HYASiC
Digital Power ASIC

PD3.1 USB TYPE-C
PROTOCOL CONTROLLER HY5312

REVISION 0.2

DOCUMENTATION NUMBER:
DS_HY5312_R0.2

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Integration Power-Link USB Type-C PD Controller

1 Features

- USB Type-C 2.2 and USB PD 3.2 / 2.0 Compliant
  - Support 7 Programmable PDOs
  - Support eMarker Detection
- Support UFCS
  - Support 3 Programmable Nums
- Support BC1.2 DCP and HVDCP Protocols
  - QC2.0 /3.0 /3.0+ Class A or Class B
  - Huawei FCP/SCP
  - Samsung AFC
  - Apple 2.4A
  - BC1.2 DCP
  - PE+1.1/2.0
- Safety Integration
  - Over voltage protection
  - Over current protection
  - Output short protection
  - Over-temperature Protection
  - CC1/CC2/DP/DM overvoltage protection
  - NTC
  - UVLO
- External N-MOSFET Supported
- Integration current-sense resistor
- Integration discharge
- Programable Cable drop compensation
- Support Constant Current and Constant Voltage Loop
- Support External I2C
- Support regulation the VIN voltage
- Adaptive power control by Temperature
- Support Dual Chip Power Link
- Support Online Update
- HBM ESD ± 4 kV rating for all pins
- QFN 3mm x 3mm - 20L

2 Applications

- Adaptor
- Power Strip

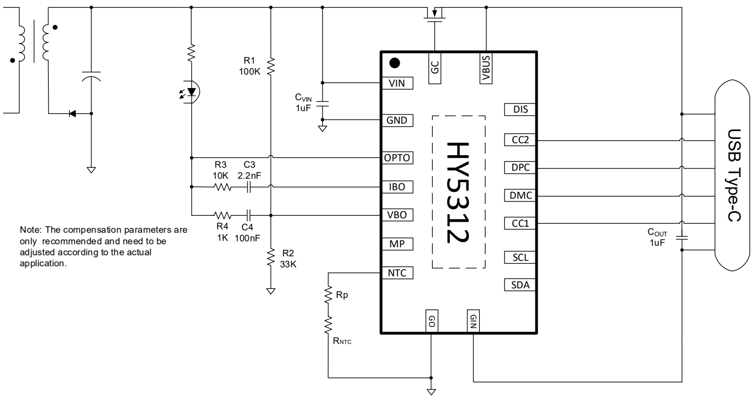
3 Description

The HY5312 is a high performance, high integration USB Type-C Power Delivery Port Controller. The HY5312 support 7 PDOs with programmable current and voltage which are fully compliant with USB Power Delivery Specification Revision 3.2, Version 1.1. Besides, the HY5312 also supports BC1.2 DCP, Apple 2.4A, QC2.0/QC3.0/QC3.0+, AFC, FCP, SCP, UFCS and PE+1.1/2.0 protocols.

The HY5312 integrates Power-Link technology, making it easy to achieve multiple port applications. It also supports external I2C and achieves intelligent power allocation.

The HY5312 integrates perfect protection such as Over Voltage Protection (OVP), Under Voltage Lockout (UVLO), Over Current Protection (OCP), output short protection, CC or DPDM Over Voltage Protection and Over-temperature Protection.

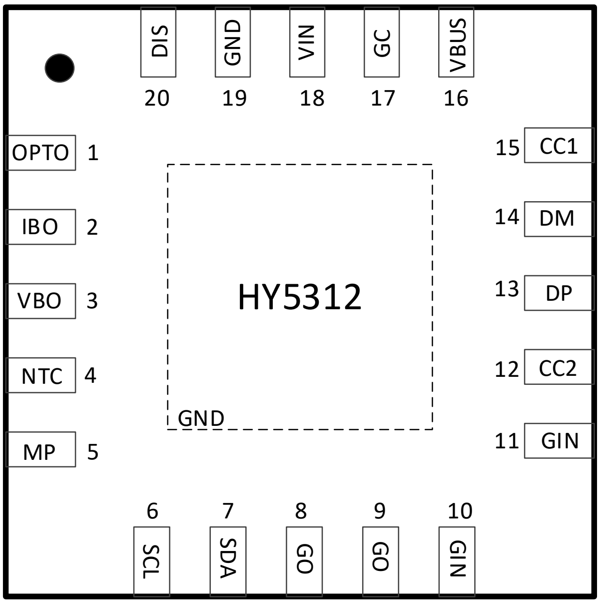
The HY5312 is available in QFN 3mm x 3mm - 20L package.



Note: The compensation parameters are only recommended and need to be adjusted according to the actual application.

