MIC2800

Digital Power Management IC 2 MHz, 600 mA DC/DC with Dual 300 mA/300 mA Low V_{IN} LDOs

Features

- 2.7V to 5.5V Input Voltage Range
- 2 MHz DC/DC Converter and Two LDOs
- Integrated Power-on Reset (POR)
  - Adjustable POR Delay Time
- LOWQ Mode
  - 30 µA Total IQ when in LOWQ Mode
- DC/DC Converter
  - Up to 600 mA of Output Current in PWM Mode
  - LOWQ Mode: NO RIPPLE Light Load Mode
  - 75 μV_{RMS} Output Noise in LOWQ Mode
  - 2 MHz PWM Mode Operation
  - > 90% Efficiency
- LDO1 Input Voltage Directly Connected to DC/DC Converter Output Voltage for Maximum Efficiency
  - Ideal for 1.8V to 1.5V Conversion
  - 300 mA Output Current from 1.8V Input
  - Output Voltage Down to 0.8V
- LDO2 – 300 mA Output Current Capable
- Thermal Shutdown Protection
- Current Limit Protection
- Simple, Leakage-Free Interfacing to Host MPU in Applications with Backup Power
- Tiny 16-Pin 3mm x 3mm QFN Package

Applications

- Embedded MPU and MCU Power
- Portable and Wearable Applications
- Low-Power RF Systems
- Backup Power Systems

General Description

The MIC2800 is a high-performance power management IC, featuring three output voltages with maximum efficiency. Integrating a 2 MHz DC/DC converter with an LDO post-regulator, the MIC2800 gives two high-efficiency outputs with a second, 300 mA LDO for maximum flexibility. The MIC2800 features a LOWQ mode, reducing the total current draw while in this mode to less than 30 µA. In LOWQ mode, the output noise of the DC/DC converter is reduced to 75 μV_{RMS}, significantly lower than other converters that use a PFM light load mode that can interfere with sensitive RF circuitry.

The DC/DC converter uses small values of L and C to reduce board space but still retains efficiencies over 90% at load currents up to 600 mA.

The MIC2800 operates with very small ceramic output capacitors and inductors for stability, reducing required board space and component cost and it is available in various output voltage options in the 16-pin 3mm x 3mm QFN leadless package.

Package Type

MIC2800
16-PIN 3mm x 3mm QFN

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Typical Application Circuit (simplified)

Functional Diagram

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1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) ..... –0.3 to +6.0V
Enable Input Voltage ($V_{EN1, EN2}$) ..... –0.3V to +(V_{IN}+0.3V)
$\overline{LOWQ}$, POR ..... –0.3V to +6.0V
Power Dissipation (Note 1) ..... Internally Limited
Lead Temperature (soldering, 10 sec.) ..... +260°C
Storage Temperature (T_S) ..... –65°C to +150°C
ESD Rating (Note 2) ..... 2 kV

Operating Ratings ‡

Supply Voltage (V_{IN}) ..... +2.7V to +5.5V
Enable Input Voltage ($V_{EN1, EN2}$) ..... 0V to +V_{IN}
$\overline{LOWQ}$, POR ..... 0V to +5.5V
Junction Temperature (T_J) ..... –40°C to +125°C
Junction Thermal Resistance QFN-16 (θ_{JA}) ..... +45°C/W

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ **Notice:** The device is not guaranteed to function outside its operating ratings.

1: The maximum allowable power dissipation of any T_A (ambient temperature) is $P_{D(max)} = (T_{J(max)} – T_A) / \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.

2: Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5 kΩ in series with 100 pF.

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TABLE 1-1: ELECTRICAL CHARACTERISTICS (Note 1)

