MagI³C Power Module

WPME-VDMM - Variable Step Down MicroModule

2.5V - 5.5V Input / 1.2A Output / 0.8V - 5.5V Output

DESCRIPTION

The VDMM 171010550 MagI³C power module provides a fully integrated DC-DC power supply including the switching regulator IC with integrated MOSFETs, controller, compensation and shielded inductor in one package.

The 171010550 offers high efficiency and delivers up to 1.2A of output current. It operates with an input voltage from 2.5V to 5.5V and is designed for a small solution size.

The selectable mode pin allows for the choice between high efficiency and low output voltage ripple at light load.

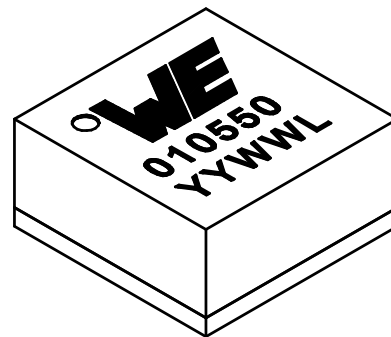The 171010550 is available in an LGA-6EP package (2.5 x 2.5 x 1.2mm).

This power 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

- Point of load power supply for low power systems
- Replacement of linear regulators
- DSP and FPGA power supply auxiliary voltages
- Portable instruments
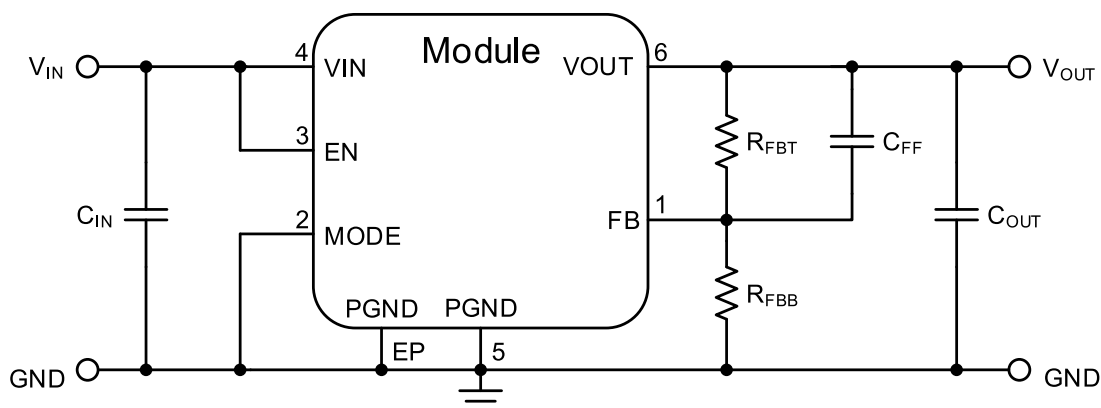- Battery powered equipment

FEATURES

- Peak efficiency up to 96%
- Input voltage range: 2.5V to 5.5V
- Typical quiescent current: 22μA
- Output voltage range: 0.8V to 5.5V
- Current capability up to 1.2A
- Constant on-time control
- Synchronous operation
- Fixed switching frequency: 4MHz
- Selectable modes of operation
- Embedded soft-start
- Undervoltage lockout (UVLO)
- Cycle-by-cycle current limit
- Short-circuit protection
- Thermal shutdown
- Ambient temp. range: -40°C to 85°C
- Junction temp. range: -40°C to 125°C
- RoHS and REACH compliant
- Complies with EN55032 class B radiated emissions standard

TYPICAL CIRCUIT DIAGRAM

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1 PINOUT

Figure 1: Pinout.

Table 1: Pin description.

SYMBOL	NUMBER	TYPE	DESCRIPTION
FB	1	Input	Feedback pin. This pin must be connected to the external resistor divider (between VOUT and PGND) to adjust the output voltage.
MODE	2	Input	Mode selection pin. Pulling this pin high will prevent PFM from engaging during light load conditions. Pulling this pin low will enable PFM operation during light load conditions. This pin must not be left floating.
EN	3	Input	Enable pin. Pulling this pin high enables the device, while pulling this pin low shuts down the device. This pin must not be left floating.
VIN	4	Power	Input voltage pin. Place the input capacitor as close as possible to VIN and PGND.
PGND	5	Power	Power ground pin. This pin must be connected to the ground plane and to the thermal pad.
VOUT	6	Power	Output voltage pin. Place output capacitors as close as possible to VOUT and PGND. For thermal performance, use a copper plane at this pin.
PGND	EP	Exposed Pad	Exposed pad. The exposed pad is internally electrically connected to PGND. It is recommended to connect it to the ground plane for optimal device heat dissipation.

2   ORDERING INFORMATION

Table 2: Ordering information.

ORDER CODE	SPECIFICATIONS	PACKAGE	PACKAGING UNIT
171010550	1.2A / 0.8V–5.5V Vout	LGA-6EP	7" Reel (1000 pieces)
178010550	1.2A / 0.8V–5.5V Vout	Eval Board	Box with 1 piece

3   SALES INFORMATION

Table 3: 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

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4   ABSOLUTE MAXIMUM RATINGS

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

Table 4: Absolute maximum ratings.

SYMBOL	PARAMETER	LIMIT		UNIT
		MIN[1]	MAX[1]	
VIN	Input pin voltage	-0.3	6	V
VOUT	Output pin voltage	-0.3	V_{IN}+0.3	V
FB	Feedback pin voltage	-0.3	V_{IN}+0.3	V
EN	Enable pin voltage	-0.3	V_{IN}+0.3	V
MODE	Mode pin voltage	-0.3	V_{IN}+0.3	V
$T_{storage}$	Assembled, non-operating storage temperature	-40	125	°C
V_{esd}	ESD Voltage (HBM), according to EN61000-4-2[4]	-4	4	kV

5   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 85°C.

Table 5: Operating conditions.

SYMBOL	PARAMETER	MIN[1]	TYP[3]	MAX[1]	UNIT
V_{IN}	Input voltage	2.5	-	5.5	V
V_{OUT}	Output voltage	0.8	-	5.5	V
T_a	Ambient temperature range[2]	-40	-	85	°C
T_{jop}	Junction temperature range	-40	-	125	°C
I_{out}	Nominal output current[5]	-	-	1.2[5]	A

6   THERMAL SPECIFICATIONS

Table 6: Thermal specifications.

SYMBOL	PARAMETER	TYP[3]	UNIT
Θ_{JA}	Junction-to-ambient thermal resistance[2]	100	K/W
Θ_{JC}	Junction-to-case (top) thermal resistance[2]	82	K/W
T_{SD}	Thermal shutdown, rising	160	°C
	Thermal shutdown, hysteresis	10	°C

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7 ELECTRICAL SPECIFICATIONS

Caution:

MIN and MAX limits are valid for the recommended ambient temperature range of -40°C to 85°C. Typical values represents statistically the utmost probable values at the following conditions: V_{IN} = 5V, V_{OUT} = 1.8V, C_{IN} = 4.7µF ceramic, C_{OUT} = 10µF ceramic, T_A = 25°C unless otherwise noted.

Table 7: Electrical specifications part 1.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN[1]	TYP[3]	MAX[1]	UNIT
Output Current						
I_{OCP}	Overcurrent limit		1.5	2.3	3.0	A
Output Voltage						
V_{FB}	Reference voltage		0.784	0.8	0.816	V
I_{FB}	Feedback pin bias current		—	0	50	nA
V_{OUT}	Line regulation	V_{IN} = V_{OUT}+1V to 5.5V, MODE = low	—	0.04	0.2	%
	Load regulation	500mA $\leq$ I_{LOAD} $\leq$ 1A	—	-0.9	—	%
	Output voltage ripple	V_{IN} = 3.6V, I_{OUT} = 100mA, MODE = high, 20MHz BWL	—	6	—	mV_{pp}
		V_{IN} = 3.6V, I_{OUT} = 100mA, MODE = low, 20MHz BWL	—	65	—	mV_{pp}
Switching Frequency						
f_{SW}	Switching frequency	MODE = high	3.6	4	4.4	MHz
Enable and Undervoltage Lockout						
V_{UVLO}	V_{IN} undervoltage threshold	V_{IN} increasing	2	2.25	2.4	V
		V_{IN} decreasing	—	2	—	V
	V_{IN} undervoltage hysteresis		—	175	—	mV
V_{EN}	EN threshold	Enable logic high	—	0.85	—	V
		Enable logic low	—	0.75	—	V
I_{EN}	EN pin input current	ENABLE = high	—	0.1	—	µA
		ENABLE = low	—	0.1	—	µA
Input Quiescent and Shutdown Current						
I_{SD}	Shutdown current	ENABLE = low	—	0.1	—	µA
I_{IN}	No load input current	V_{OUT} = 3.3V, MODE = low, switching, no load	—	40	—	µA
		V_{OUT} = 3.3V, MODE = high, switching, no load	—	12.7	—	mA
		V_{IN} = 3.3V, MODE = low, switching, no load	—	27.7	—	µA
		V_{IN} = 3.3V, MODE = high, switching, no load	—	9.6	—	mA
I_Q	Quiescent current	MODE = low, ENABLE = high, no switching	—	22	—	µA
		MODE = high, ENABLE = high, no switching	—	25	—	µA
Soft-Start						
t_{SS}	Soft-start time	Rising edge to 95% of V_{OUT}	—	128	—	µs

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Table 8: Electrical specifications part 2.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN[1]	TYP[3]	MAX[1]	UNIT
Efficiency						
η	Efficiency	V_{IN} = 3.6V, I_{OUT} = 50mA, MODE = low	—	87	—	%
		V_{OUT} = 3.3V, I_{OUT} = 50mA, MODE = low	—	90	—	%
		V_{IN} = 3.6V, V_{OUT} = 3.3V, I_{OUT} = 200mA, MODE = low	—	96	—	%
Mode Selection						
V_{MODE}	Mode threshold	Mode logic high	—	0.85	—	V
		Mode logic low	—	0.75	—	V
I_{MODE}	Mode input current	MODE = high	—	0.1	—	µA
		MODE = low	—	0.1	—	µA
Output Capacitance						
C_{OUT_MAX}	Maximum output capacitance		—	220	—	µF

8   RoHS, REACH

Table 9: RoHS, REACH.

RoHS directive		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).

9   PACKAGE SPECIFICATIONS

Table 10: Package specifications.

ITEM	PARAMETER	TYP[3]	UNIT
Lead finish	ENEPIG	—	—
Weight	—	0.0204	g

10   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) Measured without heatsink, natural convection. (0 - 20LFM / 0- 0.1m/s) on the 178010550 evaluation board, a 40 x 40mm two layer board, with 35µm (1 ounce) copper.

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

(4) The human body model is a 100pF capacitor discharged through a 1.5Ωk resistor into each pin. Test method is per JESD-22-114.

(5) Depending on ambient temperature; see THERMAL DERATING.

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11   TYPICAL PERFORMANCE CURVES

If not otherwise specified, the following conditions apply: V_{IN} = 5V, V_{OUT} = 3.3V; C_{IN} = 4.7µF X5R ceramic, C_{OUT} = 10µF X5R ceramic, C_{FF} = 22pF, T_A = 25°C.

11.1   RADIATED EMISSIONS EN55032 (CISPR-32) CLASS B COMPLIANT

Measured with module on the design example in a Fully Anechoic Room (FAR) at 3m antenna distance.

11.1.1 TEST SETUP

Input wire length:

- Radiated Emission: 160cm (80cm Horizontal + 80cm Vertical)

Output wire length:

- Short wire (with input filter): Load directly on evaluation board

- Long wire (with input filter): 1m
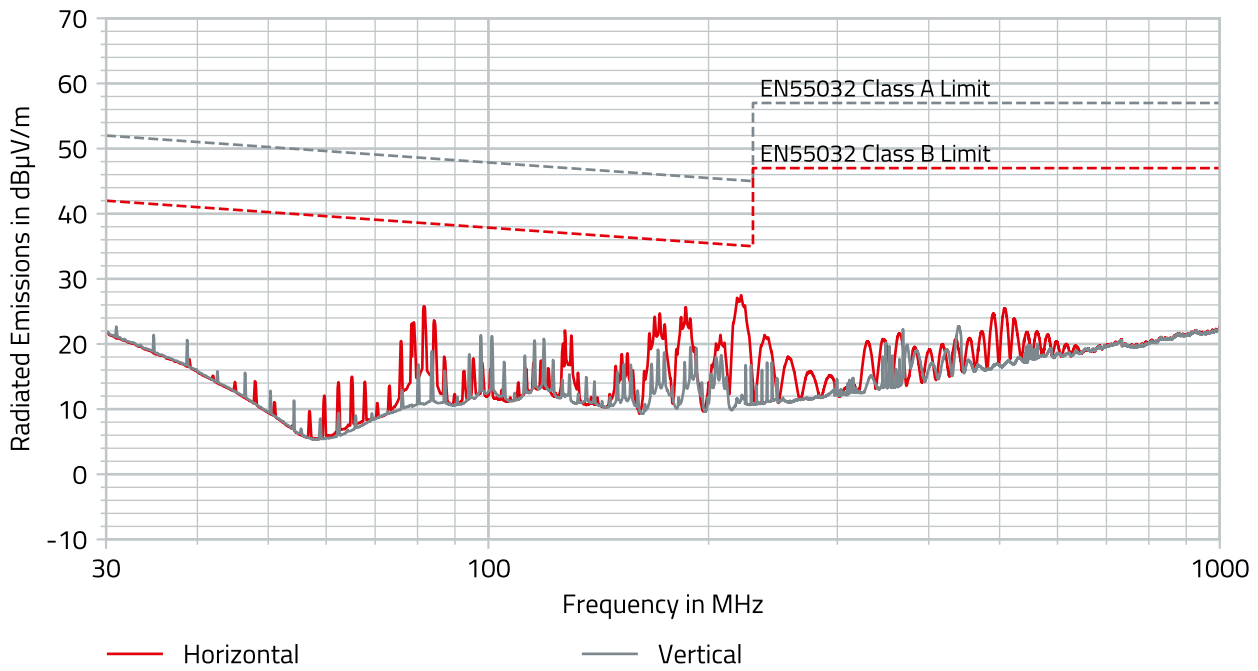
11.1.2 RADIATED EMISSIONS (Without Input Filter)