Fig. 1. Typical Application Schematic

4 Pin Configurations and Function Descriptions



QFN 3mm x 3mm - 20L

Fig. 2. Packages Top View

Table 1. Pin Function Descriptions

Pin	Name	Description
1	OPTO	Optical coupler
2	IBO	Current feedback compensation
3	VBO	Output voltage feedback and compensation
4	NTC	An external negative temperature coefficient resistor connected to this pin for remote temperature sensing
5	MP	Communication with another chip through this pin if Power link function enable. If not used must tie to GND net.
6	SCA	I2C Bus Clock
7	SDA	I2C Bus Date
8,9	GO	Current detection positive point and current output
10,11	GIN	Current detection positive point and current input
12	CC2	Configuration channel interface pin to USB Type-C
13	DP	USB Type-C DP
14	DM	USB Type-C DM
15	CC1	Configuration channel interface pin to USB Type-C
16	VBUS	USB Type-C VBUS voltage sense
17	GC	External N-MOSFET gate control of USB Type-C VBUS power path
18	VIN	Power supply for internal circuits and the input voltage sense
19	GND	Ground
20	DIS	External discharge loop control, could connect a resistor to VIN when used. When used for car charging, it can be used as bus voltage detection When used for adjusted VIN voltage, can Driver a N-MOSFEET to control FB voltage
EP	GND	Ground

5 Specification

5.1 Absolute Maximum Ratings

Table 2. Absolute Maximum Ratings

Parameter	Min	Max	Unit
VBO, IBO, GIN, GO, NTC, MP	-0.3	6.5	V
VIN, VBUS, GC, OPTO, DIS	-0.3	28	V
CC1, CC2, DP, DM	-0.3	26	V
Junction Temperature Range	-40	150	°C
Ambient Temperature Range	-40	150	°C
Storage Temperature Range	-55	150	°C
Lead Temperature Range (Soldering 10 sec)		260	°C
ESD Human Body Model (100pF Capacitance, Series 1.5KΩ)	-4000	+4000	V

Note: Exceeding the specified limits for the operating conditions of the device can result in permanent damage to the device. The parameters provided are only the limit values for the operating conditions, and operating the device outside of the recommended working conditions is not advisable. The device's reliability may be affected by prolonged operation under extreme conditions.

5.2 Recommended Operating Conditions

Table 3. Recommended Operating Conditions

Parameter	Min	Max	Unit
Input Voltage VIN	3	24	V
Junction Temperature Range	-40	150	°C

5.3 Electrical Characteristics

V_{in} = 5 V, T_{AMB} = 25 °C (unless noted otherwise)

Table 4. Electrical Characteristics

Symbol	Parameter	Test Conditions	Min	Typ.	Max	Unit
VIN						
V_{IN}	Input Voltage		3		24	V
V_{IN_UVLO}		Rising		4		V
$V_{IN\_UVLO\_HYS}$	Input Under-Voltage Lockout (UVLO)			1		V
I_Q	Input Quiescent Current	CC Locked		2.5		mA
		CC Unlocked		200		uA
VOUT						
V_{OVP_TH}	V_{OUT} = 5V	For fixed PDO. For the continuous mode, it will select the threshold based on the range		6		V
	V_{OUT} = 9V			10.5		V
	V_{OUT} = 12V			13.8		V
	V_{OUT} = 15V			17.8		V
	V_{OUT} = 20V			24		V
Discharge						
I_{DIS}	Discharge Current	VOUT=20V			130	mA
R_{VBUS}	Bleeding resistor			100		kΩ
BMC Transmitter (CC1, CC2)						
$_{z}$Driver	TX Output Impedance		30	54	70	Ω
V_{Swing}	BMC Amplitude		1.050	1.125	1.200	V
V_{TXLOW}	Transmit LOW				75	mV
$f_{BitRate}$	BMC Rate		270	300	330	kbps
BMC Receiver (CC1, CC2)						
V_{RXHI}	Receiver HIGH	Rising edge		840		mV
V_{RXLOW}	Receiver LOW	Falling edge		530		mV
Type-C DFP specification (CC1, CC2)						
V_{D_SRC3A}	Detach threshold when detached in 3A DFP mode	Rising threshold	2.5	2.625	2.75	V
		Hysterias		0.05		V
V_{Rd_SRC3A}	Ra, Rd detection threshold in 3A mode (falling)	0V $\leqslant V_{CCx} \leqslant$ 2.5V	0.75	0.79	0.83	V
		Hysterias		0.02		V
I_{RP_SRC}	CC1/CC2 Broadcasting current	3A DFP, R_D=5.1K	1.6	1.68	1.76	V
$T_{CCDebounce}$	Deglitch filter for UFP attach detection		120	150	180	ms
$T_{PDDebounce}$	Deglitch filter for UFP detach detection		12	15	18	ms
Constant Current						
CC	Constant current point	Configurable				
OCP	Short current protection			16		A
HVDCP interface (DP, DM)						
V_{DAT_REF}	Data threshold voltage		0.25	0.325	0.4	V

