NU1300: Wireless Power Controller for WPC Transmitter

1 Feature

- Input Voltage: 4.5V to 5.5V
- Compliant with WPC 1.2 to Work with A5 and A11 Coils
- Reliable and Accurate Foreign Object Detection (FOD)
- LED for Charging Status and Fault Reporting
- Built-In Demodulation Circuit for Communications
- PWM Output from 100KHz to 220KHz in 100Hz Steps
- Input Low Voltage Detection
- Limited Power to Prevent Overloading Input Sources
- Overcurrent Protection
- Over-temperature Protection with NTC Input
- Buzzer Output for Charging Status
- Internal Oscillator
- Interface with NU1005/6 to Form High Performance Total Solution
- 28 Pin 4mm x 4mm QFN Package

2 Applications

- Wireless Power Transmitter Compliant with WPC V1.2
- Wireless Power for Smart Phones
- Wireless Power Transmitter for Smartwatches and Wearables
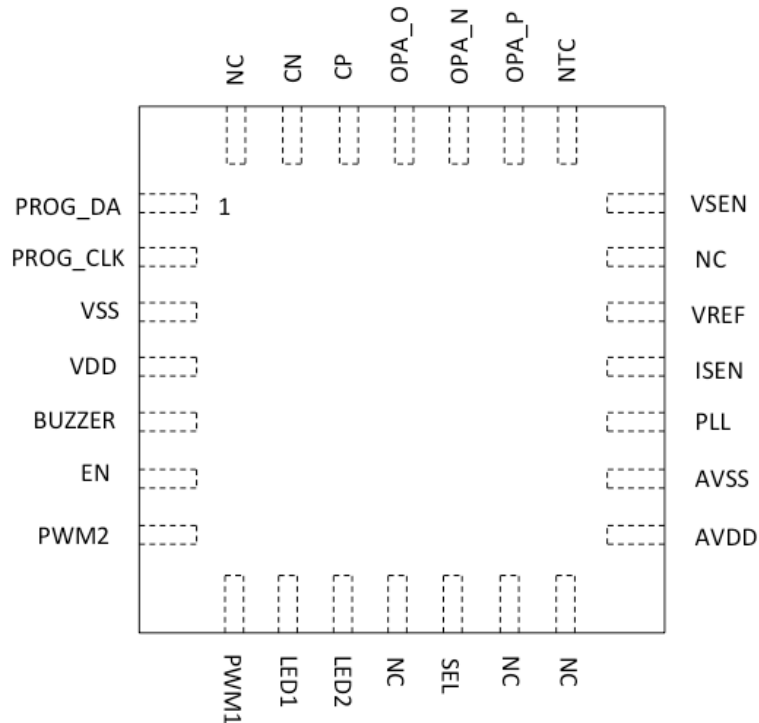- General Wireless Power Transmitter for Consumer, Industrial and Medical Applications

3 Descriptions

NU1300 is a highly integrated digital controller for wireless power transmitter compliant with WPC 1.2 standard. This device and NU1005/6, the companion power ICs, form simple, high performance and cost effective wireless power transmitter solutions suitable for wide range of applications.

NU1300 integrates all essential functions to deliver regulated power and maintain robust communications with WPC compliant receivers. The integrated demodulation circuit removes external amplifiers and comparators. The device is housed in a 4mmx4mm QFN package, making it a compact transmitter controller. Used with NU1005/6, the smallest and most integrated power IC, the two-chip turnkey design provides the most space-saving solutions.

NU1300 also emphasizes on providing reliable and robust charging experience by preventing any transient conditions, such as receiver load variations and Rx/Tx coupling changes, from disrupting communications and continuous charging. The device adopts a proven foreign object detection (FOD) scheme to detect metal objects and prevent harmful heating. The device also integrates the protection features such as over-temperature and overcurrent protections, input low voltage detection and input power limit.

