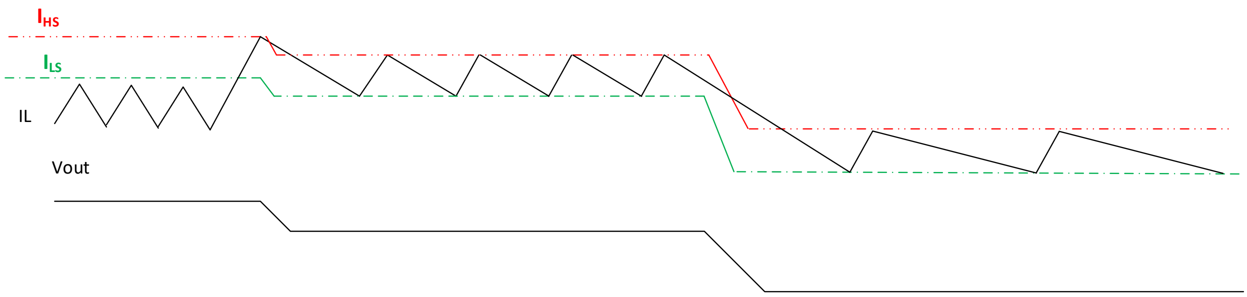
PWM Operation

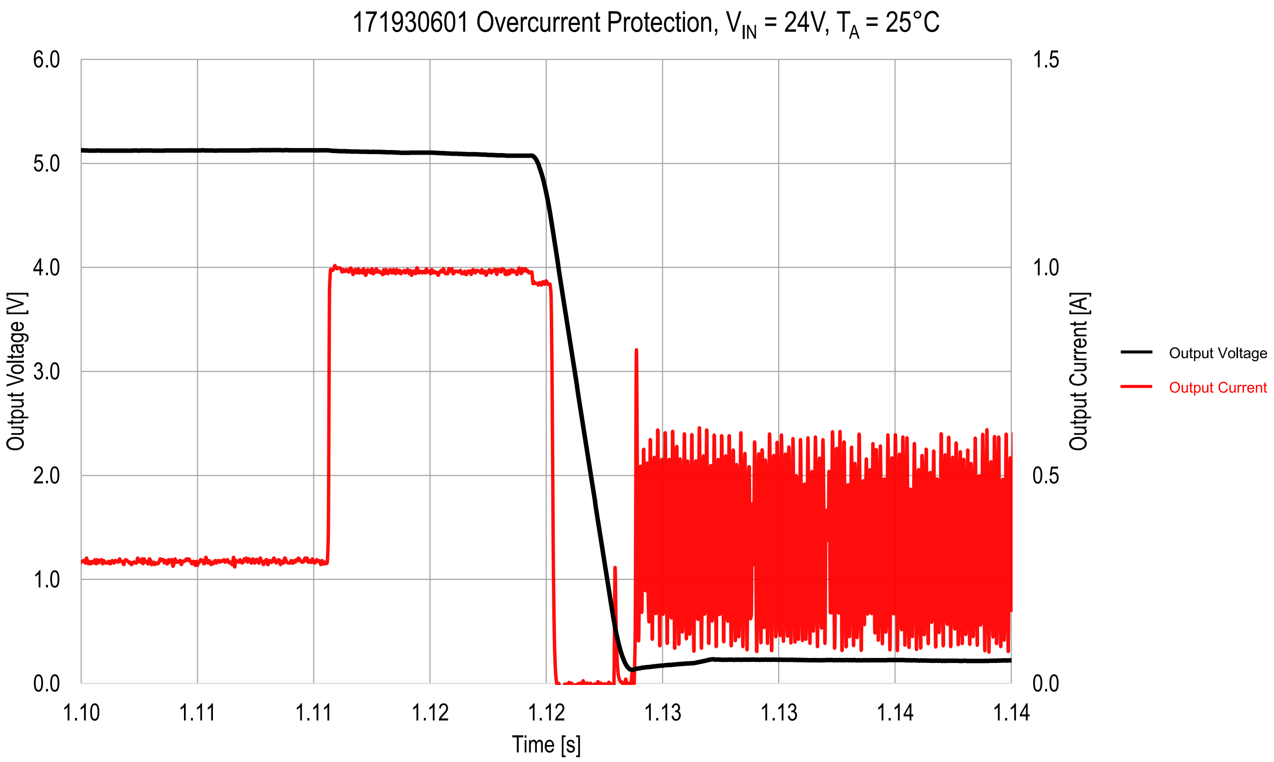


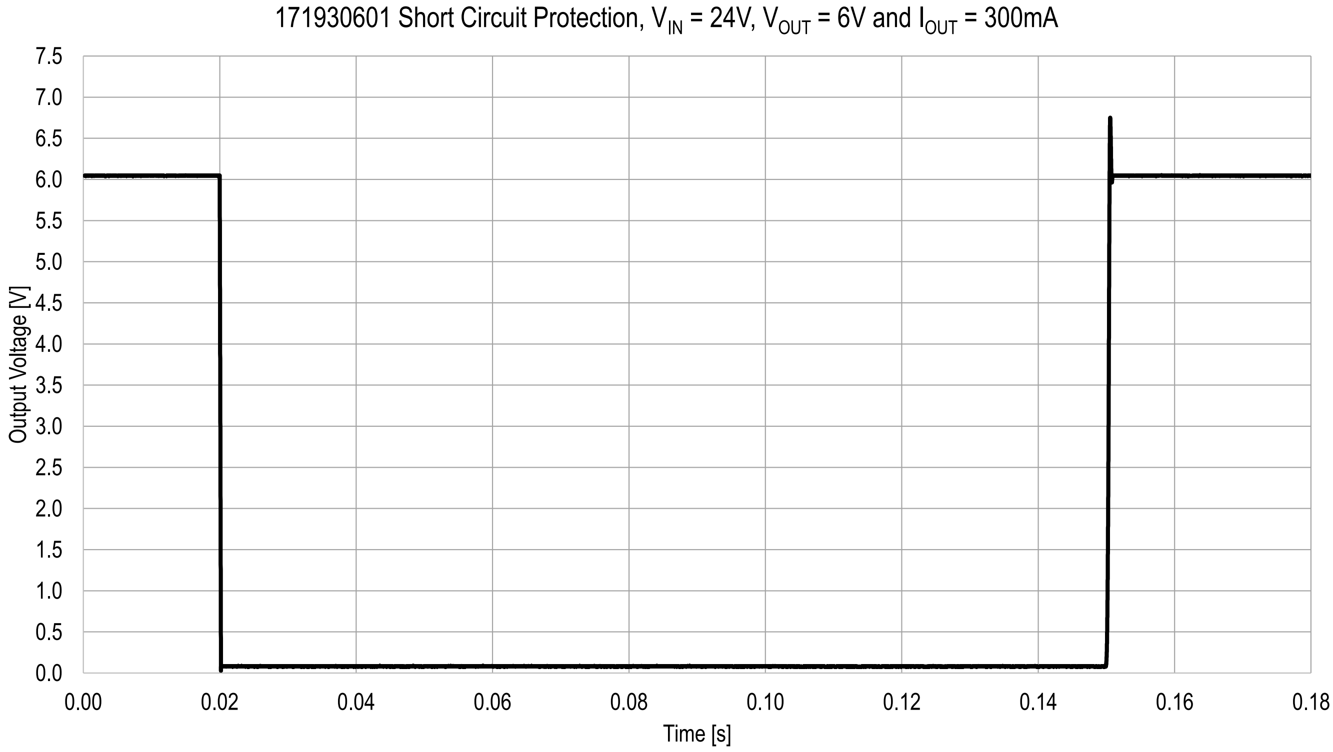
PROTECTION FEATURES

Overcurrent Protection (OCP) and Short Circuit Protection (SCP)

The overcurrent and short circuit protections are implemented using a cycle-by-cycle scheme. The high-side switch current is sensed and when the current exceeds the high side limit value (1.3A Typ.), the high-side switch is turned off and the low-side switch is turned on, until the current hits the low-side switch limit value (0.9A Typ.). When the low-side switch limit is reached, the high side switch is turned on again and the cycle repeats itself. In addition, a frequency foldback circuit is enabled to reduce the high and low side current limits, further reducing the rms current and heat dissipation through the MicroModule. The pictures below shows the operation of the converter under OCP and SCP conditions.







Note that an output voltage overshoot is expected upon return to normal operation after an overcurrent or short circuit fault. This is due to the soft-start funcitonality only activating when the module first turns on.

Over Temperature Protection (OTP)