Symbol	Parameter	Test Conditions	Min	Typ.	Max	Unit
$T_{DP\_DEGLTICH\_HIGH}$	Denounce time for DP high detection			1.1		s
$T_{DM\_DEGLTICH\_LOW}$	Denounce time for DM low detection			1		ms
T_{VOUT_CHG}	Denounce time for VOUT variation		20	40	60	ms
R_{DP_LKG}	DP Leakage resistor			650		kΩ
R_{DM_DWN}	DM Pull down resistor			20		kΩ
V_{TH_PD}	Device connection threshold		0.25	0.325	0.4	V
TD_{PD}	Debounce time for device connection detection		120	160	200	ms
ΔI_{UP}	Voltage step up current	R1= 100 kΩ		0.2		μA
ΔI_{DOWN}	Voltage step down current	R1 = 100 kΩ		0.2		μA
T_{DUR_STEP}	Step time for continuous mode	QC3.0 mode		120		μs
Apple 2.4A Mode						
V_{DAT_2P7}	VDP/VDM	Apple 2.4A mode Voltage	2.57	2.7	2.84	V
UFCS Mode						
$V_{U\_TX\_VOH}$	UFCS TX valid high		2.56	3.3	3.6	V
$V_{U\_TX\_VOL}$	UFCS TX valid low				0.5	V
$V_{U\_RX\_VOH}$	UFCS RX valid high		1.4			V
$V_{U\_RX\_VOL}$	UFCS RX valid low				0.99	V
FCP mode						
V_{TX_VOH}	DM FCP TX valid high		1.8			V
V_{TX_VOL}	DM FCP TX valid low				0.3	V
V_{RX_VOH}	DM FCP RX valid high			1.2		V
V_{RX_VOL}	DM FCP RX valid low			0.9		V
UI	Unit interval for PHY	F_{CLK} = 125 kHz	144	160	176	μs
NTC						
I_{NTC}	NTC source current			48		μA
V_{NTC_TH}	NTC Protection Threshold	Rising		0.6		V
		Falling		0.3		V
V_{NTC_HYS}		Hysterias		0.3		V
OTP						
T_{J1}	Over temperature protection	Rising edge		150		°C
		Hysteresis		20		°C

6 Function Description

6.1 Overview

The HY5312 is a high performance, high integration USB Type-C Power Delivery Port Controller. The HY5312 support 7 PDOs with programmable current and voltage which are fully compliant with USB Power Delivery Specification Revision 3.2, Version 1.1. Besides, the HY5312 also supports BC1.2 DCP, Apple 2.4A, QC2.0 / 3.0 / QC3.0+, AFC, FCP, SCP, UFCS and PE+ 1.1 / 2.0 protocols. It is an ideal solution for power supply devices liking car chargers, quick charger adapters, and smart power strips.

The HY5312 integrates Power-Link technology, making it easy to achieve multiple port applications, it also supports external I2C and achieves intelligent power allocation.

The HY5312 integrates the CV and CC loop control, to eliminate TL431, so that the BOM is minimized.

The HY5312 integrates current-sensing resistor, which Optimize BOM costs. GIN is the current input pin, GOUT is the current output pin, and the traces must be wide.

The output voltage of the HY5312 has a programmable line compensation function. After the output current increases, the output voltage will be correspondingly increased to compensate for the voltage drop caused by the connection line impedance. For specific configuration requirements, please contact HYASiC.

The HY5312 has multiple protection functions, including output over-voltage protection, output short circuit protection, data pin short circuit protection, over-current protection and over-temperature protection.

