HT6329S - High-Efficiency, Small Inductor, Multiphase 36V Dual-Buck DC-DC Controller with max. 700kHz for 3.3V-40A application

APPLICATION

- Low-EMI Applications (Patented dithering technique)
- Automotive ADAS Power Supply
- CPU Power supply for NVIDIA/Qualcomm-like AI-Chipsets, in multi-phase operations
- USB Type C PD3.1 and Type A QC3.0 Fast Charging Application for dual-buck mode operations
- Automotive LED Lighting
- LCD / TV / Monitor Power

GENERAL DESCRIPTION

HT6329S is an easy to use, high efficiency, dual-channel outputs, synchronous step-down switching controller designed for high-power dual buck controller, in single chip.

HT6329S allows a wide input voltage range from 4.7V to 36V, and provides a wide range of output. It can also deliver up to 140W or higher with appropriate FETs at each channel. It also provides selectable switching frequency for circuit design with different size of inductor at high conversion efficiency and power density

HT6329S has soft start function, which prevent the inrush current at startup from affecting the stability of the input power. On the protection side, it has a variety of protections for both input and output against over voltage, short circuit or under voltage conditions (see Multi-Protection section).

The external feedback provides the flexibility in interfacing with protocol IC to provide fast battery charging scheme like QC3.0 or PD3.1.

FEATURES

Dual-Channel Synchronous Buck Controller

- Wide input voltage range: 4.7V to 36V
- Dual Channel with independent input voltage
- Dual channel or single-output multiphase
- Multiphase mode may have output up to 3V, 45A current in typical cases.
- Independent external feedback for each channel
- Selectable switching frequency at 300kHz, 500kHz and 700kHz
- Support Constant Current (CC) / Constant Voltage (CV) mode
- Soft start

Multi-Protection

- Input under-voltage lockout (UVLO)
- Output over-voltage protection (OVP)
- Output short-circuit protection (SCP)
- Over-temperature protection (OTP)

DEVICE INFORMATION

Part Number	Package	Dimensions (mm)
HT6329S	WQFN32	5.0 x 5.0 x 0.75

See package outline and dimension on page 13.

