2 to 4 Phase PWM Extender for Multiphase Synchronous Buck Converter

General Description

The uP1911R is a high precision sequence array, which is intended for operation phase number extension in multiphase synchronous-rectified buck converter. It consists of three individual sequence circuits to support up to 2 to 4 phase extension application. This part has 4 PWM outputs for external MOSFET drivers, and 4 ISEN inputs. With this phase extender, a 2-phase buck PWM controller is able to control a 4-phase synchronous buck regulator. This device has an internal LDO that regulates 12V input to a 5.2V output as the power supply of control logic. Designed with 12V CMOS process, the uP1911R provides high switching speed and low power dissipation. The uP1911R is available in WQFN3x3 - 16L package.

Ordering Information

Order Number	Package	Top Marking
uP1911RQDD	WQFN3x3 -16L	uP1911R

Note: uPI products are compatible with the current IPC/ JEDEC J-STD-020 requirement. They are halogen-free, RoHS compliant and 100% matte tin (Sn) plating that are suitable for use in SnPb or Pb-free soldering processes.

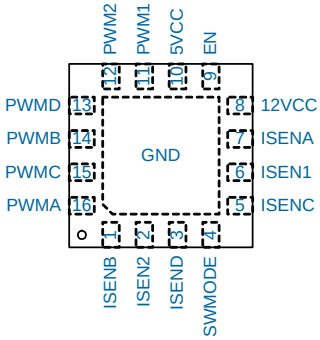
Features

- **5V/12V Supply Voltage**
- **Integrated 5.2V LDO Regulator for 12V Input**
- **Support 1 to 2, 2 to 4 Phase Extension**
- **Low Power Dissipation**
- **Low Charge Injection**
- **Near Zero Switching Time**
- **RoHS Compliant and Halogen Free**
- **WQFN3x3 - 16L Package**

Applications

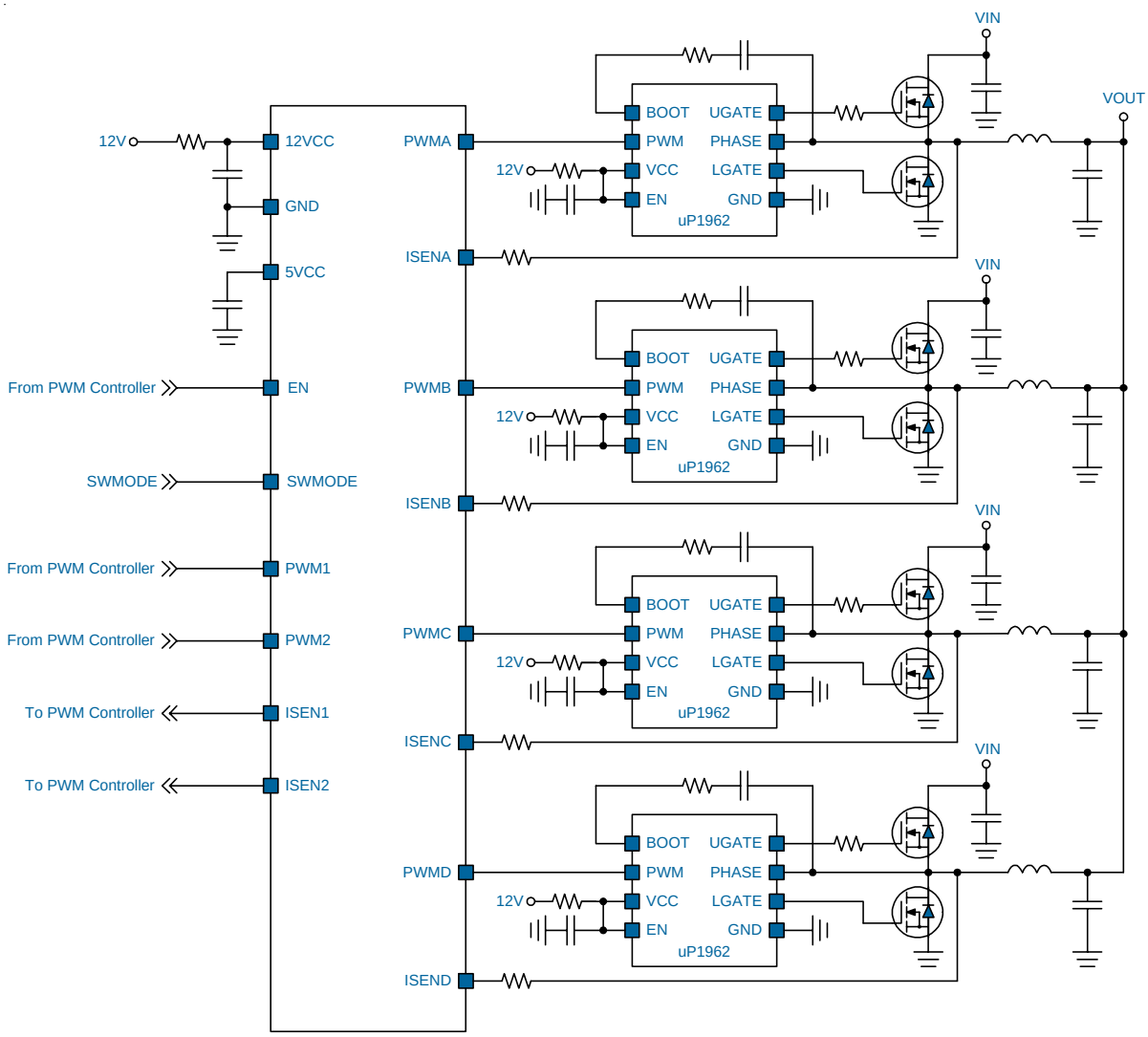
- **Desktop Computer**
- **Motherboards**