6.2 Function Block

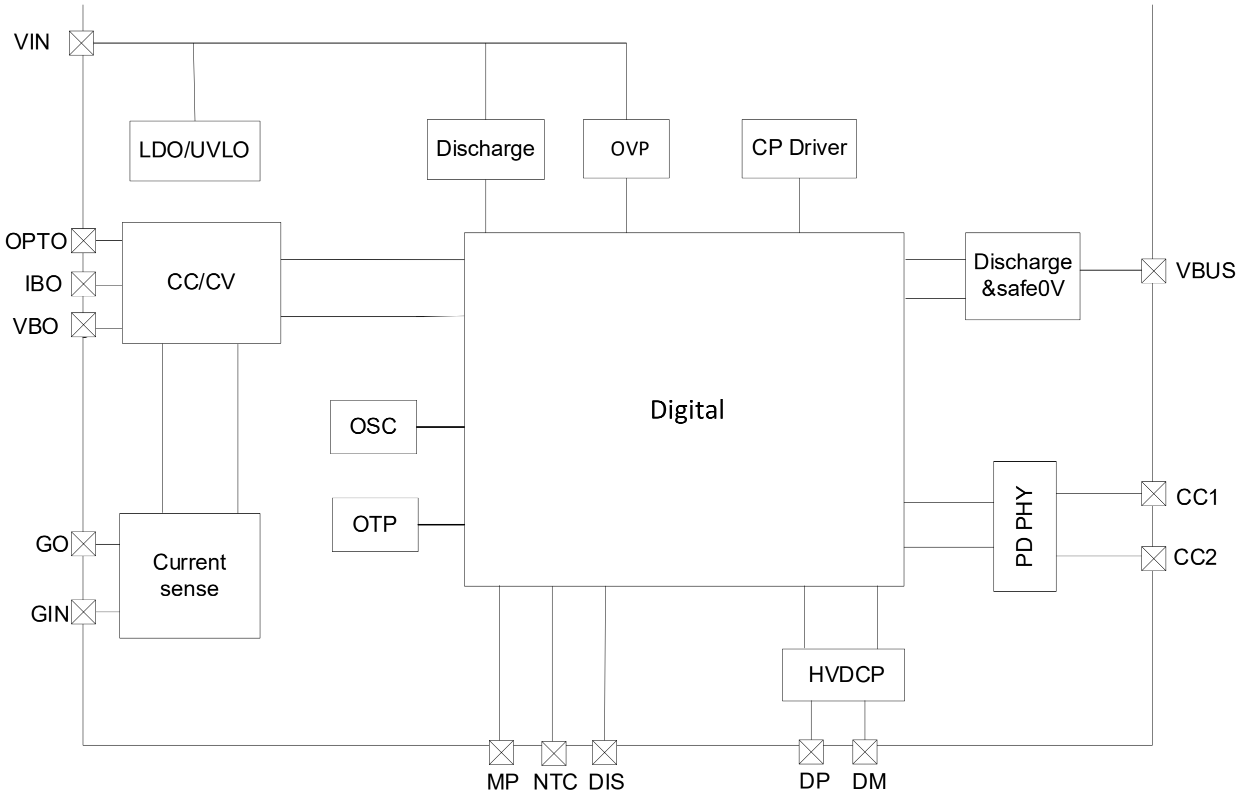


Fig. 3. Function Block

7 Application Notes

7.1 VIN PIN & VBUS PIN

The VIN pin is the chip's internal power supply input and voltage sense input, connected to the AC-DC or DC-DC output, it is recommended to connect an external 1uF capacitor to GND near this pin. It is also an internal discharge drain pathway. Used to drain the charge stored by the output capacitor of the external AC/DC power supply when the device is removed or the device requests a step-down, so that the voltage is regulated to safe 5V or the target voltage.

The VBUS pin is used to sense the USB Type-C port voltage, and is also used as a USB Type-C port Discharge path, and it is recommended to connect an external 1uF capacitor to GND.

7.2 GC PIN

The GC pin is used to drive the external NMOS FET of the power path, connected to the gate of the NMOS FET. When the HY5312 detects that a device is connected or removed, it controls NMOS to turn on or off. When a fault occurs, the NMOS will be quickly turned off to protect the device and improve safety.

7.3 MP PIN

This pin is used to perform communication between two chips if Power-Link function enable.

7.4 Constant Voltage and Constant Current

The HY5312 integrates CV and CC loop control. As shown in the figure below, CV loop control is realized through VBO and OPTO, where OPTO is connected to an external optocoupler and VBO is connected to a voltage divider network point composed of R1 and R2. When the device requests a voltage to step-up or step-down, the HY5312 feeds back the network node according to sink or source current in 0.2uA/step through VBO. Whether it is VBO feedback or OPTO feedback, R1 must be 100 K, R2 is 33 K in OPTO feedback applications, and R2 is calculated based on the actual situation of the front-end power supply in FB feedback applications.

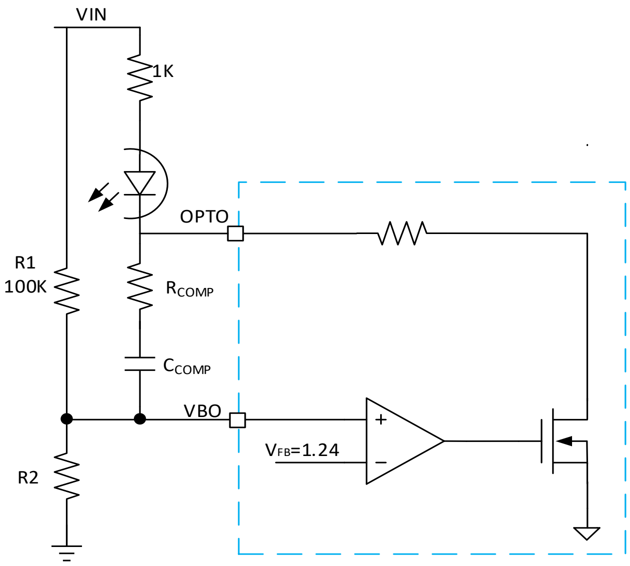


Fig. 4. OPTO Feedback

To suppose the input voltage is VIN, and VBO of the power source is regulated to V_{FB}, then there is how to calculate the resistance of R2:

$$R2 = \frac{V_{FB} \times \mathrm{R1}}{\mathrm{VIN} - V_{FB}}$$

Equation 1

The HY5312 implements constant current control and current sampling via OPTO, IBO, and GO and GIN with an external sampling resistor of 5mΩ. The sampling resistor should be layout in Kelvin connection, with one end being the GIN and the other end being the GO of the chip. The sampled current information is also used by the HY5312 to determine whether is over current or short circuit. The compensation network between OPTO and IBO needs to be adjusted for the specified application.

