ZCC2404 Datasheet

USB Type-C Power Delivery Controller

Features

- USB Type-C Downstream Facing Port(DFP)
- Support PD2.0,PD3.0 (TID: 4827)
- Support BC1.2 DCP, Apple2.4A, QC2.0 and QC3.0
- Built-in shunt regulator for constant voltage and constant current control
- Built-in MCU and flash controller
- Programmable cable compensation
- Built-in discharge MOS
- Driver for NMOS load switch
- Power saving mode in standby mode
- PDO selection by external resistor
- CC1/CC2/DP/DM over voltage protection
- Protection: OVP/UVP/OCP/OTP etc.
- Package: QFN-16, 4mm×4mm

Applications

USB type-C adapters, car-chargers, wall chargers, power banks and etc.

Description

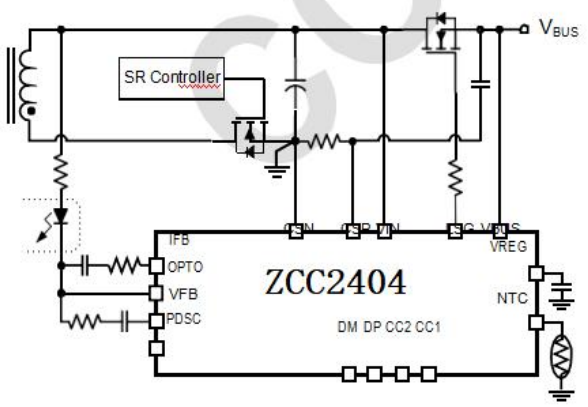
The ZCC2404 is a highly integrated USB PD controller that supports PD3.0 and Qualcomm® Quick Charge™ QC2.0, QC3.0. It is design for USB DFP (Source) charging applications such as power adapters, car chargers and etc.

The ZCC2404 built-in two high-precision DACs and shunt regulators to provide high-precision VBUS output and CV/CC control. It minZCCizes external components and saves BOM cost by integrating BMC PHY, Type-C detection, voltage and current monitors, output bleeding circuit, load-switch NMOS gate driver and system ESD design.

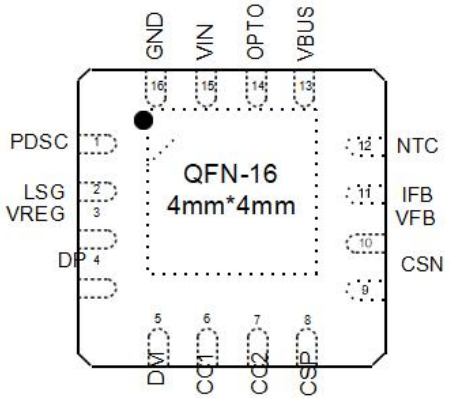
The ZCC2404 also provides comprehensive protections such as over voltage protection (OVP), under voltage protection (UVP), over temperature protection (OTP), over current protection (OCP) etc.

The ZCC2404 is available in QFN16 package.

Typical Application Circuit



Pin Configuration



Ordering Information

Part Number	Package	Top Marking[1]	Shipment
ZCC2404	QFN-16 (4mm x 4mm)	ZCC2404 XYYML	Tape & Reel