Pin Configuration



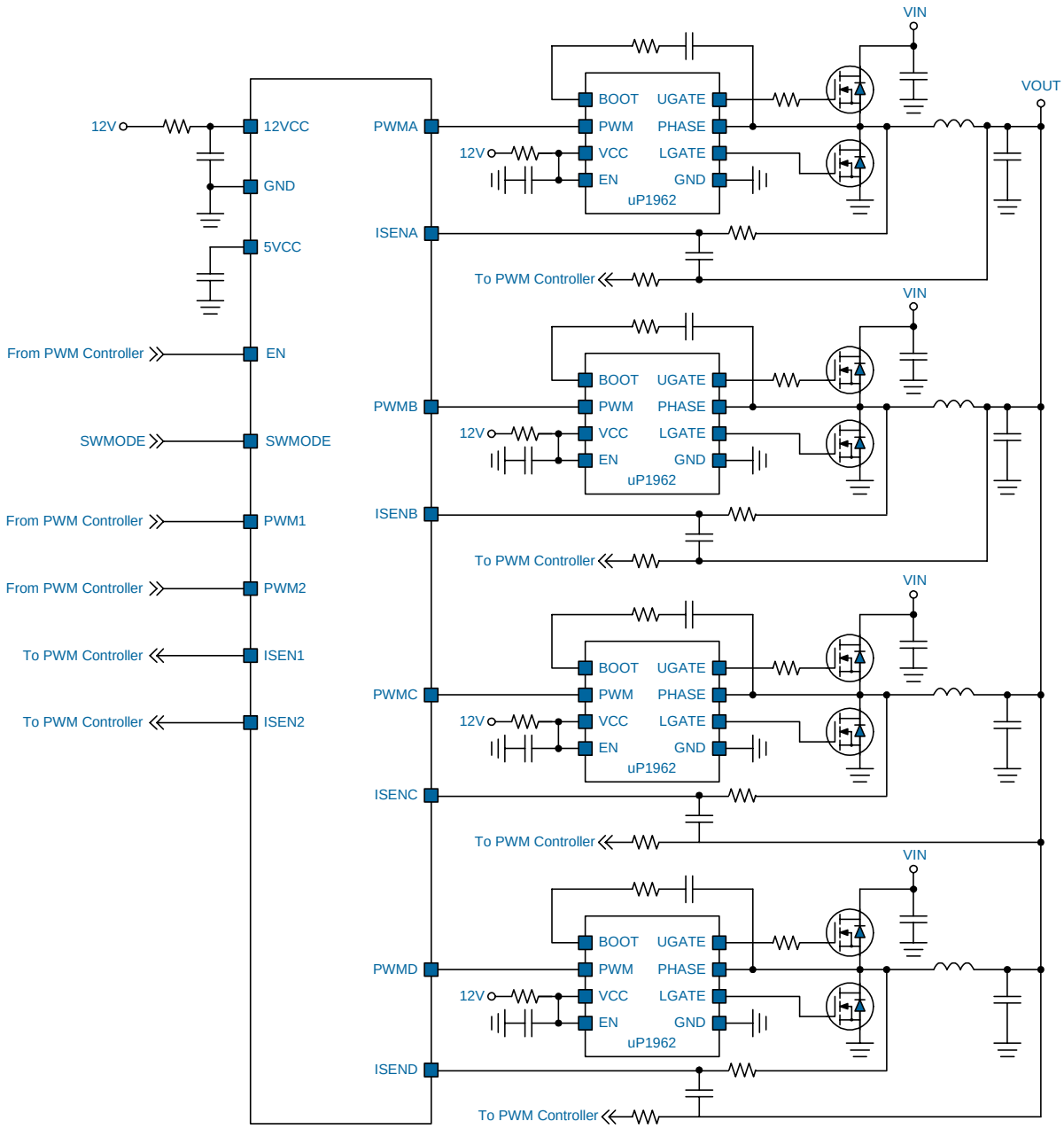
Typical Application Circuit

Low-Side MOSEFET Rds(on) Current Sense



Typical Application Circuit

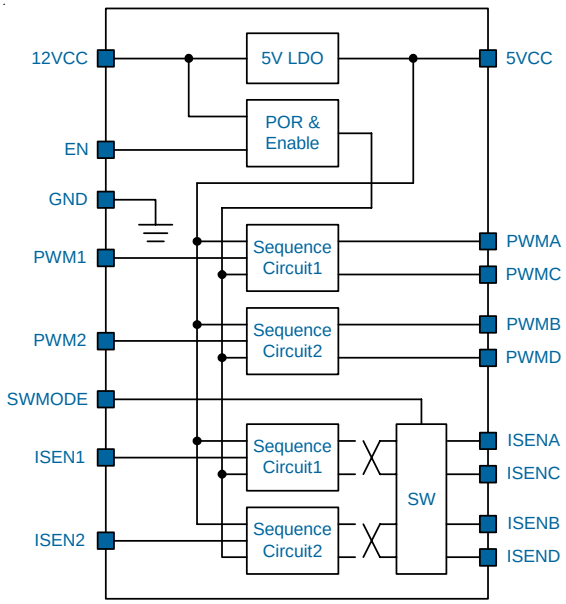
Inductor DCR Current Sense



Functional Pin Description

No.	Pin Name	Pin Function
1	ISENB	**ISENB Input.** Connect this pin to phase 2 switching node via a resistor.
2	ISEN2	**ISEN2 Output.** Connect this pin to PWM controller ISEN2 pin.
3	ISEND	**ISEND Input.** Connect this pin to phase 4 switching node via a resistor.
4	SWMODE	**SWMODE Input.** This pin controls the internal analog switch on-state connection timing of ISENA(B) or ISENC(D) to ISEN1(2). Connect this pin to GND at the default, and it can be connected to 5VCC for another switching timing. See ISEN Connection Sequence section for detail.
5	ISENC	**ISENC Input.** Connect this pin to phase 3 switching node via a resistor.
6	ISEN1	**ISEN1 Output.** Connect this pin to PWM controller ISEN1 pin.
7	ISENA	**ISENA Input.** Connect this pin to phase 1 switching node via a resistor.
8	12VCC	**12V Supply Voltage.** Connect a minimum of 1uF ceramic capacitor from this pin to ground.
9	EN	**PWM Output Disable.** This pin disables normal operation and forces all PWM outputs off when it is pulled low.
10	5VCC	**LDO Output Voltage.** This pin is the output of internal LDO that regulates 12VCC to a 5.2V output. Connect a minimum of 1uF ceramic capacitor from this pin to ground. For single 5V input operation, connect this pin together with 12VCC to 5V.
11	PWM1	**PWM1 Input.** Connect this pin to the PWM controller PWM1 output.
12	PWM2	**PWM2 Input.** Connect this pin to the PWM controller PWM2 output.
13	PWMD	**PWMD Output.** Connect this pin to the input of external MOSFET driver for phase 4.
14	PWMB	**PWMB Output.** Connect this pin to the input of external MOSFET driver for phase 2.
15	PWMC	**PWMC Output.** Connect this pin to the input of external MOSFET driver for phase 3**.**
16	PWMA	**PWMA Output.** Connect this pin to the input of external MOSFET driver for phase 1**.**
Exposed Pad		**Ground.** This pin is the signal ground of the IC. Tie this pin to the ground island/plane through the lowest impedance connection available.

