

FEATURES

- Digital dual-phase interleaved PFC controller with inherent current matching
- High flexibility digital PWM
 - PWM frequency ranges from 20 kHz to 200 kHz
 - Switching frequency spread spectrum for improved EMI
- High performance control loop
 - 25 MHz sigma-delta ADC for line voltage and current sense, 12.5 MHz sigma-delta ADC for output voltage
 - Enhanced dynamic loop response
 - Input voltage feedforward to avoid reverse current during AC drop
 - Control loop parameters can be configured separately for operating modes and input voltage
 - Support HVDC input
- Multi-mode operations
 - Continuous Conduction Mode (CCM) in heavy load Conditions
 - Discontinuous Conduction Mode (DCM) in light load conditions
 - Burst mode in the zero load conditions
 - The mode parameters can be configured separately for high line and low line
- Advanced control functions
 - True RMS power metering
 - Inrush current control with programming relay delay
 - Output voltage follows power variation
 - Relay power-saving mode
 - PFC quick start function
- Extensive fault protections
 - Fast over-voltage protection
 - Bulk under-voltage protection and over-voltage protection
 - External NTC thermal protection
 - Cycle-by-cycle current limit
 - Average switching current protection
- Built-in 128 bytes MTP to store custom configurations
- Low power consumption
- I2C and UART interfaces
- Programming via easy-to-use Graphical User Interface (GUI)
- Available in QFN-24L packages
- -40°C to 125°C operating temperature

APPLICATIONS

Ultra-High Efficiency Power Supplies
LED Lighting
Industrial Power Supplies
Server/Telecom
EV/E-Bike Charger
Supercomputing
Variable-Frequency Drivers (VFD)

GENERAL DESCRIPTION

The OSU1011A is a highly flexible digital Power Factor Correction (PFC) controller designed to drive the dual phase interleaved PFC stage.

A rectified diode bridge and dual-phase interleaved boost converter each has a fast-switching leg driven at the PWM switching frequency and a fast-recovery diode make up the dual-phase interleaved PFC. OSU1011A supports shut-down one PWM channel under light load condition which can achieve high efficiency at light load.

The OSU1011A offers RMS value of input voltage, current, and power. Through the I2C and UART interfaces, this information can be communicated to a microcontroller.

The OSU1011A operates from a single 3.3 V supply. The device is available in 4 mm x 4 mm QFN-24L package specified over an ambient temperature range of -40°C to +125°C.