Electrical Characteristics: V_{IN} = EN1 = EN2 = $\overline{LOWQ}$ = VOUT (Note 2) + 1V; $C_{OUTDC/DC}$ = 2.2 µF, C_{OUT1} = C_{OUT2} = 2.2 µF; $I_{OUTDC/DC}$ = 100 mA;
$I_{OUTLDO1}$ = $I_{OUTLDO2}$ = 100 µA; T_J = 25°C, **bold** values indicate –40°C ≤ TJ ≤ +125°C; unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
UVLO Threshold	$UVLO_{TH}$	**2.45**	2.55	**2.65**	V	Rising input voltage during turn on
UVLO Hysteresis	$UVLO_{HYS}$	—	100	—	mV	
Ground Pin Current	I_{GND}	—	800 55	1100 85 **95**	µA	V_{FB} = GND (not switching); LDO2 Only (EN1 = LOW)
Ground Pin Current in Shutdown	I_{GND_SHDN}	—	0.2	5	µA	All EN = 0V
Ground Pin Current (LOWQ mode)	I_{GND_LOWQ}	—	30 20	60 **80** **70**	µA µA µA	All channels ON, $I_{DC/DC}$ = I_{LDO1} = I_{LDO2} = 0 mA DC/DC and LDO1 OFF; IL_{DO2} = 0 mA
Overtemperature Shutdown	T_{SD}	—	160	—	°C	
Overtemperature Shutdown Hysteresis	T_{SDHYS}	—	23	—	°C	
Enable Inputs (EN1; EN2; /LOWQ)						
Enable Input Voltage Logic Low	V_{IH}	—	—	**0.2**	V	
Enable Input Voltage Logic High	V_{IL}	**1.0**	—	—	V	
Enable Input Current	I_{ENLK}	—	0.1	**1**	µA	V_{IL} ≤ 0.2V
		—	0.1	**1**	µA	V_{IH} ≥1.0V
Turn-on Time						
Turn-on Time (LDO1 and LDO2)	$t_{TURN-ON}$	—	240 120	**500** **350**	µs	EN2 = V_{IN} EN1 = V_{IN}
Turn-on Time (DC/DC)	$t_{TURN-ON}$	—	83	**350**	µs	EN2 = V_{IN}; I_{LOAD} = 300 mA; C_{BYP} = 0.1 µF
POR Output						
POR Threshold Voltage, Failing	V_{THLOW_POR}	90	91	—	%	Low Threshold, % of nominal ($V_{DC/DC}$ or V_{LDO1} or V_{LDO2}) (Flag ON)
POR Threshold Voltage, Rising	V_{THIGH_POR}	—	96	99	%	High Threshold, % of nominal ($V_{DC/DC}$ AND V_{LDO1} AND V_{LDO2}) (Flag OFF)
VOL	VOL_{POR}	—	10	**100**	mV	POR Output Logic Low Voltage; IL = 250 µA
IPOR	$ILEAK_{POR}$	—	0.01	**1**	µA	Flag Leakage Current, Flag OFF
CSET INPUT						
CSET Pin Current Source	I_{CSET}	0.75	1.25	1.75	µA	V_{CSET} = 0V
CSET Pin Threshold Voltage	VTH_{CSET}	—	1.25	—	V	POR = High

Note 1: Specification for packaged product only.
2: V_{OUT} denotes the highest of the three output voltage.

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TABLE 1-2: ELECTRICAL CHARACTERISTICS - DC/DC CONVERTER

Electrical Characteristics: $V_{IN} = V_{OUTDC/DC} + 1V$; EN1 = V_{IN}; EN2 = GND; $I_{OUTDC/DC}$ = 100 mA; L = 2.2 µH; $C_{OUTDC/DC}$ = 2.2 µF; T_J = 25°C, **bold** values indicate –40°C to + 125°C; unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
LOWQ = High (Full Power Mode)						
Output Voltage Accuracy	V_{OUT}	–2 **–3**	—	+2 **+3**	%	Fixed Output Voltages
Current Limit in PWM Mode	I_{LIM}	0.75	1	1.6	A	$V_{OUT} = 0.9*V_{NOM}$
FB pin voltage (ADJ only)	V_{FB}	—	800	—	mV	
FB pin input current (ADJ only)	I_{FB}	—	1	5	nA	
Output Voltage Line Regulation	$(\Delta V_{OUT}/V_{OUT})/\Delta V_{IN}$	—	0.2	—	%/V	V_{OUT} > 2.4V; $V_{IN} = V_{OUT}$ + 300 mV to 5.5V, I_{LOAD}= 100 mA V_{OUT} < 2.4V; V_{IN} = 2.7V to 5.5V, I_{LOAD}= 100 mA
Output Voltage Load Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.2	1.5	%	20 mA < I_{LOAD} < 300 mA
Maximum Duty Cycle	DC_{MAX}	100	—	—	%	$V_{FB} \leq 0.4V$
High-Side Switch ON-Resistance		—	0.6	—	Ω	I_{SW} = 150 mA $V_{FB} = 0.7_{VFB_NOM}$
Low-Side Switch ON-Resistance			0.8			I_{SW} = -150 mA $V_{FB} = 1.1_{VFB_NOM}$
Oscillator Frequency	f_{osc}	**1.8**	2	**2.2**	MHz	
Output Voltage Noise	V_N	—	60	—	μV_{RMS}	C_{OUT} = 2.2 µF; C_{BYP} = 0.1 µF; 10 Hz to 100 KHz
LOWQ = Low (Light Load Mode)						
Output Voltage Accuracy	V_{OUT}	–2.0	—	+2.0	%	Variation from nominal V_{OUT}
		–3.0		**+3.0**		Variation from nominal V_{OUT}; –40°C to +125°C
Output Voltage Temp. Coefficient	TC_{VOUT}	—	40	—	ppm/C	
Line Regulation	$(\Delta V_{OUT}/V_{OUT})/\Delta V_{IN}$	—	0.02	0.3 **0.6**	%/V	$V_{IN} = V_{OUT}$ + 1V to 5.5V; I_{OUT} = 100 µA
Load Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.2	1.5	%	I_{OUT} = 100 µA to 50 mA
Ripple Rejection	PSRR	—	50 30	—	dB	f = up to 1 kHz; C_{OUT} = 2.2 µF; C_{BYP} = 0.1 µF f = 20 kHz; C_{OUT} = 2.2 µF; C_{BYP} = 0.1 µF
Current Limit	I_{LIM_LOWQ}	80	120	190	mA	V_{OUT} = 0V