Thermal protection helps prevent catastrophic failures due to accidental device overheating. The junction temperature of the MagI³C MicroModule should not be allowed to exceed its maximum ratings. Thermal protection is implemented by an internal thermal shutdown circuit, which activates when the junction temperature reaches 155°C (typ). Under the thermal shutdown condition both MOSFETs remain off causing V_{OUT} to drop. When the junction temperature falls below 140°C (typ) the internal soft-start is released, V_{OUT} rises smoothly, and normal operation resumes.

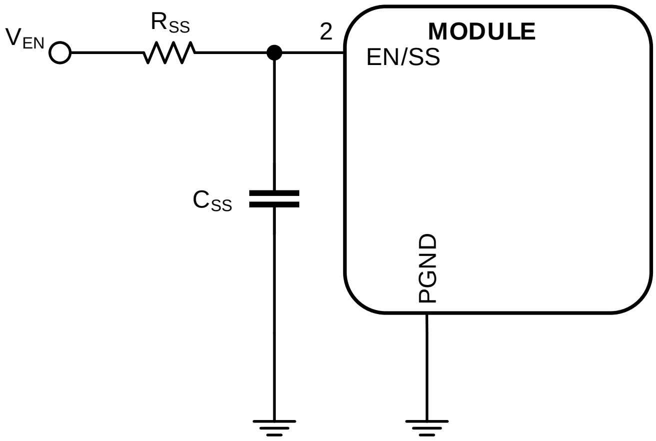
Input Undervoltage Lockout (UVLO)

The device incorporates input undervoltage lockout (UVLO) to protect against unexpected behavior at input voltages below the recommended values. The thresholds of the UVLO are indicated in the Electrical Specifications on page 5.

Enable / Adjustable Soft-Start

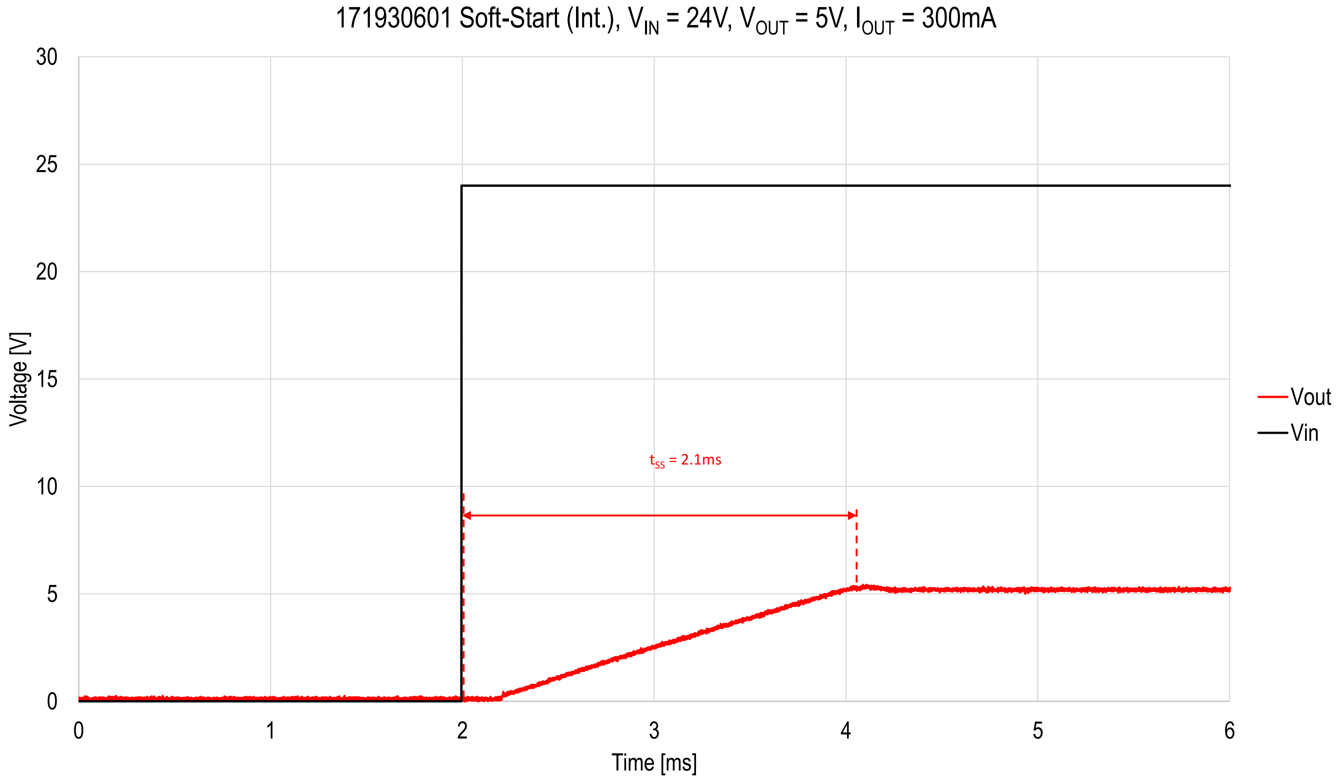
The 171930601 MagI^{3}C MicroModule combines the enable and soft-start function into a single pin and is enabled by setting the pin EN/SS high. Enabling the device achieves a 2ms soft-start time. After setting EN/SS high, the module prepares for operation. Once prepared, the module begins switching and the internal soft-start regulates the output voltage rise until the desired output voltage is met allowing normal operation to take place. To increase the soft-start time, use the schematic below.