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Typical Application Circuit

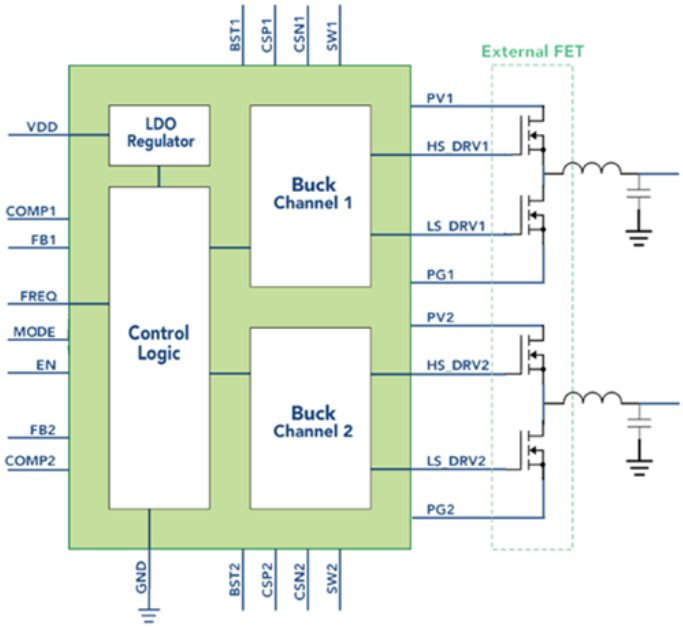

Fig. 1.1 – HT6329S Application Circuit

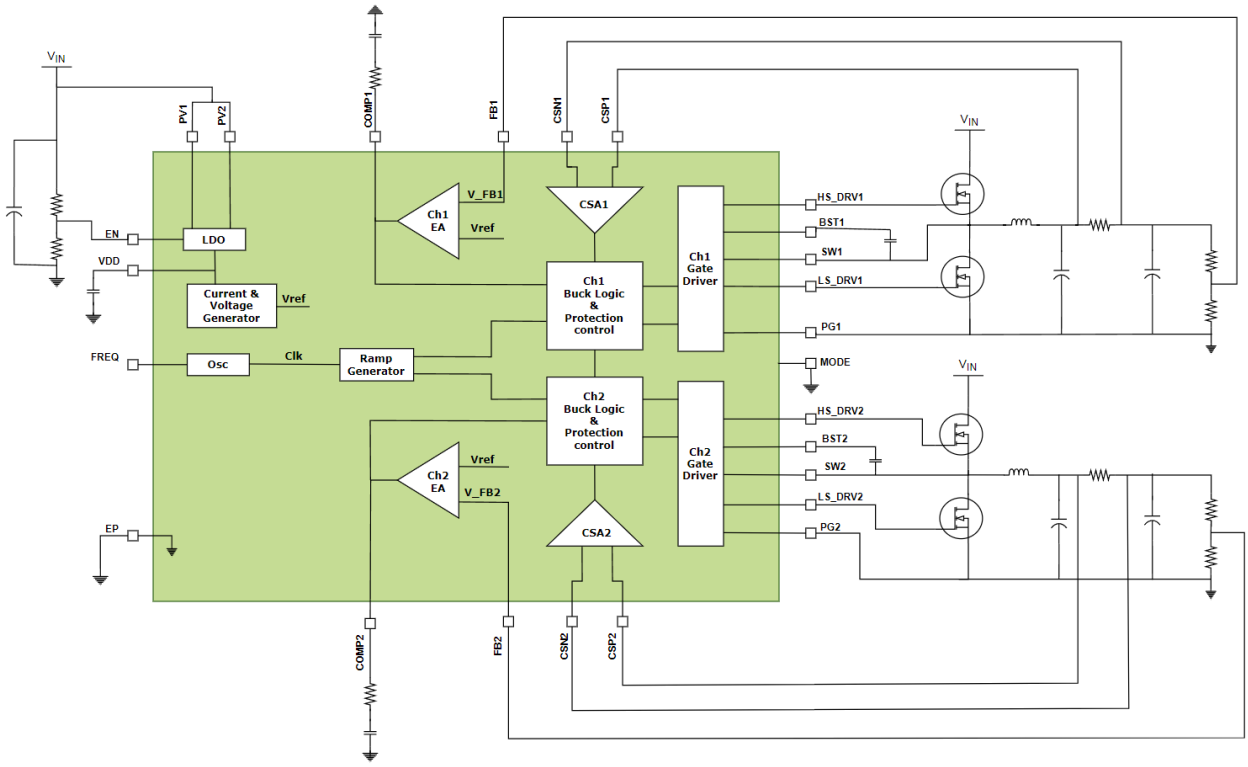

Fig. 1.2 – Detailed HT6329S Application Circuit (MODE pin connects to GND, Dual Output)

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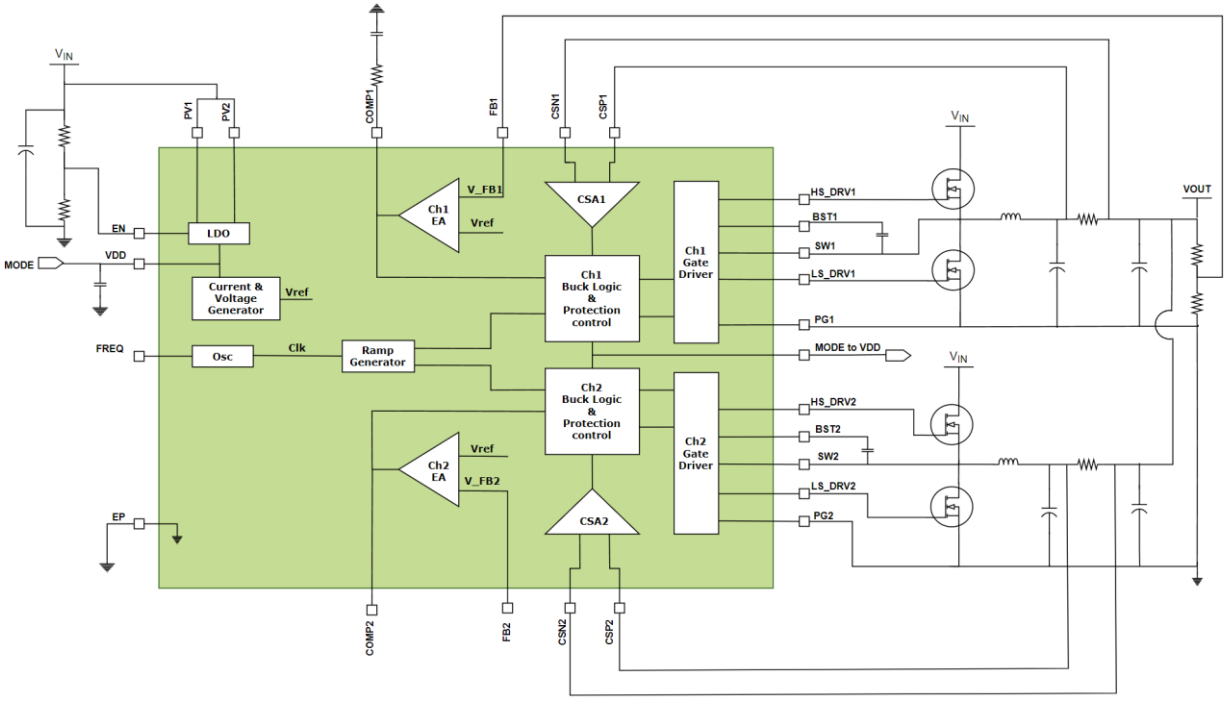

Fig. 1.3 – Detailed HT6329S Application Circuit (MODE pin connects to VDD, Interleaved Single Output)