7.5 Line-Drop compensation

The Built-in line drop compensation function of the HY5312 has programmable compensation coefficient to meet different application, according to output current. The HY5312 currently supports five types of line drop compensation coefficients: 0 mV/A, 50 mV/A, 100 mV/A, 150 mV/A, 200 mV/A. The default configuration is 100 mV/A.

7.6 NTC Protection

The HY5312 uses the NTC pin to sense the external temperature. As show in Fig.5, there is an internal current source 48 µA at the NTC pin. With an external NTC resistor from NTC pin to ground, the HY5312 can detect the voltage across this NTC resistor and calculate the temperature per the T-R characteristics. When the NTC PIN is used to power reduction function, the threshold is 0.6V, when it used to protection function, the rising threshold is 0.6V and the falling threshold 0.3V.

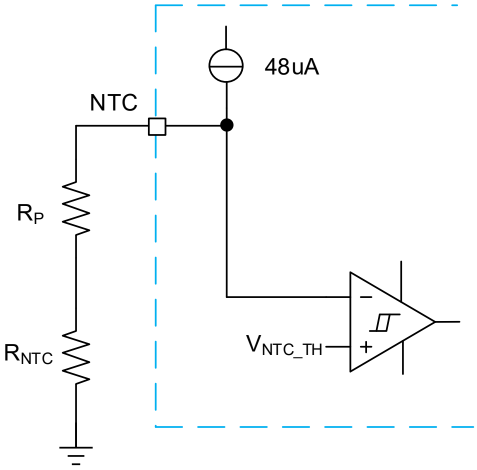


Fig. 5. NTC Protection

7.7 Over Voltage Protection

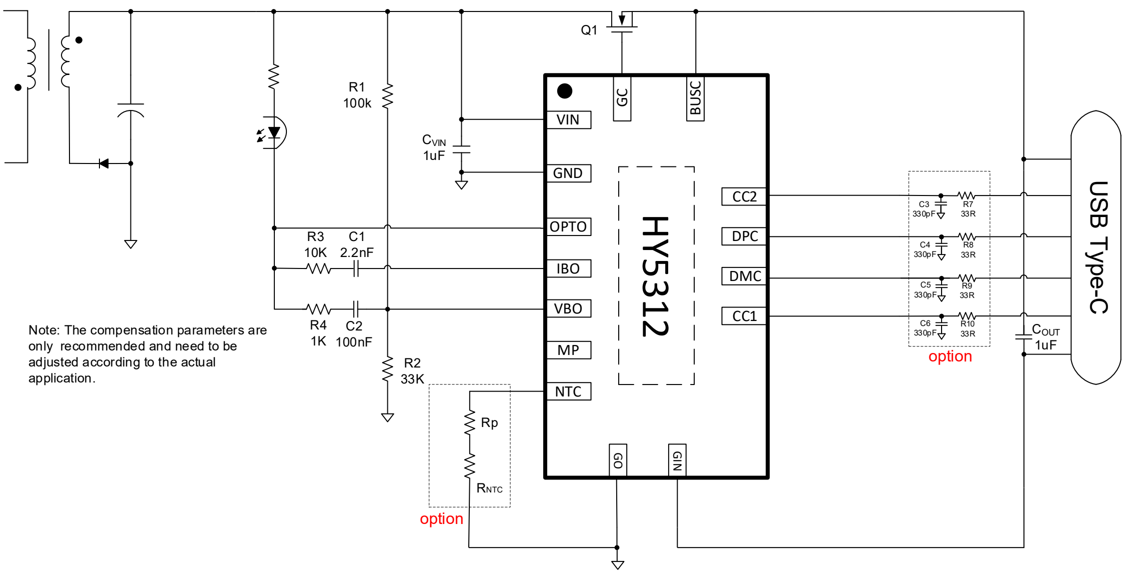
The HY5312 supports OVP by monitoring the voltage of VIN pin, once the voltage exceeds the over voltage threshold of the required the OVP procedure will be triggered, and then the HY5312 turns off external NMOS FET quickly.

7.8 OCP and short protection

The HY5312 monitors output current through the internal sense resistor connected to GIN and GO for over current and short-circuit protection. When the output current exceeds the over current protection threshold or short-circuit protection threshold corresponding to the requested, the over current or short-circuit protection procedure is triggered, and then the HY5312 turns off external NMOS FET quickly.

8 Typical Application Circuit

8.1 AC/DC - OPTO feedback



Note: The compensation parameters are only recommended and need to be adjusted according to the actual application.