4 Pin Configuration and Functions

PROG_DA — 1

Top pins (left to right): NC, CN, CP, OPA_O, OPA_N, OPA_P, NTC

Left pins (top to bottom): PROG_DA, PROG_CLK, VSS, VDD, BUZZER, EN, PWM2

Right pins (top to bottom): VSEN, NC, VREF, ISEN, PLL, AVSS, AVDD

Bottom pins (left to right): PWM1, LED1, LED2, NC, SEL, NC, NC

28-Pin QFN
Top View

Pin		I/O	O/T	Description
Name	**No.**			
PROG_DA	1	I	-	Data input for flash memory program pin. Make the pin accessible for potential need for firmware update.
PROG_CLK	2	I	-	Clock input for flash memory program pin. Make the pin accessible for potential need for firmware update.
VSS	3	-	-	Digital GND pin.
VDD	4	-	-	Digital power input pin. Connect a decoupling capacitor of 0.1uF to 1uF between VDD and VSS pins.
BUZZER	5	O	Analog	Buzzer output pin to indicate charge status.
EN	6	O	CMOS	Enable output to connect to NU1005/6 EN input pin through a 1KΩ resistor.
PWM2	7	O	CMOS	PWM output to NU1005/6. Connect this pin to the PWM2 pin of NU1005/6.

				When the MODE pin of NU1005/6 is set to logic low, this pin is not used.
PWM1	8	O	CMOS	PWM output to NU1005/6. Connect this pin to the PWM1 pin of NU1005/6.
LED1	9	I	-	LED1 driver input.
LED2	10	I	-	LED2 driver input.
NC	11,13,14,20, 28		-	No connect.
SEL	12	O	CMOS	The logic output pin to select the input signal for voltage or current demodulation.
AVDD	15	-	-	Analog power input pin. Connect a decoupling capacitor of 0.1uF to 1uF between AVDD and AVSS pins.
AVSS	16	-	-	Analog GND pin.
PLL	17	I	-	PLL input pin for the internal PLL circuit. Connect this pin to a RC network circuit recommended by **Typical Application Circuit.**
ISEN	18	I	-	Current signal input pin for FOD and Overcurrent Protection. The ISNS current signal from the NU1005/6 feeds into this pin as shown in **Typical Application Circuit.**
VREF	19	I	-	2.5V reference input pin. Connect this pin to the VREF pin of NU1005/6.
VSEN	21	I	-	Voltage signal input pin for FOD and Low Voltage Detection. Connect this pin to the input power source.
NTC	22	I	-	Connect this pin to an external NTC thermistor.
OPA_P	23	I	-	Positive input of the internal operational amplifier used for demodulation circuit.
OPA_N	24	I	-	Negative input of the internal operational amplifier used for demodulation circuit.
OPA_O	25	O	Analog	Output of the internal operational amplifier used for demodulation circuit.
CP	26	I	-	Positive input to the internal comparator. It is typically connected to the OPA_O pin through a low-pass filter of 50ns time constant.
CN	27	I	-	Negative input to the internal comparator. It is typically connected to

				the OPA_O pin through a low-pass filter of 1us time constant.

5 Specifications

5.1 Absolute Maximum Ratings

	MIN	MAX	UNIT
VDD, AVDD	-0.3	6	V
All Input Pins	-0.3	VDD+0.3	V
Operating Temperature	-40	85	°C
Storage Temperature	-50	125	°C

5.2 ESD Ratings

		UNIT
Human Body Model	+/-8000	V
Charged Device Model	+/-2000	V

5.3 Electrical Characteristics

VDD=AVDD=5V, Ta=25°C(unless otherwise noted)

| PARAMETERS		TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT						
I_{VDD}	Input operating current	No PWM output		5.0	7.5	mA
I_{SLEEP}	Sleep input current	Controller in sleep mode		2.5	5.0	μA
V_{LVD}	Input low voltage detection			4		V
DRIVERS Output						
I_{LED}	LED1 and LED2 sink current		10	20		mA
I_{BUZZER}	Buzzer source current		40	80		mA
VIN, IIN and NTC INPUTS						
V_{ADI}	ADC input voltage range	V_{REF}=2.5V	0		2.5	V
V_{NTC}	NTC trigger threshold	V_{REF}=2.5V		2		V