TYPICAL APPLICATION CIRCUIT

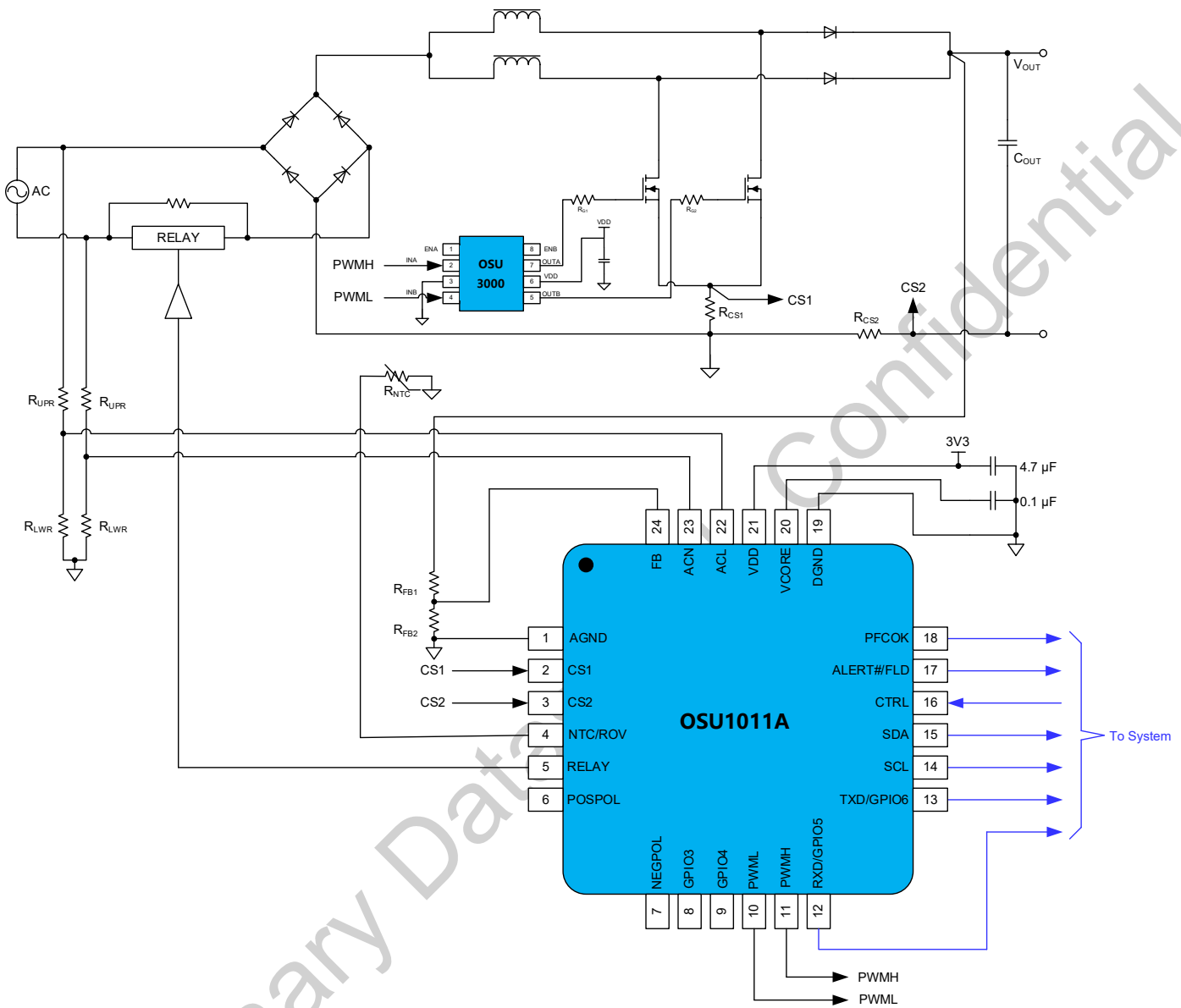


Figure 1 Typical Application Circuit

TABLE OF CONTENTS

Features	1
Applications	1
General Description.....	1
Typical Application Circuit	2
Table of Contents	3
Pin Configuration and Function Descriptions	4
Specifications.....	6
Absolute Maximum Ratings	11
Thermal Resistance	11
ESD Caution.....	11
Application Information	12
DUAL-PHASE INTERLEAVED PFC	12
Package Outline Dimensions	13
Package Top Marking.....	14
Ordering Guide	15
Tape And Reel Information.....	16
Important Notice	17