TABLE 1-3: ELECTRICAL CHARACTERISTICS - LDO 1

Electrical Characteristics: $V_{IN} = V_{OUTDC/DC}$; EN1 = V_{IN}; EN2 = GND; C_{OUT1} = 2.2 µF, I_{OUT1} = 100 µA; T_J = 25°C, **bold** values indicate –40°C≤ T_J ≤ +125°C; unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
LOWQ = High (Full Power Mode)						
Output Voltage Accuracy	V_{OUT}	–2.0	—	+2.0	%	Variation from nominal V_{OUT}
		–3.0		**+3.0**		Variation from nominal V_{OUT}; –40°C to +125°C
Output Current Capability	I_{OUT}	300 120	—	—	mA	V_{IN} ≥ 1.8V V_{IN} ≥ 1.5V
Load Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.17 0.3	1.5	%	I_{OUT} = 100 µA to 150 mA I_{OUT} = 100 µA to 300 mA
Current Limit	I_{LIM}	350	500	700	mA	V_{OUT} = 0V
Ripple Rejection	PSRR		70 44	—	dB	f = up to 1 kHz; C_{OUT} = 2.2 µF; C_{BYP} = 0.1 µF f = 20 kHz; C_{OUT} = 2.2 µF; C_{BYP} = 0.1 µF
Output Voltage Noise	V_N	—	30	—	μV_{RMS}	C_{OUT} = 2.2 µF; C_{BYP} = 0.1 µF; 10 Hz to 100 KHz
LOWQ = Low (Light Load Mode)						
Output Voltage Accuracy	V_{OUT}	–3.0	—	+3.0	%	Variation from nominal V_{OUT}
		–4.0		**+4.0**		Variation from nominal V_{OUT}; –40°C to +125°C
Load Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.2	0.5 **1.0**	%	I_{OUT} = 100 µA to 10 mA
Current Limit	I_{LIM}	50	85	125	mA	V_{OUT} = 0V
Ripple Rejection	PSRR	—	70 42	—	dB	f = up to 1 kHz; C_{OUT} = 2.2 µF; C_{BYP} = 0.1 µF f = 20 kHz; C_{OUT} = 2.2 µF; C_{BYP} = 0.1 µF

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TABLE 1-4: ELECTRICAL CHARACTERISTICS - LDO2