Figure 2: 171010550 radiated emissions (3m antenna distance) I_{OUT} = 1.2A without input filter

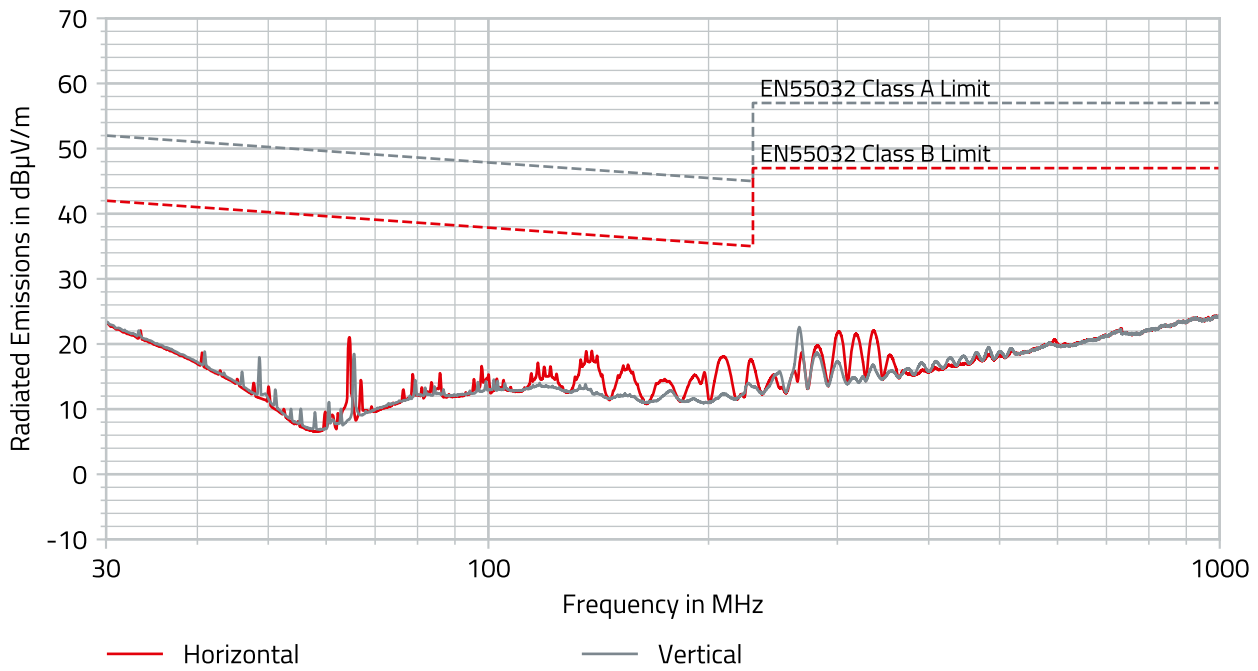### 11.1.3 RADIATED EMISSIONS (With Input Filter)

Figure 3: 171010550 radiated emissions (3m antenna distance) I_{OUT} = 1.2A with input filter

The EMI behavior at the specified output current will be identical regardless of whether the MODE pin is pulled high or low.

11.2 DC Performance Curves
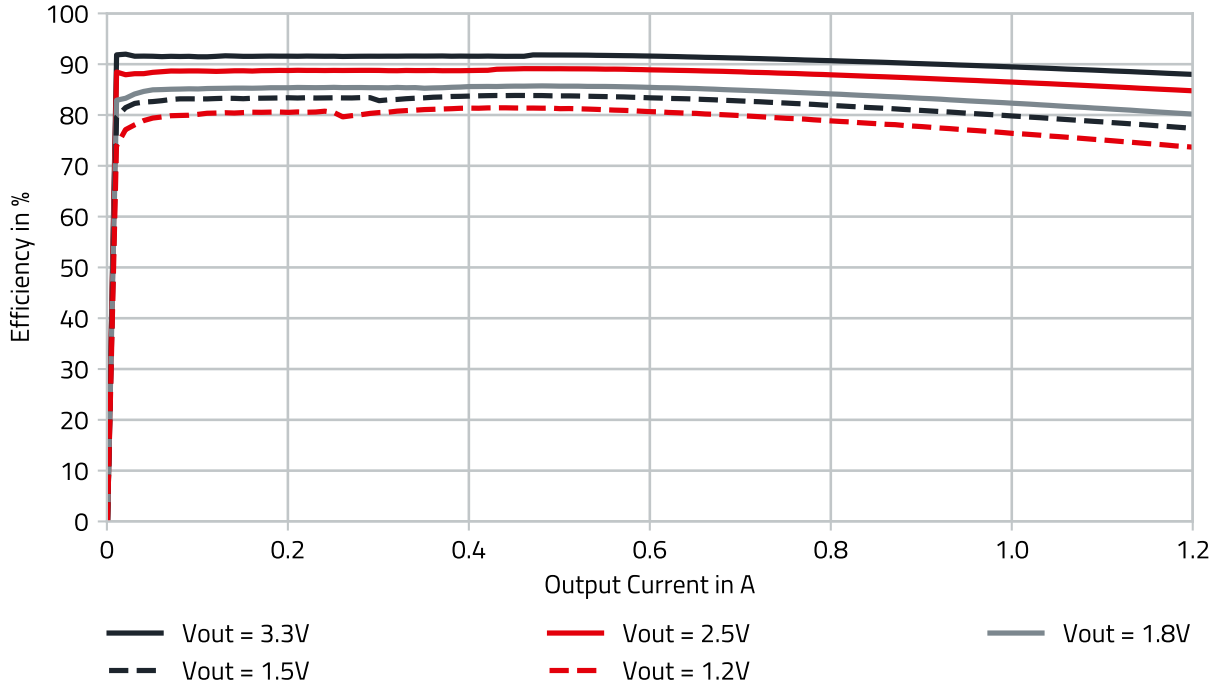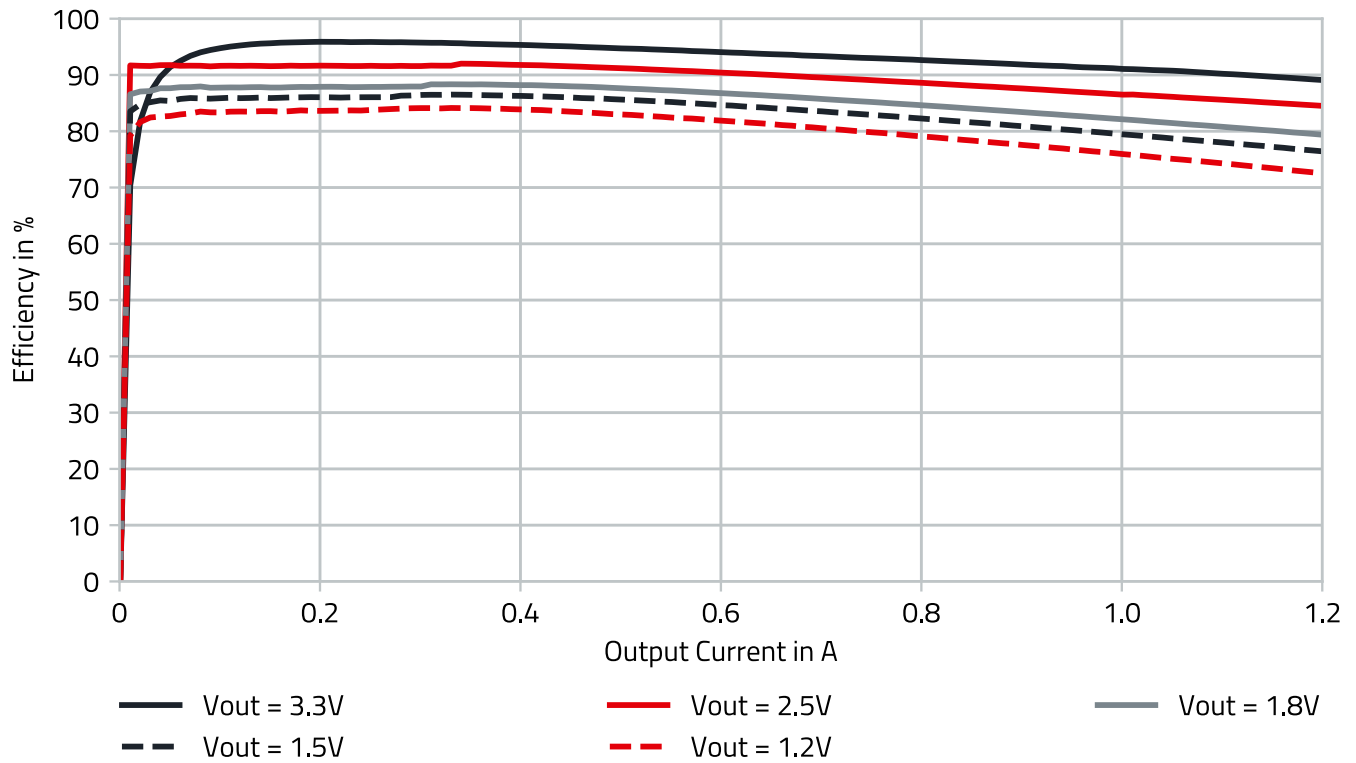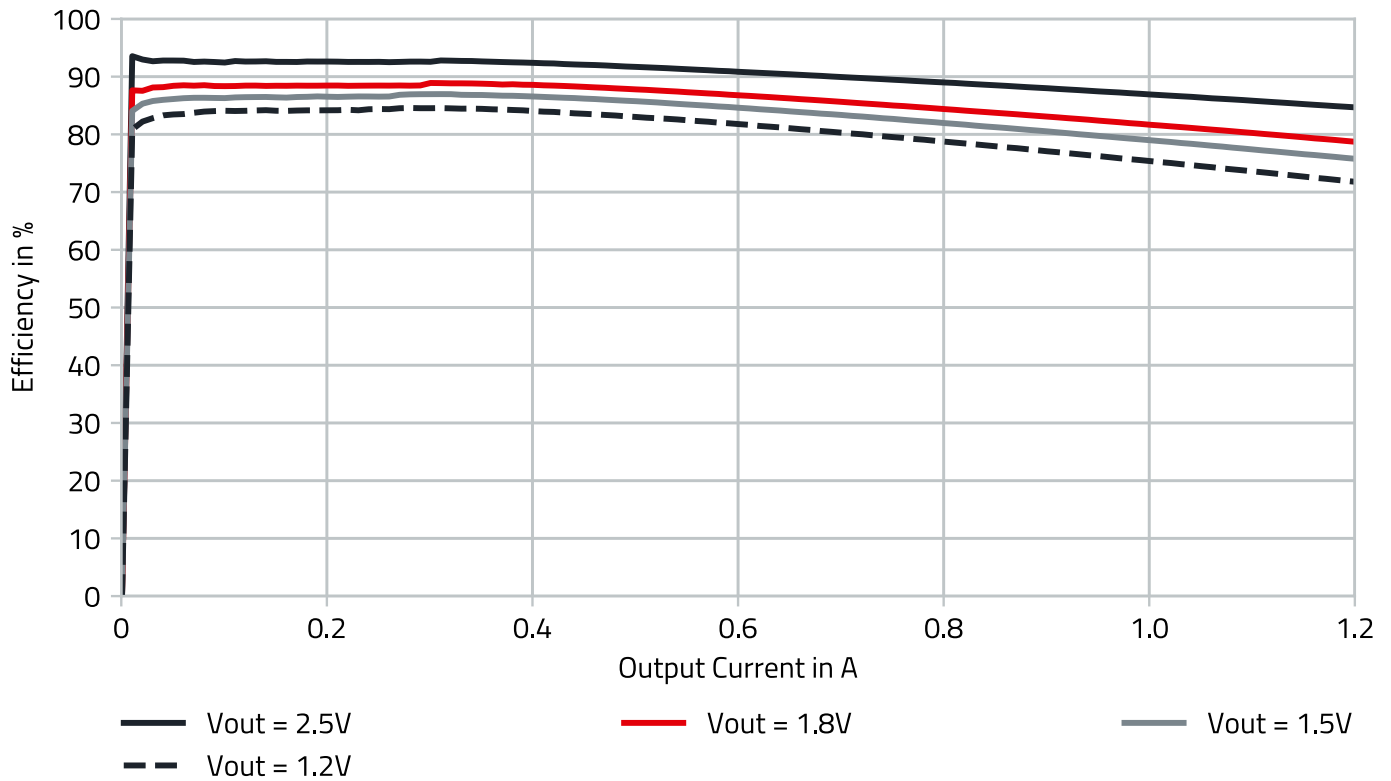
11.2.1 Efficiency 5V$_{IN}$ MODE = Low

Figure 4: 171010550 efficiency V_{IN} = 5V, MODE = low.