Preliminary Datasheet, Confidential

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

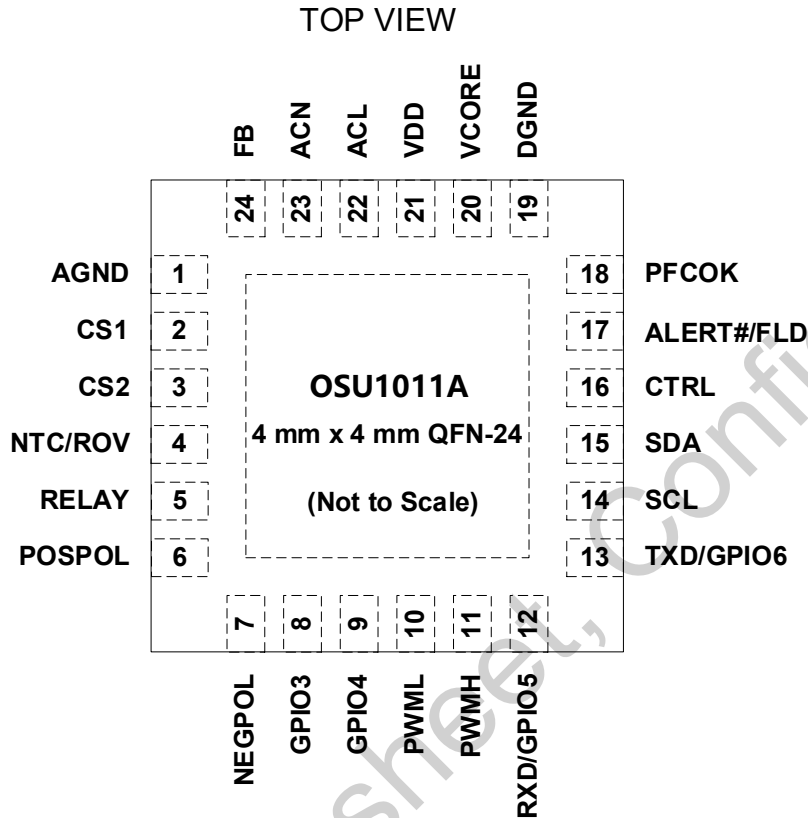


Figure 2 OSU1011A-AA000-QN24R Pin Assignment

Table 1. Pin Function Descriptions for OSU1011A-AA000-QN24R

Pin No.	Name	Type ¹	Description
1	AGND	P	Analog ground. AGND should be connected directly to DGND.
2	CS1	AI	CS1 Sense. This pin senses the inductor current upslope through current sense transformers or sense resistor in the DIPFC topology. It is used to reconstruct the inductor current. It is also used for cycle-by-cycle current limiting. The signal is referred to AGND.
3	CS2	AI	CS2 Sense. The pin optionally senses the inductor current downslope. The signal is referred to AGND.
4	NTC/ROV	AI	Dual Function Pin. NTC: Temperature sense input, which is inverse proportional to the temperature, triggers the comparator when OTP happens. ROV: redundant OVP comparator with a programmable reference. The signal is referred to AGND.
5	RELAY/GPI OO	DO	Relay Control Output. The response delay can be programmed. The signal is referred to DGND. It can be re-used as GPIO pin.
6	POSPOL	DO	Positive Polarity of AC Input. Positive Output of the internal AC polarity detection circuit. The signal is referred to DGND.
7	NEGPOL	DO	Negative Polarity of AC Input. Negative output of the internal AC polarity detection circuit. The signal is referred to DGND.
8	GPIO3	DO	General-purpose IO. The signal is referred to AGND.
9	GPIO4	DO	General-purpose IO. The signal is referred to AGND.
10	PWML	DO	PWM logic level output for control of channel 1 switch. The signal is referred to DGND.

Pin No.	Name	Type ¹	Description
11	PWMH	DO	PWM logic level output for control of channel 2 switch. The signal is referred to DGND.
12	RXD/GPIO5	DIO	UART_RX Pin. The signal is referred to DGND. It can be re-used as GPIO pin.
13	TXD/GPIO6	DIO	UART_TX Pin. The signal is referred to DGND. It can be re-used as GPIO pin.
14	SCL	AIO	I²C Serial Clock Line. The SCL signal is referred to DGND.
15	SDA	AIO	I²C Serial Data Line. The SDA signal is referred to DGND.
16	CTRL	DI	Remote Control Pin. The signal is referred to DGND.
17	ALERT#/FL D	DIO	I²C Alert Pin. The signal is referred to DGND. It can be re-used as fast-load transition detection.
18	PFCOK	DIO	PFCOK Indicates Pin. The PFCOK function is held low when the PFC output voltage is out of regulation and during fault conditions. It is a push-pull output.