Note 1. *Line1: Part Number*

Line2: X=Product Code, YY=Year Code, M=Month Code, L=Lot Number

1. Block Diagram

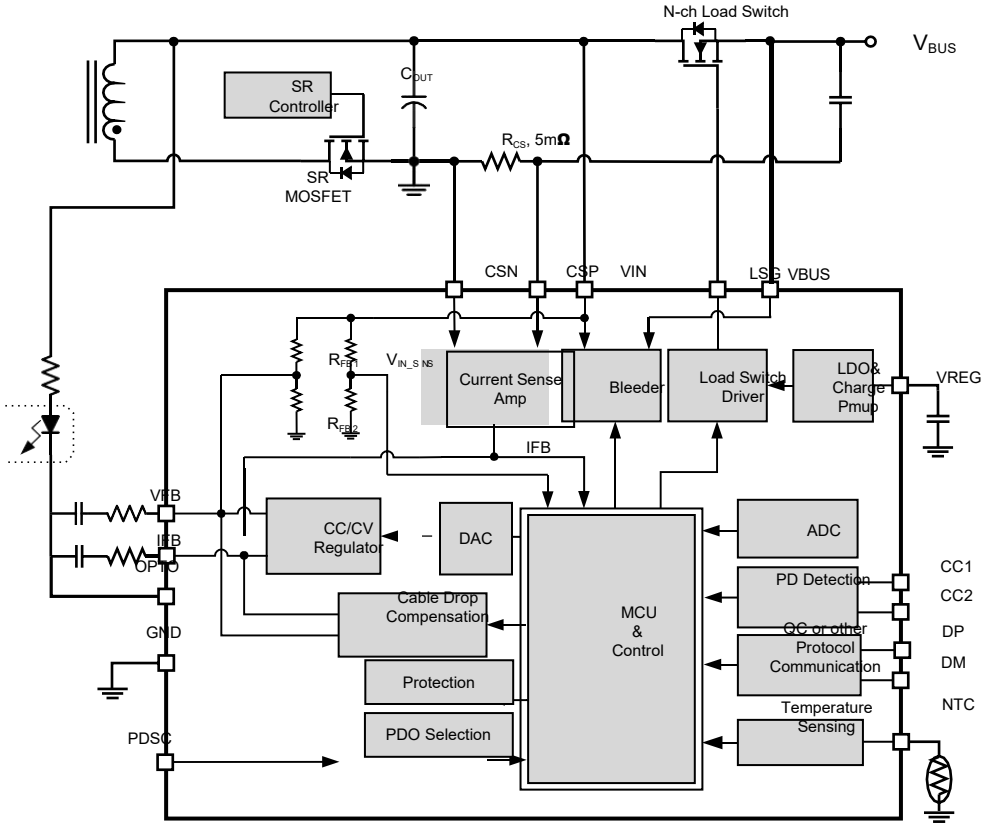


Figure 1. ZCC2404 Block Diagram

2. Pin Description

PIN NO.	PIN Name	Type	Description
1	PDSC	ADIO	PDO selection by connecting a resistor to GND
2	LSG	AO	NMOS load switch gate
3	VREG	P	Regulator output for system power
4	DP	ADIO	USB D+ line
5	DM	ADIO	USB D- line
6	CC1	ADIO	USB Type-C CC1 line
7	CC2	ADIO	USB Type-C CC2 line
8	CSP	AI	Positive input of the current sense amplifier
9	CSN	AI	Negative input of the current sense amplifier
10	VFB	AI	Voltage loop feedback
11	IFB	AI	Current loop feedback
12	NTC	ADIO	Type-C connector temperature sensing pin
13	VBUS	AI	VBUS sense and discharge
14	OPTO	AO	OPTO driver
15	VIN	P	Supply input voltage. Connect this pin to GND via a recommended ceramic capacitor
16	GND	P	Ground
Exposed Thermal Pad	GND	P	Connect to Ground

Legend: A: Analog,

3. Electrical Characteristics

3.1 Absolute Maxmum Ratings[1]

Supply Voltage VIN Pin		VIN,VBUS	-0.3V to 30.0V
Input / Output Voltage Range		OPTO, LSG,CC1,CC2	-0.3V to 30.0V
		VREG, CSP, CSN, IFB, VFB, DM, DP,PDSC,NTC	-0.3V to 6.0V
Operating Temperature[2]			-40ºC to +125ºC
Storage Temperature			-65ºC to +125ºC
Thermal Resistance(Junction to Air)[3], θ_{JA}			47ºC/W
Thermal Resistance(Junction to Case)[3], θ_{JC}			4.5ºC/W
ESD	HBM[4]	VBUS, DP ,DM	5kV
		Other Pins	2kV
	MM[4]	All Pins	500V

注: 1. Stresses beyond those listed under "Absolute ZCC Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification are not ZCCplied. Exposure to absolute maxZCCum rating conditions for extended periods may affect device reliability;

2. Not to exceed the ZCC junction temperature of the IC, which relate to the power consumption of the IC and the thermal resistance of the IC package;

3. Measured on JESD51-7, 4-layer PCB;

4. Based on JEDEC JS-001-2012 & JESD 22-C101;

3.2 Recommended Operating Conditions

VIN supply voltage	3.0V ~ 22.0V
CSP-CSN input voltage	0V ~ 0.1V
Operating ambient temperature range, T_A	-40ºC ~ +85ºC
Operating junction temperature range, T_J	-40ºC ~ +125ºC

3.3 Electrical Characteristics

All specifications below are at ambient 25ºC, V_{IN}= 5V, unless otherwise noted.