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11.2.2 Efficiency 3.6V$_{IN}$ MODE = Low

Figure 5: 171010550 efficiency V_{IN} = 3.6V, MODE = low.

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11.2.3 Efficiency 3.3V$_{IN}$ MODE = Low

Figure 6: 171010550 efficiency V_{IN} = 3.3V, MODE = low.

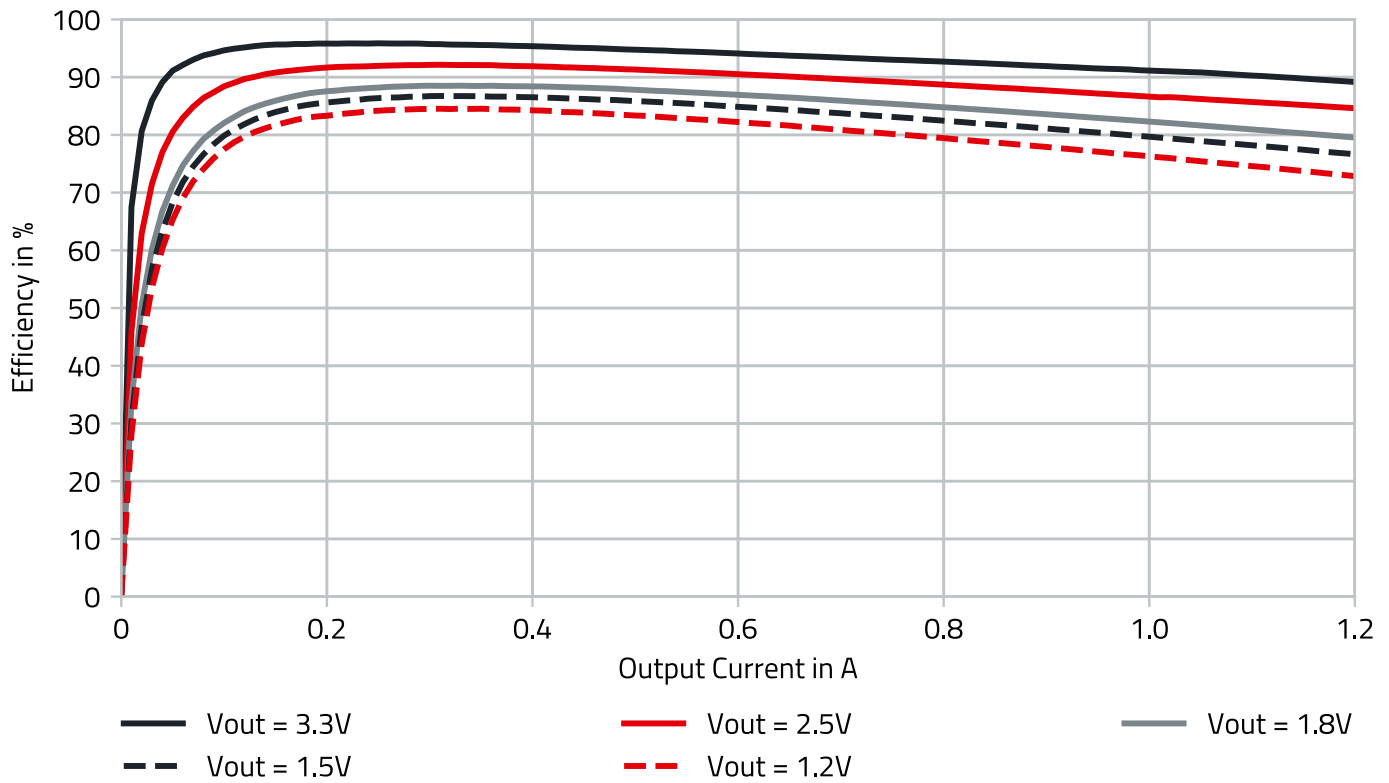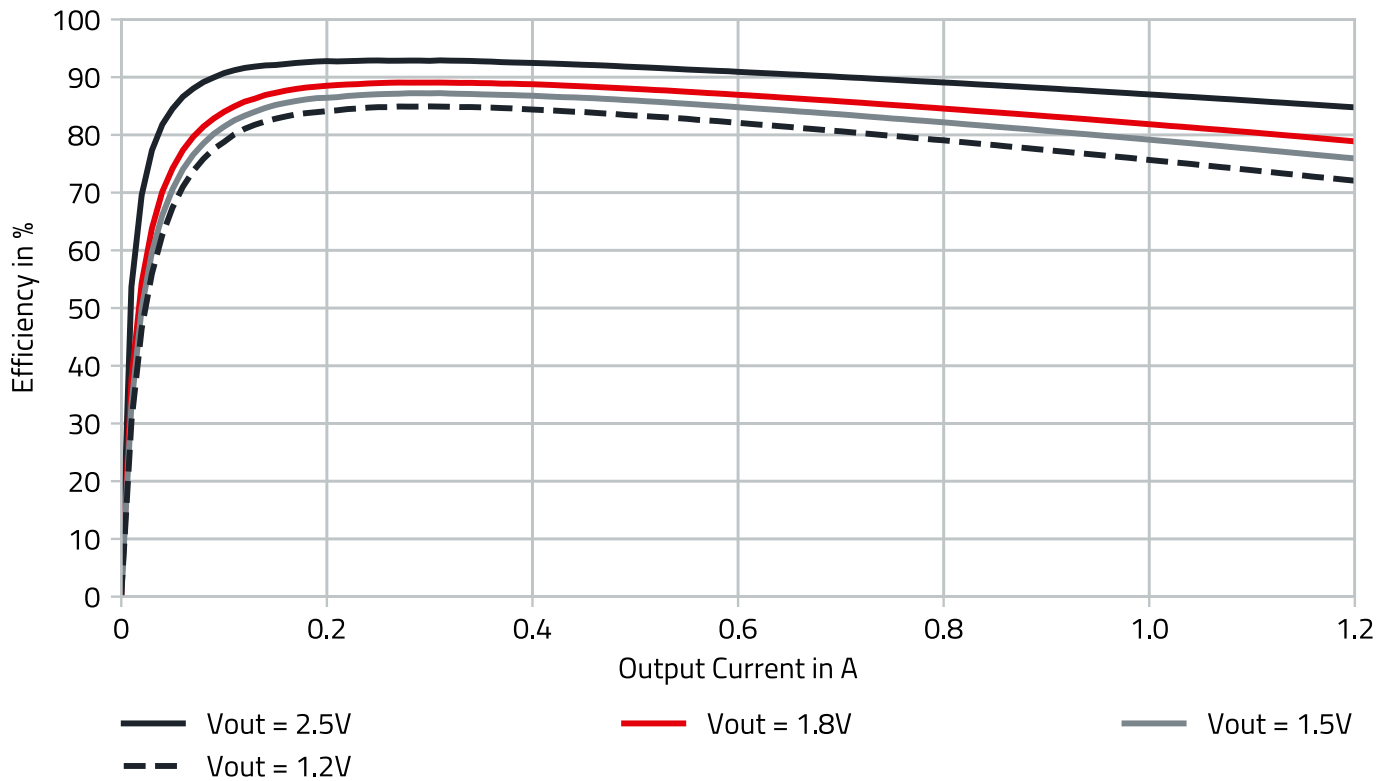### 11.2.4 Efficiency 5V$_{IN}$ MODE = High
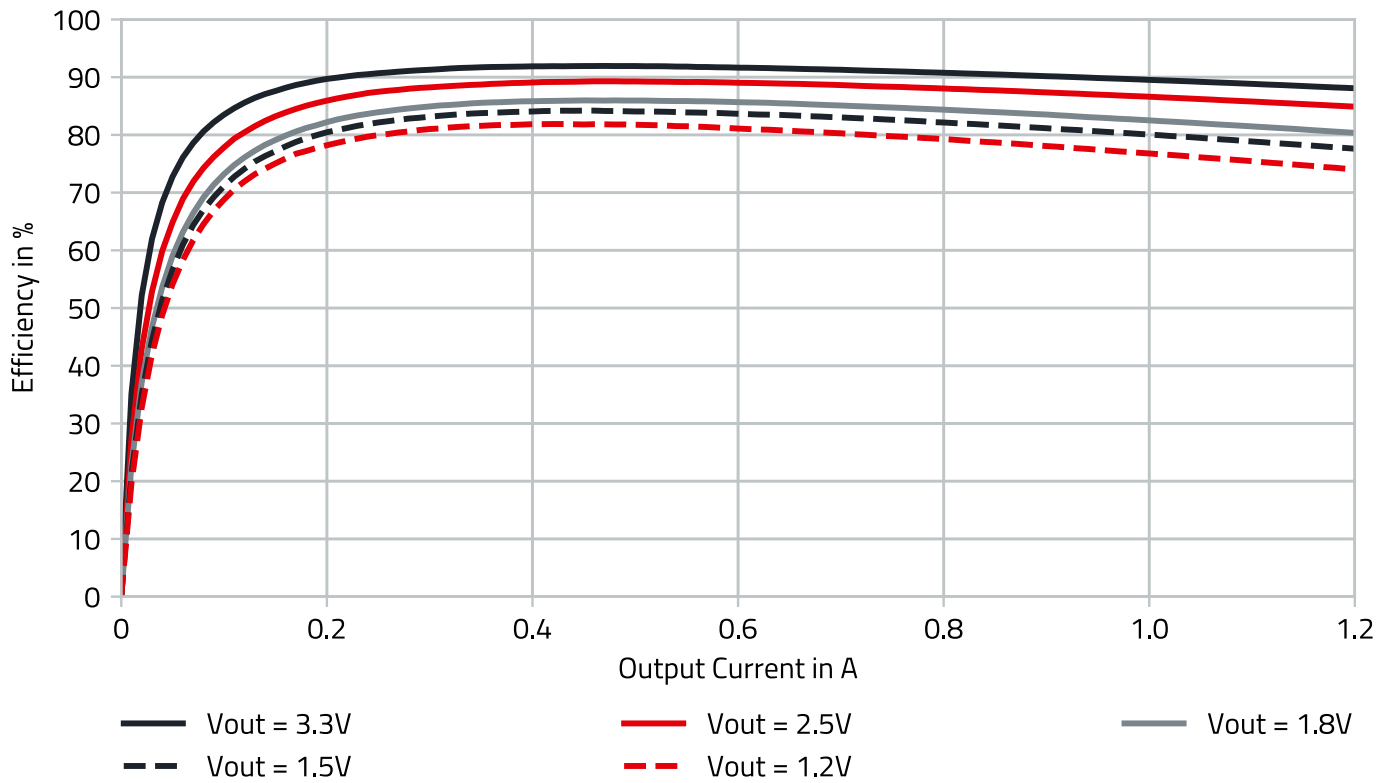
Figure 7: 171010550 efficiency V$_{IN}$ = 5V, MODE = high.

11.2.5 Efficiency 3.6V$_{IN}$ MODE = High

Figure 8: 171010550 efficiency V_{IN} = 3.6V, MODE = high.

11.2.6 Efficiency 3.3V$_{IN}$ MODE = High

Figure 9: 171010550 efficiency V$_{IN}$ = 3.3V, MODE = high.
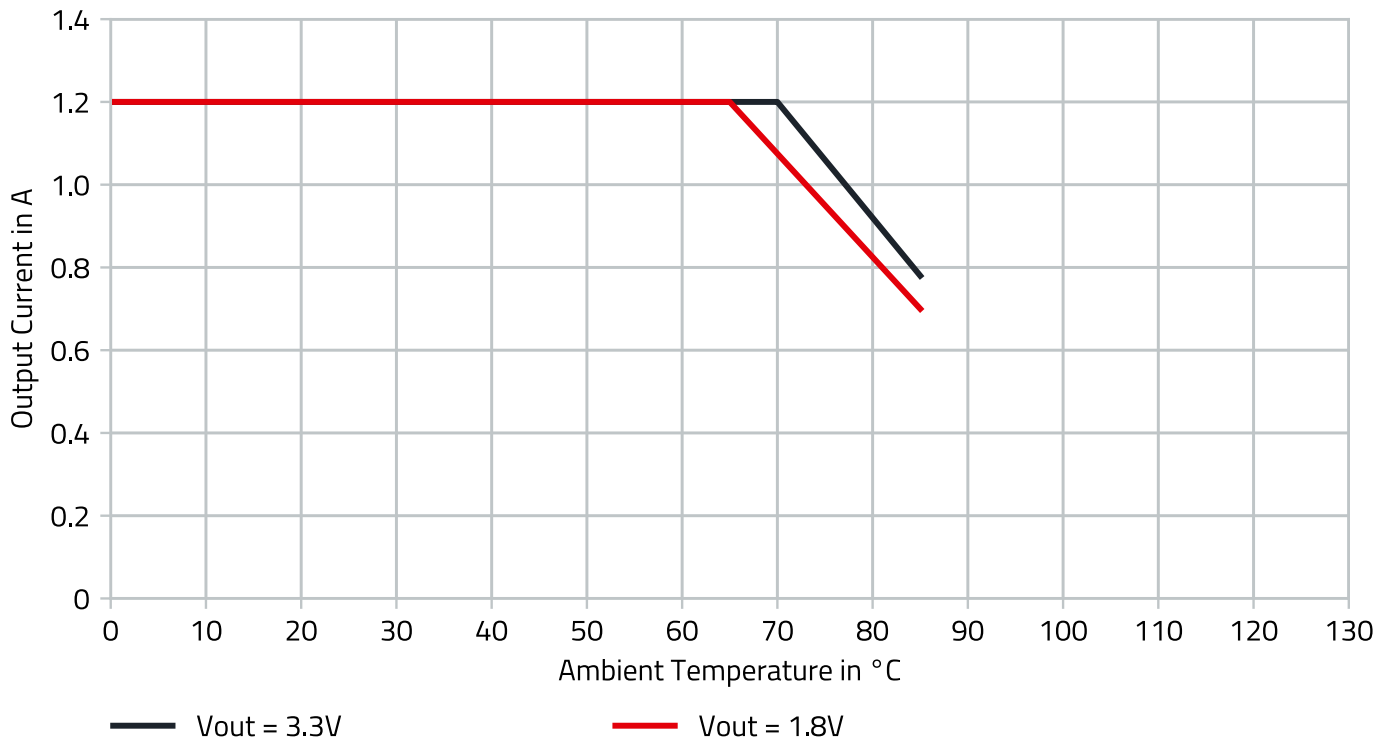
11.2.7 Thermal Derating

Figure 10: 171010550 output current thermal derating V_{IN} = 5V.