Electrical Characteristics: $V_{IN} = V_{OUTLDO2} + 1.0V$; EN1 = GND; EN2 = V_{IN}; $C_{OUT2} = 2.2\ \mu F$; $I_{OUTLDO2} = 100\ \mu A$; $T_J = 25°C$, **bold** values indicate–40°C≤ T_J ≤ +125°C; unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
LOWQ = High (Full Power Mode)						
Output Voltage Accuracy	V_{OUT}	–2.0	—	+2.0	%	Variation from nominal V_{OUT}
		–3.0		**+3.0**		Variation from nominal V_{OUT}; –40°C to +125°C
Line Regulation	$(\Delta V_{OUT}/V_{OUT})/\Delta V_{IN}$	—	0.02	0.3 **0.6**	%/V	$V_{IN} = V_{OUT}$ +1V to 5.5V; $I_{OUT} = 100\ \mu A$
Load Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.20 0.25 0.40	 **1.5**	%	$I_{OUT} = 100\ \mu A$ to 150 mA $I_{OUT} = 100\ \mu A$ to 200 mA $I_{OUT} = 100\ \mu A$ to 300 mA
Dropout Voltage	V_{DO}	—	70 94 142	 **300**	mV	I_{OUT} = 150 mA; $V_{OUTLDO2}$ >= 2.7V I_{OUT} = 200 mA; $V_{OUTLDO2}$ >= 2.7V I_{OUT} = 300 mA; $V_{OUTLDO2}$ >= 2.7V
Ripple Rejection	PSRR	—	75	—	dB	f = up to 1 kHz; $C_{OUT} = 2.2\ \mu F$; $C_{BYP} = 0.1\ \mu F$
			40			f = 20 kHz; $C_{OUT} = 2.2\ \mu F$; $C_{BYP} = 0.1\ \mu F$
Current Limit	I_{LIM}	400	550	850	mA	$V_{OUT} = 0V$
Output Voltage Noise	V_N	—	25	—	μV_{RMS}	$C_{OUT} = 2.2\ \mu F$; $C_{BYP} = 0.1\ \mu F$; 10 Hz to 100 KHz
LOWQ = Low (Light Load Mode)						
Output Voltage Accuracy	V_{OUT}	–3.0	—	+3.0	%	Variation from nominal V_{OUT}
		–4.0		**+4.0**		Variation from nominal V_{OUT}; –40°C to +125°C
Line Regulation	$(\Delta V_{OUT}/V_{OUT})/\Delta V_{IN}$	—	0.02	0.3 **0.6**	%/V	$V_{IN} = V_{OUT}$ +1V to 5.5V
Load Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.2	**1.0**	%	$I_{OUT} = 100\ \mu A$ to 10 mA
Dropout Voltage	V_{DO}	—	22	35 **50**	mV	I_{OUT} = 10 mA; $V_{OUTLDO2}$ >= 2.7V
Ripple Rejection	PSRR	—	75 55	—	dB	f = up to 1 kHz; $C_{OUT} = 2.2\ \mu F$; $C_{BYP} = 0.1\ \mu F$ f = 20 kHz; $C_{OUT} = 2.2\ \mu F$; $C_{BYP} = 0.1\ \mu F$
Current Limit	I_{LIM}	50	85	125	mA	$V_{IN} = 2.7V$; $V_{OUT} = 0V$

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TABLE 1-5: TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Storage Temperature Range	T_S	–65	—	+150	°C	
Lead Temperature	—	—	—	+260	°C	Soldering, 10 sec.
Junction Temperature	T_J	–40	—	+125	°C	
Package Thermal Resistance						
16-Ld QFN	θ_{JA}	—	45	—	°C/W	

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.

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2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

FIGURE 2-1: *DC/DC 1.87V_{OUT} Efficiency.*

FIGURE 2-2: *DC/DC 1.8V_{OUT} Efficiency.*

FIGURE 2-3: *DC/DC Current Limit vs. Temperature.*

FIGURE 2-4: *DC/DC Enable Threshold vs. Supply Voltage.*

FIGURE 2-5: *DC/DC Turn-on Delay vs. Supply Voltage.*

FIGURE 2-6: *DC/DC LowQ Mode Power Supply Rejection Ratio vs. Input Voltage.*

FIGURE 2-7: *DC/DC LowQ Mode Power Supply Rejection Ratio vs. Output Current.*

FIGURE 2-8: *DC/DC LowQ Mode LDO Current Limit vs. Supply Voltage.*

FIGURE 2-9: *DC/DC LowQ Mode LDO Output Voltage vs. Output Current.*

FIGURE 2-10: *DC/DC LowQ Mode LDO Output Noise Spectral Density.*

FIGURE 2-11: *Power Supply Rejection Ratio (LDO1 LowQ Mode).*

FIGURE 2-12: *Power Supply Rejection Ratio (LDO1 Normal Mode).*

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FIGURE 2-13: *Power Supply Rejection Ratio (LDO2 LowQ Mode).*