6 Block Diagram
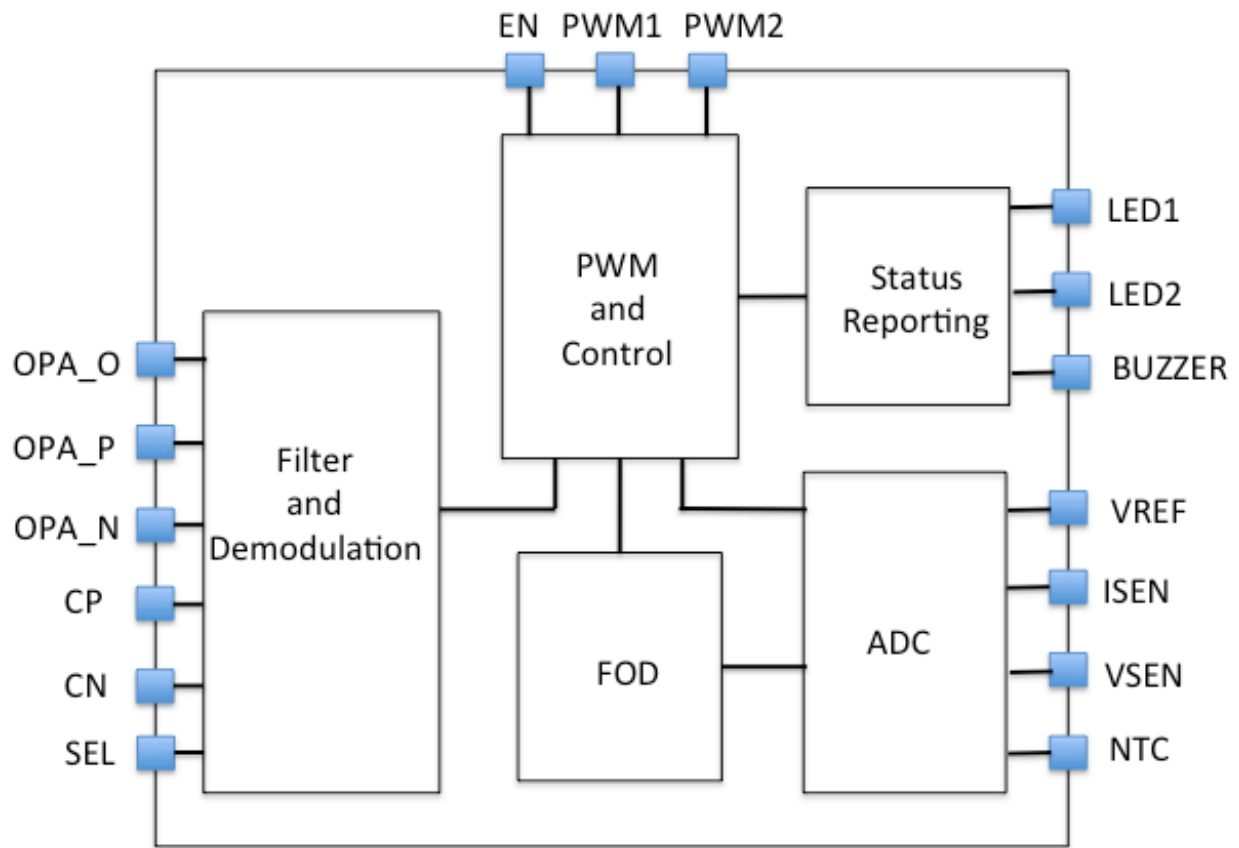
7 Application Descriptions

7.1 General Descriptions

The WPC wireless charging system is essentially a flat form of transformer. It transfers power from transmitter to receiver by inductive magnetic coupling between two coils. The following figure shows the block diagram of a typical WPC 5W transmitter.
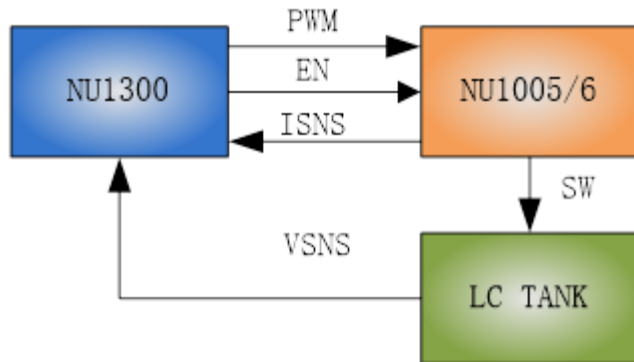
Upon powering up, NU1300 periodically applies analog ping to look for the presence of a receiver. In case of non-existence, NU1300 enters sleep mode by powering down all its logic and NU1005/6 through the EN signal to minimize the idle power.