19	DGND	P	Digital Ground. DGND should be connected directly to AGND.
20	VCORE	P	1.8 V VDD for Digital Core. The VCORE signal is referred to DGND. Connect a 100 nF capacitor from VCORE to DGND.
21	VDD	P	3.3 V Main Supply. The VDD signal is referred to AGND. Connect a 4.7 μ F capacitor from VDD to AGND.
22	ACL	AI	AC Line Voltage Sense. The signal is referred to AGND.
23	ACN	AI	AC Neutral Voltage Sense. The signal is referred to AGND.
24	FB	AI	PFC Output Voltage Sense. The signal is referred to AGND.

¹ Legend:

A = Analog Pin
P = Power Pin
D = Digital Pin
I = Input Pin
O = Output Pin

SPECIFICATIONS

V_{DD} = 3.0 V to 3.6V, T_J = -40°C to +125°C for minimum and maximum specifications, and T_A = 25 °C for typical specifications, unless otherwise noted.

Table 1. Specifications

Parameter	Symbol	Conditions	Min	Typ	Max	Units
POWER SUPPLY						
Operating Supply Voltage	V _{DD}	4.7 μF capacitor connected to AGND	3	3.3	3.6	V
Supply Current	I _{DD}	Normal operation		10.0		mA
		V _{DD} = 3.3 V while programming			7.5	mA
Shutdown Current	I _{DD_SD}	PFC off state		8.1		mA
Sleep Mode Current	I _{DD_SM}	Sleep mode enabled.		1.0		mA
POWER-ON RESET						
Power-on Reset	V _{DD_POR}	V _{DD} rising	2.7	2.8	2.9	V
UVLO	V _{DD_UVLO}	V _{DD} falling	2.55	2.65	2.75	V
VCORE PIN						
Output Voltage	V _{CORE}	100 nF capacitor connected to DGND	1.7	1.8	1.9	V
OSCILLATOR, CLOCK, PLL						
Oscillator Frequency	f _{OSC}		11.875	12.5	13.125	MHz
PLL Frequency	f _{PLL}		190	200	210	MHz
Digital PWM Resolution	t _{PWM_RES}	For PWML and PWMH pins		5		ns
PWMH, PWML, GPIO3, GPIO4, POSPOL, NEGPOL, RELAY PINS						
Output Low Voltage	V _{PWMOL}	Sink current = 10 mA			0.4	V
Output High Voltage	V _{PWMOH}	Source current = 10 mA	V _{DD} -0.4			V
Rise time	t _{RISE}	V _{DD} = 3.3 V , C _{LOAD} = 50pF 10%V _{DD} to 90%V _{DD}		25		ns
Fall time	t _{FALL}	V _{DD} = 3.3 V , C _{LOAD} = 50 pF 90% V _{DD} to 10%V _{DD}		25		ns
Output Source Current	I _{OL}	V _{DD} = 3.3 V	-10			mA
Output Sink Current	I _{OH}	V _{DD} = 3.3 V			10	mA
SWITCHING FREQUENCY						
Frequency Range	f _{SW}		20		195	kHz
Accuracy			-3%		3%	
ACN AND ACL PINS						
Input Impedance				78		kΩ
Input Voltage Range	V _{AC}		0		2.8	V
Amplifier Gain	G _{AC_OP}			0.5		
ADC						
ADC range			0		1.4	V
ADC Clock Frequency				25		MHz
Equivalent Resolution		Data updating frequency 25 kHz		10		Bits
Voltage Sense Accuracy		20% to 90% of usable range -40°C < T _A < 125°C	-2.0		2.0	%