Note: Both thermal derating graphs were measured on the 178010550 Evaluation Board (40 x 40mm two layer board, with 35μm (1 ounce) copper). Please see T_A limits in OPERATING CONDITIONS.

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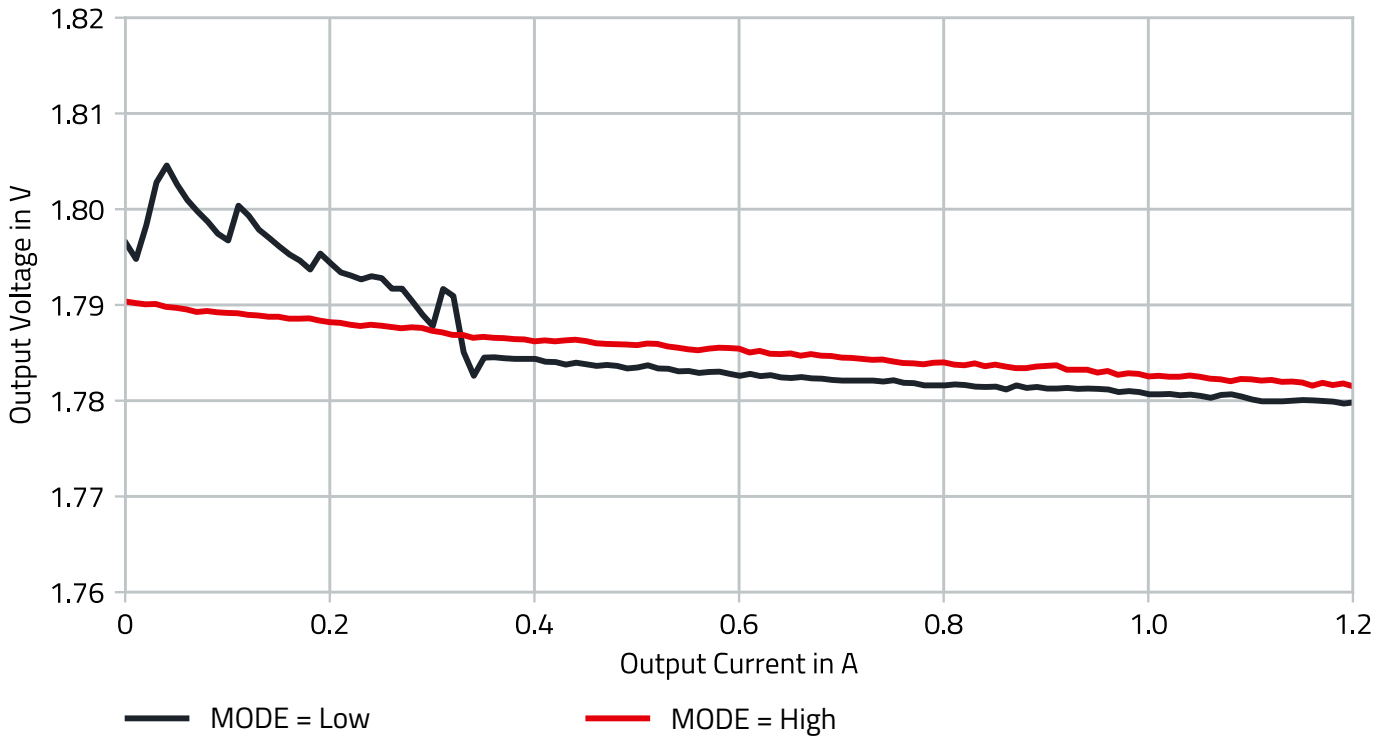YOU EXPECT

11.2.8 Load Regulation

Figure 11: 171010550 load regulation V_{IN} = 3.6V, V_{OUT} = 1.8V.

11.2.9 Line Regulation

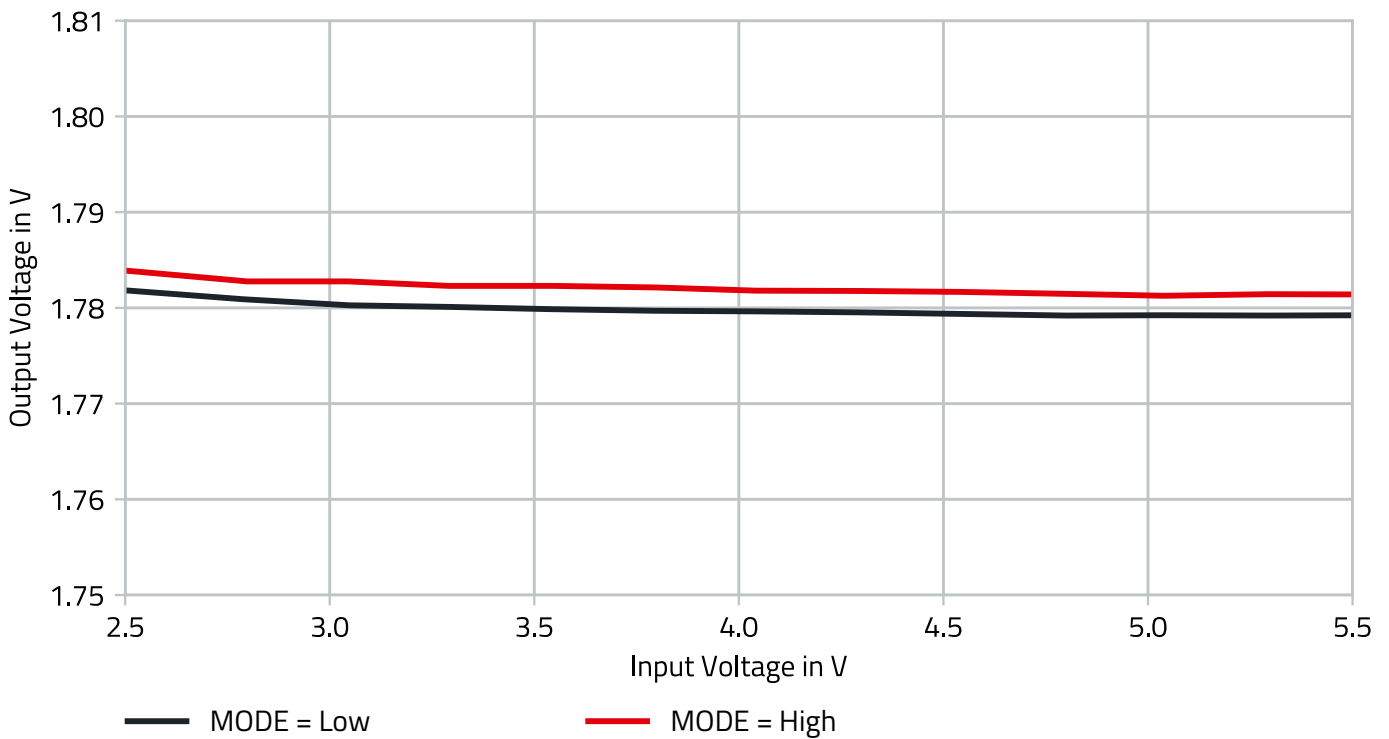Figure 12: 171010550 line regulation V_{OUT} = 1.8V, I_{OUT} = 1.2A.

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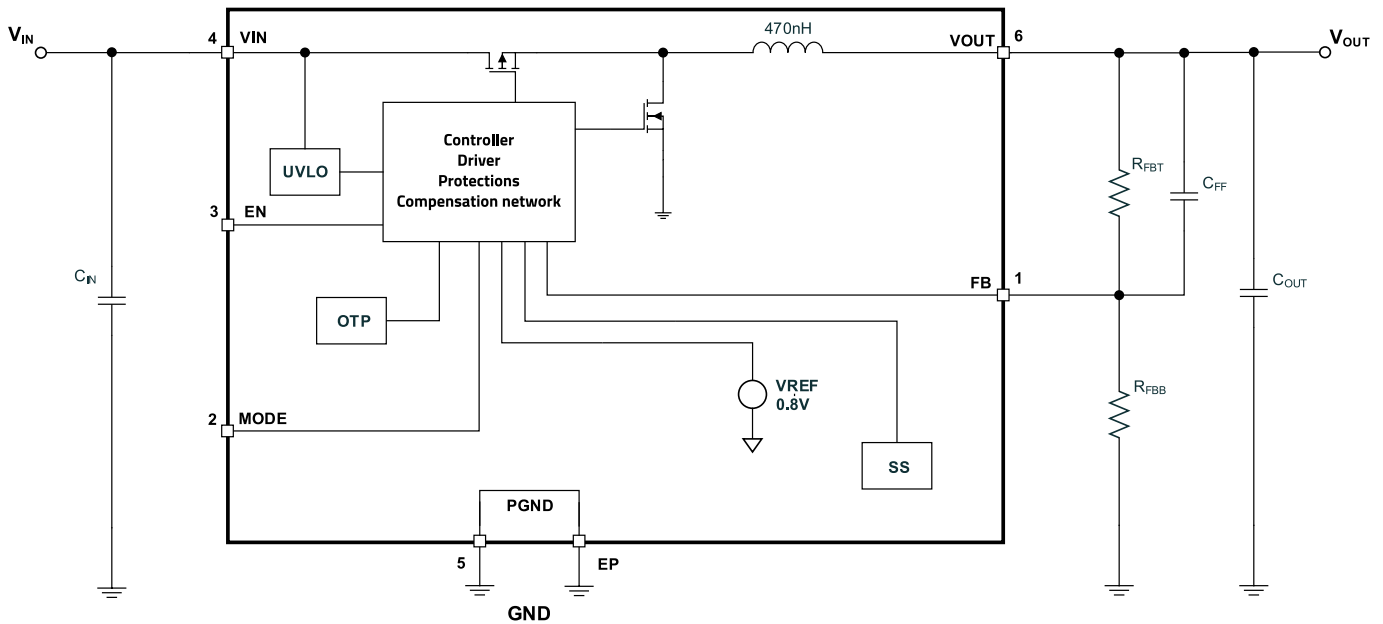
12 BLOCK DIAGRAM

Figure 13: 171010550 block diagram.

13 CIRCUIT DESCRIPTION

The MagI³C power module 171010550 is a synchronous step down regulator with integrated MOSFETs, control circuitry and power inductor. The control scheme is based on a constant on-time (COT) 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 internal comparator compares this signal with the internal 0.8V reference. If the feedback voltage is below the reference, the high side MOSFET is turned on for a fixed on-time.

The constant on-time control scheme does not require external compensation circuitry which makes the overall design very simple. Nevertheless, it requires a certain minimum ripple at the feedback pin. The MagI³C power module 171010550 generates this ripple internally and is supported by the C_{FF} capacitor which bypasses AC ripple directly to the feedback pin from the output. With this architecture very small output ripple values under 10mV$_{PP}$ (similar to current or voltage mode devices) can be achieved.

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14   DESIGN FLOW

The following simple steps will show how to select the external components to design the 171010550 into an application.

Essential Steps

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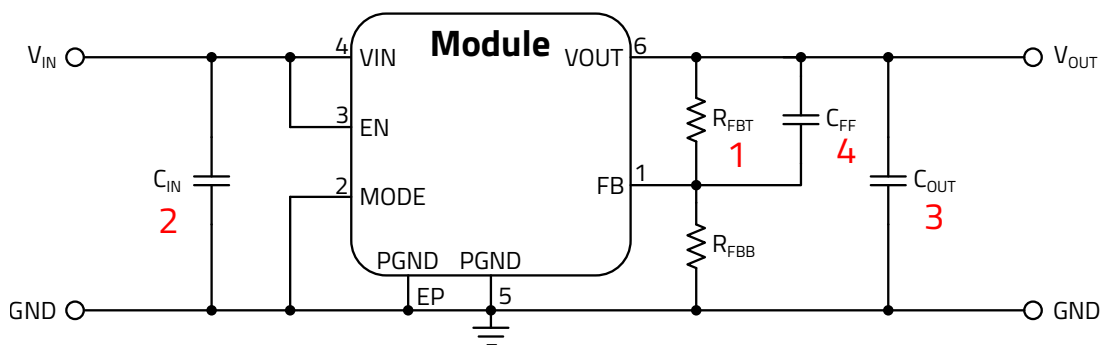3. Select output capacitor
4. Select feed-forward capacitor

Figure 14: Design flow schematic.

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14.1   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 bottom resistor of the divider is provided to the FB pin and compared with an internal reference voltage of 0.8V (V$_{REF}$). The output voltage adjustment range is from 0.8V to 5.5V. The output voltage can be calculated according to the following formula:

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

One resistor must be chosen and then the other resistor can be calculated. For example, if R$_{FBT}$ = 100kΩ then the resistance value of the lower resistor in the feedback network is indicated in the table below for common output voltages.