Symbol	Parameter	Test Conditions	ZCC			Unit
			Min	Typ	Max	
Supply Voltage						
V_{INON}	Turn-on threshold voltage	V_{IN} rising	3.6	3.7	3.8	V
V_{INOFF}	Turn-off threshold voltage	V_{IN} falling	2.80	2.85	2.90	
I_{OPR}	Operating current		–	10	20	mA
I_Q	VIN operating current in standby mode	V_{IN}=5V, V_{CSP}-V_{CSN}=0mV	–	1.5	2.0	mA
Internal Regulator						
V_{REG}	5V internal regulator voltage	I_{REG}=1mA, 6V< V_{IN}<20V	4.8	5.0	5.2	V
C_{VREG}	Output capacitor range		1	–	10	μF
Current Sense Section						
A_{CS}	Current sense amplifier gain	R_{CS}=5mΩ	–	80	–	V/V
Feedback Section						
I_{OPTO_MAX}	MaxZCCum OPTO sinking current		2	–	20	mA
Load Switch Driver Section						
V_{DRVH_LSG}	Output voltage high	V_{IN}⩾3V, V_{LSG}-V_{BUS}	4	–	10	V
V_{DRVL_LSG}	Output voltage low	V_{LSG}-V_{BUS}	–	–	0.3	V
R_{UP_LSG}	Pull-up ZCCpedance of LSG driver	LSG switch-on	–	3	6	kΩ
R_{DWN_LSG}	Pull-down ZCCpedance of LSG driver	LSG switch-off	–	150	300	Ω
Thermal Shutdown Section						
T_{SSHDM}	External thermal shutdown trip threshold	Can be programmed from 80℃ to 120℃，10℃/step	–	120	–	ºC
T_{ASHDM}	Internal thermal shutdown trip threshold		135	145	155	ºC
ΔT_{ASHDM}	Internal thermal shutdown hysteresis		20	30	40	ºC
DP/DM Section						
V_{DPDML}	DP/DM low threshold voltage		0.25	0.35	0.4	V
V_{DPDMH}	DP/DM high threshold voltage		1.8	2.0	2.2	V
R_{DP}	DP pull low resistance		300	900	1500	kΩ
R_{DM}	DM pull low resistance		14.25	19.53	24.80	kΩ
R_{ON_DPDM}	DPDM switch on-resistance	When DP and DM pins are shorted	–	20	40	Ω