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Pin Configuration

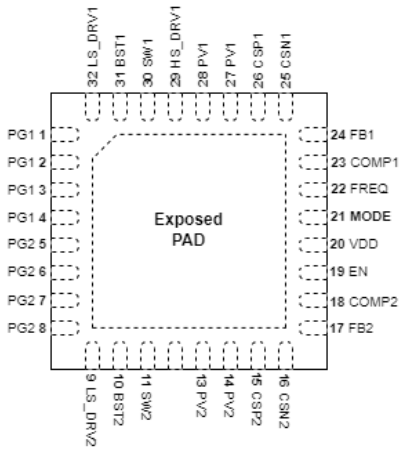

Fig. 2 - 32-pin WQFN, 5x5 mm^2, 0.5mm pitch TOP VIEW

Pin Functions

Pin	Name	Description
1,2,3,4	PG1	Power Ground Channel 1
5,6,7,8	PG2	Power Ground Channel 2
9	LS_DRV2	Low Side Gate Drive Channel 2
10	BST2	Bootstrap Channel 2. Connect a capacitor and a resistor to SW2. Recommend 0.1uF and 2Ω.
11	SW2	Inductor Connection Channel 2
12	HS_DRV2	High Side Gate Drive Channel 2
13, 14	PV2	Input Power Channel 2. Connect a capacitor to GND. Recommend 1uF.
15	CSP2	Current Sense Positive Channel 2
16	CSN2	Current Sense Negative Channel 2
17	FB2	Feedback Channel 2
18	COMP2	Compensation Channel 2
19	EN	Chip Enable. 1.35V enables the device. When V_{EN} > 8V, the device operates in forced PWM mode at light load and disables dithering.
20	VDD	VDD Regulator. Connect a decoupling capacitor to GND. Recommend 2.2uF.
21	MODE	Connect to GND for dual-output. Connect to VDD for interleaved single-output operation .
22	FREQ	Frequency Selection Pin. See Application Information Section for detail.
23	COMP1	Compensation Channel 1
24	FB1	Feedback Channel 1
25	CSN1	Current Sense Negative Channel 1
26	CSP1	Current Sense Positive Channel 1
27, 28	PV1	Input Power Channel 1. Connect a capacitor to GND. Recommend 1uF.
29	HS_DRV1	High Side Gate Drive Channel 1
30	SW1	Inductor Connection Channel 1
31	BST1	Bootstrap Channel 1. Connect a capacitor and a resistor to SW1. Recommend 0.1uF and 2Ω.
32	LS_DRV1	Low Side Gate Drive Channel 1
33	EPAD	Signal Ground & Thermal Dissipation Pad

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Absolute Maximum Ratings

PV1, PV2, SW1, SW2, EN	-0.3V to 40V
HS_DRV1, HS_DRV2, BST1, BST2	-0.3V to 36V
LS_DRV1, LS_DRV2	-0.3V to 6V
CSP1, CSN1, CSP2, CSN2	-0.3V to 22V
VDD, COMP1, COMP2, FB1, FB2, FREQ, MODE	-0.3V to 6V
Operating Temperature Range	-40°C to 85°C
Maximum Junction Temperature	-40°C to 125°C
Storage Temperature Range	-65°C to 125°C
Soldering Temperature	300°C

Electrical Characteristics (T_A=25°C, Vin = 12V unless specified)

Limits apply over the operating temperature range, unless else specified. Max and Min limits are provided through design, test or statistical dependence. Typical values are the most likely parametric norm at room temperature, and are stated for reference only. Unless otherwise specified the following conditions apply: V_{IN} = 12V.

Parameters	Symbol	Test Conditions	Rating			Unit
			MIN	TYP	MAX	
Input Characteristics						
Input Voltage	V_{IN}		4.7		36	V
EN Threshold	V_{EN}			1.35		V
EN Hysteresis	V_{ENHYS}			110		mV
Quiescent Current	I_Q	Output at no load		1.5		mA
Shutdown Current	I_{stb}	V_{EN} = 0V		20		µA
Output Characteristics						
Output Voltage Range	V_{OUT}	V_{IN} = 36V	3		20	V
Output Current Limit	I_{Limit_FB}	R_{SENSE} = 10mΩ		3.6		A
Reference Voltage						
Output Voltage Reference	V_{FB}	Measured at FB1, FB2		1		V
Regulator Reference	V_{DD}	Measured at VDD		5.4		V
Switching Characteristics						
Switching Frequency	f_{sw}	FREQ=Z		300		kHz
		FREQ=L		500		kHz
		FREQ=H		700		kHz
Minimum On-Time	$t_{ON, Min}$			80		ns
Dither Generator						
Dither Modulation Frequency	f_{DITH}			1560		Hz
Maximum Switching Frequency	f_{OSCMAX}			850		kHz
Minimum Switching Frequency	f_{OSCMIN}			700		kHz
MODE						
Dual Output mode input low threshold	V_{MODE_LOW}			1		V
Interleaved mode input high threshold	V_{MODE_HIGH}			3.5		V