Table 11: Output voltage selection.

V$_{OUT}$ (V)	1.2	1.5	1.8	2.5	3.3	3.6	5
R$_{FBB}$ (E96) (kΩ)	200	115	80.6	47.5	32.4	28.7	19.1

Figure 15: Output voltage schematic.

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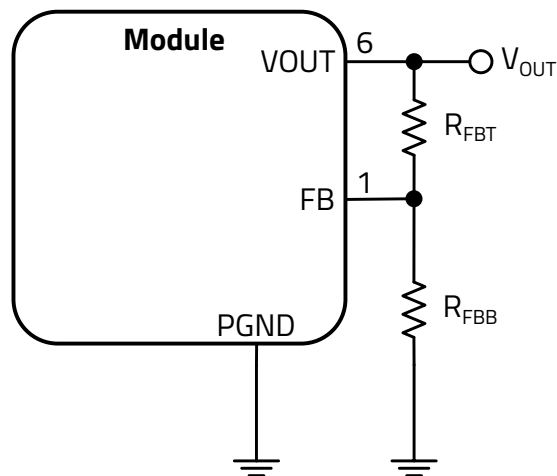YOU EXPECT

14.2 STEP 2 Select The Input Capacitor (C_{IN})

An external input capacitor is required to provide the high input pulse current. The external input capacitor must be placed as close as possible to the VIN and PGND pins. For this MagI³C power module, it is recommended to use an MLCC (multi-layer ceramic capacitor) of 4.7µF. Attention must be paid to the voltage, frequency, and temperature deratings as well as the thermal class of the selected capacitor. The Würth Elektronik part number 885012207053 has been experimentally verified to work with this power module.

14.3 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 10µF is recommended for all application conditions. Attention must be paid to the voltage, frequency, and temperature deratings as well as the thermal class of the selected capacitor. The Würth Elektronik part number 885012107014 has been experimentally verified to work with this power module.

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

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

where ΔI_{L} is the inductor current ripple and can be calculated with the following equation:

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

14.4 STEP 4 Select The Feed-Forward Capacitor (C_FF)

The 171010550 MagI³C power module allows for the selection of a feed forward capacitor, C_{FF}, providing a trade-off between response time and efficiency while also affecting the transition current threshold between COT and PFM operation. A lower value of C_{FF} will increase the light load conversion efficiency while slowing down the response time and increasing the overshoot and undershoot. Increasing the C_{FF} value will decrease the response time and the overshoot and undershoot while decreasing light load conversion efficiency. Increasing the value of C_{FF} results in higher value of current needed to leave PFM operation.

A C_{FF} of 22pF has been evaluated experimentally as a value with suitable efficiency and transient characteristics for most applications. The Würth Elektronik part number 885012005009 has been experimentally verified to work with this power module.

The pictures below show the transient behavior of the 171010550 in response to a load transition from 0A to 1.2A using the recommended C_{FF} = 22pF, as well as other values of C_{FF}.
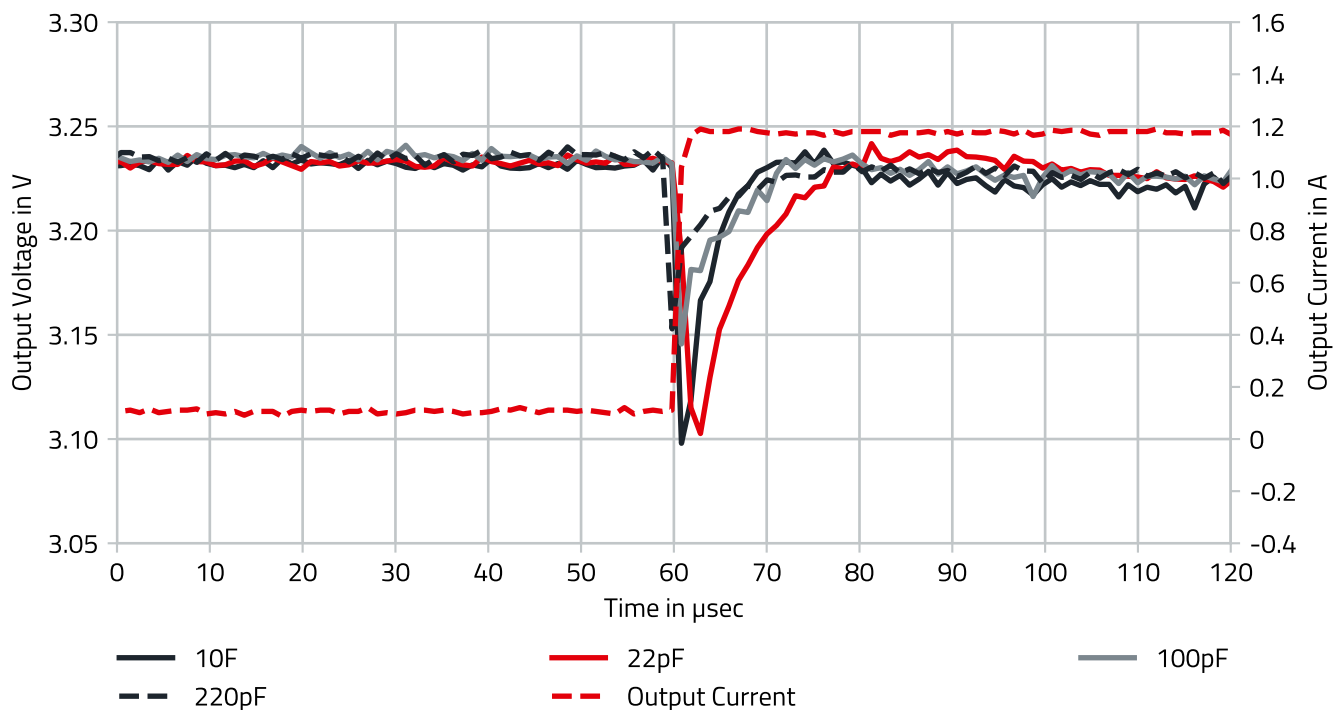

Figure 16: 171010550 load transient V_{IN} = 5V, V_{OUT} = 3.3V from 0.1A to 1.2A, MODE = high, T_A = 25°C.

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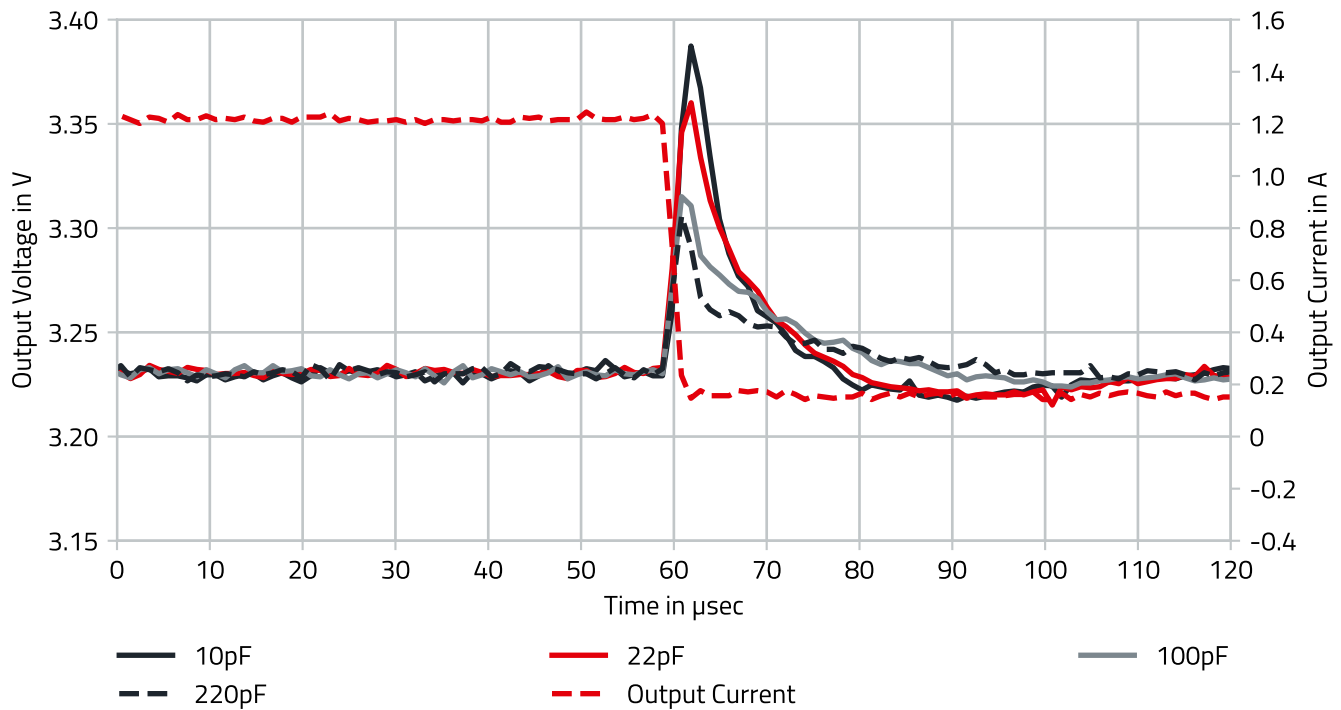
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Figure 17: 171010550 load transient V_{IN} = 5V, V_{OUT} = 3.3V from 1.2A to 0.1A, MODE = high, T_A = 25°C.

These behaviors are valid only for the specified conditions and must be verified in the real application.

The C_{FF} value only affects the efficiency during light load conditions when the MODE pin is pulled low.

As explained in the section MODES OF OPERATION, during light load conditions with the MODE pin pulled low the device does not continuously switch, instead delivering energy to the load in bursts. The frequency between bursts is influenced by various parameters, including the C_{FF} value.

Increasing C_{FF} will cause the power module to burst more often, resulting in a decrease in light load efficiency.

While the recommended C_{FF} value of 22pF will work for most applications, the user can adjust the performance of the power module based on their application by trading between light load efficiency and transient response. This customization tailors the behavior of the power module to the application's needs. Any deviations from the recommended values and components should be thoroughly evaluated by the customer to ensure the device operates properly.

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15 MODES OF OPERATION

The MODE pin of the 171010550 can be pulled either high or low to alter the light load performance of the power module based on the application requirements.
When pulled high, COT operation will be forced throughout the entire load current range. When pulled low, PFM operation will occur during light load conditions.
The power module will operate in one of four modes, depending on the operating conditions.

15.1 Constant On-Time (COT) Operation

The power module operates at a fixed switching frequency of 4MHz where the duty cycle (D) is determined by the following equation:

$$D = \frac{V_{\text{OUT}}}{V_{\text{IN}}} \tag{4}$$

The on-time is determined by the duty cycle and the switching frequency as follows:

$$t_{\text{ON}} = \frac{D}{f_{\text{SW}}} \tag{5}$$

The on and off-times can be related to the switching frequency as follows:

$$\frac{1}{f_{\text{SW}}} = t_{\text{ON}} + t_{\text{OFF}} \tag{6}$$

This mode of operation has a minimum off-time value of 60ns.

15.2 Fixed Off-Time Operation

When the minimum off-time of 60ns is reached and the duty cycle must increase futher, the power module fixes the off-time to 60ns and begins increasing the on-time. This results in a decrease in switching frequency proportional to the increase in duty cycle.

15.3 100% Duty Cycle Operation

When the input voltage approaches the output voltage and the duty cycle approaches 100%, the power module will leave the high side MOSFET on continuously and the output voltage will be limited by the input voltage. Further decreases of input voltage will result in a corresponding decrease in output voltage.

15.4 Pulse Frequency Modulation (PFM) Operation

If the MODE pin is pulled low PFM operation is initiated when the power module enters discontinuous mode. A burst of switching cycles increases the output voltage above the set value followed by a period of dead time where the output current is only delivered by the output capacitor. This results in slightly increased output voltage ripple in exchange for significantly increased conversion efficiency.
The frequency of the bursts depends on the load and is significantly lower than the default switching frequency. As the output current demand increase the bursts become more frequent until the module automatically transitions out of PFM operation.
The burst frequency is a function of input voltage, output voltage, output current, C_{FF}, and C_{OUT}. Changing any of these parameters will alter the device's behavior during PFM operation.