Symbol	Parameter	Test Conditions	LZCCi ts			Unit
			Min	Typ	Max	
t_{OVP_DPDM}	DP/DM pin OVP debounce tZCCe		160	200	240	μs
Type-C Section (CC1 and CC2 pins)						
V_{OH_CC}	Output high voltage of BMC transmitter		1.050	1.125	1.200	V
V_{OL_CC}	Output low voltage of BMC transmitter		0	–	0.075	V
I_{PU_CC}	CC1 and CC2 pull-up current	Default current @ 5V	64	80	96	μA
		1.5A @ 5V	166	180	194	
		3A @ 5V	304	330	356	
V_{IH_CC}	High level input voltage	Default current @ 5V	1.50	1.60	1.65	V
		1.5A @ 5V	1.50	1.60	1.65	
		3A @ 5V	2.45	2.60	2.75	
V_{IL_CC}	Low level input voltage	Default current @ 5V	0.15	0.20	0.25	V
		1.5A @ 5V	0.35	0.40	0.45	
		3A @ 5V	0.75	0.80	0.85	
V_{OVP_CC}	CC pins over voltage protection		5.70	5.85	6.00	V
t_{OVP_CC}	CC pins OVP debounce tZCCe	TZCCe from OVP asserted until OVP FETs turnoff	–	70	100	ns
USB PD BMC Transmitter and Receiver Specification						
f_{BIT}	BMC signal bit rate		270	300	330	Kbps
t_{RISE_BMC}	BMC signal TX rise tZCCe	10% and 90% amplitude points, minZCCum is under an unloaded condition	300	–	–	ns
t_{FALL_BMC}	BMC signal TX fall tZCCe	10% and 90% amplitude points, minZCCum is under an unloaded condition	300	–	–	ns
t_{HOLD_BMC}	TZCCe to cease driving the line after the final high-to-low transition		1	–	–	μs
t_{IFG_BMC}	TZCCe from the end of the last bit of a frame until the start of the first bit of the next preamble		25	–	–	μs
t_{END_BMC}	TZCCe to cease driving the line after the end of the last bit of the frame		–	–	23	μs
t_{STA_BMC}	TZCCe before the first bit of the preamble when the transmitter shall start driving		-1	–	1	μs

Symbol	Parameter	Test Conditions	LZCCi ts			Unit
			Min	Typ	Max	
t_{RXFTR_BMC}	BMC receiver bandwidth lZCCiting filter		100	–	–	ns
N_{NIDLE_BMC}	Number of transitions to be detected to declare bus non-idle		3	–	–	
t_{NIDLE_BMC}	TZCCe window for detecting non-idle		12	–	20	μs

4. Operational Description

The ZCC2404 is a highly integrated secondary-side USB PD Type-C controller with various functions and protections for off-line AC/DC or car charging converters. It supports USB PD 3.0 specification and Qualcomm® Quick Charge™ technologies. Functions blocks include shunt regulator, MCU, USB PD BMC PHY, and Type-C detection, resulting in low external component count, small form factor and low BOM cost.

Refer to Block Diagram for the following discussions. All parameters mentioned below are typical values.

4.1 VIN Supply

The ZCC2404 is supplied via the VIN pin connected to the secondary DC voltage of an AC/DC Flyback converter or DCDC converter. When VIN rises above V_{INON}, the IC wakes up and regulates the output voltage as default 5V at normal mode. When VIN drops below V_{INOFF}, the IC shut down again. A 100nF bypass ceramic capacitor is recommended from this pin to ground.

4.2 CV/CL Regulators

Two regulators are paralleled and connected to OPTO pin. The operation of each feedback loop is sZCCilar to that of the traditional TL431 shunt regulator. Refer to Figure 2, the constant output voltage is determined as:

$$V_O = V_{DAC\_CV} \times \frac{R_{FB1}+R_{FB2}}{R_{FB2}} = K_{DIV} \times V_{DAC\_CV} \quad (1)$$

The ratio of the internal resistor divider K_{DIV} is 8, and V_{DAC_CV} can be programmed by MCU from 0.24V to 2.8V with 1.25mV step to achieve high-precision CV regulation.

The constant current can be calculated by:

$$I_{O\_CL} = \frac{V_{DAC\_CL}}{A_{CS} \times R_{CS}} \quad (2)$$

A_{CS} is the current sense amplifier gain and default 80V/V. V_{DAC_CL} can be programmed by MCU as V_{DAC_CV}.

Since CS pins sense small amount of voltage, the sensing resistor should be positioned as close as possible to CS pins. An external π-type RC low pass filter can be added on the CS pins to be ZCCmunized from noise.