Functional Block Diagram



Supply Voltage

The uP1911R works with a single 12V or 5V supply input voltage. Figure 1 and Figure 2 show the ways of being powered from 12V and 5V, respectively. For single 12V input operation, connect 12VCC to a 12V voltage source, and bypass this pin to ground with at least 1uF ceramic capacitor for noise decoupling. An internal LDO regulator regulates this 12V input to a 5.2V at 5VCC pin as the power for the whole chip. Connect 1uF ceramic capacitor from 5VCC to ground for noise decoupling. For single 5V input operation, connect both 12VCC and 5VCC to a 5V voltage source, and bypass 5VCC to ground with at least 1uF ceramic capacitor for noise decoupling. When the uP1911R is directly supplied from 5V, the internal LDO is inactive. The 12VCC voltage is monitored for power on reset (POR). If 12VCC voltage is higher than the POR rising threshold, the PWM outputs and ISEN sequence circuits will be enabled. The POR threshold has a hysteresis to avoid advertently shutdown.

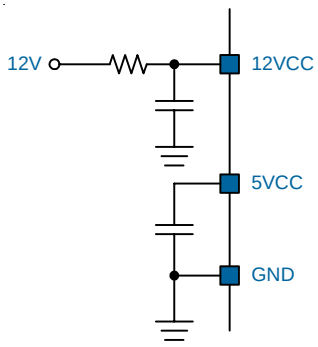


Figure 1. Single 12V Supply Input

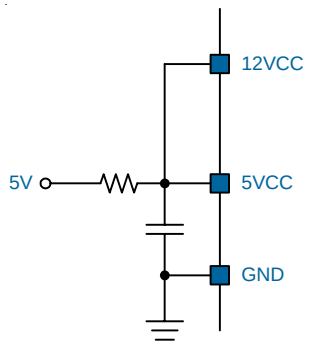


Figure 2. Single 5V Supply Input

PWM Output Sequence

The uP1911R has two individual sequence circuits to control the PWM input and output sequence. Figure 3 shows the sequence of PWM1, PWMA and PWMC. The PWM1 receives PWM signal from the voltage regulator (VR) controller and outputs the received signal to PWMA or PWMC in an alternating way. That is to say PWMA and PWMC output the received signal in turn. For 2-phase to 4-phase application, the uP1911R receives signals PWM[1,2] from VR controller and outputs them to PWM[A:D]. Therefore, the operation phase number is extended from 2 to 4, and the 2-phase PWM VR controller can be used in a 4-phase VR design. Figure 4 shows the 2-phase to 4-phase PWM extension.

For the PWM controller uses its PWM pin as a multi-function pin,a resistor will be connected from PWM pin to GND to set parameter. Note that this resistor must be greater than 15KΩ. Lower resistor value will cause incorrect PWM voltage level at the PWM pin when the PWM controller output is in tri-state (high-impedance state).