FIGURE 2-14: *Power Supply Rejection Ratio (LDO2 Normal Mode).*

FIGURE 2-15: *LDO2 Output Voltage vs. Temperature.*

FIGURE 2-16: *Ground Current vs. Temperature.*

FIGURE 2-17: *Ground Current vs. Output Current.*

FIGURE 2-18: *LDO2 Dropout Voltage vs. Output Current.*

FIGURE 2-19: *LDO 2 Dropout Voltage vs. Temperature.*

FIGURE 2-20: *Dropout Characteristics.*

FIGURE 2-21: *LDO1 Output Noise Spectral Density.*

FIGURE 2-22: *LDO2 Output Noise Spectral Density.*

FIGURE 2-23: *DC/DC Load Transient PWM Mode.*

FIGURE 2-24: *DC/DC Line Transient PWM Mode.*

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FIGURE 2-25: *Enable Transient PWM Mode.*

FIGURE 2-26: *DC/DC Load Transient LowQ Mode.*

FIGURE 2-27: *DC/DC Line Transient LowQ Mode.*

FIGURE 2-28: *Enable Transient LowQ Mode.*

FIGURE 2-29: *LDO2 Load Transient Normal Mode.*

FIGURE 2-30: *LDO Load Transient LowQ Mode.*

FIGURE 2-31: *LDO2 Line Transient Normal Mode.*

FIGURE 2-32: *LDO2 Line Transient LowQ Mode.*

FIGURE 2-33: *DC/DC LowQ Mode to PWM Mode Transition.*

FIGURE 2-34: *DC/DC PWM Mode to LowQ Mode Transition.*

FIGURE 2-35: *DC/DC PWM Waveform.*

FIGURE 2-36: *POR Behavior, EN1 = High, Low-to-High Transition on EN2.*

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FIGURE 2-37: *POR Behavior, EN2 = High, Low-to-High Transition on EN1.*

FIGURE 2-38: *C_{SET} Pin Voltage and POR Delay Time Behavior for Correct Sequencing.*

FIGURE 2-39: *ESR vs. Load - LDO.*

FIGURE 2-40: *ESR vs. Load - LDO1.*

FIGURE 2-41: *ESR vs. Load - LDO2.*

NOTES:

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3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number 16-Pin QFN	Pin Name	Description
1	$\overline{LOWQ}$	LOWQ Mode. Active Low Input. Logic High = Full Power Mode; Logic Low = LOWQ Mode; Do not leave floating.
2	BIAS	Internal circuit bias supply. It must be decoupled to signal ground with a 0.1 µF capacitor and should not be loaded.
3	SGND	Signal ground
4	PGND	Power ground
5	SW	Switch (Output): Internal power MOSFET output switches.
6	V_{IN}	Supply Input – DC/DC. Must be tied to PIN7 externally.
7	V_{IN}	Supply Input – LDO2. Must be tied to PIN6 externally.
8	LDO2	Output of LDO regulator 2.
9	FB	Feedback. Input to the error amplifier for DC/DC converter. For fixed output voltages connect directly to V_{OUT} and an internal resistor network sets the output voltage.
10	LDO	LDO Output: Connect to V_{OUT} of the DC/DC for LOWQ mode operation.
11	LDO1	Output of LDO regulator 1.
12	POR	Power-on Reset Output: Open-drain output. Active low indicates an output undervoltage condition on either one of the three regulated outputs.
13	C_{SET}	Delay Set Input: connect external capacitor to GND to set the internal delay for the POR output. When left open, there is a minimum delay. This pin cannot be grounded.
14	C_{BYP}	Reference Bypass: connect external 0.1 µF to GND to reduce output noise. May be left open.
15	EN1	Enable Input (DC/DC and LDO1). Active High Input. Logic high = On; Logic low = Off; do not leave floating.
16	EN2	Enable Input (LDO 2). Active High Input. Logic high = On; Logic low = Off; do not leave floating.

3.1 $\overline{LOWQ}$

The $\overline{LOWQ}$ pin provides a logic level control between the internal PWM mode and the low noise linear regulator mode. With $\overline{LOWQ}$ pulled low (<0.2V), quiescent current of the device is greatly reduced by switching to a low noise linear regulator mode that has a typical IQ of 20 µA (LDO2 ON only). In LowQ mode the LDO output can deliver 60 mA of current to the output. By placing $\overline{LOWQ}$ high (>1V), the device transitions into a constant frequency PWM buck regulator mode. This allows the device the ability to efficiently deliver up to 600 mA of output current at the same output voltage, and to support load transients generated by processor activity.

LOWQ mode also limits the output load of both LDO1 and LDO2 to 10 mA.

The ESD protection of the $\overline{LOWQ}$ pin is free from clamping diodes to the input supply rails, therefore the $\overline{LOWQ}$ signal can be driven by host I/Os under backup power domains without the risk of parasitic leakage, even if the main power to the MIC2800 is removed.