Parameter	Symbol	Conditions	Min	Typ	Max	Units
AUX Positive Comparator						
Threshold Range <small>错误:未定义符号.</small>			40		340	mV
Threshold Accuracy		Test at 200mV Threshold	-30		30	
Resolution				4		Bit
LSB				20		mV
Hysteresis				40		mV
Propagation Delay					1.0	µs
AUX Negative Comparator						
Threshold Range <small>错误:未定义符号.</small>			40		340	mV
Threshold Accuracy		Test at 200mV Threshold	-30		30	
Resolution				4		Bit
LSB				20		mV
Hysteresis				40		mV
Propagation Delay					1.0	µs
AC Line Frequency Monitor						
High Threshold	f _{5060_H}		68	70	72	Hz
Lower Threshold	f _{5060_L}		37	40	43	Hz
Detection Timer	N _{LINE_DET}		0.5		2	cycles
Exceed Timer	N _{LINE_FREQ_EXC}			2		cycles
Brown-out and SAG						
Vin On Threshold	V _{IN_ON}	Programmable, K _{AC_DIV_EXT} =1/200	0	78	255	VAC
Vin Off Threshold	V _{IN_OFF}	Programmable, K _{AC_DIV_EXT} =1/200	0	71	255	VAC
Brown-out Debounce	t _{BO_DEB}		-	0.5	-	cycles
Line Sag Timeout Range	t _{SAG_TO}	Programmable 4 to 32 AC cycles	4	12	32	cycles
High/Low Line Detection						
High Threshold	V _{HLINE}	Programmable, K _{AC_DIV_EXT} =1/200	120	168	180	VAC
Low Threshold	V _{LLINE}	Programmable, K _{AC_DIV_EXT} =1/200	120	156	180	VAC
High Line to Low Line Debounce Time	t _{H2L_DED}			1		cycles
VAC ZERO CROSSING DETECTION						
VAC Zero Detection Comparator		Between ACL Pin to ACN pin				
Threshold	V _{POL_DET}		-10	0	10	mV
Hysteresis Width	V _{POL_HYS}			10		mV
Propagation Delay	t _{POL_PD}				1.0	µs
Digital Polarity Detection						
Digital Propagation Delay				5		µs
VIN_POL Detection Debounce	t _{POL_DEB}		5		80	µs
VIN_POL Detection LSB				5		µs
FB PIN						
Input Voltage			0		2.8	V

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input Impedance				350		kΩ
Amplifier Gain				0.5		
ADC						
ADC Range			0		1.4	V
ADC Clock Frequency				12.5		MHz
Equivalent Resolution				11		Bits
Voltage Sense Accuracy		20% to 90% of usable range -40°C < T _A < 125°C	-1		1	%
Fast Over-Voltage Protection						
Threshold Range	V _{FB_FOV_LIM}		1.9		2.5	V
Threshold Accuracy		Factory trimmed at 2.2 V	-1.5		1.5	%
Resolution				6		Bits
Hysteresis				100		mV
Propagation Delay	t _{FB_FOV_PD}				160	ns
Debounce Time	t _{FB_FOV_DB}	Programmable in 4 steps	40		100	μs
Blanking time	t _{FB_FOV_BK}			10		μs
Open Loop Protection						
Sink Current	I _{FB_SNK}			250		nA
Threshold	V _{FB_OL}		2		70	V
Resolution				4		Bits
Hysteresis	V _{FB_OLHYS}			18		V
Debounce Time	t _{FB_OLDB}	Programmable in 4 steps	1		4	cycles
Slow Over-Voltage Protection						
Threshold	V _{FB_SOV_LIM}		V _{REF}		V _{REF} +68	V
Resolution				5		Bits
Accuracy			-2		+2	%
Debounce Time	t _{FB_SOV_DB}		0		0.48	ms
Slow Under-Voltage Protection						
Threshold			V _{REF} -68		V _{REF}	V
Resolution	V _{FB_SUV_LIM}			5		Bits
Accuracy			-2		+2	%
Debounce Time	t _{FB_SUV_DB}		0		30	ms
CS1 AND CS2 PINS						
Input Voltage			0		1.4	V
Input Impedance				160		kΩ
Amplifier Gain				1		
ADC						
ADC Range			0		1.4	V
ADC Clock Frequency				25		MHz
Equivalent Resolution		Updating frequency at 100 kHz		8		Bits
Current Sense Accuracy		20% to 90% of usable range -40°C < T _A < 125°C	-1.5		1.5	%
CS1 Fast Over Current Protection						
Threshold Range	V _{CS1_OC_LIM}		1.0		1.5	V