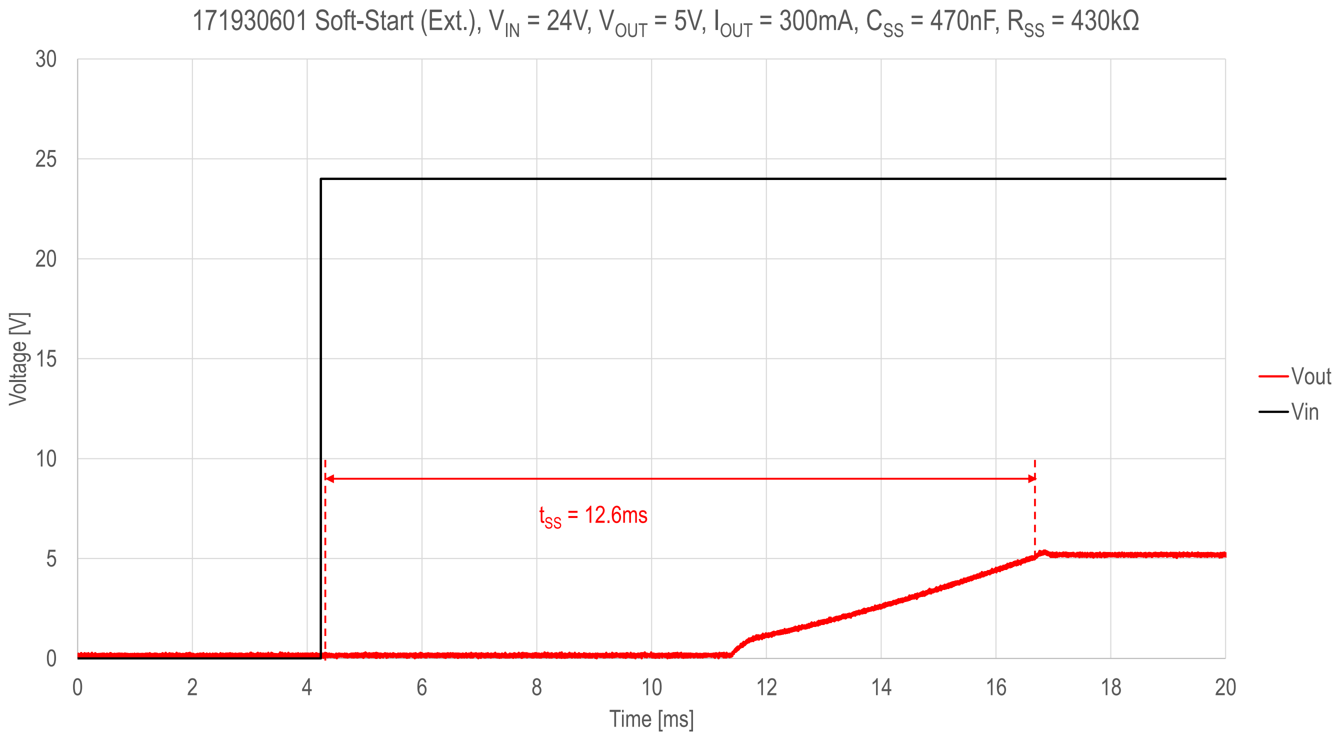
Adujstable soft-start permits the regulator to slowly ramp to its steady state operating point after being enabled, thereby reducing inrush current from the input supply and slowing the output voltage rise time to prevent overshoot. Upon turn-on, after all UVLO conditions have been passed, an internal circuit slowly ramps the EN/SS input to implement the internal soft-start. If the preset soft-start time is enough for the application, the EN/SS should be set to high. Longer soft-start periods are achieved by adding an external capacitor and a resistor to this pin as shown in the figure below:



The following equation can be used to set the soft-start time:

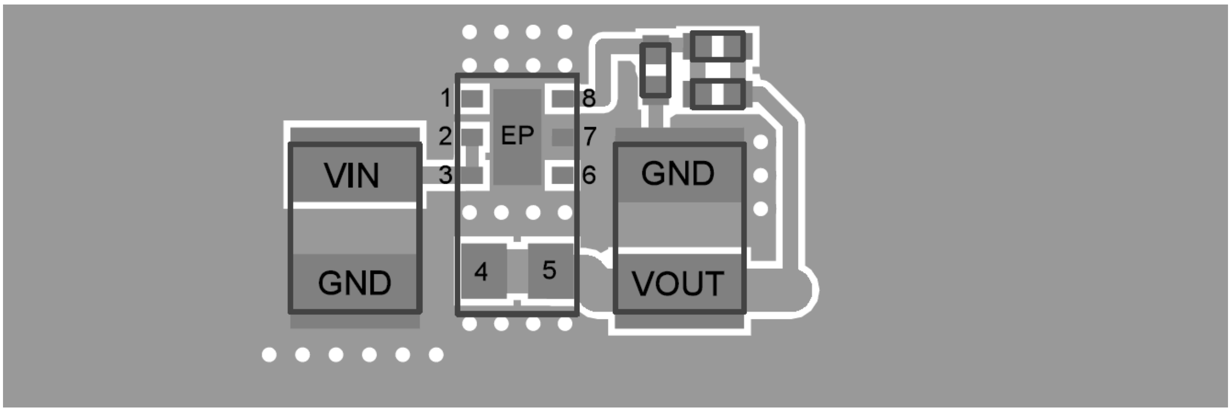
$$T_{SS} = C_{SS} \cdot R_{SS} \cdot \ln\left(\frac{V_{EN}}{V_{EN} - 1.45}\right) \quad (5)$$