3.2 BIAS

The BIAS pin supplies the power to the internal control and reference circuitry. The bias is powered from AVIN through an internal 6Ω resistor. A small 0.1 µF ceramic capacitor is required for bypassing.

3.3 SGND

Signal ground (SGND) is the ground path for the biasing and control circuitry. The current loop for the signal ground should be as small as possible.

3.4 PGND

Power ground (PGND) is the ground path for the high current PWM mode. The current loop for the power ground should be as small as possible.

3.5 SW

The switch (SW) pin is the common connection between the internal power MOSFETs and connects directly to the inductor. Due to the high-speed switching on this pin, the switch node should be routed away from sensitive nodes.

3.6 V_{IN}

Two input voltage pins provide power to the switch mode DC/DC and LDO2 separately. The LDO1 input voltage is provided by the DC/DC LDO pin. VIN provides power to the LDO section and the bias through an internal 6Ω resistor. Both V_{IN} pins must be tied together.

For the switch mode DC/DC regulator, VIN provides power to the MOSFET along with current limiting sensing. Due to the high switching speeds, a 4.7 µF minimum ceramic capacitor is recommended close to VIN and the power ground (PGND) pin for bypassing.

3.7 LDO2

Regulated output voltage of LDO2. Power is provided by VIN. The minimum recommended output capacitance is 2.2 µF ceramic.

3.8 FB

Connect the feedback pin to V_{OUT} for fixed output voltage versions. For adjustable output version, an external resistor divider is used to program the output voltage.

3.9 LDO

The LDO pin is the output of the LOWQ mode linear regulator and should be connected to the output of the DC/DC converter. In LOWQ mode ($\overline{LOWQ}$ < 0.2V), the LDO supplies the output current and supports the output voltage in place of the DC/DC stage. In PWM mode ($\overline{LOWQ}$ > 1V) the LDO pin provides power to LDO1.

3.10 LDO1

Regulated output voltage of LDO1. Input power is provided by the DC/DC switching regulator. The minimum recommended output capacitance is 2.2 µF ceramic.

3.11 Power-on Reset (POR)

The Power-on Reset (POR) output is an open-drain N-channel device, requiring a pull-up resistor to either the input voltage or output voltages for proper voltage levels. The POR output has a delay time that is programmable with a capacitor from the C_{SET} pin to ground. The delay time can be programmed to be as long as 1 second.

In steady-state conditions, the POR output is high if at least one channel (LDO2 and DC-DC, LDO1) is enabled and has reached regulation. This is equivalent to performing a logic OR operation on the status of the output voltages.

If any of the outputs is subsequently pulled out of regulation (e.g., due to a momentary overload), the POR signal goes low and it remains low as long as the affected output is out of regulation. If the affected output returns in regulation, POR is asserted high after the delay time programmed with the capacitor at the C_{SET} pin.

The ESD protection of the POR pin is free from clamping diodes to the input supply rails. Therefore, the POR signal can be asserted to host I/Os under backup power domains or pulled up to backup power sources without the risk of parasitic leakage, even if the main power to the MIC2800 is removed.

3.12 C_{SET}

The C_{SET} pin is a current source output that charges a capacitor that sets the delay time for the Power-on Reset output from low-to-high. The delay for POR high-to-low (detecting an undervoltage on any of the outputs) is always minimal. The current source of 1.25 µA charges a capacitor up from 0V. When the capacitor reaches 1.25V, the output of the POR is allowed to go high. The delay time in microseconds is equal to the C_{SET} capacitor value in picofarads.

EQUATION 3-1:

$$PORDelay(\mu s) = C_{SET}(pF)$$

3.13 C_{BYP}

The internal reference voltage can be bypassed with a capacitor to ground to reduce output noise and increase power supply rejection (PSRR). A quick-start feature allows for quick turn on of the output voltage. The recommended nominal bypass capacitor is 0.1 µF, but it can be increased, which will also result in an increase to the start-up time.

3.14 EN1, EN2

Both enable inputs are active high, requiring 1.0V for guaranteed logic HIGH level detection (V_{IH}=1.0V MIN). EN1 provides logic control of both the DC/DC regulator and LDO1. EN2 provides logic control for LDO2 only. The enable inputs are CMOS logic and cannot be left floating.