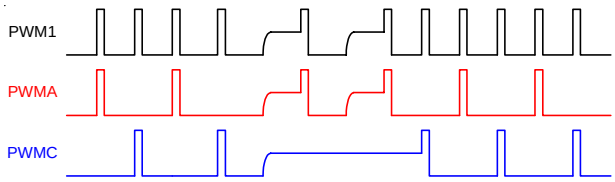


Figure 3. Sequence of PWM1, PWMA and PWMC

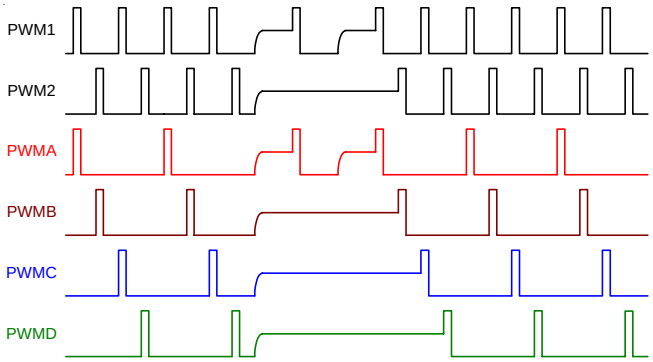


Figure 4. Sequence of PWM[1,2] and PWM[A:D]

Enable

Logic low of EN disables all PWM outpus off and tie the EN pin to controller.

ISEN Connection Sequence

The uP1911R provides two individual sequence circuits to control the ISEN connection sequence. The ISEN connection sequence is for LGATE sensing or DCR sensing. When SWMODE connects to GND, Figure 5 shows the sequence of PWM outputs and the ISEN connection states. The on-state of the connection betweenISEN1 and ISENA begins at the PWMC falling edge,and it ends at the next PWMA falling edge. The on-state of the connection between ISEN1 and ISENA allows switching node voltage signal passing from ISENA to ISEN1. The operational principle of ISEN1 to ISENC is similar as described above. The on-state of the connection between ISEN1 and ISENC begins at the PWMA falling edge, and it ends at the next PWMC falling edge.

When SWMODE connects to 5VCC, Figure 6 shows the sequence of PWM outputs and the ISEN connection states. The on-state of the connection between ISEN1 and ISENA begins at the PWMA falling edge,and it ends at the next PWMC falling edge. The on-state of the connection between ISEN1 and ISENA allows switching node voltage signal passing from ISENA to ISEN1. The operational principle of ISEN1 to ISENC is similar as described above. The on-state of the connection between ISEN1 and ISENC begins at the PWMC falling edge, and it ends at the next PWMA falling edge.

The connection between ISEN1 to ISENA and ISEN1 to ISENC changes in an alternating way. That is to say when ISEN1 to ISENA connection is ON, ISEN1 to ISENC connection is OFF, and vice versa.

There is a break-before-make delay time to ensure that ISENA and ISENC never connect to each other. ISEN2 and ISEN[B,D] works in a similar way.

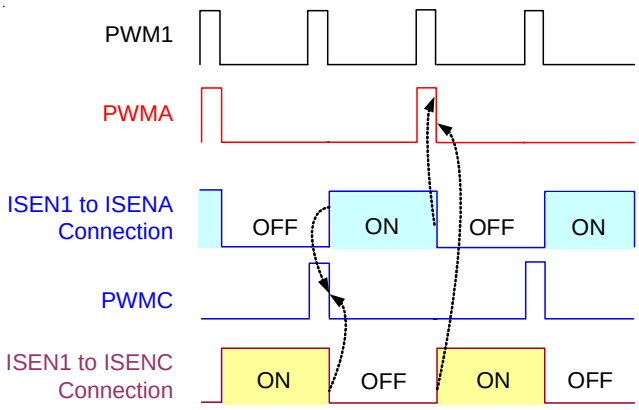


Figure 5. Sequence of PWM Outputs and ISEN Connection States

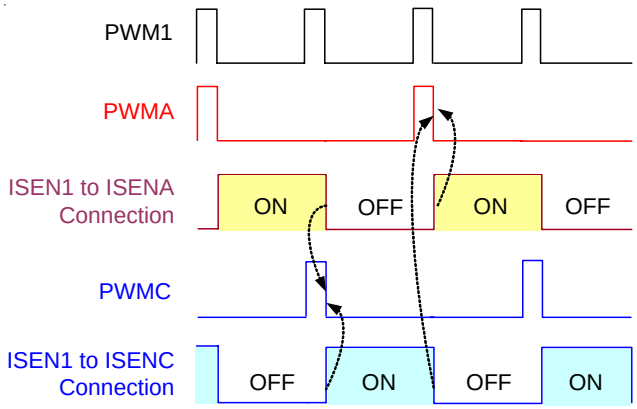


Figure 6. Sequence of PWM Outputs and ISEN Connection States

Absolute Maximum Rating

(Note 1)

Supply Input Voltage 12VCC ---------- -0.3V to +15V

ISENA~D/ISEN1~2/EN/SWMODE/PWM1~2 ---------- -0.3V to +7V

Storage Temperature Range ---------- -65°C to +150°C

Junction Temperature ---------- 150°C

Lead Temperature (Soldering, 10 sec) ---------- 260°C

ESD Rating (Note 2)

HBM (Human Body Mode) ---------- 2kV

MM (Machine Mode) ---------- 200V

Thermal Information

Package Thermal Resistance (Note 3)

WQFN3x3 - 16L θ_{JA} ---------- 68°C/W

WQFN3x3 - 16L θ_{JC} ---------- 6°C/W

Power Dissipation, P_D @ T_A = 25°C

WQFN3x3 - 16L ---------- 1.47W

Recommended Operation Conditions

(Note 4)

Operating Junction Temperature Range ---------- -40°C to +125°C

Operating Ambient Temperature Range ---------- -40°C to +85°C

Supply Input Voltage, 12VCC ---------- +4.5V to +13.2V

Note 1. Stresses listed as the above *Absolute Maximum Ratings* may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2. Devices are ESD sensitive. Handling precaution recommended.