171930601 Soft-Start (Int.), VIN = 24V, VOUT = 5V, IOUT = 300mA
Voltage [V]
Time [ms]
tSS = 2.1ms
Vout
Vin

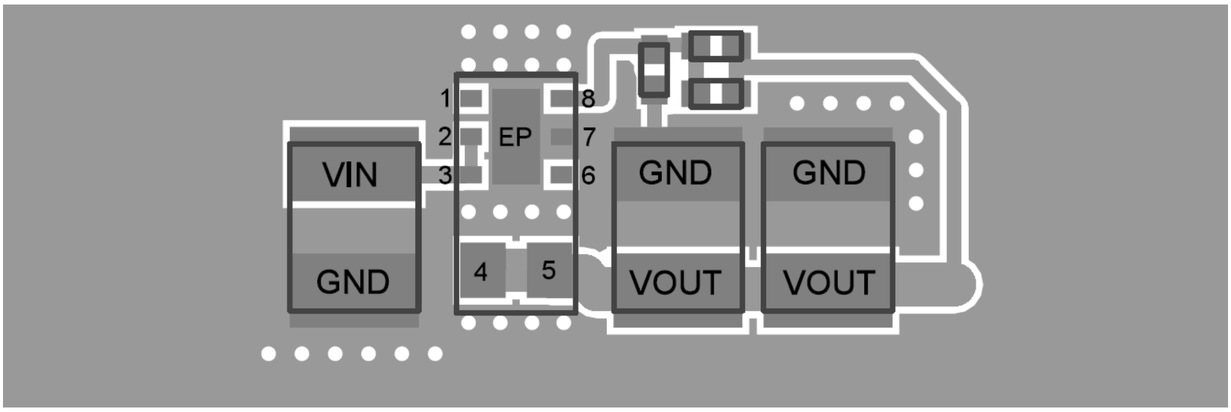

171930601 Soft-Start (Ext.), VIN = 24V, VOUT = 5V, IOUT = 300mA, CSS = 470nF, RSS = 430kΩ
Voltage [V]
Time [ms]
tSS = 12.6ms
Vout
Vin

LAYOUT RECOMMENDATION

Layout for operating temperatures up to 85°C



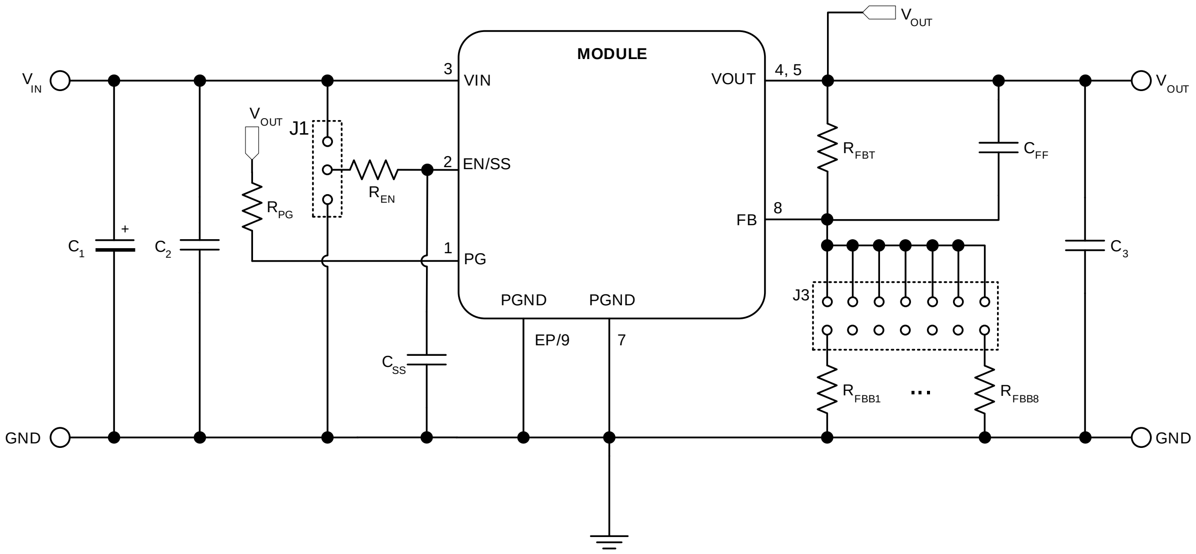
Layout for operating temperatures up to 105°C



The pictures above show a possible layout for the 171930601 MagI^{3}C MicroModule. Nevertheless, some recommendations should be followed when designing the layout:

1. The input and output capacitors should be placed as close as possible to the VIN and VOUT pins of the device.
2. The feedback resistor divider should be placed as close as possible to the FB pin.
3. Avoid placing vias in any of the pads for the module. Due to the small size of the pads, significant amounts of solder can be pulled through the vias during heating, resulting in incomplete connections between the module and board.

