

# HT7228P – 36V, 1MHz max, Dual 3.6A Synchronous Buck Converter with Low EMI and High Efficiency

## APPLICATION

- USB Type C PD3.1 and Type A QC3.0 fast charging supply
- Low-EMI Applications (Patented dithering technique)
- Automotive ADAS Power Supply
- Automotive LED Lighting
- LCD / TV / Monitor Power
- Low EMI Application (*Patent Pending*)
- Combine-mode, support single-channel, higher power (*Patent Pending*)

## GENERAL DESCRIPTION

HT7228P is an easy to use, high efficiency, dual-channel, synchronous step-down switching converter designed for high-power dual ports DC-DC applications. Integrated with 4 power MOSFETs. It has a wide input range from 4.7 V to 36 V, typical output voltage can be configured from 3V to 20V with typical current of 2.5A. The switching frequency is adjustable up to 1MHz by an external resistor to covers wide range of applications allowing small form factor components like inductors and capacitors.

HT7228P has soft start function, which prevents 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).

A typical application of HT7228P is USB fast charger, the external feedback provides the flexibility in interfacing with protocol IC to provide fast charging scheme like QC3.0 or PD3.1 at both output channels simultaneously with less components needed.

## FEATURES

### Dual-Channel Synchronous Buck converter

- Low  $R_{DS(ON)}$  internal power MOSFET 100mΩ/100mΩ
- Wide input voltage range: 4.7V to 36V
- Output current up to 3.6A at each channel
- Independent external feedback for each channel
- Adjustable switching frequency from 350kHz to 1MHz
- Support Constant Current (CC) / Constant Voltage (CV) mode
- Combine mode for higher output power applications
- Soft start
- 20μA typical shutdown current

### 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)
HT7228P	WQFN32	5.0 x 5.0 x 0.75

See package outline and dimensions on p.12

**Typical Application Circuit**

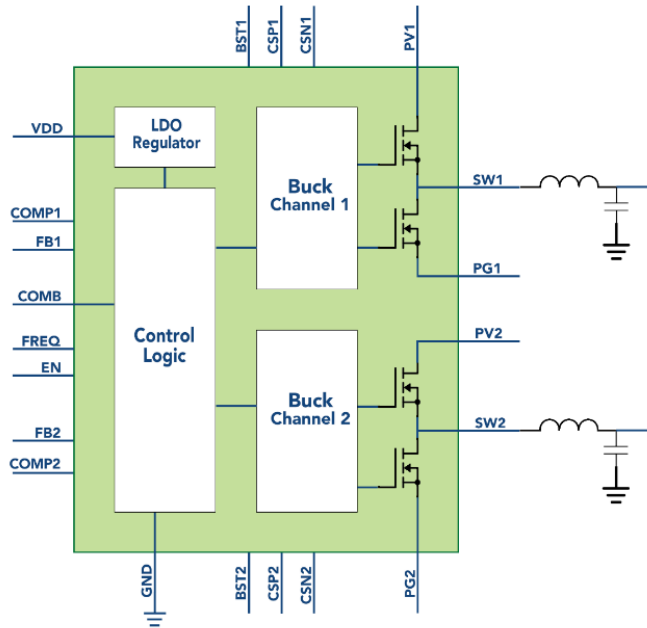


Fig. 1.1 - HT7228P Block diagram (COMB=0)