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The enable pins provide logic level control of the specified outputs. When both enable pins are in the OFF state, supply current of the device is greatly reduced (typically < 1 µA). When the DC/DC regulator is in the OFF state, the output drive is placed in a “tri-stated” condition, where both the high side P-channel MOSFET and the low-side N-channel are in an OFF or nonconducting state. Do not drive either of the enable pins above the supply voltage.

4.0 APPLICATION INFORMATION

The MIC2800 is a digital power management IC with a single integrated buck regulator and two low dropout regulators. LDO1 is a 300 mA low dropout regulator that uses power supplied by the onboard buck regulator. LDO2 is a 300 mA low dropout regulator using the supply from the input pin. The buck regulator is a 600 mA PWM power supply that utilizes a LOWQ light load mode to maximize battery efficiency in light load conditions. This is achieved with a $\overline{\text{LOWQ}}$ control pin that, when pulled low, shuts down all the biasing and drive current for the PWM regulator, drawing only 20 µA of operating current. This allows the output to be regulated through the LDO output, capable of providing 60 mA of output current. This method has the advantage of producing a clean, low-current, ultra-low-noise output in LOWQ mode. During LOWQ mode, the SW node becomes high-impedance, blocking current flow. Other methods of reducing quiescent current, such as Pulse Frequency Modulation (PFM) or bursting techniques may create large-amplitude, low-frequency ripple voltages that can be detrimental to system operation.

When more than 60 mA is required, the $\overline{\text{LOWQ}}$ pin can be forced high, causing the MIC2800 to enter in PWM mode. In this case, the LDO output makes a “hand-off” to the PWM regulator with virtually no variation in output voltage. The LDO output then turns off, allowing up to 600 mA of current to be efficiently supplied through the PWM output to the load.

4.1 Output Capacitor

LDO1 and LDO2 outputs require at least a 2.2 µF ceramic output capacitor for stability. The DC/DC switch mode regulator requires at least a 2.2 µF ceramic output capacitor to be stable. All output capacitor values can be increased to improve transient response. X7R/X5R dielectric type ceramic capacitors are recommended because of their temperature performance. X7R-type capacitors change capacitance by 15% over their operating temperature range and are the most stable type of ceramic capacitors. Z5U and Y5V dielectric capacitors change value by as much as 50% to 60% respectively over their operating temperature ranges and are therefore not recommended.

4.2 Input Capacitor

A minimum 1 µF ceramic is recommended on the V_{IN} pin for bypassing. X5R or X7R dielectrics are recommended for the input capacitor. Y5V dielectrics lose most of their capacitance over temperature and are therefore, not recommended. A minimum 1 µF is recommended close to the V_{IN} and PGND pins for high frequency filtering. Smaller-case-size capacitors are recommended due to their lower ESR and ESL. The value of the input capacitor can be increased as needed to better suppress the input ripple generated by the DC/DC converter.

4.3 Inductor Selection

The MIC2800 is designed for use with a 2.2 µH inductor. Proper selection should ensure the inductor can handle the maximum average and peak currents required by the load. Maximum current ratings of the inductor are generally given in two methods; permissible DC current and saturation current. Permissible DC current can be rated either for a 40°C temperature rise or a 10% to 20% loss in inductance. Ensure that the inductor selected can handle the maximum operating current. When saturation current is specified, make sure that there is enough margin that the peak current will not saturate the inductor. Peak inductor current can be calculated as follows:

EQUATION 4-1:

$$I_{PK} = I_{OUT} + \frac{V_{OUT}\left(1 - \frac{V_{OUT}}{V_{IN}}\right)}{2 \times f \times L}$$

4.4 POR Delay Time

The POR signal also goes low for the duration of the delay time given by Eq. 3.1 when only one of the enable inputs (EN1, EN2) transitions from low to high, with the other being already high and the corresponding output being in regulation. This is shown in Fig. 2-36 and Fig. 2-37. At the low-to-high transition of either enable input, the C_{SET} pin capacitor is discharged to ground, and the POR delay time is restarted.

At start-up, in order to prevent a momentary high glitch of the POR signal between the first and the second enable, it is recommended to set the POR delay time longer than the maximum delay expected between the enable signals plus the turn-on time $t_{TURN\text{-}ON}$.

For a given delay between the enable signals, an example of correct POR delay time design is shown in Fig. 2-38. It can be seen that the C_{SET} voltage is reset to ground by the latter low-to-high enable transition before it reaches the VTH_{CSET} voltage (1.25V TYP).