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Parameters	Symbol	Test Conditions	Rating			Unit
			MIN	TYP	MAX	
Input Under-voltage Lockout						
Input Under-Voltage Lockout Threshold **High**	V_{UVLO}			4.7		V
Input Under-Voltage Lockout Hysteresis	V_{UVHYS}		0.53	0.64	0.71	V
Output Under-voltage Lockout						
Output Under-voltage Protection	V_{UVP}			V_{OUT}*60%		V
Output Over-voltage Protection						
Output Over-Voltage Protection	V_{OVP}			V_{OUT}*120%		V
Over-Temperature Protection						
Thermal Shutdown	T_{SD}	Increasing Temperature		140		°C
Thermal Shutdown Hysteresis	T_{SD_HYS}	Decreasing temperature		30		°C

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Typical Characteristics (T_A=25°C, Vin = 12V, Vout = 3V, unless specified)

For MODE = VDD, L = 2 x 4.7uH (DCR_{max} = 4.7mΩ), Fsw = 500 kHz, $FET\_Rds_{(on,\ max)}$@4.5V_{gs} = 7.1mΩ

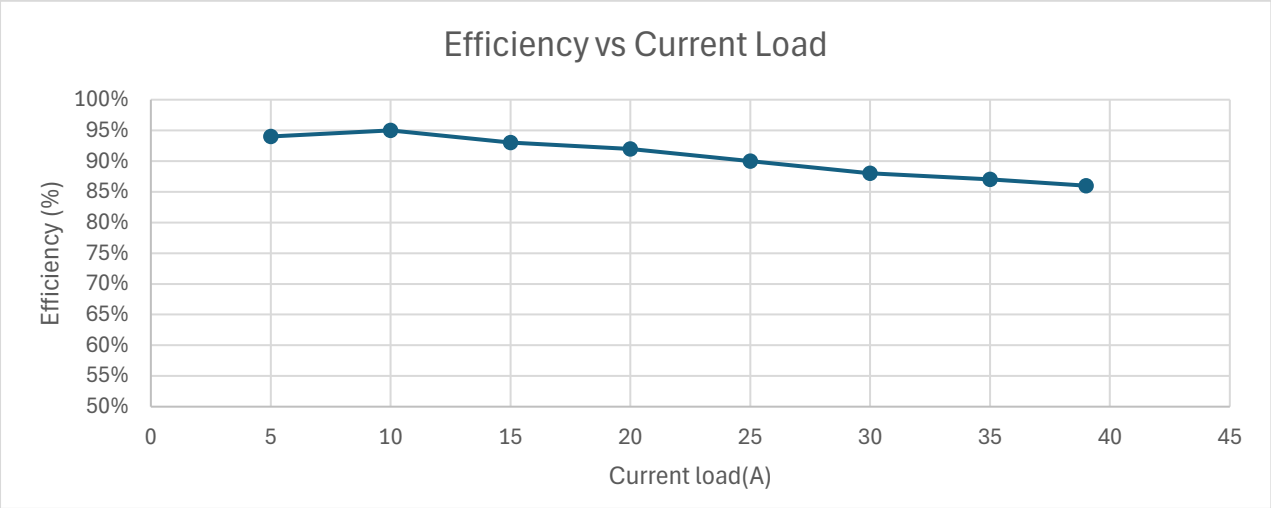

Fig. 3.1 – Efficiency vs Output Current