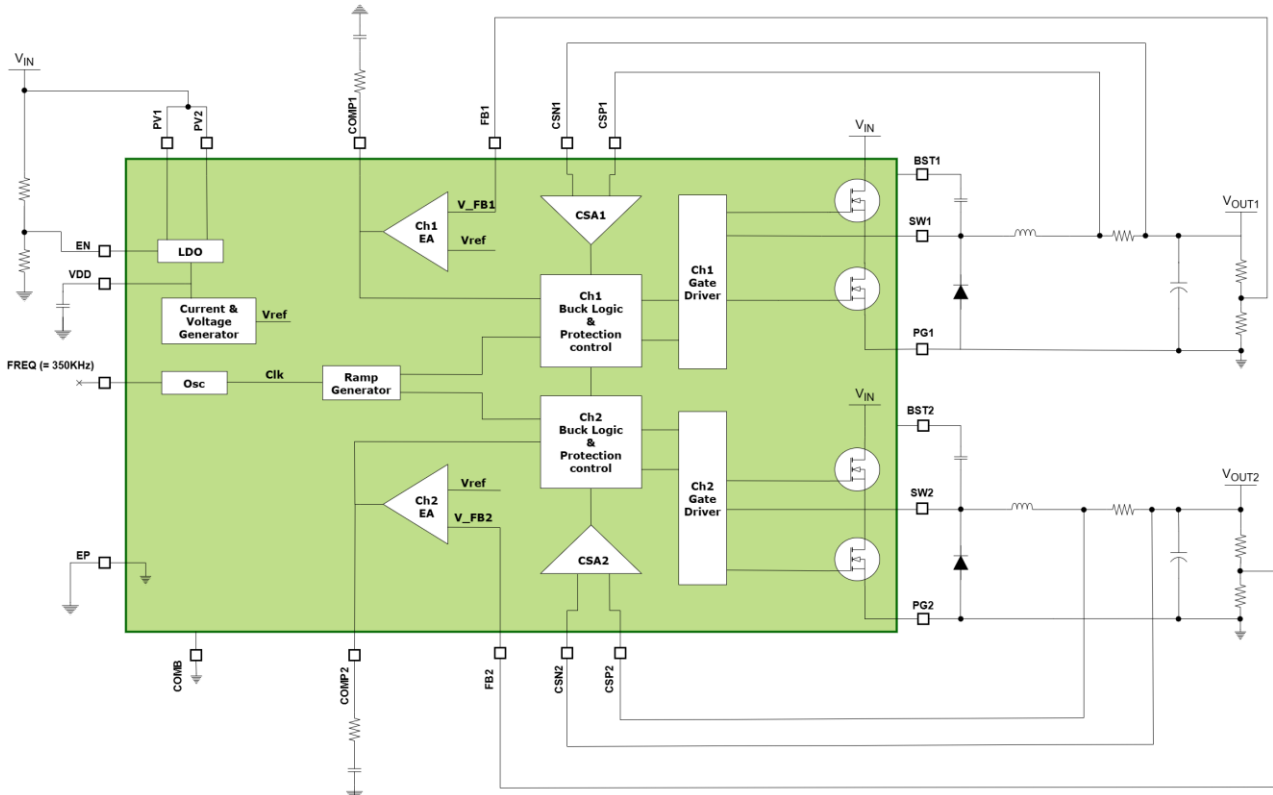


Fig. 1.2 - HT7228P Application Schematics (COMB=0)

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Typical Application (Contd.)

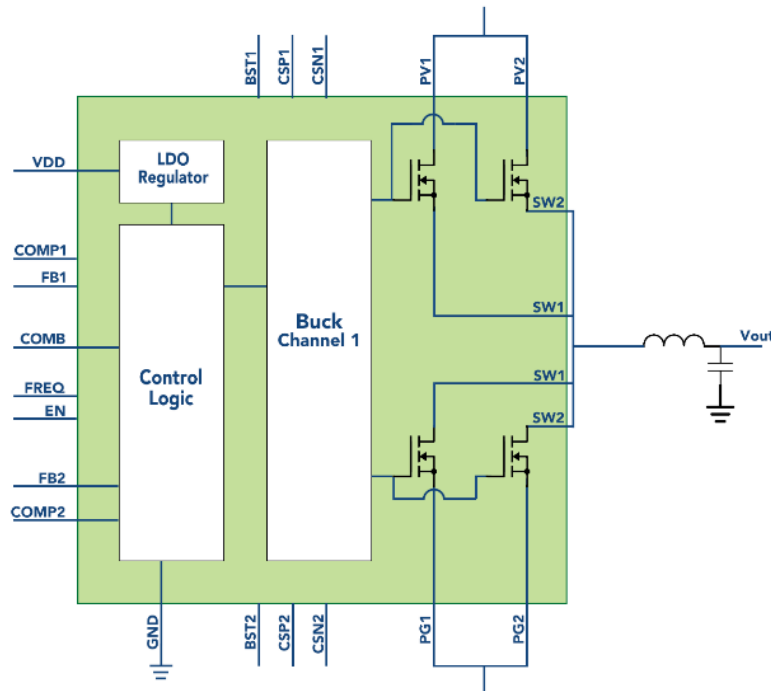


Fig. 2.1 - HT7228P Block diagram (COMB=1)