Note 3. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

Note 4. The device is not guaranteed to function outside its operating conditions.

Note 5. Guaranteed by design.

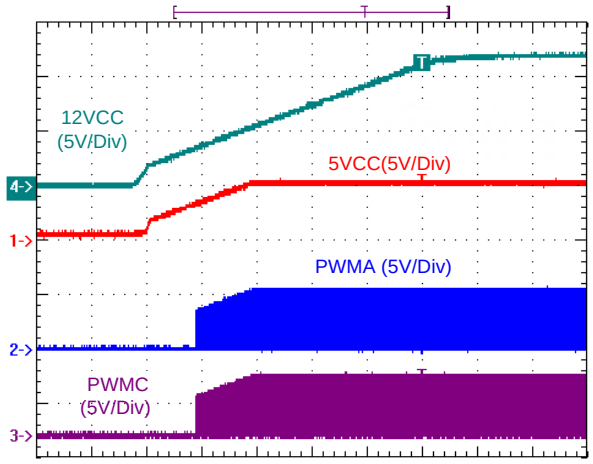
Electrical Characteristics

(Test Condition: 12VCC = 12V, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Input Voltage						
POR Threshold	$12V_{CC\_RTH}$	PWM [A:D] outputs enabled	3.0	3.4	4.4	V
POR Hysteresis	$12V_{CC\_HYS}$		0.1	0.3	0.46	V
Supply Input Current	I_{12VCC}		--	2.5	5.0	mA
5VCC Regulated Voltage	V_{5VCC}	12VCC = 12V	4.95	5.20	5.45	V
Analog Switch						
On Resistance	R_{ON}	ISEN[1,2] to ISEN[A:D] current = 0.5mA	100	200	300	Ω
Analog Switch Dynamic Characteristics						
Turn Off Time	T_{OFF}	R_{LOAD} = 10kΩ, C_{LOAD} = 4.7pF, V_{ISEN} = 1V (Note 5)	--	15	--	ns
Turn On Time	T_{ON}	R_{LOAD} = 10kΩ, C_{LOAD} = 4.7pF V_{ISEN} = 1V (Note 5)	--	30	--	ns
Break-Before-Make Delay	T_{DLY}	C_{LOAD} = 4.7pF (Note 5)	--	3.4	--	ns
PWM Digital Logic Gate Output Characteristic						
High-Z to High Threshold Level	V_{IH_HiZ-H}	PWM[A:D], R_{LOAD} = 10kΩ to GND, and 10kΩ to 5VCC	--	2.34	2.80	V
High to High-Z Threshold Level	V_{IL_HiZ-H}		1.80	2.18	--	V
Low to High-Z Threshold Level	V_{IH_L-HiZ}		--	0.83	1.20	V
High-Z to Low Threshold Level	V_{IL_HiZ-L}		0.40	0.67	--	V
Output High Voltage	V_{OH}	R_{LOAD} = 10kΩ to GND	4.5	4.9	--	V
Output Low Voltage	V_{OL}	R_{LOAD} = 10kΩ to 5VCC	--	0.1	0.4	V
Output Minimum Low Time	T_{L_MIN}	PWM[1,2] input = 3.3V to 1.5V (Note 5)	--	200	--	ns
Output High to Low Delay Time	T_{HL_DLY}		--	15	60	ns
Output Low to High Delay Time	T_{LH_DLY}		--	15	60	ns
SWMODE Voltage						
Input High	V_{SW_H}		2.2	--	--	V
Input Low	V_{SW_L}		--	--	0.8	V
Enable Voltage						
Input High	V_{EN_H}		2.2	--	--	V
Input Low	V_{EN_L}		--	--	0.8	V
Enable Delay Time						
Enable High Delay	V_{EN_H}		800	2500	5000	ns
Enable Low Delay	V_{EN_L}		100	500	1000	ns

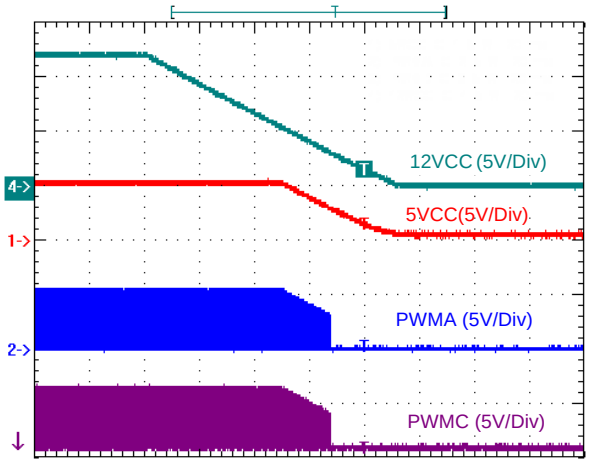
Typical Operation Characteristics

Power ON from 12V



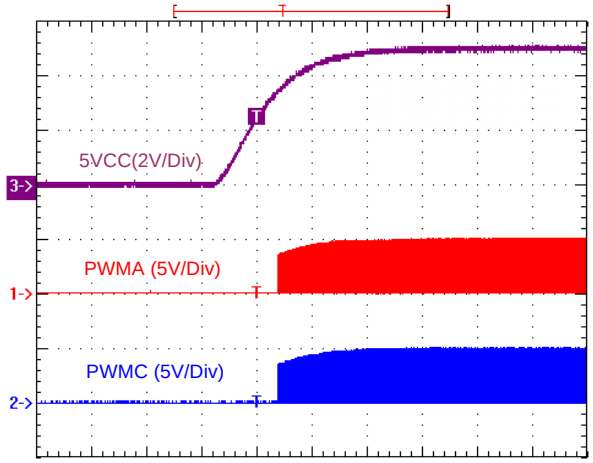
4ms/Div
V_{CC} = 12V, PWM Freq. = 300kHz