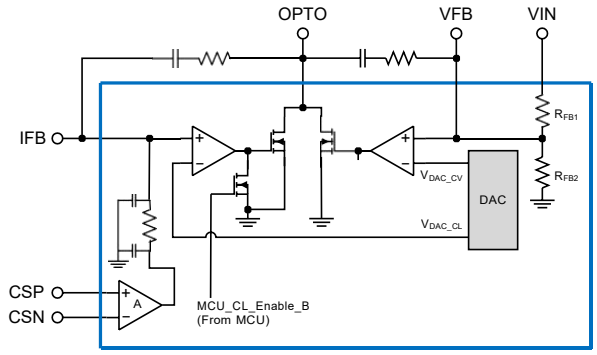


Figure 2. Voltage and current regulation block

4.3 Cable Drop Compensation

To regulate the output voltage constantly at the end of a cable regardless of output current, the cable drop compensation function is ZCCplemented. The cable compensation voltage can be described as:

$$\Delta V_{O\_COMR} = k_{COMP} \times A_{CS} \times R_{CS} \times I_{OUT} = k_{COMP} \times V_{IFB} \quad (3)$$

The amplified current sense voltage V_{IFB} would be turned into a sink current at VFB pin to pull V_{IN} higher than programmed voltage. Where K_{COMP} can be programmed from 0 to 0.75V/V with 0.05V/V step, and set the compensation coefficient above 200mV/A is not recommendable.

4.4 Load Switch Control

The ZCC2404 ZCCplements Type-C block to enable and disable an external load switch. Once the communication is set up with an UFP, or a 5.1kΩ resistor at the CC1/CC2 pin is detected, the load switch MOSFET will be turned on. When a detachment is acknowledged, the load switch will be turned off, and bleeder is enabled at the same tZCCe. If any protection condition occurs, the load switch will also be turned off to prevent the UFP from being damaged.

4.5 V_{IN_SNS} Over &Under Voltage Protection

When the V_{IN_SNS} voltage is lower than $k_{VINSNS\_UVP} \times V_{DAC\_CV}$ (***i.e. VINSNSUVP***), or higher than $k_{VINSNS\_OVP} \times V_{DAC\_CV}$ (***i.e. VINSNSOVP***), the load switch will be turned off, and a safe restart protection is trigger.

The protection ratio can be programmed by MCU controller.

4.6 Over Current Protection

The OCP level can be programmed individual for each PDO. OCP is only triggered if the load current is continuously higher than the setting current level for more than the OCP trip debounce tZCCe. The load switch will be turned off, and an interrupt will be generated to MCU, then the V_{DAC_CV} will be reset to 0.625V.

The OCP trip threshold can be set by MCU from 110% to 180% respect to rated current, the default value is 110%.

4.7 DP/DM Over Voltage Protection

When the DP or DM pin is shorted to VBUS or the voltage exceeds 4.4V for longer than 200μs, a safe restart protection is trigger. The load switch will be turned off, and an interrupt will be generated to MCU, then the V_{DAC_CV} will be reset to 0.625V.

4.8 CC1/CC2 Over Voltage Protection

The ZCC2404 is able to handle 30V on its CC1 and CC2 pins, and provides short-to-V_{BUS} or exceeds 5.85V over voltage protection. Same as DP/DM OVP, a safe-restart behavior is happened when protection is triggered.

4.9 Internal Thermal Shutdown (TSDN)

The ZCC2404 has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's power dissipation rating. If the rating is exceeded for a continued period, the junction temperature T_J will rise above 145ºC and will activate the TSDM circuit. It will generate an interrupt to MCU, the bleeder function is disabled and a safe restart happens. The discharge function will be terminated until the chip temperature falls below 115ºC.

4.10 External Temperature Detection

The ZCC2404 provides the NTC pin to measure the connector temperature for thermal monitoring or protection. The NTC pin sources a constant bias current for a remote NTC thermistor. When temperature is larger than the OTP trip point which is set by MCU, the load switch will be turned off and an interrupt is generated to MCU.

4.11 PDO Selection

The ZCC2404 can select three gear PDO by setting PDSC resistor as below.