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Threshold Accuracy		Factory trimmed at 1.25 V	-1.2		0.48	%
Resolution				6		Bits
LSB				7.8		mV
Hysteresis				25		mV
Propagation Delay					100	ns
Blanking Time		Programmable in 4 steps	480		1920	ns
Debounce Time		Programmable in 4 steps	80		200	ns
CTRL PIN						
Input High Voltage	V _{CTRL_IL}				0.8	V
Input Low Voltage	V _{CTRL_IH}		2.0			V
Debounce Time	t _{CTRL_DEB}			10		μs
Leakage Current	i _{CTRL_LK}				1.0	μA
PFCOK PINS						
Output Low Level					0.8	V
Output High Level			2.0			V
Debounce Time			0		200	ms
OVER AVERAGE SWITCHING CURRENT PROTECTION						
Average OCP Threshold		CS1 Sense ratio is 10:1	0		14	A
Resolution				7		Bits
Accuracy			-2		+2	%
Debounce				2		Switch cycle
NTC/ROV PIN						
Current Source	I _{NTC}		43	46	49	μA
Over-temperature Threshold	V _{NTC_OT}		0.36	0.4	0.41	V
OT Recover Threshold	V _{NTC_REC}		0.78	0.8	0.82	V
Debounce Time	t _{NTC_DEB}	Programmable in 2 steps		500	1000	ms
Redundant Over-Voltage Protection						
Threshold Range	V _{ROV_LIM}		1.9	2.2	2.5	V
Threshold Accuracy		Factory trimmed at 2.2 V	-2.00		1.64	%
Resolution				6		Bits
Hysteresis				100		mV
Propagation Delay					160	ns
Debouncing Time		Programmable in 4 steps	40		100	μs
Blanking Time				10		μs
SDA/SCL PINS						
Input Voltage Low					0.8	V
Input Voltage High			2.2			V
Output Voltage Low					0.4	V
Pull-Up Current			100		350	μA
Leakage Current			-5		+5	μA
SERIAL BUS TIMING						

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Clock Frequency	f _{IIC}				400	kHz
Glitch Immunity	t _{SW}				50	ns
Bus Free Time	t _{BUF}		4.7			μs
Start Setup Time	t _{SU_STA}		4.7			μs
Start Hold Time	t _{HD_STA}		4			μs
SCL Low Time	t _{LOW}		4.7			μs
SCL High Time	t _{HIGH}		4			μs
SCL, SDA Rise Time	t _{R_I2C}				1000	ns
SCL, SDA Fall Time	t _{F_I2C}				300	ns
Data Setup Time	t _{SU_DAT}		250			ns
Data Hold Time	t _{HD_DAT}		300			ns
TXD/RXD PINS (UART)						
Baud Rate	f _{UART}	Programmable with (0:9600; 1: 1200; 2: 57600; 3: 115200)	1200	9600	115200	bps
Data Length				8		
Stop Bits				1		
Polarity Check Bit				1		
EEPROM RELIABILITY						
Endurance		T _A = 85°C	10,000			Cycles
		T _A = 125°C	1000			Cycles
Data Retention		T _A = 85°C	20			Years
		T _A = 125°C	15			Years

ABSOLUTE MAXIMUM RATINGS

Table 2. Absolute maximum ratings

Parameter	Rating
VDD (Continuous)	4.2 V
ACL, ACN, FB, CS1, CS2, RELAY, NTC/ROV, POSPOL, NEGPOL, GPIO3, GPIO4, PWML, PWMH, RXD/GPIO5, TXD/GPIO6, SCL, SDA, CTRL, ALERT#/FLD ,PFCOK	-0.3 V to V _{DD} + 0.3 V
V _{CORE}	2 V
Operating Temperature Range	-40°C to +125°C
Storage Temperature Range	-65°C to +150°C
Maximum Junction Temperature	150°C
Soldering Conditions	JEDEC J-STD-020
Electrostatic Discharge (ESD)	
Human Body Model	±6000 V
Charge Device Model	±2000 V

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

THERMAL RESISTANCE

Thermal performance is directly linked to printed circuit board (PCB) design and operating environment. Close attention to PCB thermal design is required.