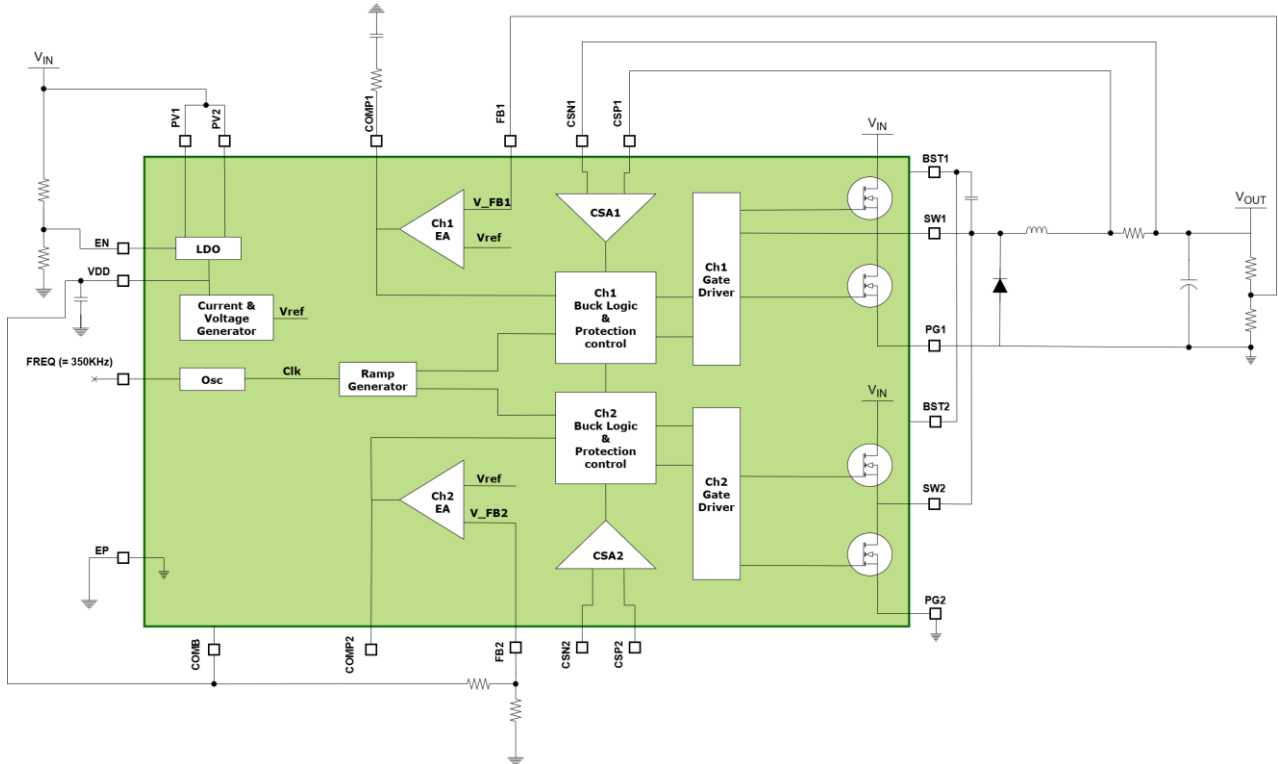


Fig. 2.2 - HT7228P Application Schematics (COMB=1)