Power OFF from 12V



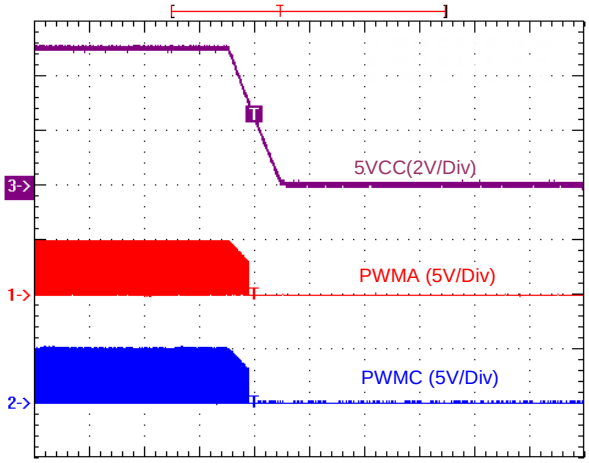
20ms/Div
V_{CC} = 12V, PWM Freq. = 300kHz

Power ON from 5V



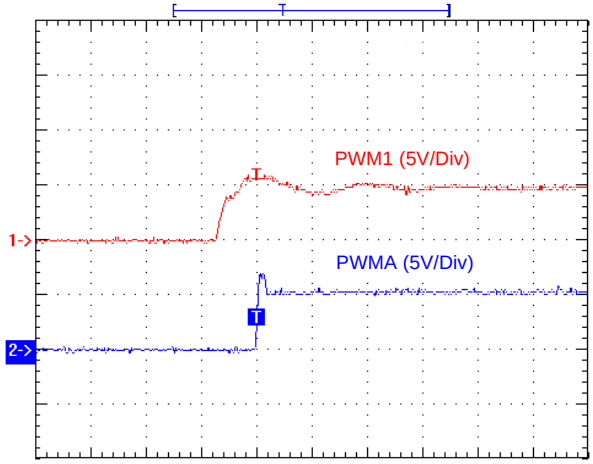
4ms/Div
V_{CC} = 5V, PWM Freq. = 300kHz

Power OFF from 5V



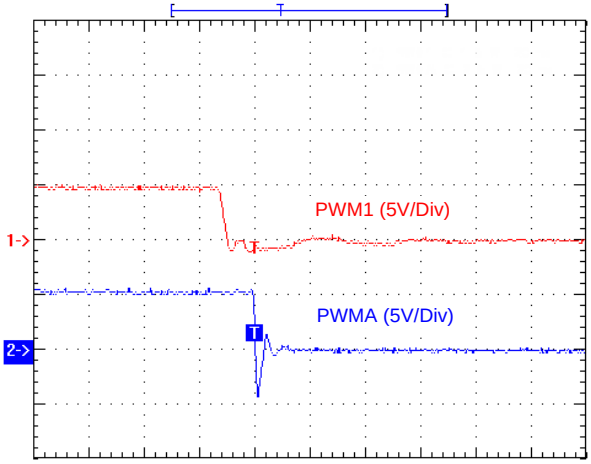
40ms/Div
V_{CC} = 5V, PWM Freq. = 300kHz