R_{PDSC}	Power	PD3.0	QC (default)
NC	20W	5V3A,9V2.2A,12V1.67A	5V3A, 9V2A, 12V1.5A
100kΩ	45W	5V3A,9V3A,12V3A,15V3A, 20V2.25A	
0Ω	60W	5V3A,9V3A,12V3A,15V3A, 20V3A	

5. Typical Application Schematic

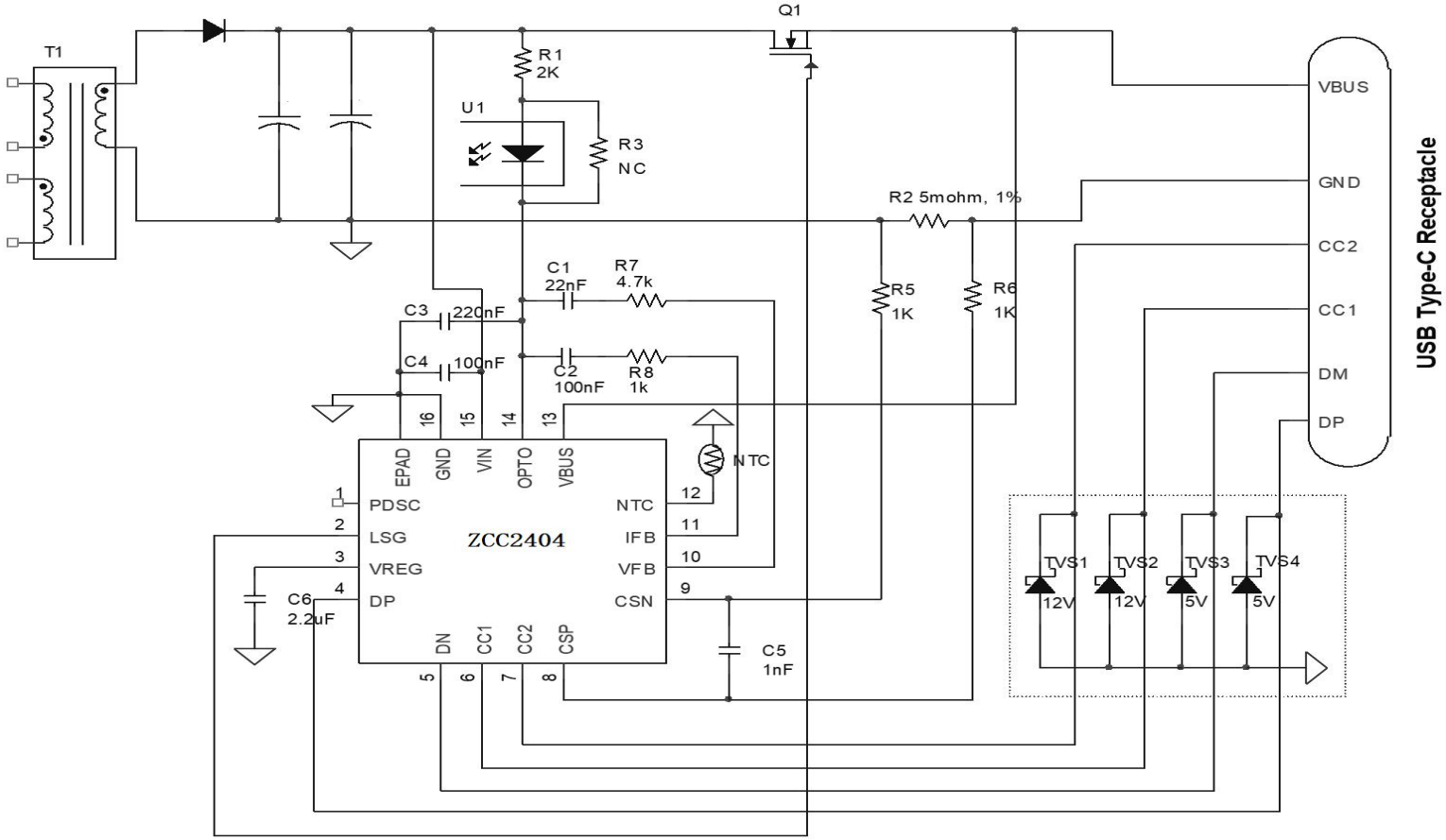
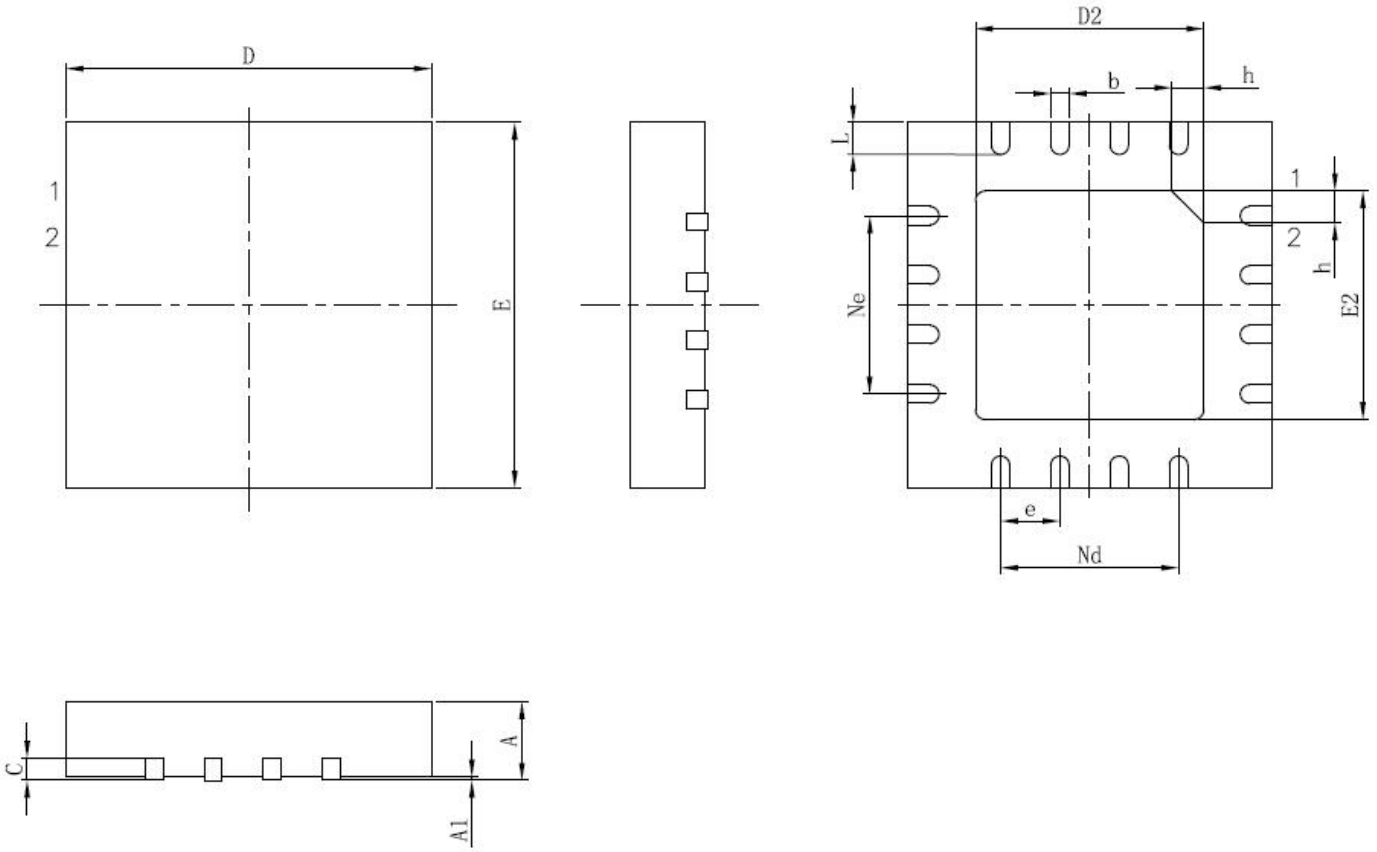


Figure 3. Typical Application Circuit

Package Information: QFN-16, 4mm×4mm



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	—	0.02	0.05
b	0.25	0.30	0.35
c	0.18	0.20	0.25
D	3.90	4.00	4.10
D2	2.10	2.20	2.30
e	0.650BSC		
Ne	1.95BSC		
Nd	1.95BSC		
E	3.90	4.00	4.10
E2	2.10	2.20	2.30
L	0.45	0.55	0.65
h	0.30	0.35	0.40
L/F载体尺寸	98*98		