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16   OUTPUT VOLTAGE RIPPLE

The output voltage ripple is influenced by the condition applied to the MODE pin and the output current drawn from the module. If the MODE pin is pulled high and the duty cycle is below 76%, the ripple is very low and it always has the same frequency as the internal oscillator (4MHz typ.). If MODE is pulled low and either the load current is low enough or the duty cycle is high enough then the output voltage ripple will be higher and the frequency lower than the nominal switching frequency (see pictures below).
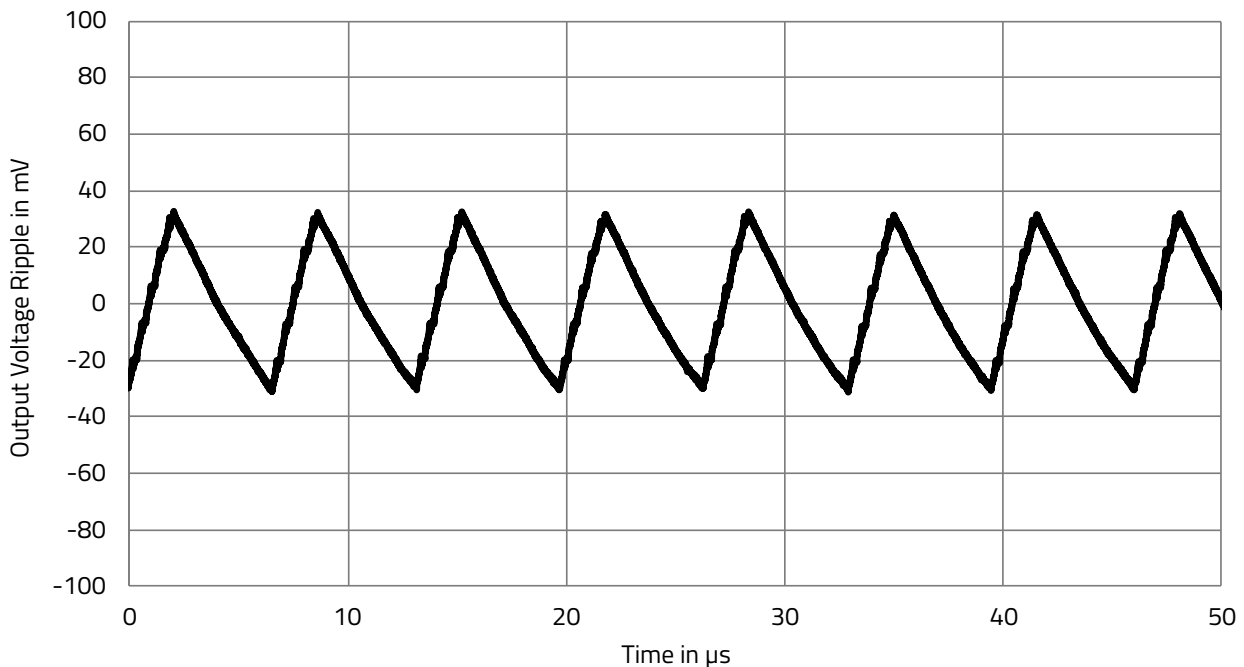

Figure 18: 171010550 output voltage ripple V_{IN} = 3.6V, V_{OUT} = 1.8V, I_{OUT} = 0.1A, C_{OUT} = 10µF, MODE = low.

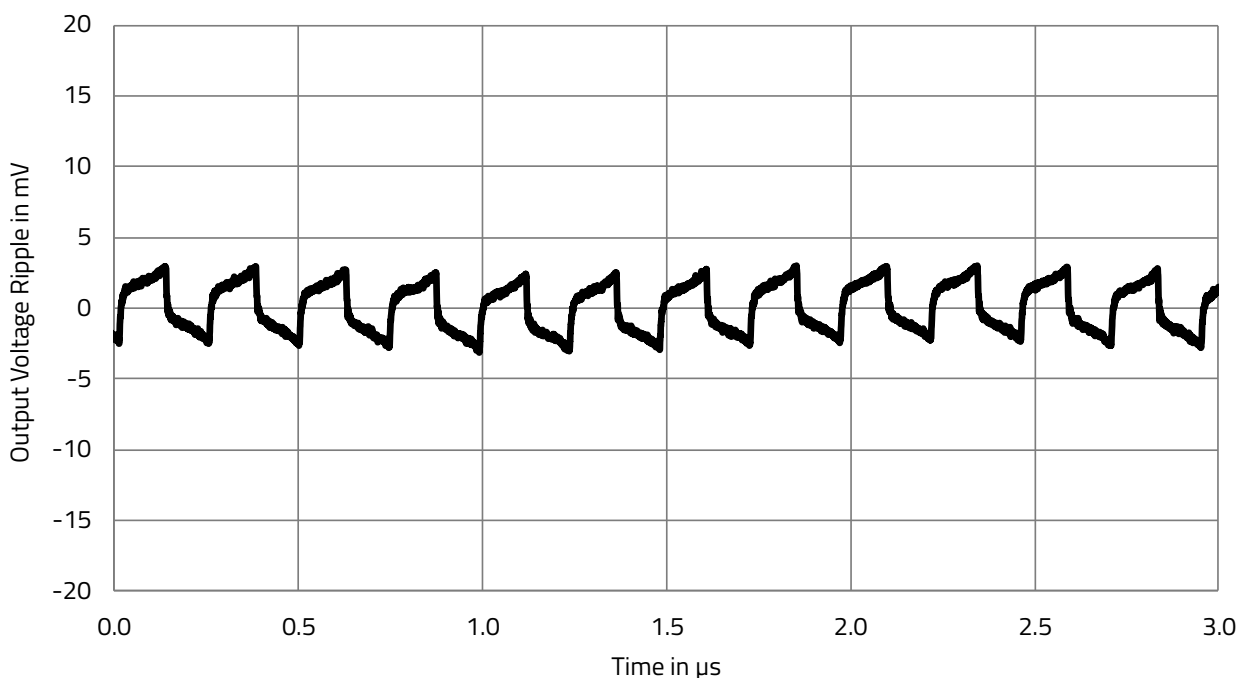Figure 19: 171010550 output voltage ripple V_{IN} = 3.6V, V_{OUT} = 1.8V, I_{OUT} = 0.1A, C_{OUT} = 10µF, MODE = high.

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17 PROTECTION FEATURES

17.1 Overcurrent Protection (OCP)

For protection against load faults, the 171010550 MagI³C power module incorporates a cycle-by-cycle current limit (see I_{OCP} in ELECTRICAL SPECIFICATIONS). During switching, the output current is limited by turning off the high-side switch when the current limit value is detected. This switching behavior continues, limiting the on-time of the device until the overcurrent condition is removed. When the overcurrent condition is removed, normal switching behavior resumes.
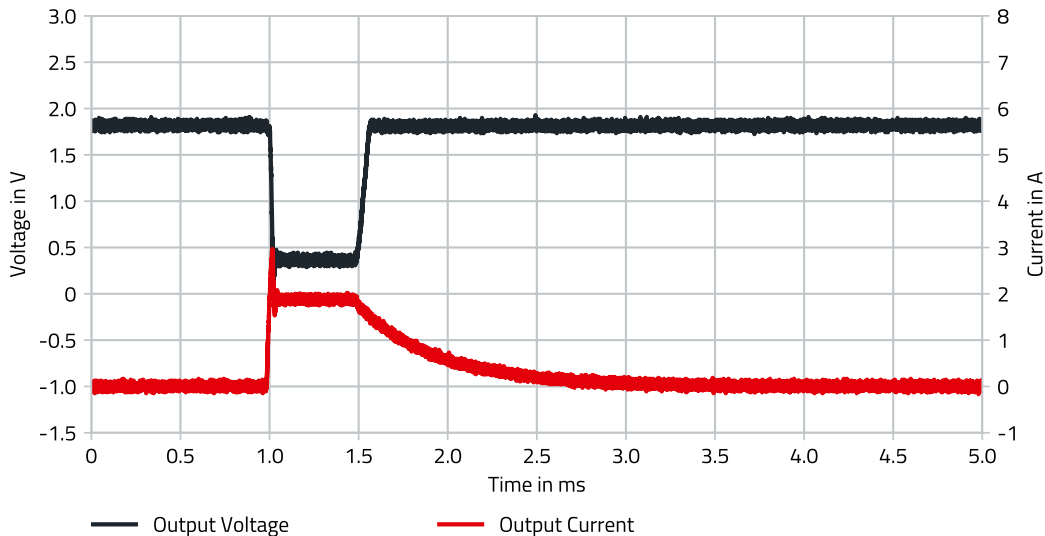

Figure 20: 171010550 overcurrent protection V_{IN} = 3.6V, V_{OUT} = 1.8V, I_{OUT} > 2A.

17.2 Short Circuit Protection (SCP)

When the 171010550 MagI³C power module experiences a short circuit condition at the output it will limit the current, typically to 2.2A, until the thermal protection circuit shuts the module off. If the short circuit condition is removed, normal switching operation will begin if the module temperature is not exceeding the thermal shutdown threshold.
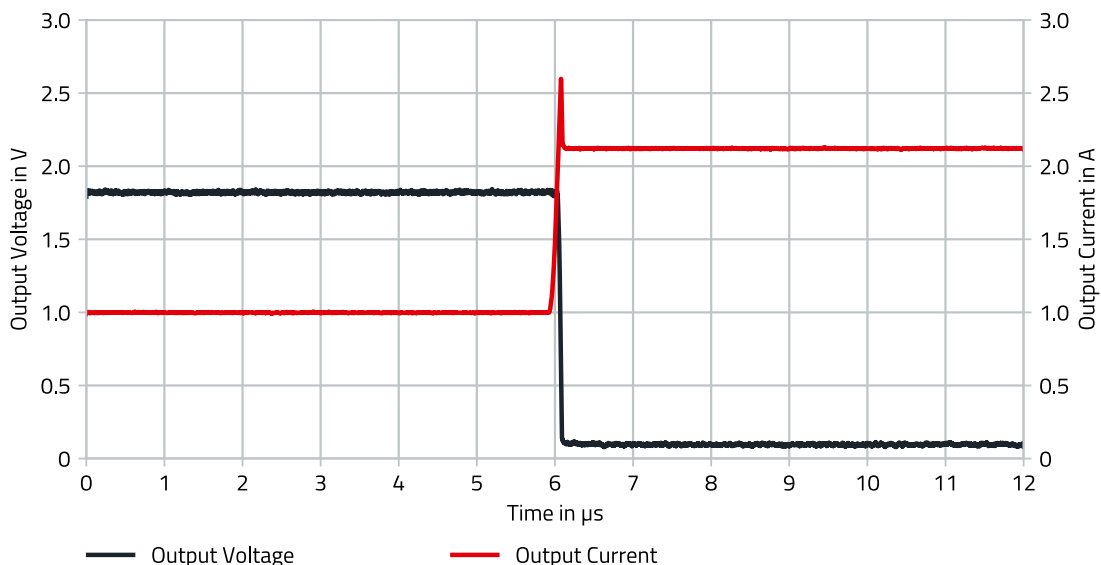

Figure 21: 171010550 short circuit protection V_{IN} = 3.6V, V_{OUT} = 1.8V, short circuit condition.

17.3 Over Temperature Protection (OTP)

Thermal protection helps prevent catastrophic failures due to accidental device overheating. The junction temperature of the 171010550 MagI³C power module 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 160°C (typ). Under the thermal shutdown condition both MOSFETs remain off causing V_{OUT} to drop. When the junction temperature falls below the hysteretic value, the internal soft-start is released, V_{OUT} rises smoothly, and normal operation resumes.

17.4 Undervoltage Lockout (UVLO)

The device incorporates input undervoltage lockout (UVLO) to protect from unexpected behavior at input voltages below the recommended values. The thresholds of the UVLO are indicated in the ELECTRICAL SPECIFICATIONS.

17.5 Soft-Start

The 171010550 MagI³C power module implements an internal soft-start in order to limit the inrush current and avoid output voltage overshoot during start-up.
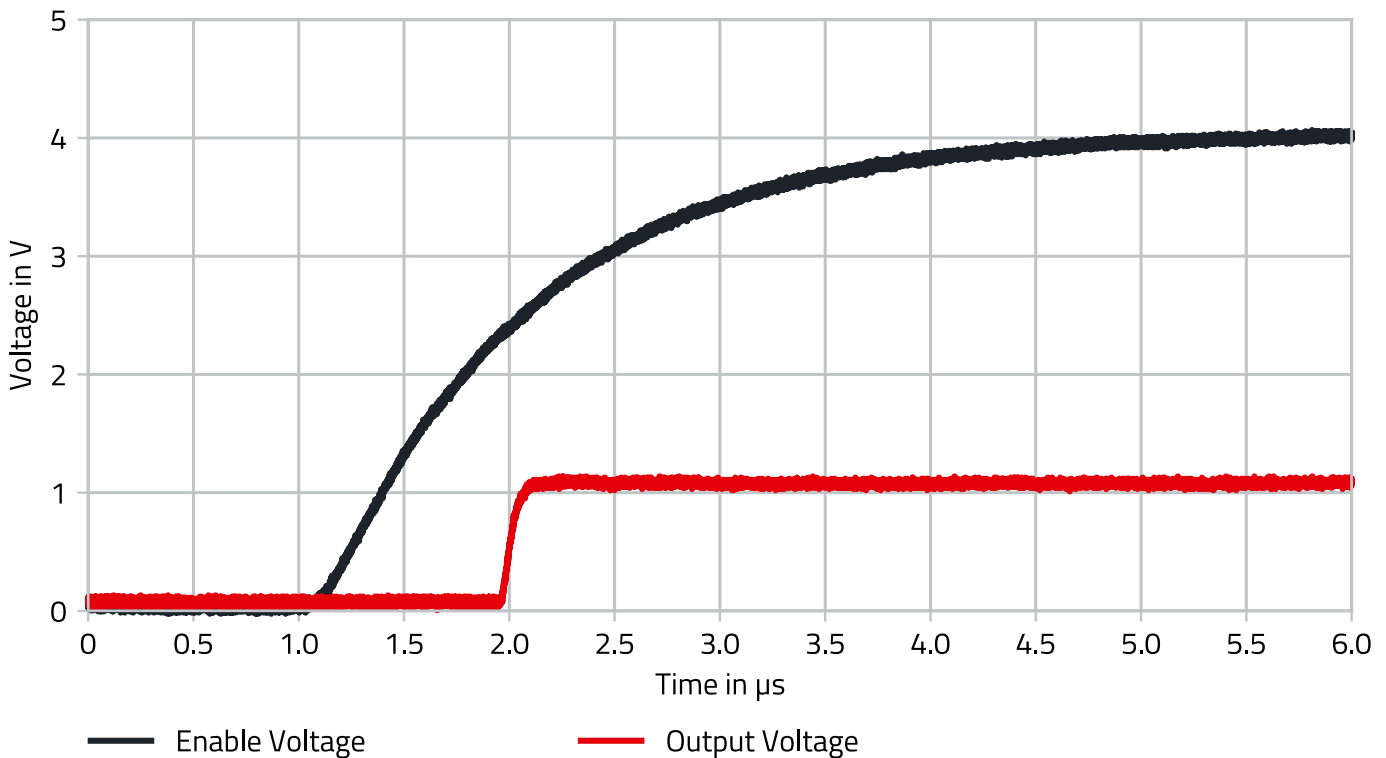

Figure 22: 171010550 soft-start V_{IN} = 3.6V, V_{OUT} = 1.8V.