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NOTES:

5.0 PACKAGING INFORMATION

5.1 Package Marking Information

16-lead QFN

Part Number	Code
MIC2800-A4SYML-TR	YA4S
MIC2800-D24MYML-TR	YD24M
MIC2800-D2FMYML-TR	YD2FM
MIC2800-G2SYML-TR	YG2S
MIC2800-G4JYML-TR	YG4J
MIC2800-G4KYML-TR	YG4K
MIC2800-G4MYML-TR	YG4M
MIC2800-G4SYML-TR	YG4S
MIC2800-G7SYML-TR	YG7S
MIC2800-G1JJYML-TR	G1JJ
MIC2800-G1JSYML-TR	G1JS
MIC2800-GFMYML-TR	YGFM
MIC2800-GFSYML-TR	YGFS
MIC2800-G4SYML-TR	YG4S

Refer to the Product Identification System section for information on the output voltage for each device.

Example

Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.
	●, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).
Note:	In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo. Underbar (_) and/or Overbar (¯) symbol may not be to scale.	

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TITLE
16 LEAD QFN 3.0x3.0mm COL PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	CQFN33-16LD-PL-1	**UNIT**	MM
Lead Frame	NiPdAu	**Lead Finish**	NiPdAu

TOP VIEW

BOTTOM VIEW

SIDE VIEW

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS, ANGLES ARE IN DEGREES.
   N IS THE TOTAL NUMBER OF TERMINALS.
2. MAX PACKAGE WARPAGE IS 0.05mm, MAX ALLOWABLE BURRS IS 0.076 mm
   IN ALL DIRECTIONS.
3. PIN #1 ID ON TOP WILL BE LASER/INK MARKED.

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

POD-Land Pattern drawing #CQFN33-16LD-PL-1

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

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APPENDIX A: REVISION HISTORY

Revision A (October 2017)

Original Release of this Document.

NOTES:

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PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART NO.	–	XX	X	X	–	XX(1)
Device		Output Voltage	Temperature	Package		Tape and Reel Option

Device:	MIC2800:	Digital Power Management IC 2 MHz, 600 mA DC/DC with Dual 300 mA/300 mA Low VIN LDOs
Output Voltages: (DC/DC, LDO1, LDO2)	A4S =	Adjustable/1.2V/3.3V
	D24M=	1.87V/1.2V/2.8V
	D2FM=	1.87V/1.5V/2.8V
	G2S =	1.8V/1.05V/3.3V
	G4J =	1.8V/1.2V/2.5V
	G4K =	1.8V/1.2V/2.6V
	G4M=	1.8V/1.2V/2.8V
	G4S =	1.8V/1.2V/3.3V
	G7S =	1.8V/1.575V/3.3V
	G1JJ=	1.8V/1.25V/2.5V
	G1JS=	1.8V/1.25V/3.3V
	G4S =	1.8V/1.2V/3.3V
Temperature:	Y =	Pb-Free with Industrial Temperature Grade (–40°C to +125°C)
Package:	ML =	16-lead, 3x3 mm QFN, 0.85 mm thickness
Tape and Reel:	TR =	Tape and Reel

Examples:

a) MIC2800-A4SYML-TR: Digital Power Management IC 2 MHz, 600 mA DC/DC with Dual 300 mA/300 mA Low VIN LDOs, Adjustable/1.2V/3.3V Output Voltage, –40°C to +125°C, 16LD QFN Package, Tape and Reel

b) MIC2800-D24MYML-TR: Digital Power Management IC 2 MHz, 600 mA DC/DC with Dual 300 mA/300 mA Low VIN LDOs, 1.87V/1.2V/2.8V Output Voltage, –40°C to +125°C 16LD QFN Package, Tape and Reel

c) MIC2800-D2FMYML-TR: Digital Power Management IC 2 MHz, 600 mA DC/DC with Dual 300 mA/300 mA Low VIN LDOs, 1.87V/1.5V/2.8V Output Voltage, –40°C to +125°C 16LD QFN Package, Tape and Reel

d) MIC2800-G2SYML-TR: Digital Power Management IC 2 MHz, 600 mA DC/DC with Dual 300 mA/300 mA Low VIN LDOs, 1.8V/1.05V/3.3V Output Voltage, –40°C to +125°C 16LD QFN Package, Tape and Reel

e) MIC2800-G4JYML-TR: Digital Power Management IC 2 MHz, 600 mA DC/DC with Dual 300 mA/300 mA Low VIN LDOs, 1.8V/1.2V/2.5V Output Voltage, –40°C to +125°C 16LD QFN Package, Tape and Reel

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

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