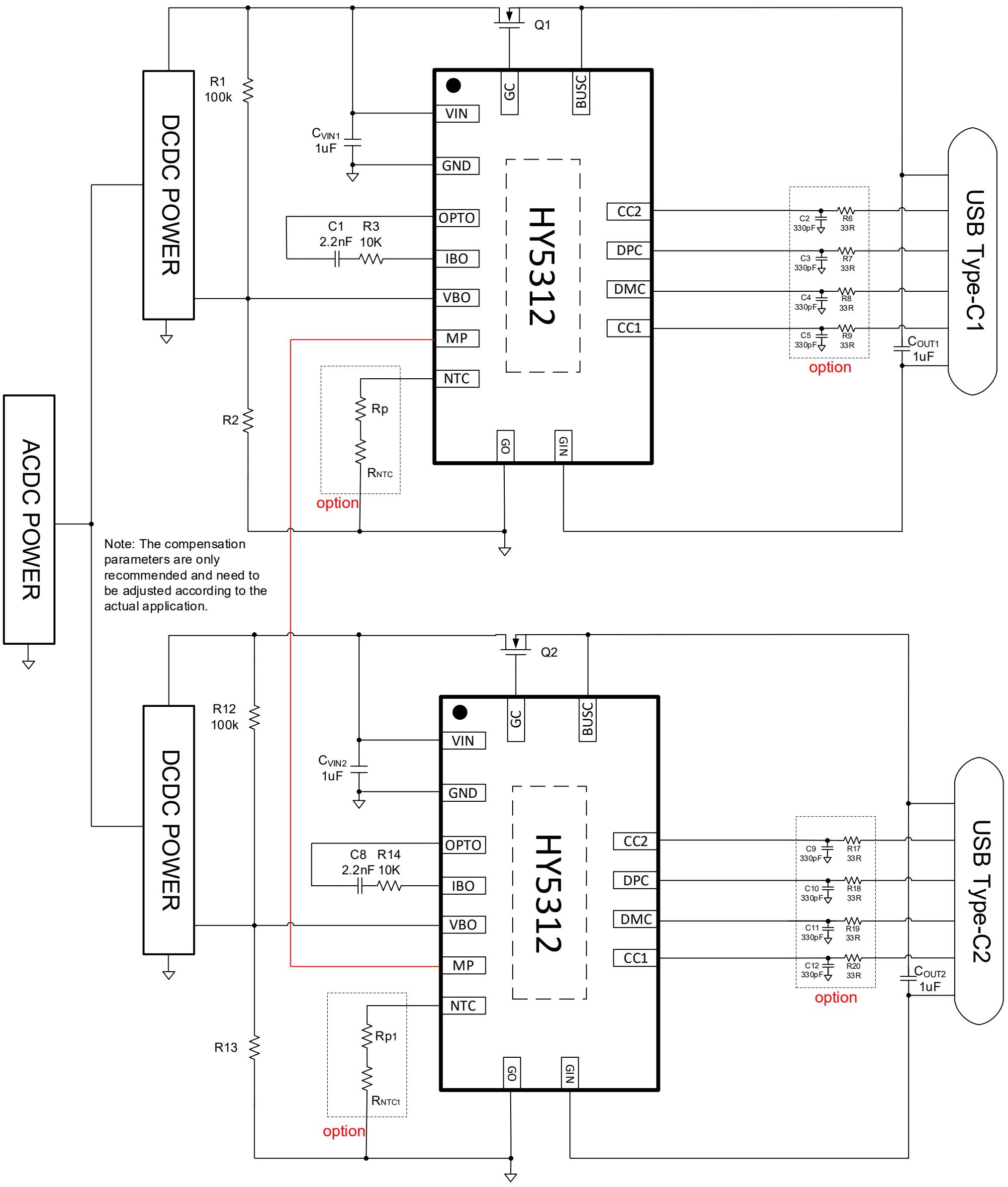
Fig. 6. Application for ACDC

Note: Must using Kelvin Connect to connect current sense resistor RS, NMOS Q1.

Table 5. OPTO feedback Application BOM list

No.	Part Name	Description	Unit	Qty	Location
1	IC	HY5312	PCS	1	
2	SMD capacitor	0603, 1uF, +/-20%, 25V, X5R	PCS	2	C_{VIN}, C_{OUT}
3	SMD capacitor	0603, 2.2nF, +/-20%, 25V, X5R	PCS	1	C1
4	SMD capacitor	0603, 100nF, +/-20%, 25V, X5R	PCS	1	C2
5	SMD resistor	0603, 330pF, +/-20%, 50V, X5R, for option	PCS	4	C3, C4, C5, C6
6	SMD resistor	0603, 100K, 1%	PCS	1	R1
7	SMD resistor	0603, 33K, 1%	PCS	2	R2
8	SMD resistor	0603, 10K, 5%	PCS	1	R3
9	SMD resistor	0603, 1K, 5%	PCS	1	R4
10	SMD resistor	0603, 33R, 5%, for option	PCS	4	R7, R8, R9, R10,
11	SMD NMOS	DFN 3mm x 3mm-8, $R_{DSON(at\ VGS=4.5V)}$<10mohm, VDS⩾30V(Recommend)	PCS	1	Q1

8.2 2C Fix Power Shared Application



Note: The compensation parameters are only recommended and need to be adjusted according to the actual application.