## Pin Configuration

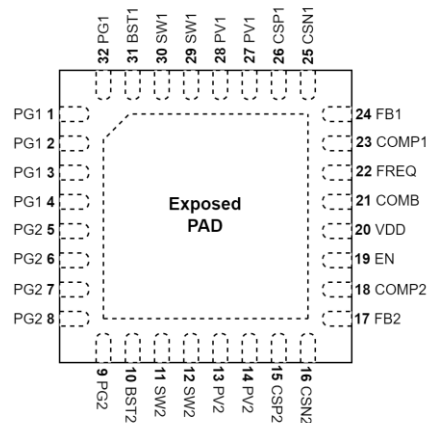


Fig. 3 - 32-pin WQFN, 5x5 mm<sup>2</sup>, 0.5mm pitch TOP VIEW

## Pin Functions

Pin	Name	Description
<b>1,2,3,4,32</b>	PG1	Power Ground Channel 1
<b>5,6,7,8,9</b>	PG2	Power Ground Channel 2
<b>10</b>	BST2	Bootstrap Channel 2. Connect a capacitor and a resistor to SW2. Recommend 0.1uF and 2Ω.
<b>11,12</b>	SW2	Inductor Connection Channel 2
<b>13, 14</b>	PV2	Input Power Channel 2. Connect a capacitor to GND. Recommend 1uF.
<b>15</b>	CSP2	Current Sense Positive Channel 2
<b>16</b>	CSN2	Current Sense Negative Channel 2
<b>17</b>	FB2	Feedback Channel 2
<b>18</b>	COMP2	Compensation Channel 2
<b>19</b>	EN	Chip Enable. 1.35V enables the device. When V <sub>EN</sub> > 8V, the device operates in forced PWM mode at light load and disables dithering.
<b>20</b>	VDD	VDD Regulator. Connect a decoupling capacitor to GND. Recommend 2.2uF.
<b>21</b>	COMB	Combine Mode Input. Logic High enables combine mode; Logic Low disables combine mode.
<b>22</b>	FREQ	Frequency Selection Pin. Floating this pin to set switching frequency to be 350kHz. See Application Information Section for more detail.
<b>23</b>	COMP1	Compensation Channel 1
<b>24</b>	FB1	Feedback Channel 1
<b>25</b>	CSN1	Current Sense Negative Channel 1
<b>26</b>	CSP1	Current Sense Positive Channel 1
<b>27, 28</b>	PV1	Input Power Channel 1. Connect a capacitor to GND. Recommend 1uF.
<b>29, 30</b>	SW1	Inductor Connection Channel 1
<b>31</b>	BST1	Bootstrap Channel 1. Connect a capacitor and a resistor to SW1. Recommend 0.1uF and 2Ω.
<b>33</b>	EPAD	Signal Ground & Thermal Dissipation Pad

## Absolute Maximum Ratings

Operation exceeding the Absolute Maximum Ratings may damage the device. If operating outside the Recommended Electrical Ratings but within the Absolute Maximum Ratings, device functionality and performance should not be assumed, and reliability may be affected.

PV1, PV2, SW1, SW2, EN, BST1, BST2	-0.3V to 40V
CSP1, CSN1, CSP2, CSN2	-0.3V to 22V
VDD, COMP1, COMP2, FB1, FB2, COMB, FREQ	-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<sub>A</sub>=25°C, V<sub>in</sub> = 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 specified the following conditions apply: V<sub>IN</sub> = 12V, T<sub>A</sub>=25°C.

Parameters	Symbol	Test Conditions	Rating			Unit
			MIN	TYP	MAX	
<b>Input Characteristics</b>						
Input Voltage	V <sub>IN</sub>		4.7		36	V
EN Threshold	V <sub>EN</sub>			1.35		V
EN Hysteresis	V <sub>ENHYS</sub>			110		mV
Quiescent current	I <sub>Q</sub>	FREQ pin open		1.5		mA
Shutdown Current	I <sub>stb</sub>	V <sub>EN</sub> = 0V		20		μA
<b>Output Characteristics (For both channel 1 and channel 2)</b>						
Output Voltage Range	V <sub>OUT</sub>		3		20	V
Output Current limit	I <sub>Limit_FB</sub>	R <sub>cs</sub> =10 mΩ		3.6		A
<b>Reference Voltage</b>						
Output Voltage Reference	V <sub>FB</sub>	Measured at FB1, FB2		1		V
VDD Regulator	V <sub>DD</sub>	Measured at VDD		5.4		V
<b>Switching Characteristics</b>						
High Side MOSFET Turn On Resistance	R <sub>DS_HS(ON)</sub>			100		mΩ
Low Side MOSFET Turn On Resistance	R <sub>DS_LS(ON)</sub>			100		mΩ
Switching Frequency	f <sub>sw</sub>		0.350		1	MHz
Minimum Off-Time	t <sub>ON, Min</sub>			80		ns
<b>COMB Pin Input</b>						
Input Threshold High	V <sub>COMB_TH_H</sub>			3.5		V
Input Threshold Low	V <sub>COMB_TH_L</sub>			1		V