PWM1 to PWMA Rising Delay



20ns/Div
V_{CC} = 12V

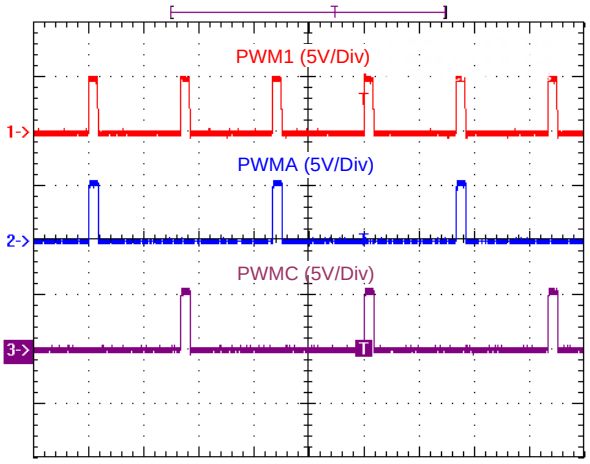
PWM1 to PWMA Falling Delay



20ns/Div
V_{CC} = 12V

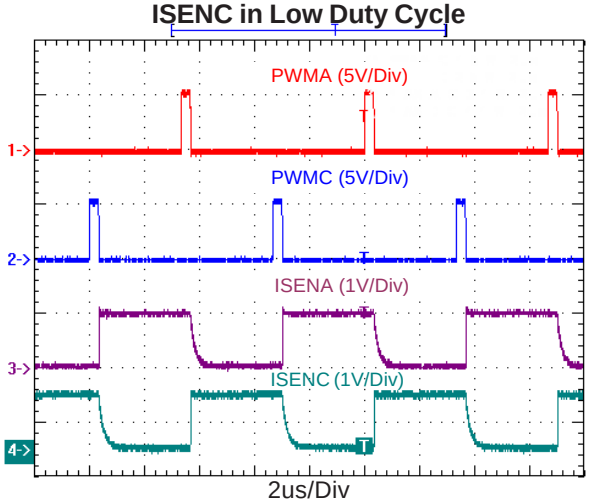
Typical Operation Characteristics

Sequence of PWM1, PWMA and PWMC



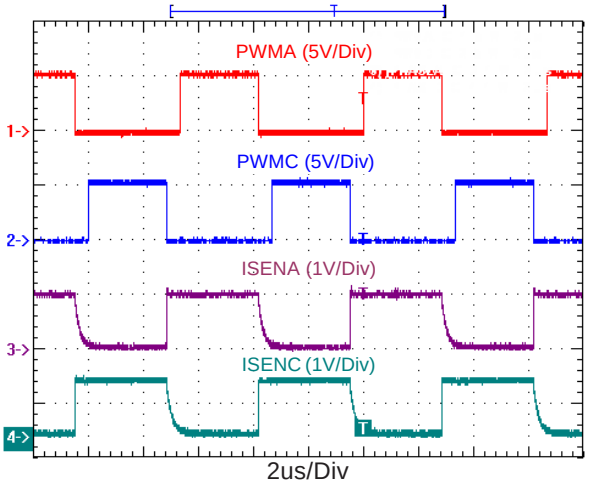
2us/Div
V_{CC} = 12V, PWM Freq. = 300kHz, D = 10%

Sequence of PWMA, PWMC and ISENA, ISENC in Low Duty Cycle



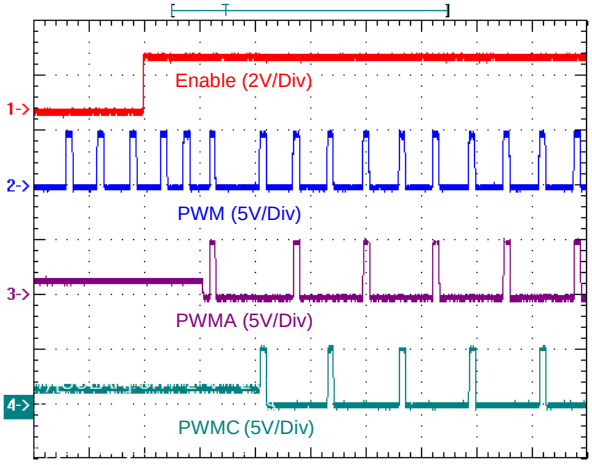
2us/Div
V_{CC} = 12V, PWM Freq. = 300kHz, D = 10%,
V_{ISEN1} = 1V, ISENA/C R_{LOAD} = 10kΩ

Sequence of PWMA, PWMC and ISENA, ISENC in High Duty Cycle



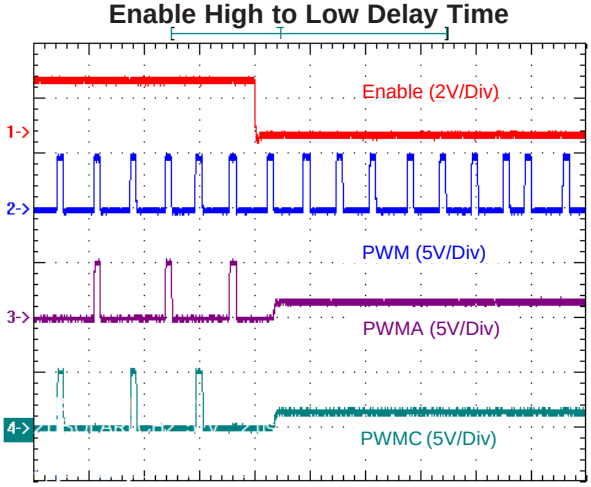
2us/Div
V_{CC} = 12V, PWM Freq. = 300kHz, D = 85%,
V_{ISEN1} = 1V, ISENA/C R_{LOAD} = 10kΩ

Enable Low to High Delay Time



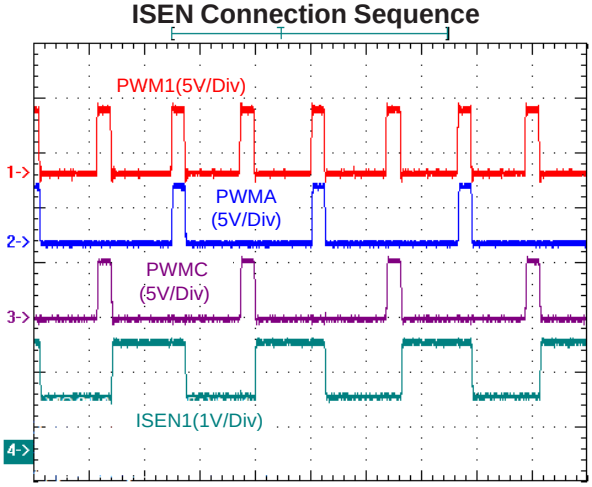
2us/Div
V_{CC} = 5V, V_{IN} = 12V

Enable High to Low Delay Time



2us/Div
V_{CC} = 5V, V_{IN} = 12V

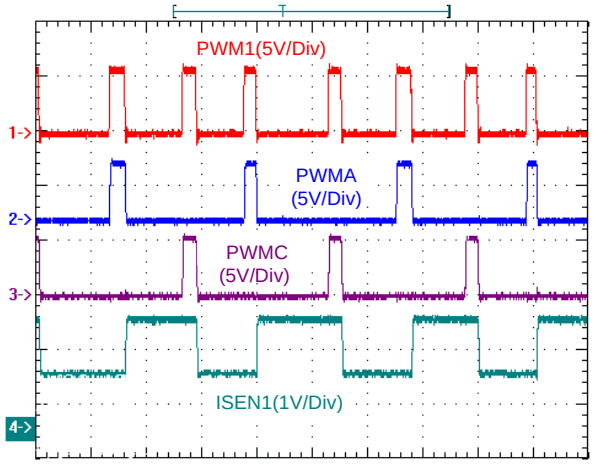
ISEN Connection Sequence



1us/Div
V_{CC} = 5V, V_{IN} = 12V, Enable = High
ISENA = 1V, ISENC = 2 V ,SWMODE = High