Fig. 7. Fix Power Shared Application

Note: If the TVS adds to CC pin， it must exceed 7V.

The following are instructions for 65 W down 30 W application:

1. When any port is working, it can charge quickly with 65 W.
2. When both ports are working, they can both charge quickly with 30 W.

8.3 2C Smart Power Shared Applications

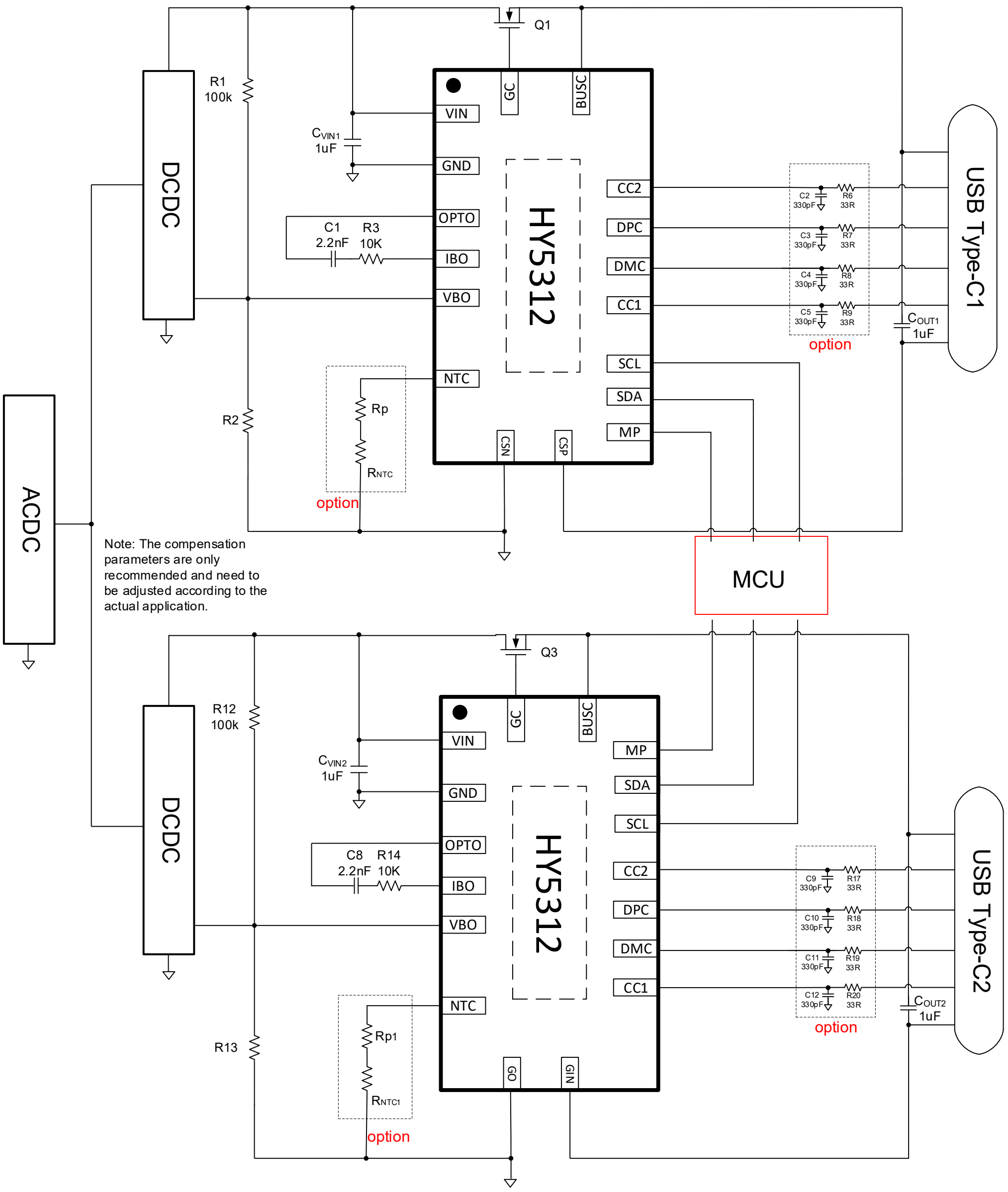


Fig. 8. Smart Power Shared Applications

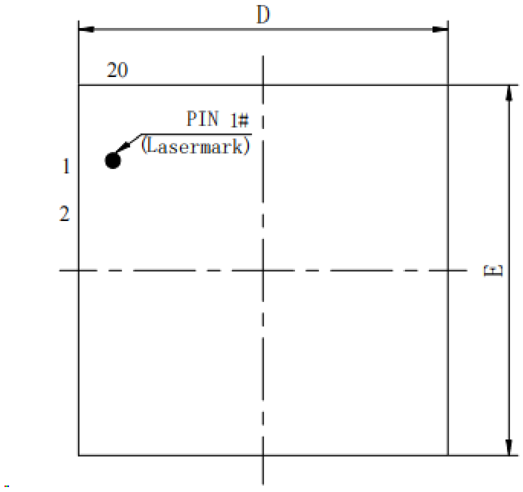
Note: If the TVS adds to CC pin， it must exceed 7V.