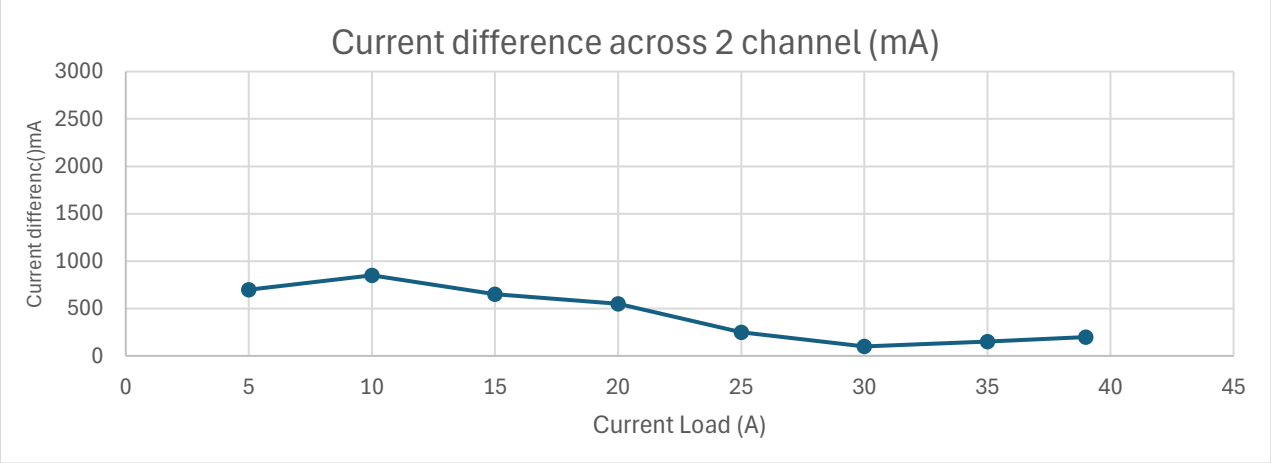

Fig. 3.2 – Current difference vs Output Current

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Functional Block Diagram

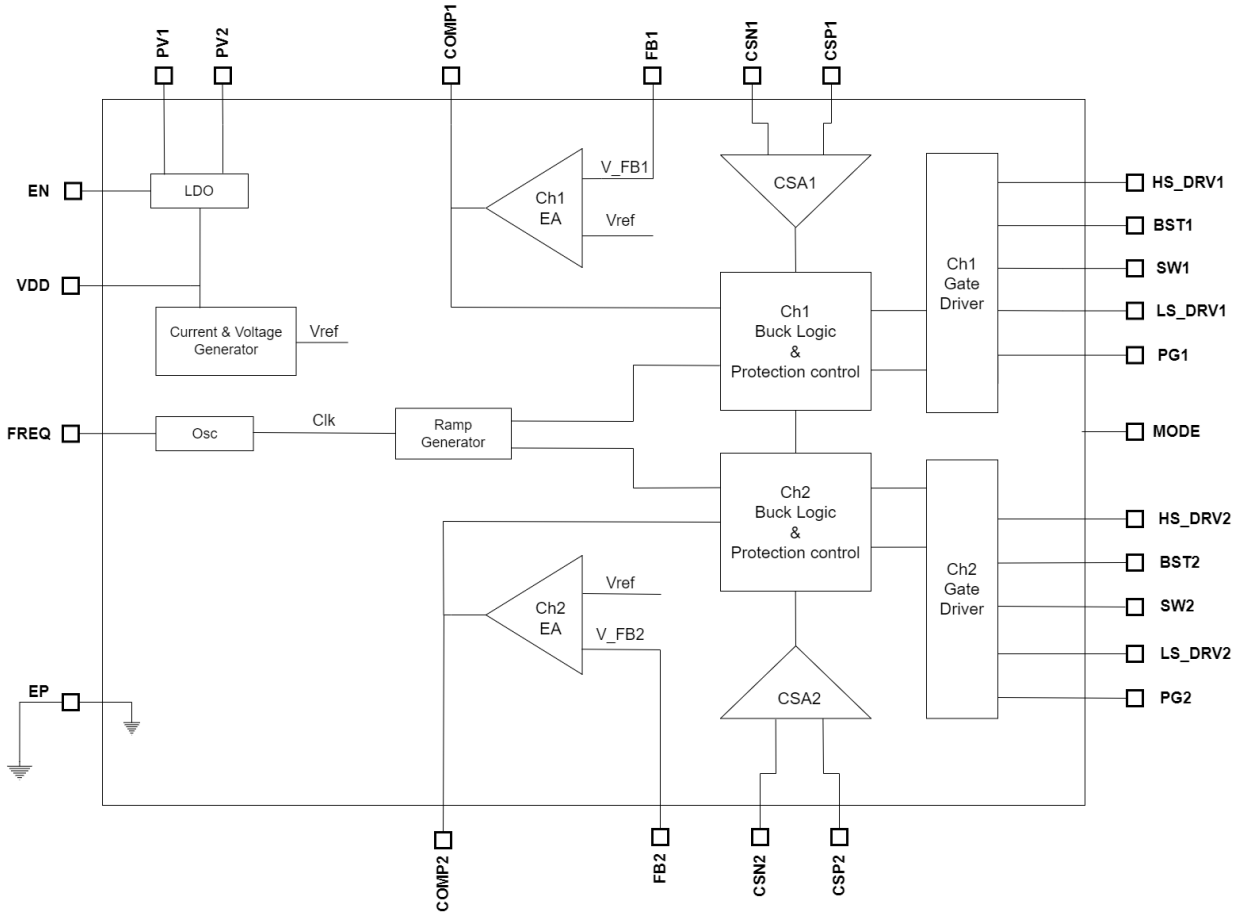

Fig. 4 – Functional Block Diagram

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Application Information

Input Protection

If the input voltage is smaller than Input UVLO, both buck channels stop the gate driver, reset and enter hiccup mode. It returns to Normal when the faults are cleared.

Output Protection

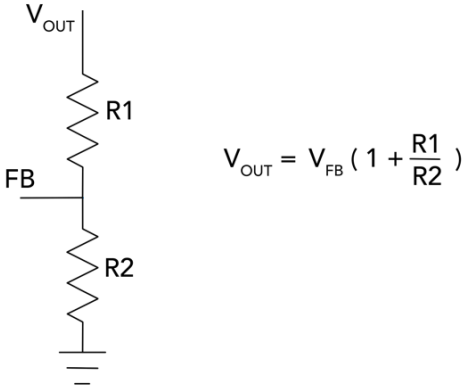
The Output Under-voltage Lockout threshold and the Output Over-voltage Protection are set at V_{OUT}*60% and V_{OUT}*120%. Once Output UVLO or OVP is triggered, the specific channel stops the gate driver, reset and enters hiccup mode.

Soft Start

HT6000 series employs an internal soft start in the buck converter to prevent large inrush current and overshoots of V_{OUT}. The soft start time is 20ms in the design.