If a receiver is detected, NU1300 prolongs the analog ping, monitors communication link and prepares the handshake with the receiver. Once the receiver is identified and authenticated, NU1300 starts to regulate output power by varying PWM frequency according to the power request from the receiver. The PWM signal generated by NU1300 is connected to the full bridge inverter integrated inside NU1005/6, which converts DC input to AC output and drives the LC tank. The WPC protocol defines a one-way communication link from the receiver to the transmitter. It is an in-band communication link using the same inductive link between the transmitter and receiver and adopting the back-scatter modulation principle. Essentially, the receiver modulates its R or C load which is monitored by the transmitter in the coupled inductor system. The transmitter receives this communication by measuring coil voltage or current signal.

NU1005/6 integrated a low-power and high-accuracy current-sensing circuit. After amplifying, filtering and averaging, ISNS signal from current sensing circuit is connected to ADC channels of NU1300 for current measurement used for FOD. The current signal is also used for communication through the integrated demodulation circuit.

NU1300 includes protection functions to prevent system from damaging under abnormal situations, such as over current/temperature and low input voltage.

Two LED and one Buzzer pins are included in NU1300 as system status indicator to improve the user experience.

7.2 Low Voltage Detection and Limited Power

After establishing the power transfer contract, NU1300 keeps monitoring the input voltage of the transmitter. If it drops below 4.5V, NU1300 will limit the output power and stop decreasing the PWM frequency even if a positive Control Error packet is received. If the input voltage reaches Input Low Voltage Detect Threshold (V_{LVD}) of typical 4V to maintain the power transfer, NU1300 will stop power transfer until the input voltage recovers above V_{LVD} .

7.3 Overcurrent and Over-Temperature Protections

If an overcurrent or over-temperature situation is detected, NU1300 will stop power transfer to ensure safety. The current signal is measured at the ISEN pin voltage. When the effective current rises above 2A repeatedly, the overcurrent protection is triggered and PWM outputs are disabled. Removing and replacing the receiver can reset this fault condition. The over-temperature condition is detected at the NTC pin. When the temperature exceeds 65°C, the over-temperature protection is enabled, and the PWM outputs are disabled. The temperature drops below 40°C, the fault condition is cleared and the system will restart.

7.4 Demodulations

NU1300 has an integrated high-performance demodulation circuit. With the help of external RC filters, the enveloper of the AC voltage over the transmitter coil or the ISNS signal output from NU1005/6 can be detected and decoded. In the **Typical Application Circuit**, an external multiplexer is controlled by the SEL pin, and used to select the voltage and current signals fed into the internal demodulation circuit. The external resistors and capacitors connected to pin 23 to pin 27 are optimized for reliable demodulation working with the integrated amplifiers and comparators. Use the recommended design and component values shown in the **Typical Application Circuit**

7.5 Foreign Object Detection

NU1300 implements a low cost, reliable FOD algorithm to ensure foreign objects detection. It calculates the power losses between transmitted power and received power reported by the receiver. The FOD parameters need to be calibrated if the coil used is different from the standard A5/A11 coils. Consult factory if a non-standard transmitter coil is used.

7.6 Buzzer and LED Operation

There are two LED pins on NU1300 which are used as system status indicators, such as idle, charging, error, etc. The following table lists the LED functions used in reference design**.**

LED #	LED Operational States					
	Idle	Charging	Charging Complete	Error	FOD	Power Limit
LED1(Green)	Off	Blink Slow	Solid On	Off	Off	Blink Slow
LED2(Red)	Off	Off	Off	Blink Three Times	Blink Slow	Blink Slow

The BUZZER Pin on NU1300 is designed to connect to an external AC Buzzer for audible notifications. Once NU1300 decides to start power transfer, a tone is generated through this pin at 2.5kHz frequency.

7.7 Layout Guidelines

Careful PCB layout is critical to system operation. Many references are available on proper PCB layout techniques.

The NU1300 and NU1005/6 design requires a 4-layer PCB layout for adequate ground plane. A 2-layer PCB can also be achieved at the cost of larger PCB size.

- Layer 1: Component placement, major routing and as much ground plane as possible
- Layer 2: Minor routing and clean ground
- Layer 3: Minor routing and clean ground
- Layer 4: Minor routing and clean ground

Additionally, here are the guidelines to follow.