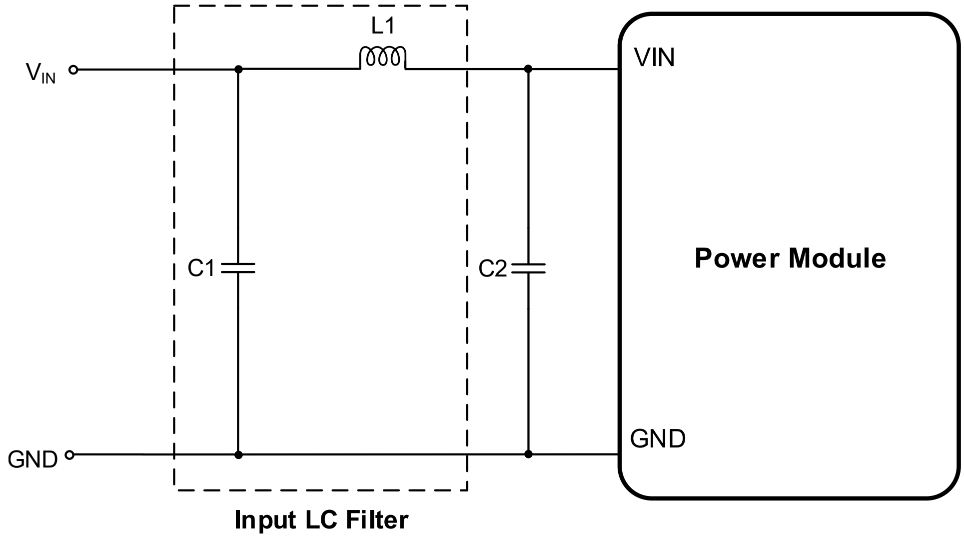
Evaluation Board Schematic



Designator	Description	Quantity	Order Code	Manufacturer
U1	MagI³C MicroModule	1	171930601	WE
C_1	Aluminum Electrolytic Capacitor 220µF, 50V	1	865060657012	WE
C_2	Ceramic chip capacitor 4.7µF/50V X7R, 1210	1	885012209048	WE
C_3 (up to 85°C)	Ceramic chip capacitor 47µF/16V X5R, 1210	1	885012109011	WE
C_3 (up to 105°C)	Ceramic chip capacitor 22µF/10V X7R, 1210	2	885012209006	WE
C_{ff}	Ceramic chip capacitor 220pF/10V NP0, 0402	1	885012005015	WE
R_{FBT}	64.9kΩ	1		
R_{FBB} Set V_{OUT} by jumper	open for V_{OUT} = 0.75V	n.p.		
	191 kΩ for V_{OUT} = 1.0V	1		
	107 kΩ for V_{OUT} = 1.2V	1		
	64.9 kΩ for V_{OUT} = 1.5V	1		
	46.4 kΩ for V_{OUT} = 1.8V	1		
	27.4 kΩ for V_{OUT} = 2.5V	1		
	19.1 kΩ for V_{OUT} = 3.3V	1		
	11.3 kΩ for V_{OUT} = 5V	1		
	To be soldered for adjustable output voltage (see Equation 1)	n.p.		

Filter Suggestion for Conducted EMI

The input filter shown in the schematic below is recommended to achieve conducted compliance according to EN55032 Class B (see also CONDUCTED EMISSIONS). For radiated EMI the input filter is not necessary. It is only used to comply with the setup recommended in the norms.



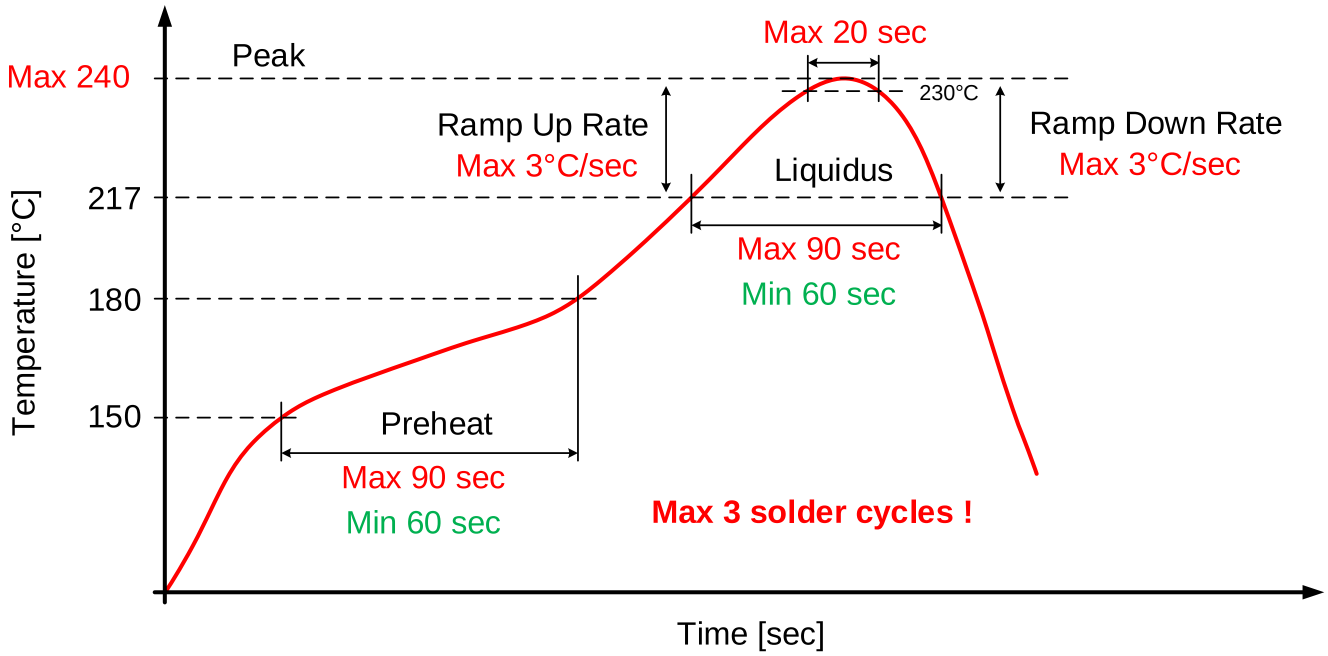
Designator	Description	Order Code	Manufacturer
C_1 (C_f)	Filter ceramic capacitor 4.7µF, X7R, 50V	885012209048	WE
L_1 (L_f)	Filter inductor 1µH, MAPI family, I_{SAT} = 3.4A, I_R = 1.4A	74438313010	WE

HANDLING RECOMMENDATIONS

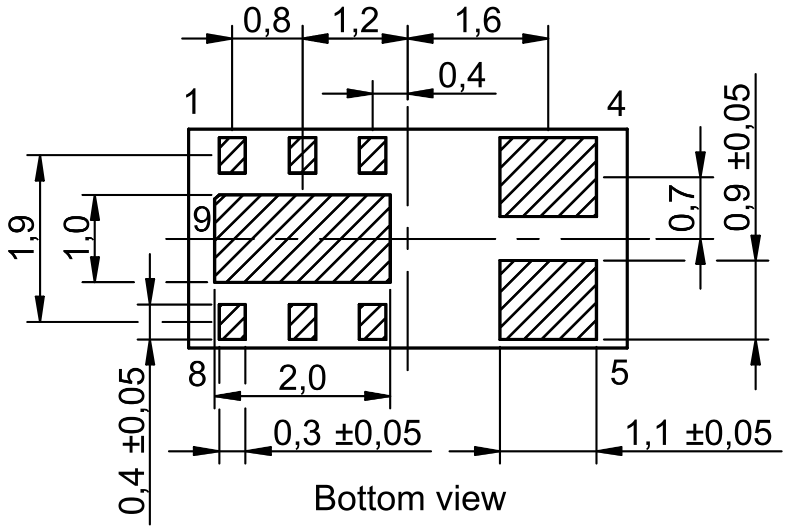
1. The power module is classified as MSL3 (JEDEC Moisture Sensitivity Level 3) and requires special handling due to moisture sensitivity (JEDEC J-STD033).
2. The parts are delivered in a sealed bag (Moisture Barrier Bags = MBB) and should be processed within one year.
3. When opening the moisture barrier bag, check the Humidity Indicator Card (HIC) for color status. Bake parts prior to soldering in case indicator color has changed according to the notes on the card.
4. Parts must be processed after 168 hour (7 days) of floor life. Once this time has been exceeded, bake parts prior to soldering per JEDEC J-STD033 recommendation.