Feedback and Output Voltage

HT6329S provides an external FB for setting the output voltage. The feedback resistor divider tap is connected and V_{FB} is regulated at 1V. The relationship between the V_{OUT} and the resistor divider tap is as follows:



$$V_{OUT} = V_{FB}\left(1 + \frac{R1}{R2}\right)$$

Fig. 5 – Feedback Resistor Network Design

Frequency Selection

The switching frequency can be selected by applying different condition to the pin FREQ.

FREQ state	f_{sw} (kHz)
Z (Floating)	300
L (Tied to GND)	500
H (Tied to VDD)	700

The efficiency of the conversion depends on the switching FET. Usually, the efficiency is higher at lower frequency because of lower switching loss.

Efficiency and External FET R_{dson}

The accuracy of the output voltage and the conversion efficiency is highly affected by the R_{dson} of the external FET. The lower the R_{dson} the higher the efficiency and voltage accuracy.

Compensation Network

The output of the Error Amplifier is connected to COMP pin, allowing external control loop compensation. A type-II compensation network is recommended to ensure system stability.

Constant Voltage / Constant Current Mode

HT6329S has the capability to operate in either CV (constant voltage) mode or CC (constant current) mode, with a smooth transition from CV to CC (See Fig.6). When in CV mode, it regulates the output voltage. Once the output current limit threshold is reached, HT6329S switches to CC mode. In CC mode, the output voltage decreases while the output current remains clamped at the predefined values. The current limit can be determined using the following equation.

$$I_{out(\max)} = \frac{36mV}{R_{sense}}$$

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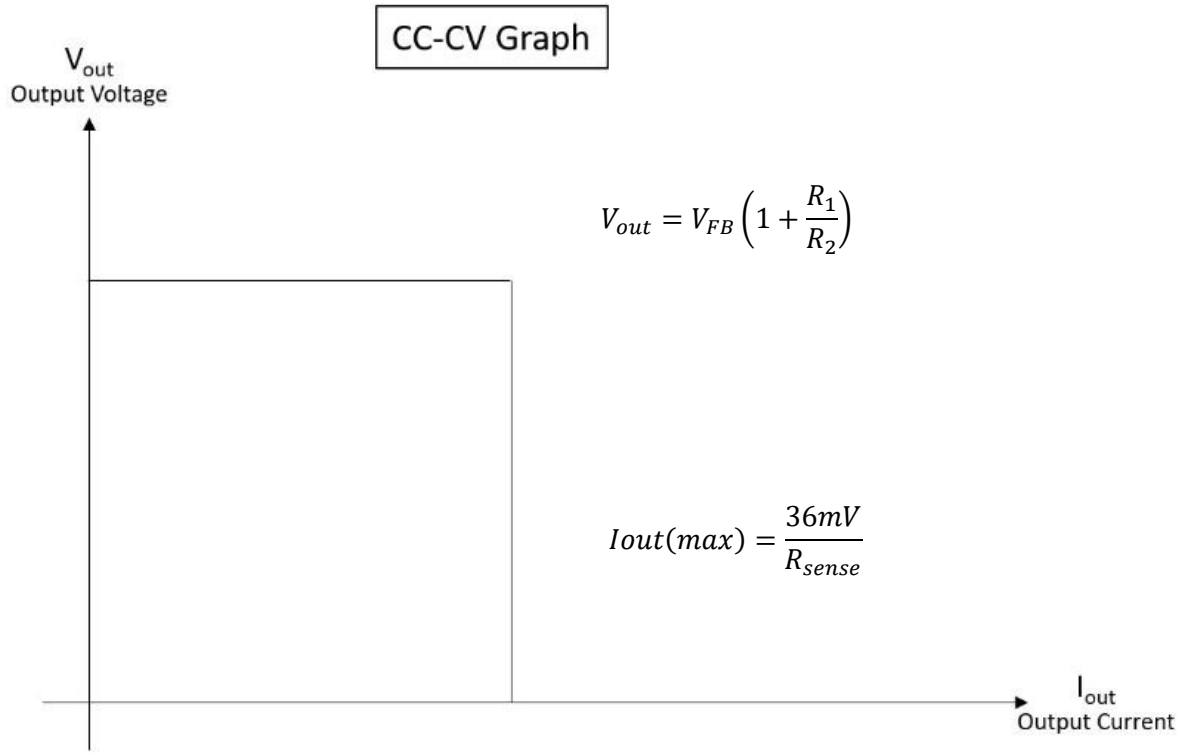

Fig. 6 - CC-CV Graph

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Typical Application Schematic