- Make routing loop as small as possible, especially the power loop, to minimize EMI noises.
- Place the signal trace on layer 2 or layer 3 to avoid noise coupling.
- Separate the analog ground plane from the power ground plane, and use only one point to join them. Please refer to the R23 of Figure 12.
- Keep analog ground plane and power ground plane low impedance. Use as much copper as possible and an appropriate number of vias.
- Refer to **Layout Guidelines** in NU1005/6 data sheet for further recommendations for complete system layout.

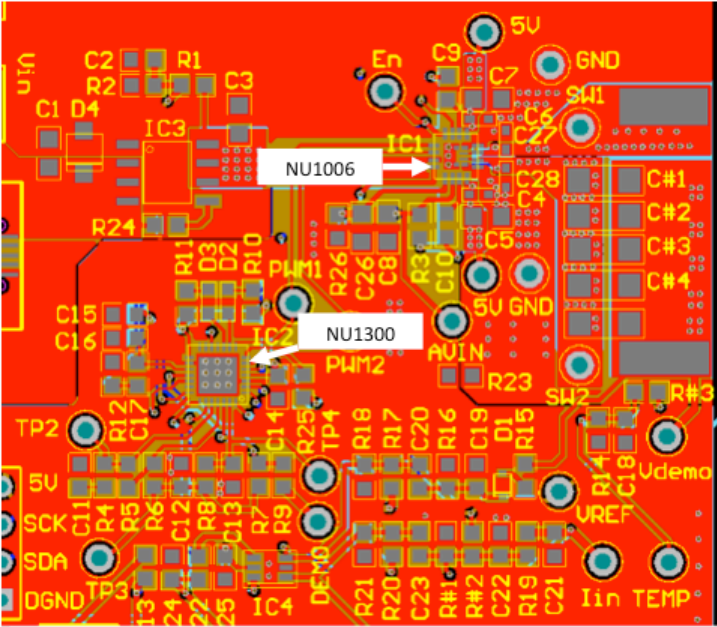# 8 Typical Application Circuit
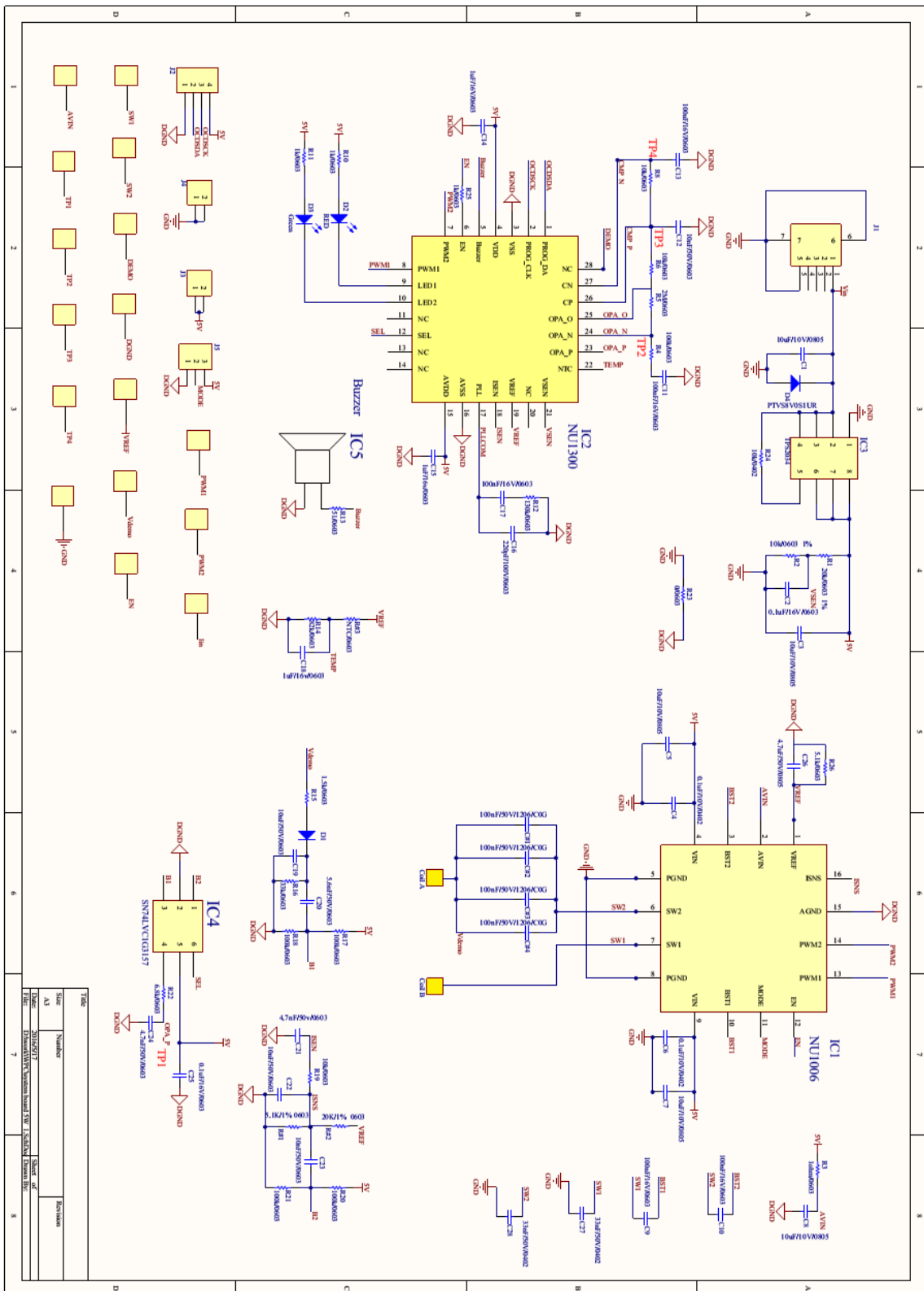
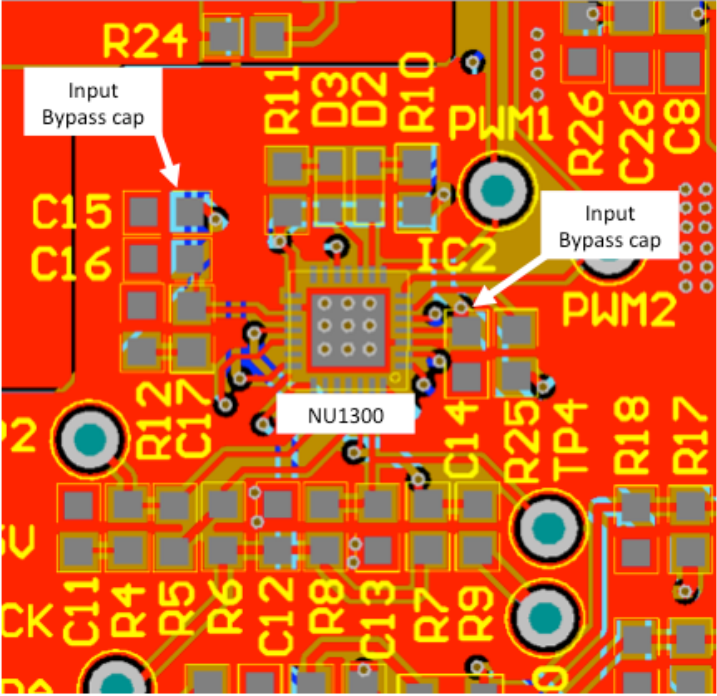# 9 Layout Examples