17.6   Enable

The 171010550 MagI³C power module is enabled by setting the pin EN high. After setting EN 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.

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18   DESIGN EXAMPLE
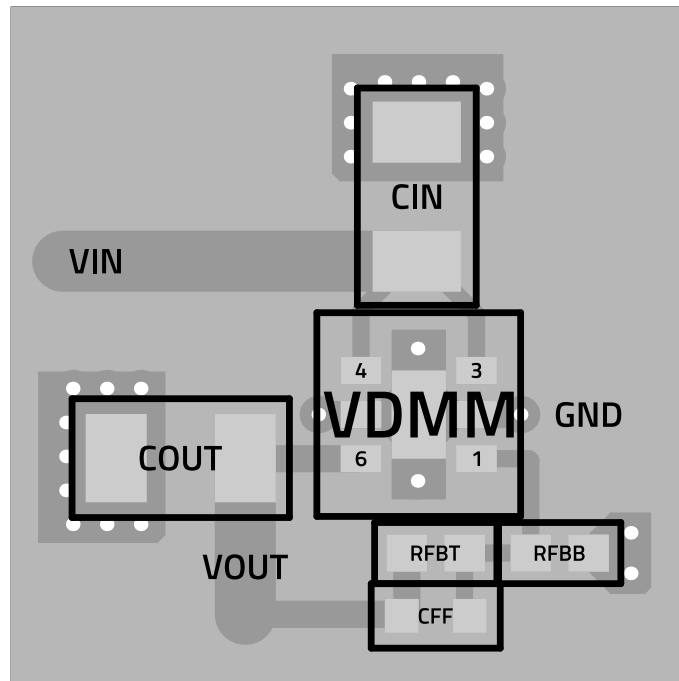
18.1   Layout

Figure 23: 171010550 layout recommendation.

The picture above shows a possible layout for the 171010550 MagI³C power module. Nevertheless, some recommendations should be followed when designing the layout:

1. The exposed pad should be connected to the bottom copper layer of the circuit board with sufficient vias to optimize the heat dissipation during operation. The above example uses 2 vias each with a drill diameter of 200µm. Ensure that nearby vias are either plugged or covered in solder mask to ensure the best solderability.

2. The input and output capacitors should be placed as close as possible to the VIN and VOUT pins of the device.

3. The feedback resistor divider should be placed as close as possible to the FB pin.

4. Pins 3 and 2 (EN and MODE respectively) must be always connected to either VIN or ground and they cannot be left floating (an example is shown in the layout depicted above, where EN and MODE pins are respectively connected to VIN and ground).

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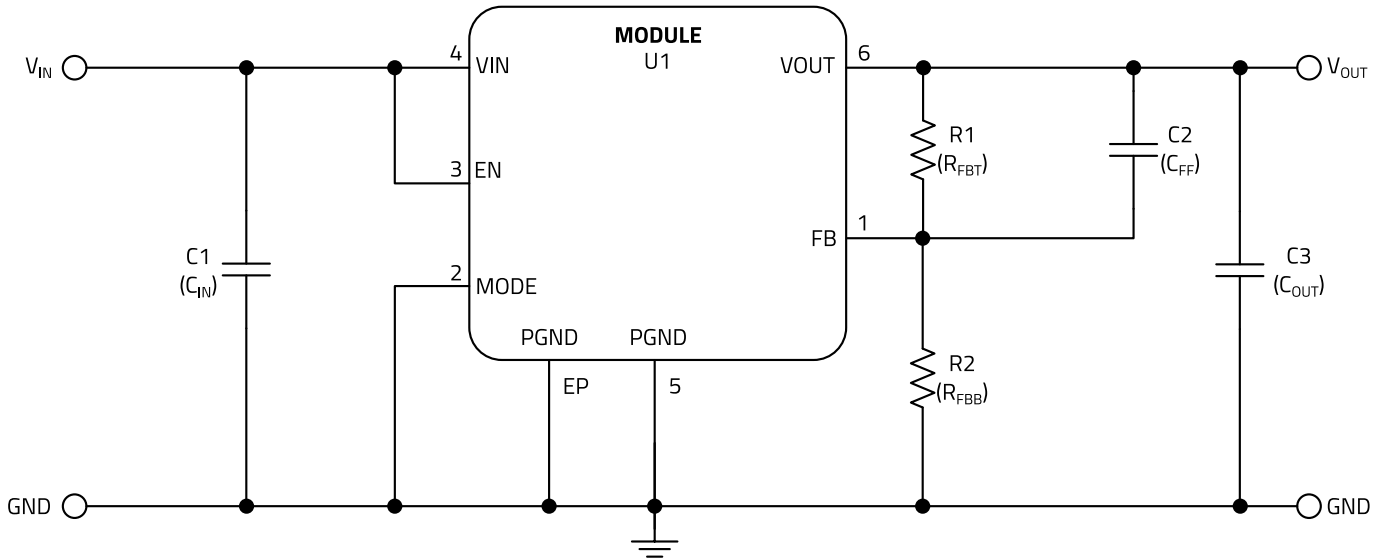**MagI³C Power Module**
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18.2 Schematic

Figure 24: 171010550 design example schematic.

18.3 Bill of Materials

Table 12: Design example bill of materials.

Designator	Description	Quantity	Order Code	Manufacturer
U1	MagI³C power module	1	171010550	WE
C1	Ceramic chip capacitor 4.7µF/16V X7R, 0805	1	885012207053	WE
C2	Ceramic chip capacitor 22pF/10V NP0, 0402	1	885012005009	WE
C3	Ceramic chip capacitor 10µF/16V X5R, 0805	1	885012107014	WE
R1	100kΩ	1		
R2	32.4kΩ for V_{OUT} = 3.3V	1		

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19   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-STD033D).
2. The parts are delivered in a sealed bag (Moisture Barrier Bag = 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-STD033D recommendation.
5. Maximum number of solder cycles is two.
6. For minimum risk, solder the module in the last solder cycle of the PCB production.
7. Please consider that the leads are finished with NiPdAu.
8. It is recommended to use a standard SAC Alloy such as SAC 305, type 3 or higher.
9. The profile below is valid for convection reflow only.
10. Vapor phase soldering following the reflow soldering profile has been experimentally verified.
11. Other soldering methods and profiles for soldering have not been verified and have to be validated by the customer at their own risk.

20   SOLDERING PROFILE

Table 13: Reflow soldering profile.

Profile Feature	Symbol	Value
Preheat temperature minimum	T_{s_min}	150°C
Preheat temperature maximum	T_{s_max}	180°C
Preheat time from T_{s_min} to T_{s_max}	t_s	60-90 seconds
Liquidous temperature	T_L	217°C
Time maintained above T_L	t_L	60-90 seconds
Classification temperature	T_C	260°C
Peak package body temperature	T_P	$T_P \leq T_C$
Time within T_C - 5°C and T_C	t_P	$t_P \leq 20$ seconds
Ramp-up Rate (T_L to T_p)		3°C/second maximum
Ramp-down rate (T_p to T_L)		3°C/second maximum
Time 25°C to peak temperature		8 minutes maximum

Please refer to JEDEC J-STD020E for further information pertaining to reflow soldering of electronic components.
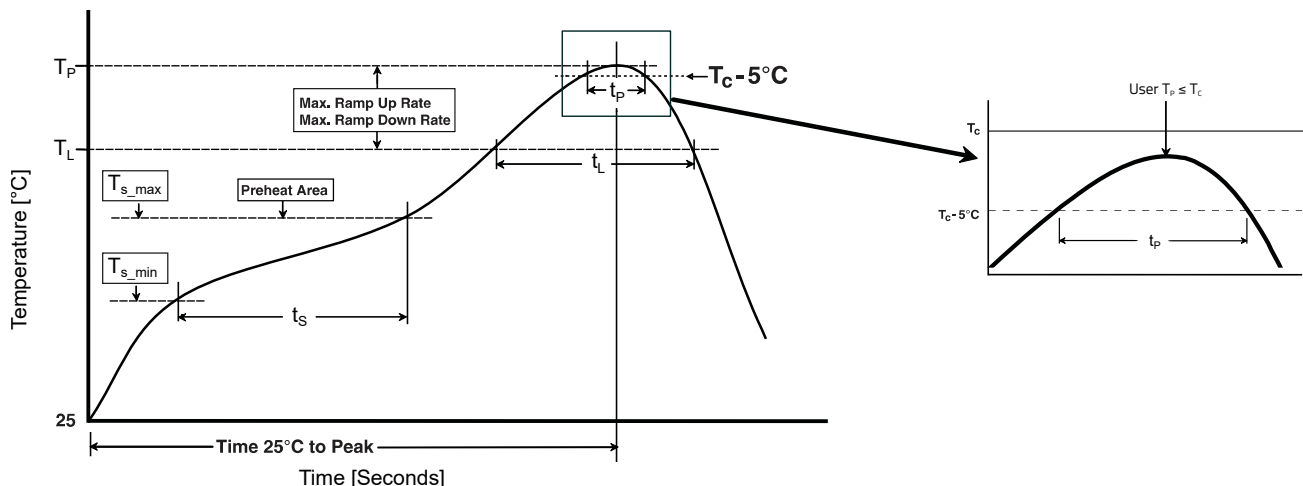

Figure 25: Soldering profile.
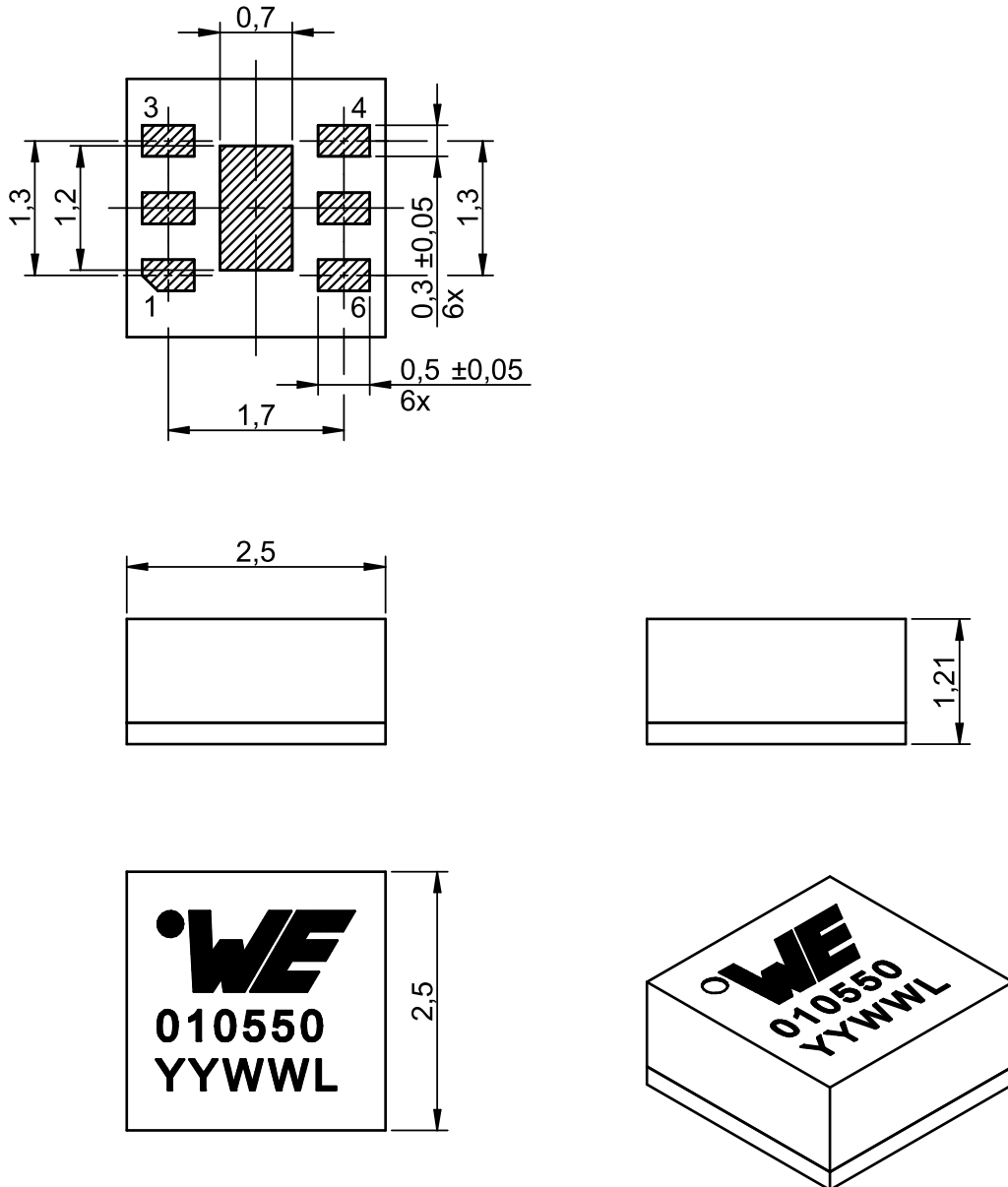
21 PHYSICAL DIMENSIONS

21.1 Component

Figure 26: Physical dimensions

All dimensions in mm
Tolerances ±0,1mm unless otherwise specified
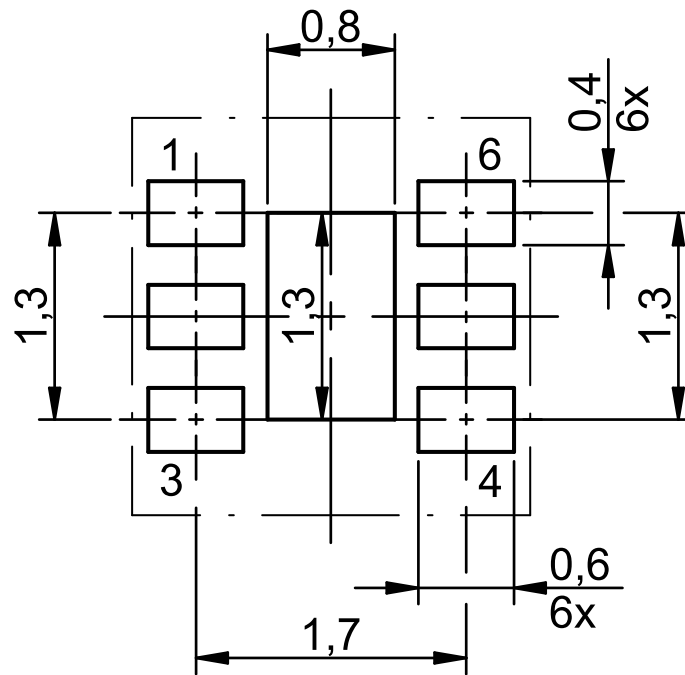
21.2 Example Landpattern

Figure 27: Example landpattern design.