### Electrical Characteristics (T<sub>A</sub>=25°C, V<sub>in</sub> = 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 specified the following conditions apply: V<sub>IN</sub> = 12V, T<sub>A</sub>=25°C.

Parameters	Symbol	Test Conditions	Rating			Unit
			MIN	TYP	MAX	
<b>Input Under-voltage Lockout</b>						
Input Under-Voltage Lockout Threshold High	V <sub>UVLO</sub>			4.7		V
Input Under-Voltage Lockout Hysteresis	V <sub>UVHYS</sub>		0.53	0.64	0.71	V
<b>Output Under-voltage Lockout</b>						
Output Under-voltage Protection	V <sub>UVP</sub>			V <sub>OUT</sub> *60%		V
<b>Output Over-voltage Protection</b>						
Output Over-Voltage Protection	V <sub>OVp</sub>			V <sub>OUT</sub> *120		V
<b>Protection</b>						
Thermal Shutdown	T <sub>SD</sub>	Increasing temperature		140		°C
Thermal Shutdown Hysteresis	T <sub>SD_HYS</sub>	Decreasing temperature		30		°C

### Typical Characteristics (T<sub>A</sub>=25°C, V<sub>in</sub> = 12V, V<sub>out</sub> = 3V, L = 22uH (DCR<sub>max</sub> = 9mΩ), F<sub>sw</sub> = 500 kHz, unless specified)