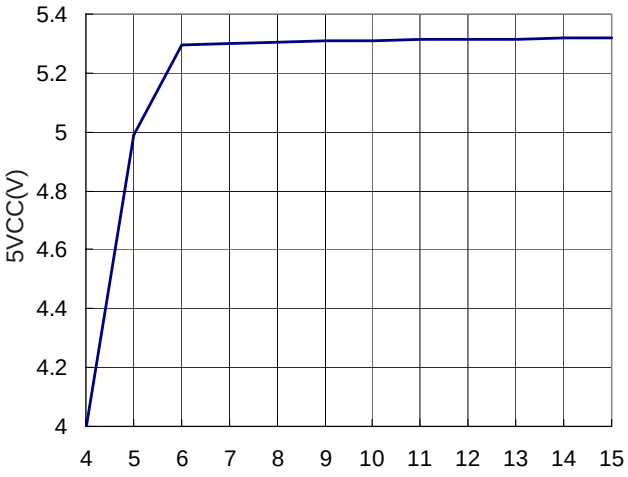
Typical Operation Characteristics

ISEN Connection Sequence



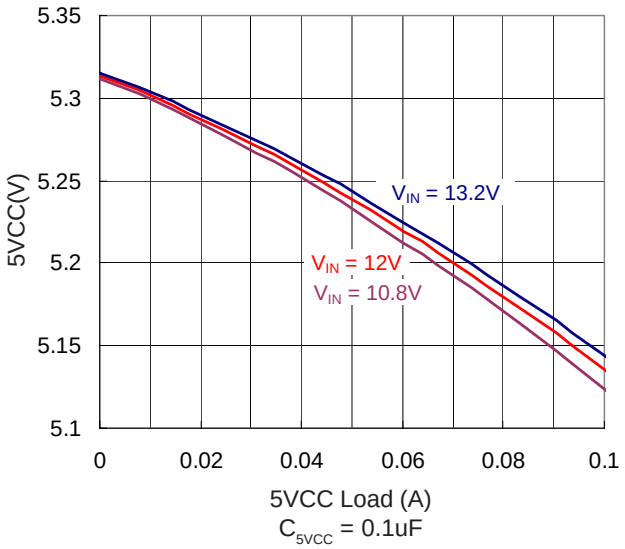
1us/Div
V_{CC} = 5V, V_{IN} = 12V, Enable = High
ISENA = 1V, ISENC = 2 V ,SWMODE = Low

5VCC Line Regulation



Load = 0A, C_{5VCC} = 0.1uF

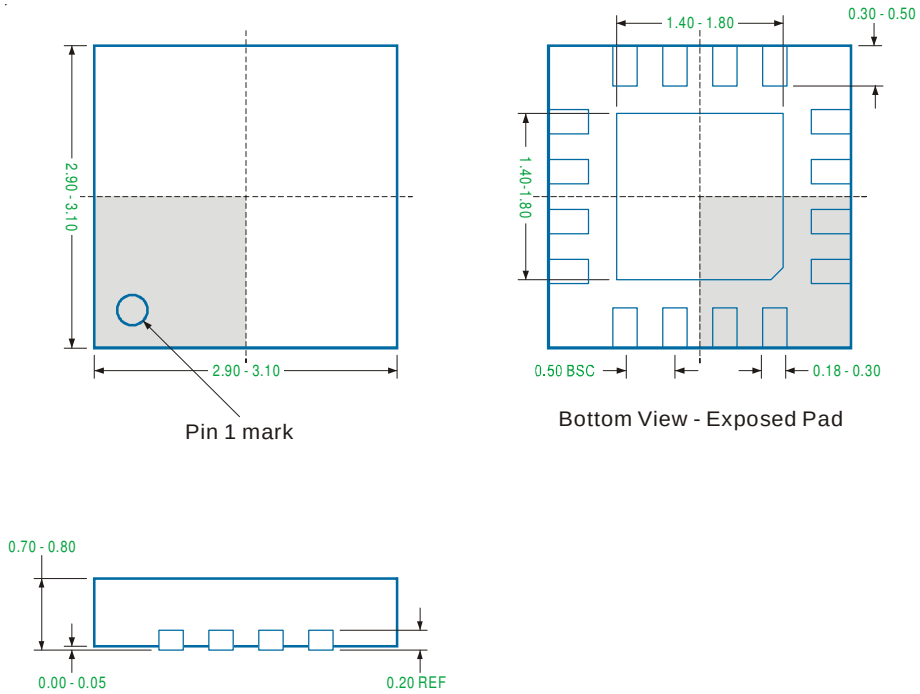
5VCC Load Regulation



C_{5VCC} = 0.1uF

Package Information

WQFN3x3-16L



Note

1. Package Outline Unit Description:
   BSC: Basic. Represents theoretical exact dimension or dimension target
   MIN: Minimum dimension specified.
   MAX: Maximum dimension specified.
   REF: Reference. Represents dimension for reference use only. This value is not a device specification.
   TYP. Typical. Provided as a general value. This value is not a device specification.
2. Dimensions in Millimeters.
3. Drawing not to scale.
4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.

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