All dimensions in mm
Stencil thickness of 100µm

171010550
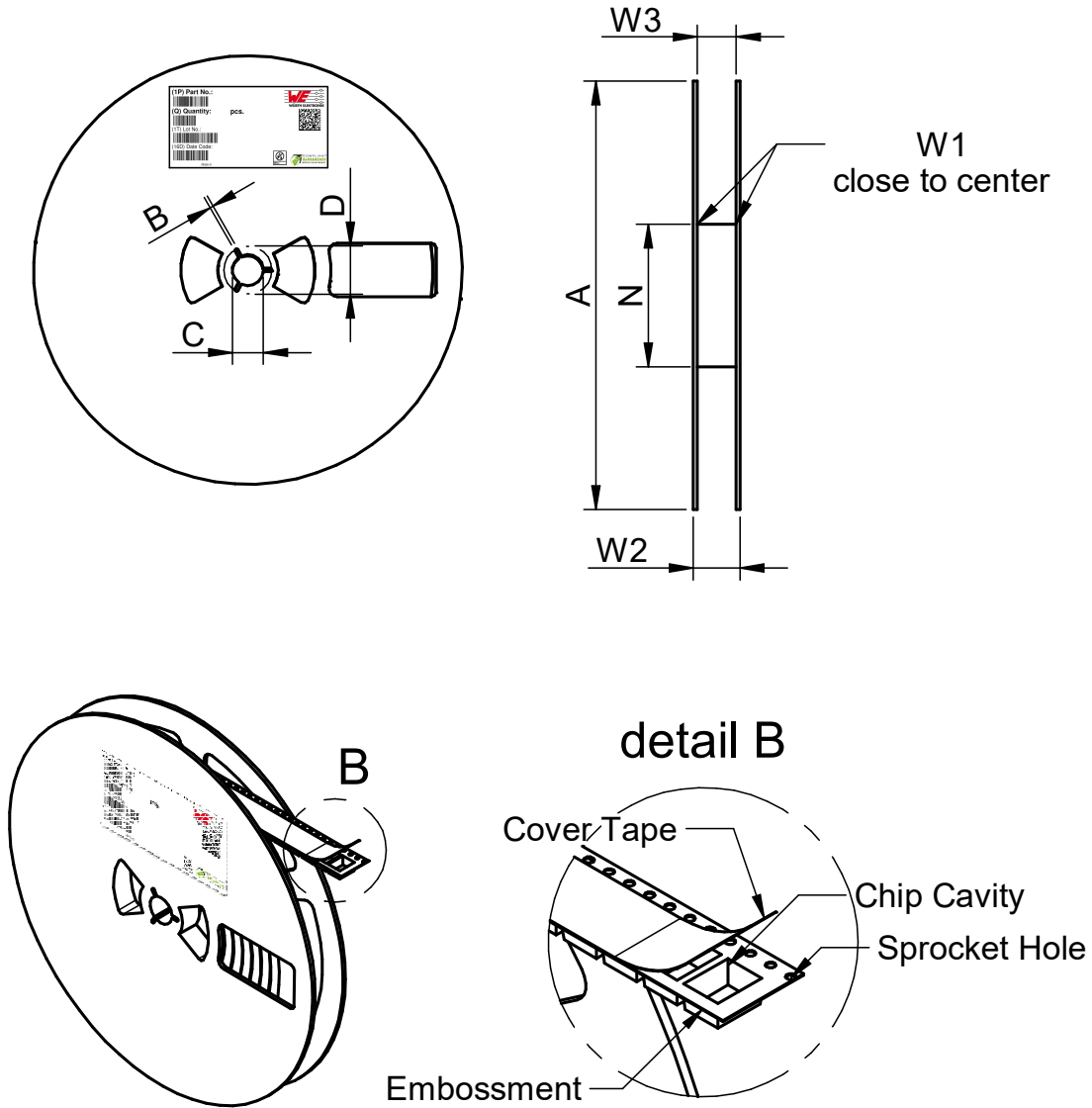**MagI³C Power Module**
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21.3 Packaging

Reel in mm

Figure 28: 171010550 Reel Dimensions

Table 14: Reel dimensions.

A	B	C	D	N	W1	W2	W3	W3	Material
±1.0	±0.5	±0.5	Min.	±0.5	±2.0	Max.	Min.	Max.	
178.00	2.20	13.00	20.20	60.00	12.40	18.40	11.90	15.40	Polystyrene

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Tape in mm
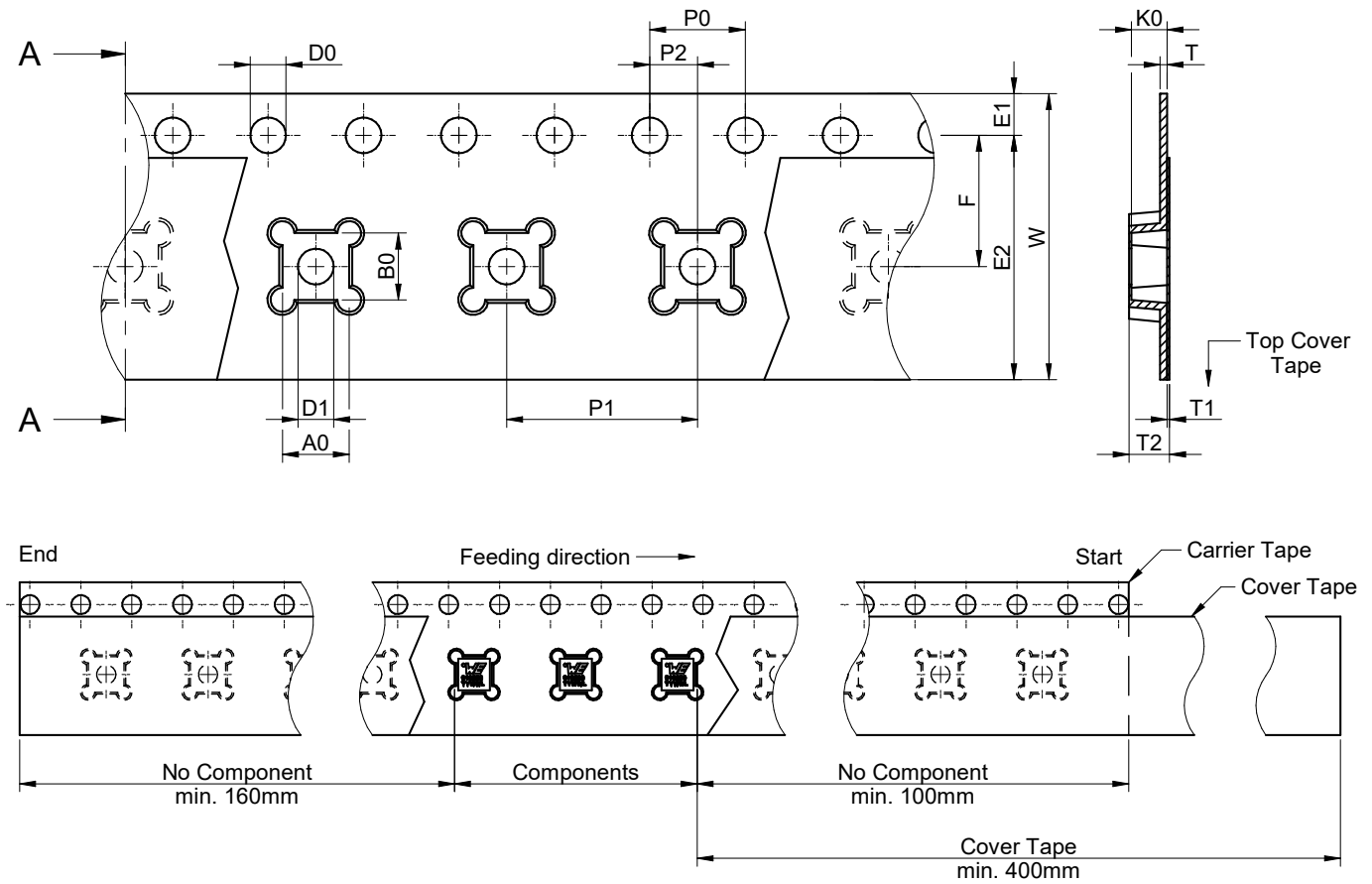
Figure 29: 171010550 Tape Dimensions

Table 15: Tape dimensions.

Tape Type	A0	B0	W	T	T1	K0	P0	P1	P2	D0	D1	E1	E2	F
	±0.1	±0.1	±0.3	±0.05		±0.1	±0.1	±0.1	±0.05	Max.	Min.	±0.1	Min.	±0.05
2a	2.8	2.8	12	0.3	0.1	1.5	4	8	2	1.5	1.5	1.75	10.25	5.5

Tape material is polystyrene.

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22   DOCUMENT HISTORY

Table 16: Document history.

Revision	Date	Description	Comment
1.0	July 2019	Initial data sheet release	
2.0	November 2021	PCN	Würth Elektronik has defined the maximum allowable output capacitance that can be used at the output of the power module. 1. The minimum and maximum storage temperature. 2. The junction to ambient thermal resistance. 3. The layout recommendation to improve readability and recommended practices. 4. The solder handling instructions (no change to actual profile). 5. The package information. 6. The evaluation board bill of material to reflect the evaluation board. 7. The cautions and warnings of the data sheet. 8. The format of the data sheet to improve readability of the document.
2.1	March 2022	Minor formatting change	Changed output voltage and feedback resistor table format in Step 1 of the Design Flow section.
3.0	May 2022	PCN	1. The maximum absolute rating maximum limit for VOUT, EN, FB and MODE. 2. The parameter description for the MODE absolute maximum rating. 3. The quiescent current values in the electrical specifications. 4. The date for the release of version 2.0 in the document history.
4.0	September 2024	PCN	Würth Elektronik has updated or corrected: 1. Line and load regulation units. 2. Input current values. 3. Modes of operation. 4. Overcurrent graph. 5. Handling recommendations. 6. Block diagram. 7. Vapor phase soldering instructions.

23   LIST OF FIGURES

24   LIST OF TABLES

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25 CAUTIONS AND WARNINGS

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

General:

- All recommendations according to the general technical specifications of the data-sheet have to be complied with.
- The usage and operation of the product within ambient conditions which probably alloy or harm the component surface has to be avoided.
- The responsibility for the applicability of customer specific products and use in a particular customer design is always within the authority of the customer. All technical specifications for standard products do also apply for customer specific products
- 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 could have a negative effect on the long term function of the product. Direct mechanical impact to the product shall be prevented as the material of the body, pins or termination could flake or in the worst case it could break. As these devices are sensitive to electrostatic discharge customer shall follow proper IC Handling Procedures.
- 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:

Follow all instructions mentioned in the datasheet, especially:

- The solder profile has to comply with the technical reflow or wave soldering specification, otherwise this will void the warranty.
- All products are supposed to be used before the end of the period of 12 months based on the product date-code.
- Violation of the technical product specifications such as exceeding the absolute maximum ratings will void the warranty.
- It is also recommended to return the body 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.

Disclaimer:

This electronic component has been designed and developed for usage in general electronic equipment only. This product is not authorized for use in equipment where a higher safety standard and reliability standard is especially required or where a failure of the product is reasonably expected to cause severe personal injury or death, unless the parties have executed an agreement specifically governing such use. Moreover Würth Elektronik eiSos GmbH & Co. KG products are neither designed nor intended for use in areas such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network etc. Würth Elektronik eiSos GmbH & Co. KG must be informed about the intent of such usage before the design-in stage. In addition, sufficient reliability evaluation checks for safety must be performed on every electronic component which is used in electrical circuits that require high safety and reliability functions or performance. 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.

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26   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.

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