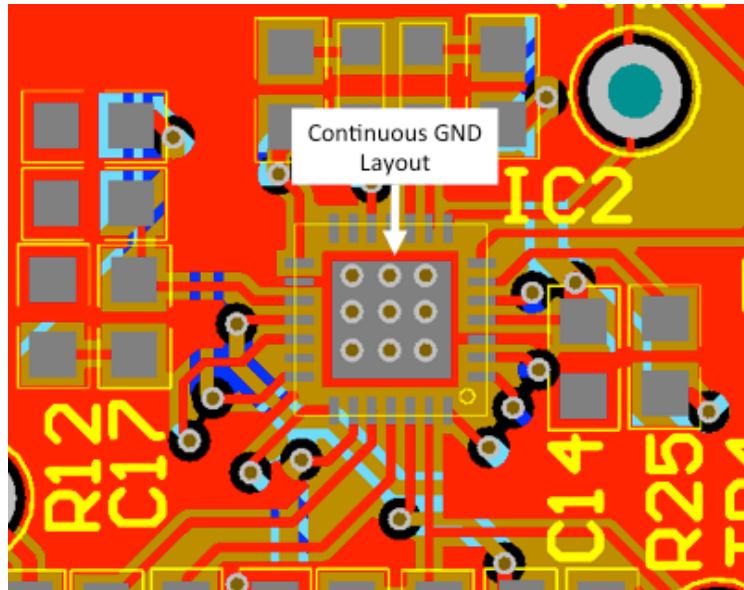Figure 1 Top Layer View

Figure 2 NU1300 Bypass Capacitor Layout

Figure 3 NU1300 Ground Layout

10 Package Information

Orderable Device	Status	Package Type	Package Drawing	Pins	Package Quantity	Eco Plan	Lead Finish	MSL Peak Temp	Op Temp ©	Device Marking
NU1300QDEB	ACTIVE	QFN	QDE	28	3000	Green (RoHS & no Sb/Br)	Pure Tin	Level-3	-40 to 85	NU1300QDE
NU1300QDES	ACTIVE	QFN	QDE	28	250	Green (RoHS & no Sb/Br)	Pure Tin	Level-3	-40 to 85	NU1300QDE

11 Mechanical Data
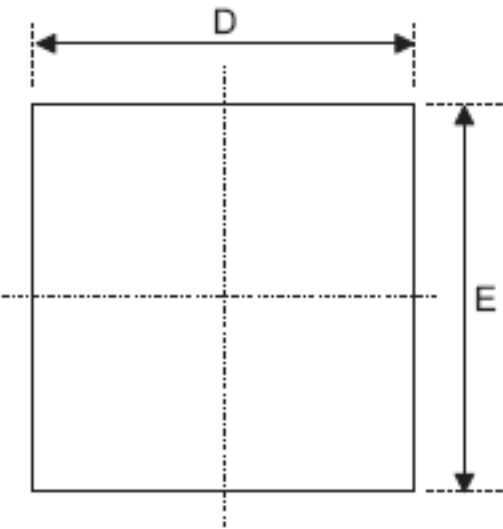
Top view
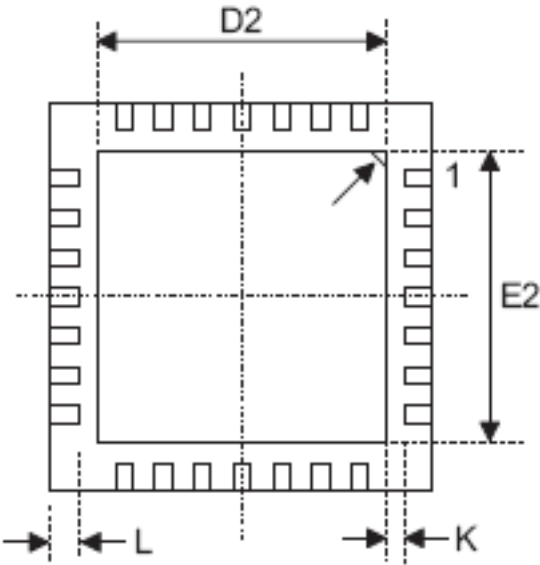
Bottom view
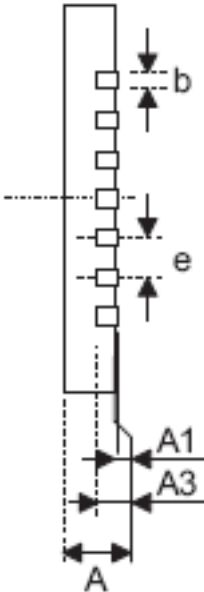
Side view

Symbol	Dimensions In Millimeters	
	Min	Max
A	0.700	0.800
A1	0.000	0.050
A3	0.203 BSC	
b	0.150	0.250
D	4.000 BSC	
E	4.000 BSC	
D2	2.550	2.650
E2	2.550	2.650
e	0.400 BSC	
L	0.300	0.500
k		

12 Revision Histories

Revision No.	Date	Changes
V1.0	5/21/16	First Draft
V1.0	1/19/17	Wording changes