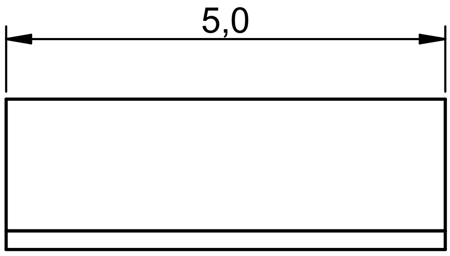
SOLDER PROFILE

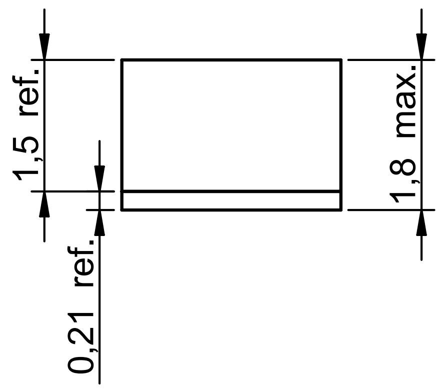
1. Measure the peak reflow temperature of the MagI^{3}C power module in the middle of the top view.
2. Ensure that the peak reflow temperature does not exceed 235°C ±5°C.
3. The reflow time period during peak temperature of 235°C ±5°C must not exceed 20 seconds.
4. Reflow time above liquidus (217°C) must not exceed 90 seconds.
5. Maximum ramp up is rate 3K per second
6. Maximum ramp down rate is 3K per second
7. Reflow time from room (25°C) to peak must not exceed 8 minutes as per JEDEC J-STD020.
8. Maximum numbers of reflow cycles is three.
9. For minimum risk, solder the module in the last reflow cycle of the PCB production.
10. For soldering process please consider lead material copper (Cu) and lead finish tin (Sn).
11. For solder paste use a standard SAC Alloy such as SAC 305, type 3 or higher.
12. Below profile is valid for convection reflow only
13. Other soldering methods (e.g.vapor phase) are not verified and have to be validated by the customer on his own risk