θ_{JA} is the natural convection junction to ambient thermal resistance measured in a one cubic foot sealed enclosure.

θ_{JC} is the junction to case thermal resistance.

Table 3. Thermal Resistance

Package Type	θ_{JA}	θ_{JC}	Unit
QFN4x4-24L	46	23	°C/W

ESD CAUTION



Electrostatic Discharge Sensitive Device.

Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

APPLICATION INFORMATION

DUAL-PHASE INTERLEAVED PFC

Dual-phase interleaved PFC typical application circuit is shown in Figure 3.

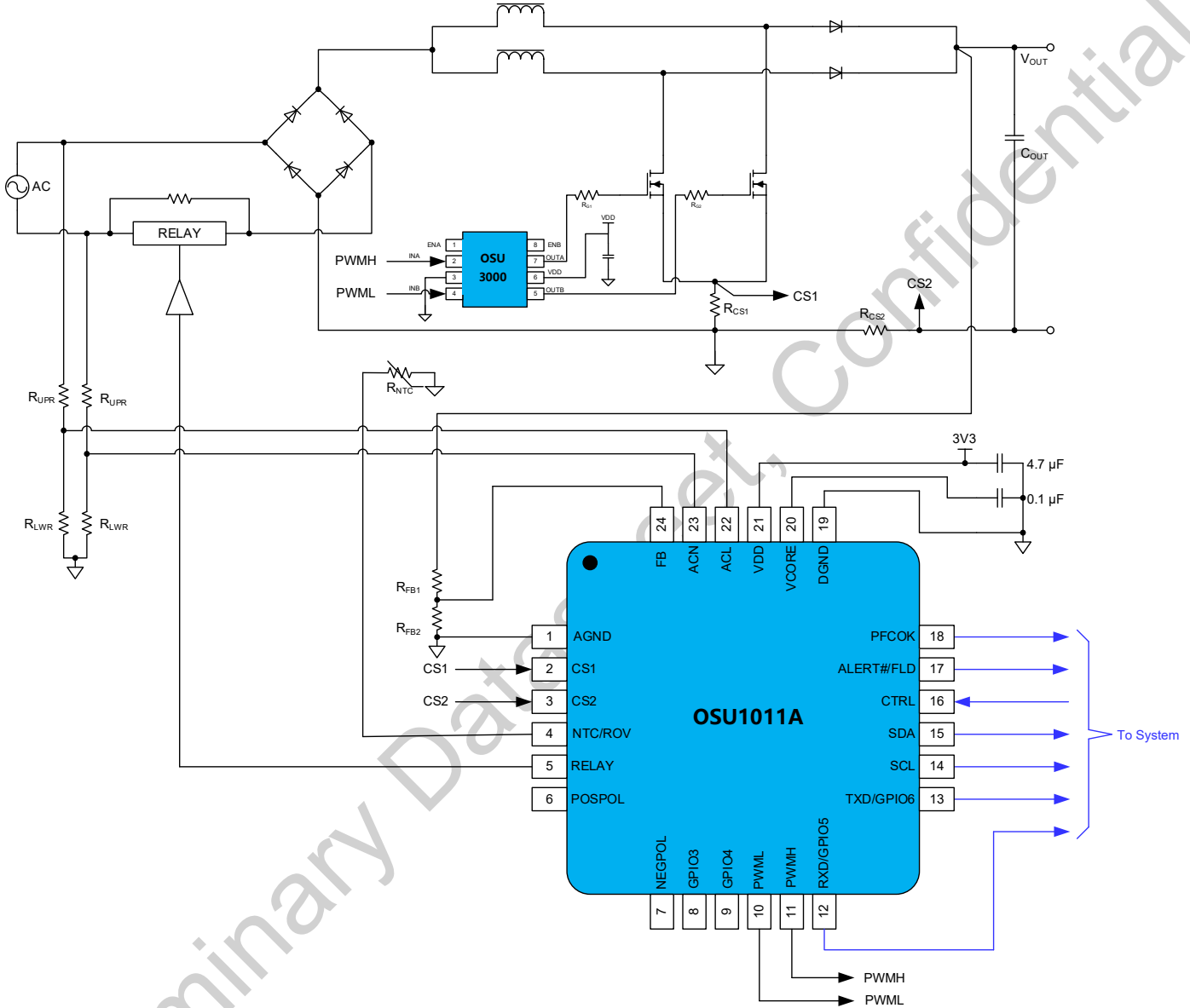
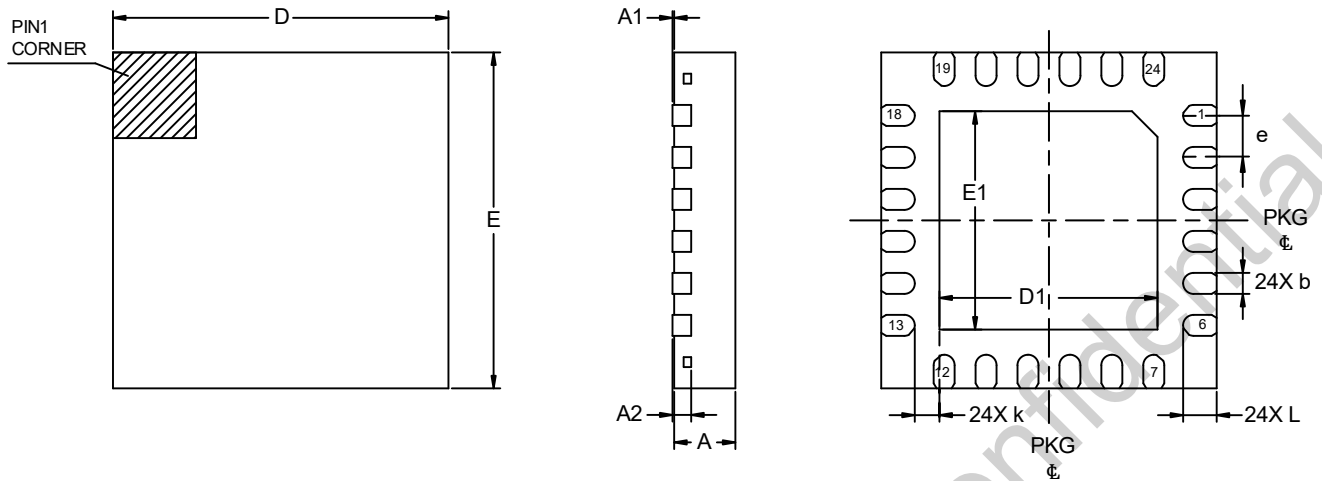