The following are instructions for 65W application:

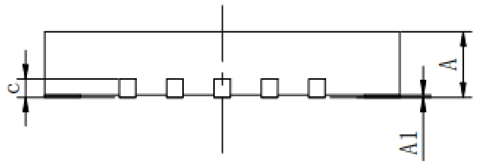
1. When any port is working, it can full charge power for 65W.
2. When C1 port operates at 45W, the C2 port operates at 18W, when C1 port operates at 18W, the C2 port operates at 45W.

9 Mechanical, Packaging & Orderable Info

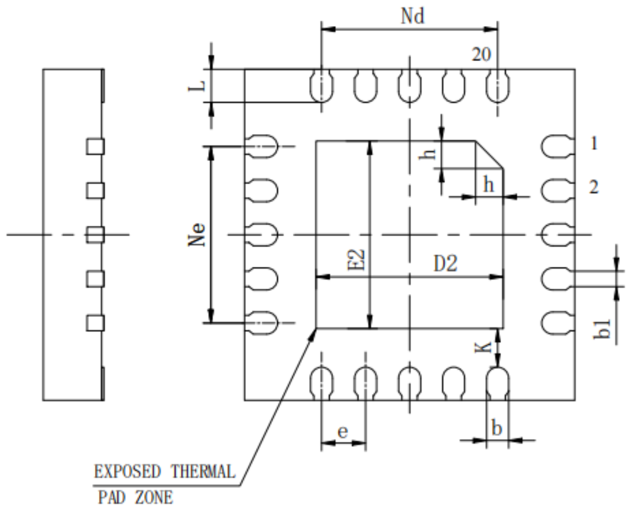
9.1 Package Outline: QFN 3mm x 3mm - 20L



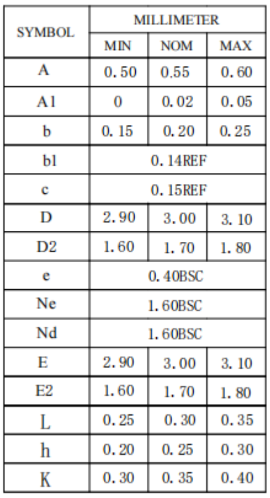
Top View



Side View



Bottom View



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0. 50	0.55	0. 60
A1	0	0. 02	0. 05
b	0. 15	0. 20	0. 25
b1	0. 14REF		
c	0. 15REF		
D	2. 90	3. 00	3. 10
D2	1. 60	1. 70	1. 80
e	0. 40BSC		
Ne	1. 60BSC		
Nd	1. 60BSC		
E	2. 90	3. 00	3. 10
E2	1. 60	1. 70	1. 80
L	0. 25	0. 30	0. 35
h	0. 20	0. 25	0. 30
K	0. 30	0. 35	0. 40

Legend

QFN 3mm X 3mm - 20L

Fig. 9. Package Outline

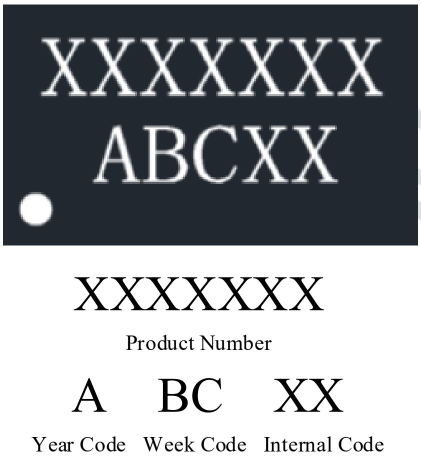
9.2 Ordering Information

Part Number	Configuration	Package	MOD
HY5312D30001Q	FPDO:5V/3A,9V/3A,12V/2.5A,15V/2A,20V/1.5A	QFN-20L	6K/Reel
	PPS:3.3-11V/3A,3.3-16V/2A		
	UFCS: 3.4-5.5V/3A, 5.5-11V/3A		
	QC2.0/QC3.0/QC3.0+(class A)/FCP/SCP/AFC/APPLE2.4A/BC1.2		
	Line drop compensation:100mV/A		
	OCP:110%		
HY5312XXXXXXX	For part numbers not listed above, please contact Hyasic		

9.3 Tape and Reel Information

Package Type	PCs/Reel	Reel/Reel Box	Reel Box/Carton Box	PCs/Carton Box
QFN 3X3-20L	6K	1	5	30K

9.4 Marking and Date Code Information



Year		Year Code
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2010	2025	B
2011	2026	C
2012	2027	D
2013	2028	E
2014	2029	F
2015	2030	G
2016	2031	H
2017	2032	J
2018	2033	K
2019	2034	L
2020	2035	M
2021	2036	N
2022	2037	P
2023	2038	Q

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11 Contact Information