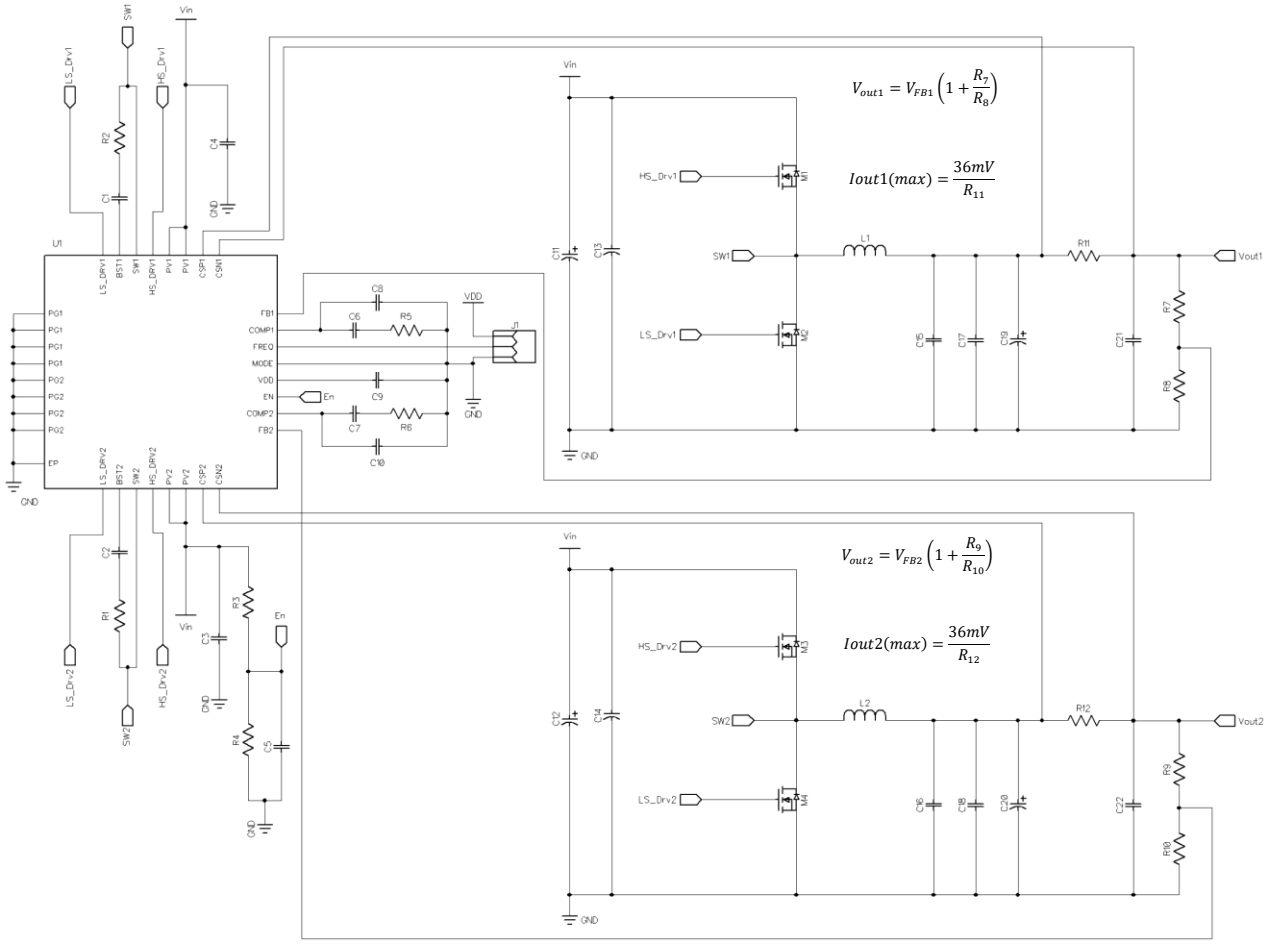

Fig. 7.1 - HT6329S simplified schematic (MODE pin connects to GND, Dual Output)