Figure 3 Dual-phase Interleaved PFC Typical Application Circuit

PACKAGE OUTLINE DIMENSIONS



TOP VIEW

SIDE VIEW

BOTTOM VIEW

SYMBOLS	DIMENSION IN MILLIMETERS		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.000	0.02	0.05
A2	0.203 REF		
b	0.18	0.25	0.30
D	4.00 BSC		
E	4.00 BSC		
D1	2.40	2.70	2.80
E1	2.40	2.70	2.80
e	0.50 BSC		
L	0.30	0.40	0.50
k	0.20 MIN		

Figure 4 OSU1011A-AA000-QN24R Dimension

PACKAGE TOP MARKING

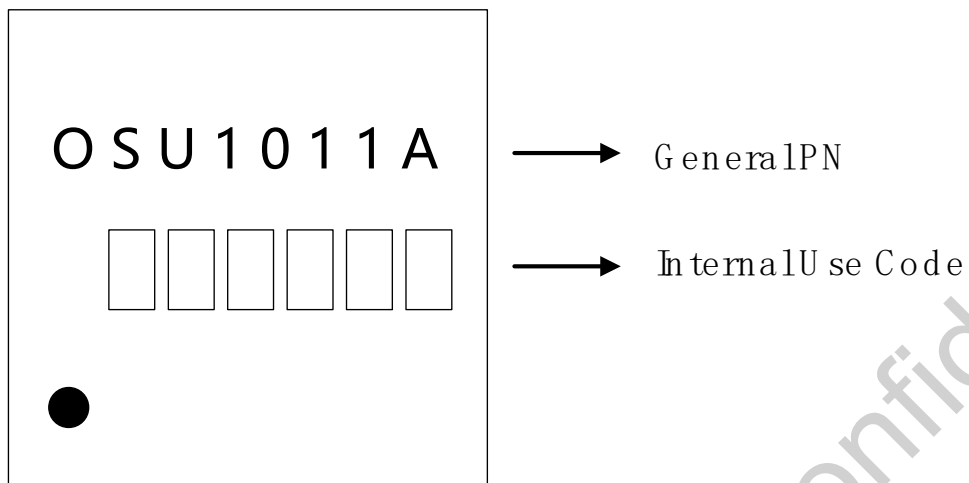


Figure 5 OSU1011A-AA000-QN24R Package Top Marking

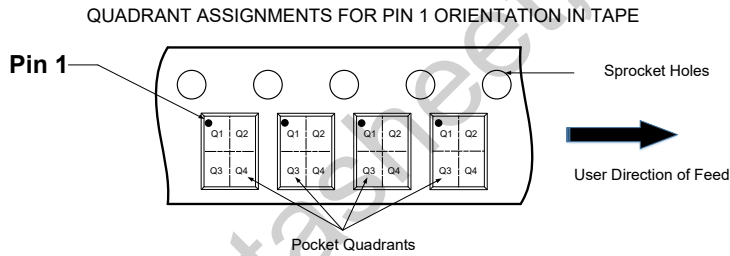
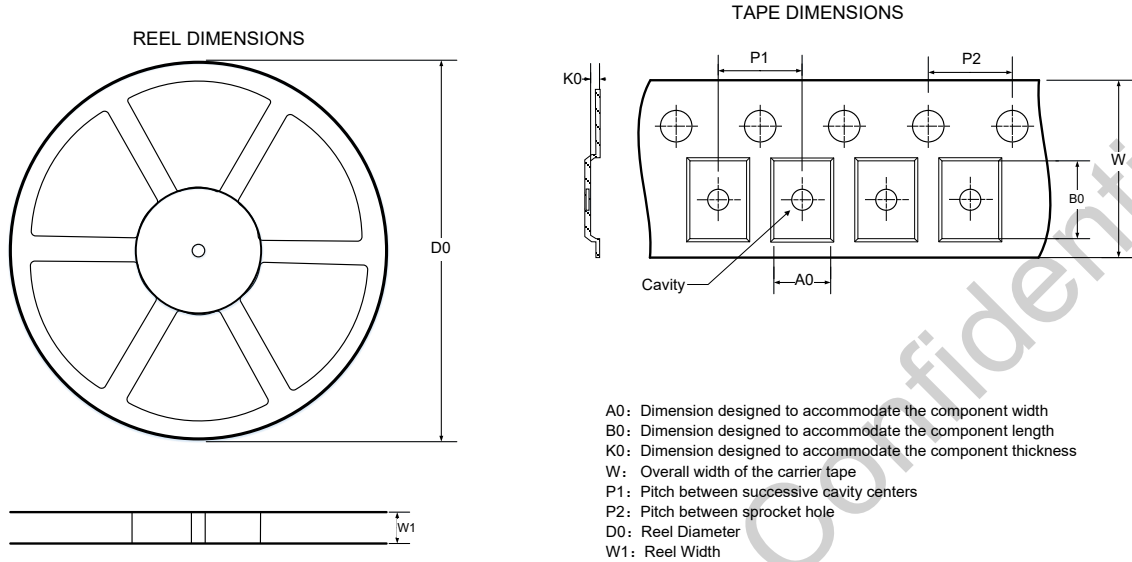
Preliminary Datasheet, Confidential

ORDERING GUIDE

Model	Temperature Range	Package Type	MSL	Package Option	Quantity
OSU1011A-AA000-QN24R	-40°C to +125°C	QFN4x4-24L	3	T&R	5000

Preliminary Datasheet, Confidential

TAPE AND REEL INFORMATION



DIMENSIONS AND PIN1 ORIENTATION

Device	Package Type	D0 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant	Quantity
OSU1011A-AAXXX-QN24R	QFN4X4-24L	330.00	12.40	4.30	4.30	1.10	8.00	4.00	12.00	Q1	5000

All dimensions are nominal

Figure 6 Tape and Reel Information

IMPORTANT NOTICE

Oriental Semiconductor Co., Ltd. and its subsidiaries (Orientalsemi) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to Orientalsemi’s terms and conditions of sale supplied at the time of order acknowledgment.

Orientalsemi warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in Orientalsemi’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent Orientalsemi deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

Orientalsemi assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using Orientalsemi components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

Orientalsemi does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which Orientalsemi components or services are used. Information published by Orientalsemi regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from Orientalsemi under the patents or other intellectual property of Orientalsemi.

Reproduction of significant portions of Orientalsemi information in Orientalsemi data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Orientalsemi is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of Orientalsemi components or services with statements different from or beyond the parameters stated by Orientalsemi for that component or service voids all express and any implied warranties for the associated Orientalsemi component or service and is an unfair and deceptive business practice.

Orientalsemi is not responsible or liable for any such statements.

Buyer 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 Orientalsemi components in its applications, notwithstanding any applications-related information or support that may be provided by Orientalsemi. Buyer 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. Buyer will fully indemnify Orientalsemi and its representatives against any damages arising out of the use of any Orientalsemi components in safety-critical applications.

In some cases, Orientalsemi components may be promoted specifically to facilitate safety-related applications. With such components, Orientalsemi’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No Orientalsemi components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those Orientalsemi components which Orientalsemi has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of Orientalsemi components which have not been so designated is solely at the Buyer’s risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

Orientalsemi has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, Orientalsemi will not be responsible for any failure to meet ISO/TS16949.

Please refer to below URL for other products and solutions of Oriental Semiconductor Co., Ltd.