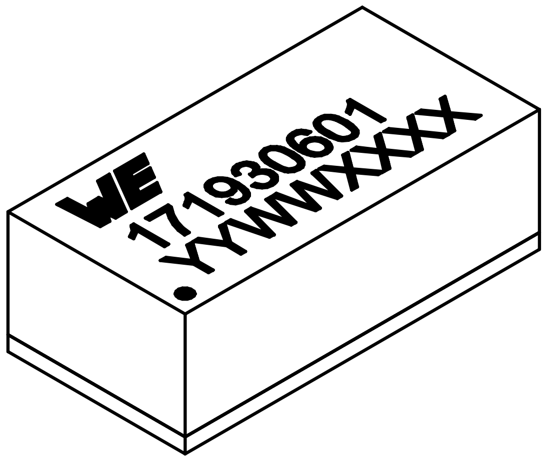


PHYSICAL DIMENSIONS



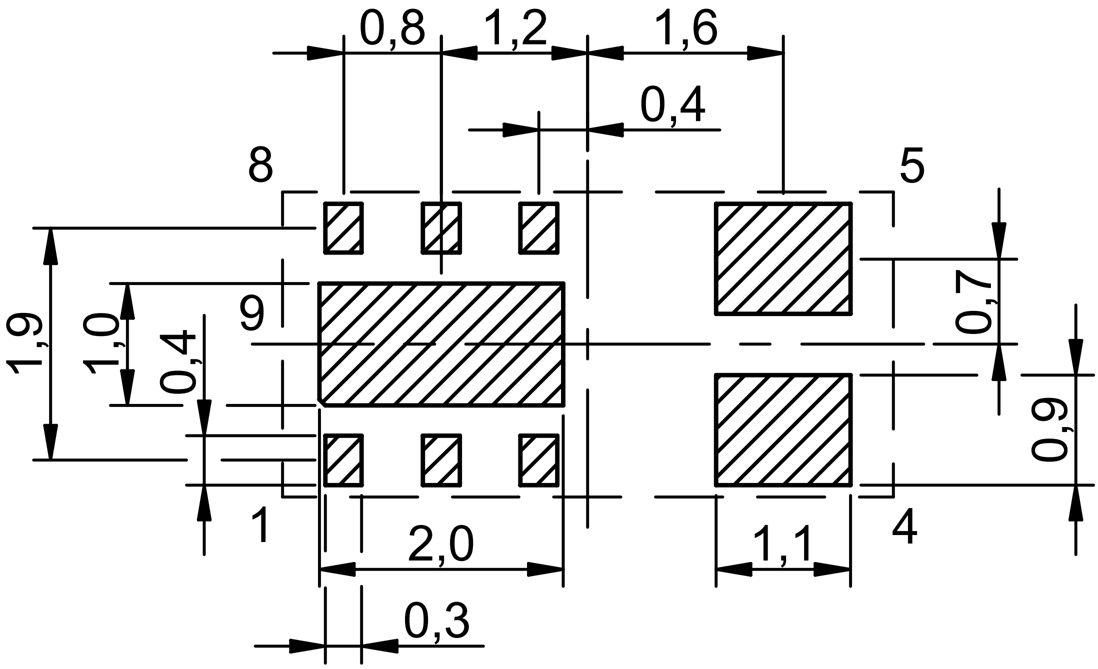






All dimensions in mm
Tolerances ±0,1mm unless otherwise indicated

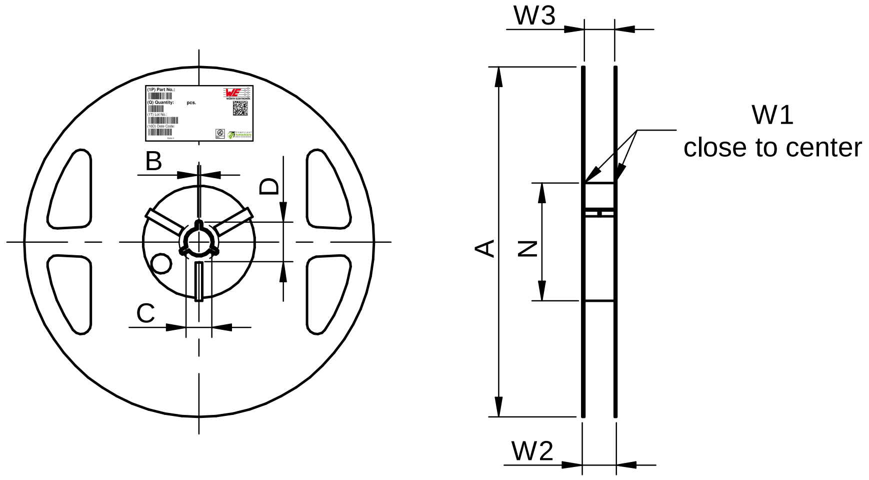
EXAMPLE LANDPATTERN DESIGN

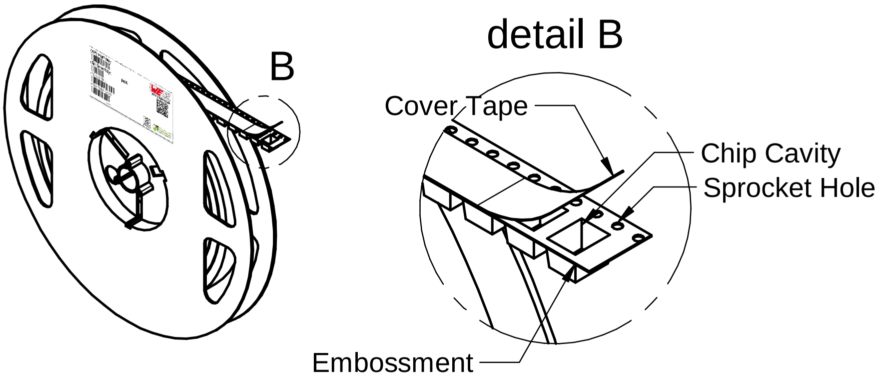


All dimensions in mm

PACKAGING

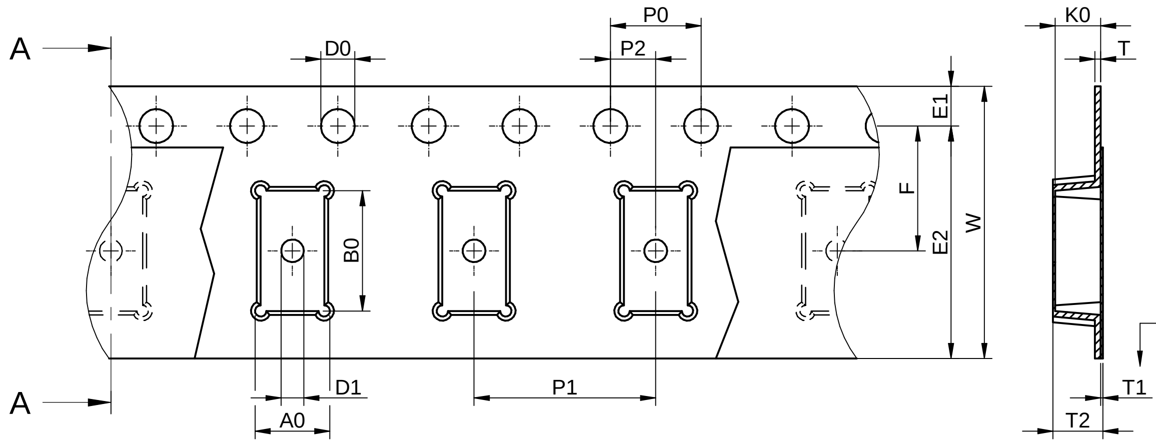
Reel (mm)

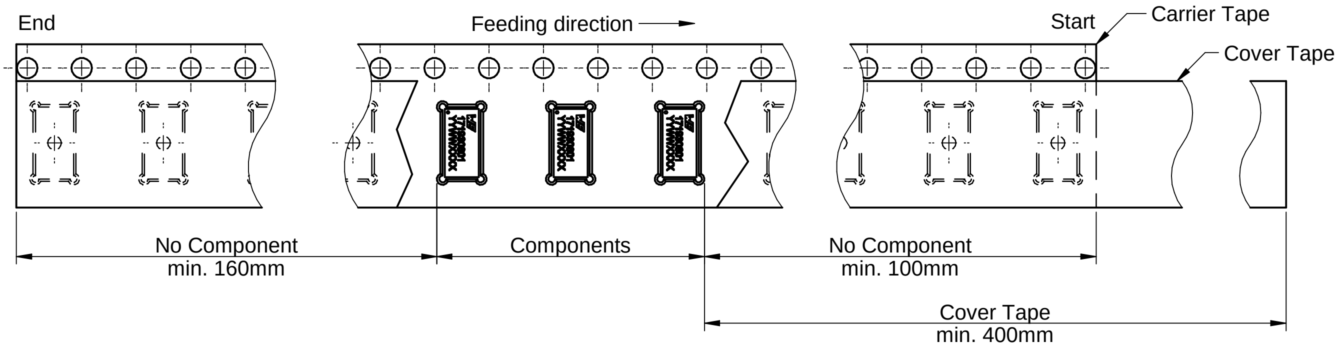




A	B	C	D	N	W2	W2	W3	W3	Material
±1.0	±0.5	±0.5	Min.	±0.5	Min.	Max.	Min.	Max.	
178.00	2.20	13.00	12.50	60.00	11.00	12.00	8.50	9.50	Polystyrene

Tape (mm)





Tape Type	A0	B0	W	T	T1	T2	K0	P0	P1	P2	D0	D1	E1	F	Material
	±0.1	±0.1	±0.3	±0.05			±0.1	±0.1	±0.1	±0.05	Max.	Min.	±0.1	±0.05	
2a	2.8	5.3	12	0.3			2	4	8	2	1.6	1	1.75	5.50	Polystyrene

DOCUMENT HISTORY

Revision	Date	Description	Comment
1.0	November 2021	Initial data sheet release	
1.1	December 2021	Updated formatting and updated front page	
1.2	April 2022	Updated formatting and corrected design flow table	1. Updated document font style 2. Corrected output voltage values in output voltage selection table in Design Flow 3. Updated Filter Suggestion for Conducted EMI section

CAUTIONS AND WARNINGS

The following conditions apply to all goods within the product series of MagI³C of Würth Elektronik eiSos GmbH & Co. KG:

General:

- This electronic component is designed and manufactured for use in general electronic equipment.
- Würth Elektronik must be asked for written approval (following the PPAP procedure) before incorporating the components into any equipment in fields such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network, etc. where higher safety and reliability are especially required and/or if there is the possibility of direct damage or human injury.
- Electronic components that will be used in safety-critical or high-reliability applications, should be pre-evaluated by the customer.
- The component is designed and manufactured to be used within the datasheet specified values. If the usage and operation conditions specified in the datasheet are not met, the component may be damaged or dissolved.
- Do not drop or impact the components as material of the body, pins or termination may flake apart.
- Würth Elektronik products are qualified according to international standards, which are listed in each product reliability report. Würth Elektronik does not warrant any customer qualified product characteristics beyond Würth Elektronik's specifications, for its validity and sustainability over time.
- All technical specifications for standard products also apply to customer specific products.
- Customer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of Würth Elektronik eiSos GmbH & Co. KG components in its applications, notwithstanding any applications-related information or support that may be provided by Würth Elektronik eiSos GmbH & Co. KG. Customer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Customer will fully indemnify Würth Elektronik eiSos and its representatives against any damages arising out of the use of any Würth Elektronik eiSos GmbH & Co. KG components in safety-critical applications.

Product specific:

Soldering:

- The solder profile must comply with the technical product specifications. All other profiles will void the warranty.
- All other soldering methods are at the customer's own risk.

Cleaning and Washing:

- Residual washing varnish agent that is used during the production to clean the application might change the characteristics of the body, pins or termination. The washing varnish agent may have a negative effect on the long term function of the component.
- Using a brush during the cleaning process may break the component. Therefore, we do not recommend using a brush during the PCB cleaning process.

Potting and Coating:

- If the component is potted in the customer application, the potting material might shrink or expand during and after hardening. Shrinking could lead to an incomplete seal, allowing contaminants into the component. Expansion could damage the components or parts of it. We recommend a manual inspection after potting to avoid these effects.
- Conformal coating may affect the product performance.

Storage Conditions:

- A storage of Würth Elektronik products for longer than 12 months is not recommended. Within other effects, the terminals may suffer degradation, resulting in bad solderability. Therefore, all products shall be used within the period of 12 months based on the day of shipment.
- Do not expose the components to direct sunlight.
- The storage conditions in the original packaging are defined according to DIN EN 61760-2.
- For a moisture sensitive component, the storage condition in the original packaging is defined according to IPC/JEDEC-J-STD-033. It is also recommended to return the component to the original moisture proof bag and reseal the moisture proof bag again.
- ESD prevention methods need to be followed for manual handling and processing by machinery.
- The storage conditions stated in the original packaging apply to the storage time and not to the transportation time of the components.

Packaging:

- The packaging specifications apply only to purchase orders comprising whole packaging units. If the ordered quantity exceeds or is lower than the specified packaging unit, packaging in accordance with the packaging specifications cannot be ensured.

Handling:

- Violation of the technical product specifications such as exceeding the absolute maximum ratings will void the warranty and also the conformance to regulatory requirements.
- The edge castellation is designed and made for prototyping, i.e. hand soldering purposes, only.
- The applicable country regulations and specific environmental regulations must be observed.
- Do not disassemble the component. Evidence of tampering will void the warranty.
- The temperature rise of the component must be taken into consideration. The operating temperature is comprised of ambient temperature and temperature rise of the component. The operating temperature of the component shall not exceed the maximum temperature specified.
- Direct mechanical impact to the component must be prevented as the material of the body, pins or termination could flake or, in the worst case, could break. As these devices are sensitive to electrostatic discharge, proper IC Handling Procedures must be followed.

These cautions and warnings comply with the state of the scientific and technical knowledge and are believed to be accurate and reliable. However, no responsibility is assumed for inaccuracies or incompleteness.

IMPORTANT NOTES

General Customer Responsibility

Some goods within the product range of Würth Elektronik eiSos GmbH & Co. KG contain statements regarding general suitability for certain application areas. These statements about suitability are based on our knowledge and experience of typical requirements concerning the areas, serve as general guidance and cannot be estimated as binding statements about the suitability for a customer application. The responsibility for the applicability and use in a particular customer design is always solely within the authority of the customer. Due to this fact it is up to the customer to evaluate, where appropriate to investigate and decide whether the device with the specific product characteristics described in the product specification is valid and suitable for the respective customer application or not. Accordingly, the customer is cautioned to verify that the datasheet is current before placing orders.

Customer Responsibility Related to Specific, in Particular Safety-Relevant, Applications

It has to be clearly pointed out that the possibility of a malfunction of electronic components or failure before the end of the usual lifetime cannot be completely eliminated in the current state of the art, even if the products are operated within the range of the specifications. In certain customer applications requiring a very high level of safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health it must be ensured by most advanced technological aid of suitable design of the customer application that no injury or damage is caused to third parties in the event of malfunction or failure of an electronic component.

Best Care and Attention

Any product-specific notes, warnings and cautions must be strictly observed. Any disregard will result in the loss of warranty.

Customer Support for Product Specifications

Some products within the product range may contain substances which are subject to restrictions in certain jurisdictions in order to serve specific technical requirements. Necessary information is available on request. In this case the field sales engineer or the internal sales person in charge should be contacted who will be happy to support in this matter.

Product R&D

Due to constant product improvement product specifications may change from time to time. As a standard reporting procedure of the Product Change Notification (PCN) according to the JEDEC-Standard we inform about minor and major changes. In case of further queries regarding the PCN, the field sales engineer or the internal sales person in charge should be contacted. The basic responsibility of the customer as per Section 1 and 2 remains unaffected.

Product Life Cycle

Due to technical progress and economical evaluation we also reserve the right to discontinue production and delivery of products. As a standard reporting procedure of the Product Termination Notification (PTN) according to the JEDEC-Standard we will inform at an early stage about inevitable product discontinuance. According to this we cannot guarantee that all products within our product range will always be available. Therefore it needs to be verified with the field sales engineer or the internal sales person in charge about the current product availability expectancy before or when the product for application design-in disposal is considered. The approach named above does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.

Property Rights

All the rights for contractual products produced by Würth Elektronik eiSos GmbH & Co. KG on the basis of ideas, development contracts as well as models or templates that are subject to copyright, patent or commercial protection supplied to the customer will remain with Würth Elektronik eiSos GmbH & Co. KG. Würth Elektronik eiSos GmbH & Co. KG does not warrant or represent that any license, either expressed or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, application, or process in which Würth Elektronik eiSos GmbH & Co. KG components or services are used.

General Terms and Conditions

Unless otherwise agreed in individual contracts, all orders are subject to the current version of the "General Terms and Conditions of Würth Elektronik eiSos Group", last version available at www.we-online.com.