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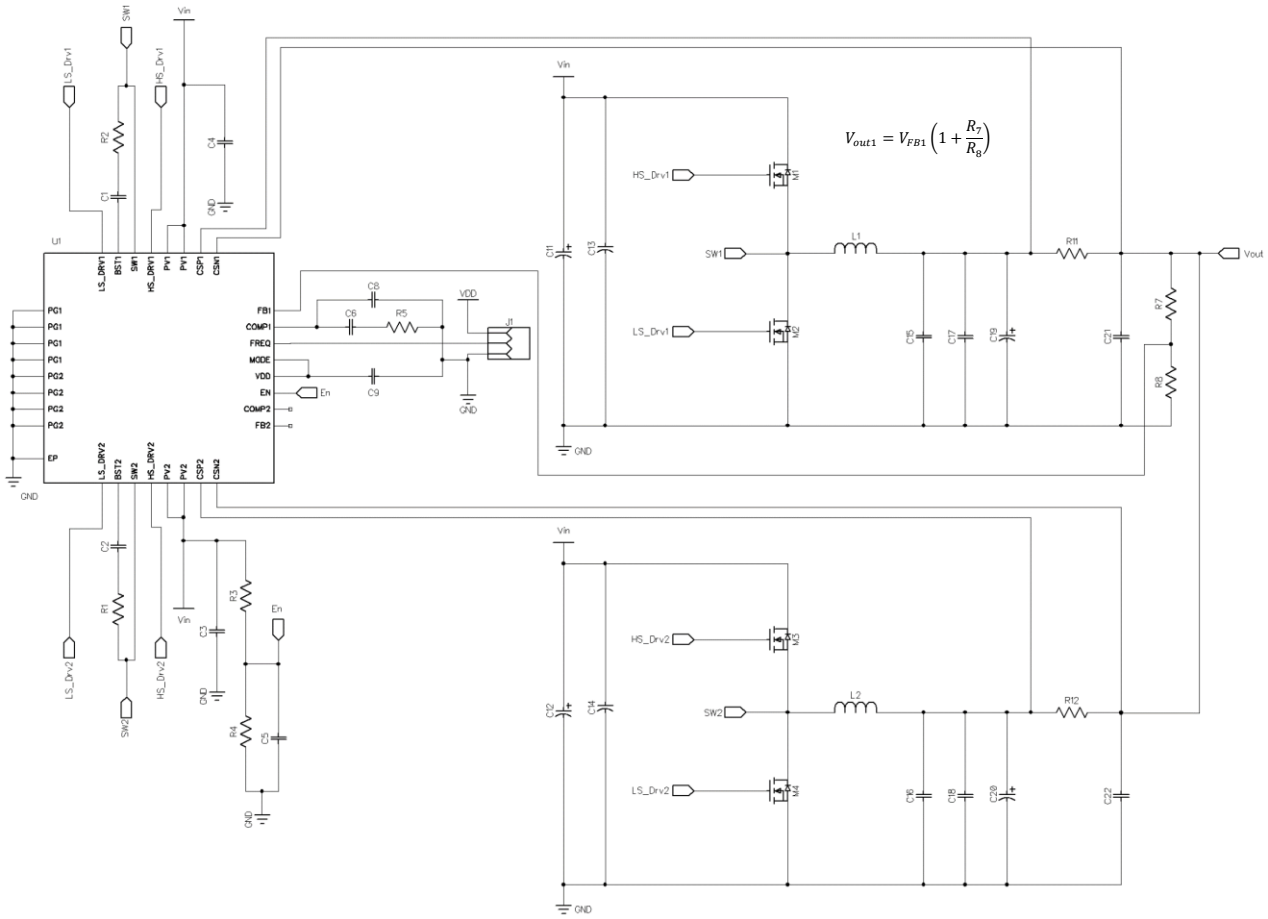

Fig. 7.2 - HT6329S simplified schematic (MODE pin connects to VDD, Interleaved Single Output)

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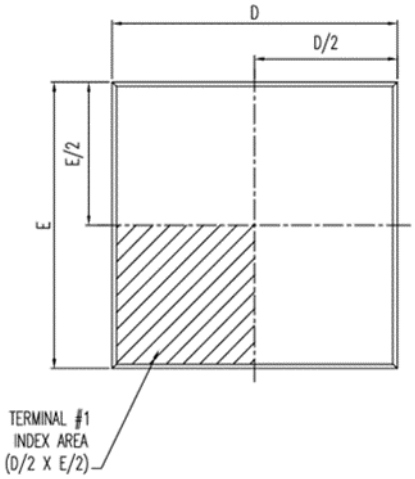
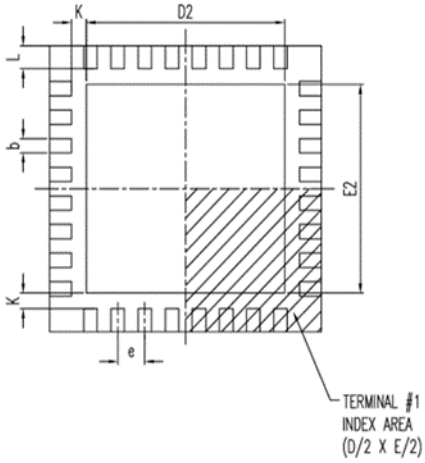
Package Outline and Dimensions

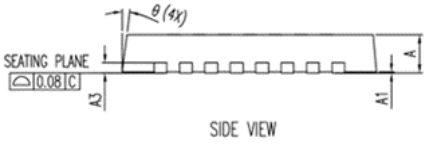
32-pin WQFN (5mm x 5mm, 0.5mm pitch)



Top View



Bottom View



Side View

SYMBOL	DIMENSION IN MM		
	MIN.	NOM.	MAX.
A	0.70	0.75	0.80
A1	0	0.02	0.05
A3		0.20 REF.	
D		5.00 BASIC	
D2	3.50	3.65	3.80
E		5.00 BASIC	
E2	3.50	3.65	3.80
e		0.50 BASIC	
b	0.18	0.25	0.30
L	0.35	0.40	0.45
K	0.20		
θ	0°		14°
JEDEC	MO-220 (Variation WHHD-4)		

NOTES :
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.15mm AND 0.30mm FROM THE TERMINAL TIP. IF THE TERMINAL HAS THE OPTIONAL RADIUS ON THE OTHER END OF THE TERMINAL, THE DIMENSION b SHOULD NOT BE MEASURED IN THAT RADIUS AREA.
3. BILATERAL COPLANARITY ZONE APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.

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Dual Ports MAX SPEED

HT6000 Series

Fast Charging is just a Breeze

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