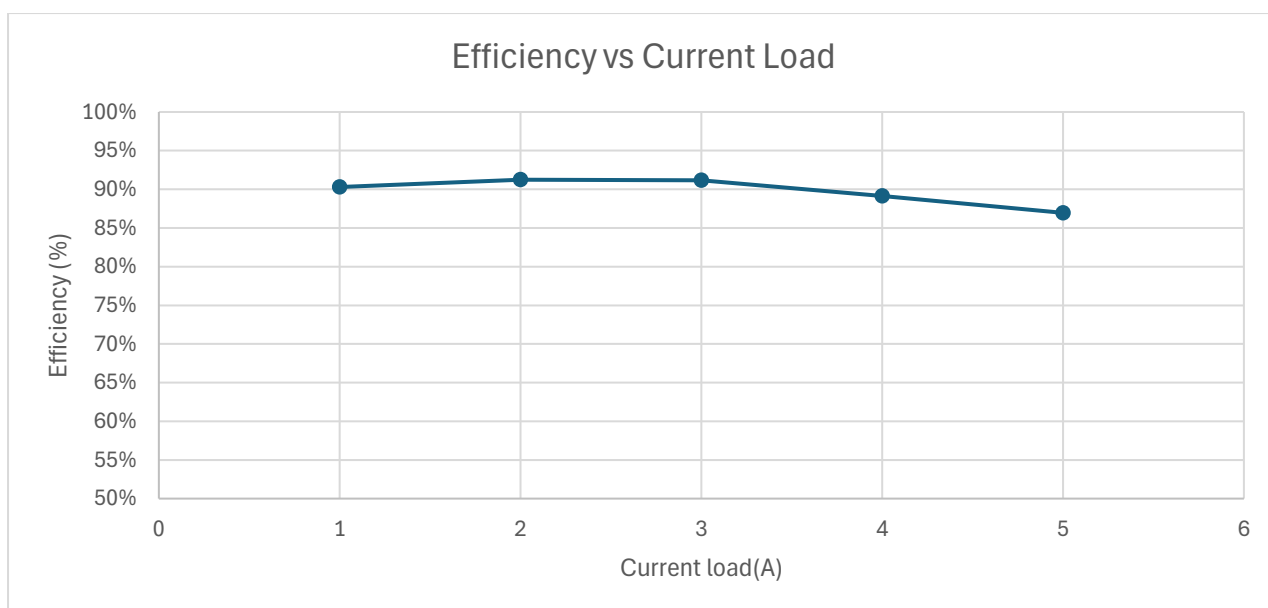


Fig. 4 - Efficiency vs Output Current

## Functional Block Diagram

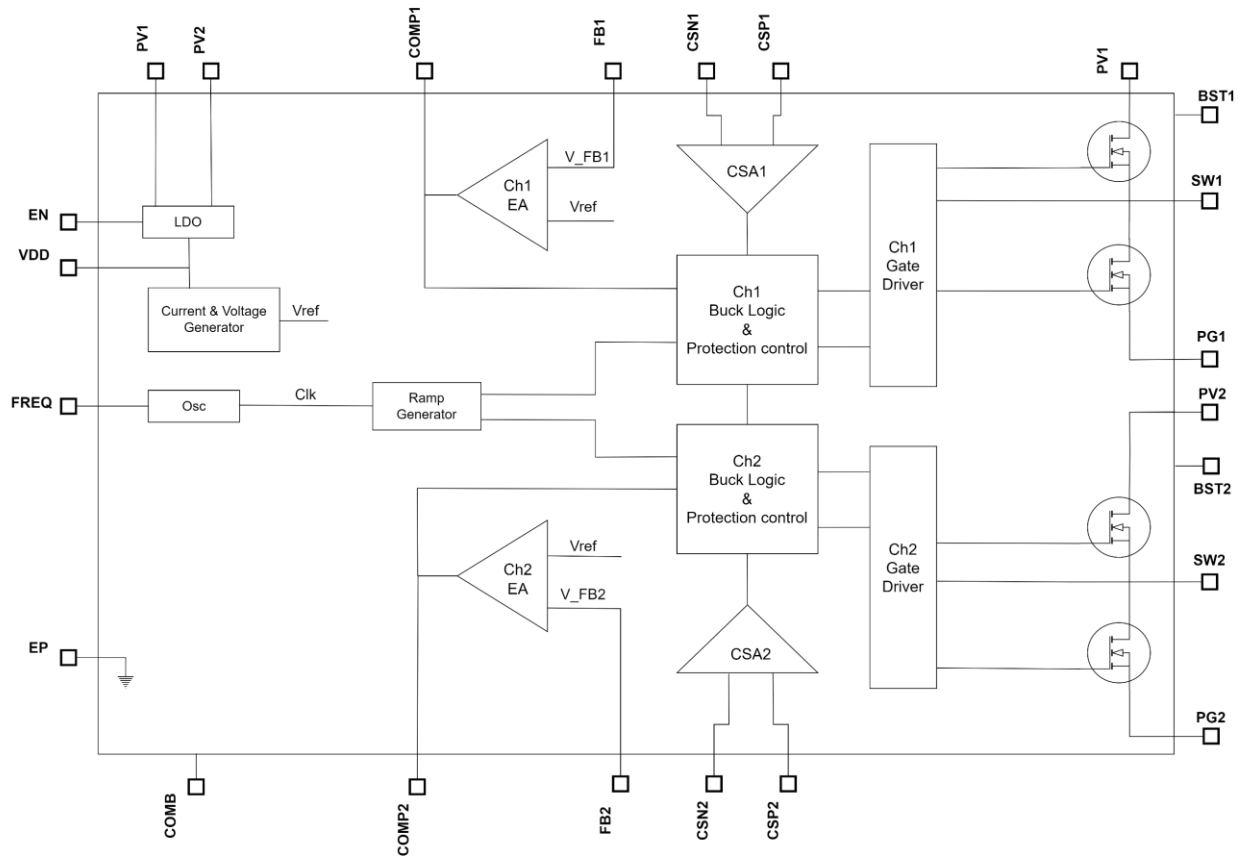


Fig. 5 - Functional Block Diagram

## 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 enter hiccup mode.

### Soft Start

HT7228P 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

HT7228P provides an external FB for setting the output voltage. Usually, 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:

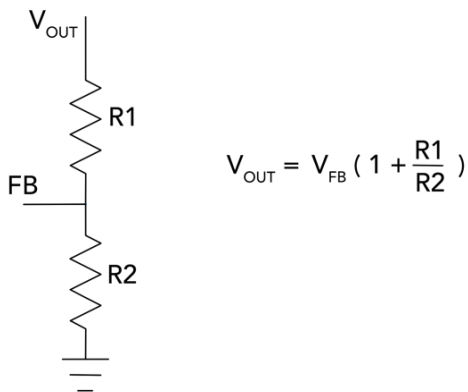


Fig. 6 – Feedback Resistor Network Design

### Frequency Selection

The FREQ can be left floating to set the switching frequency to be 350kHz. The switching frequency can also be adjusted by an appropriate resistor connected from FREQ pin to GND. The relationship between the resistor and switching frequency is shown in Fig. 6. The efficiency of the conversion depends on the switching FET. The efficiency is usually slightly higher at lower frequency because of the lower switching loss.

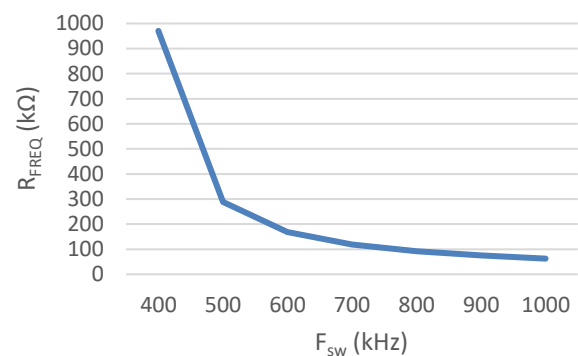


Fig. 7 – Switching frequency and resistor relationship

### Combine Mode

The Combine Mode can be enabled by setting COMB = VDD. In Combine Mode, channel 1 takes up the output current from channel 2. Once the Combined Mode is active, the control over channel 2 is disable.

### 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

HT7228P 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.7). When in CV mode, it regulates the output voltage. Once the output current limit threshold is reached, HT7228P 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.

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

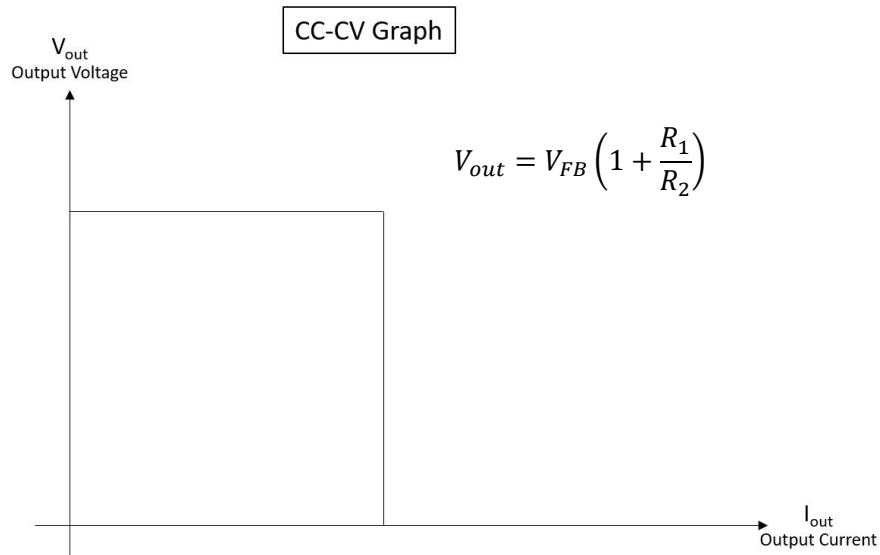


Fig. 8 - CC-CV graph

**Typical Application Circuit**

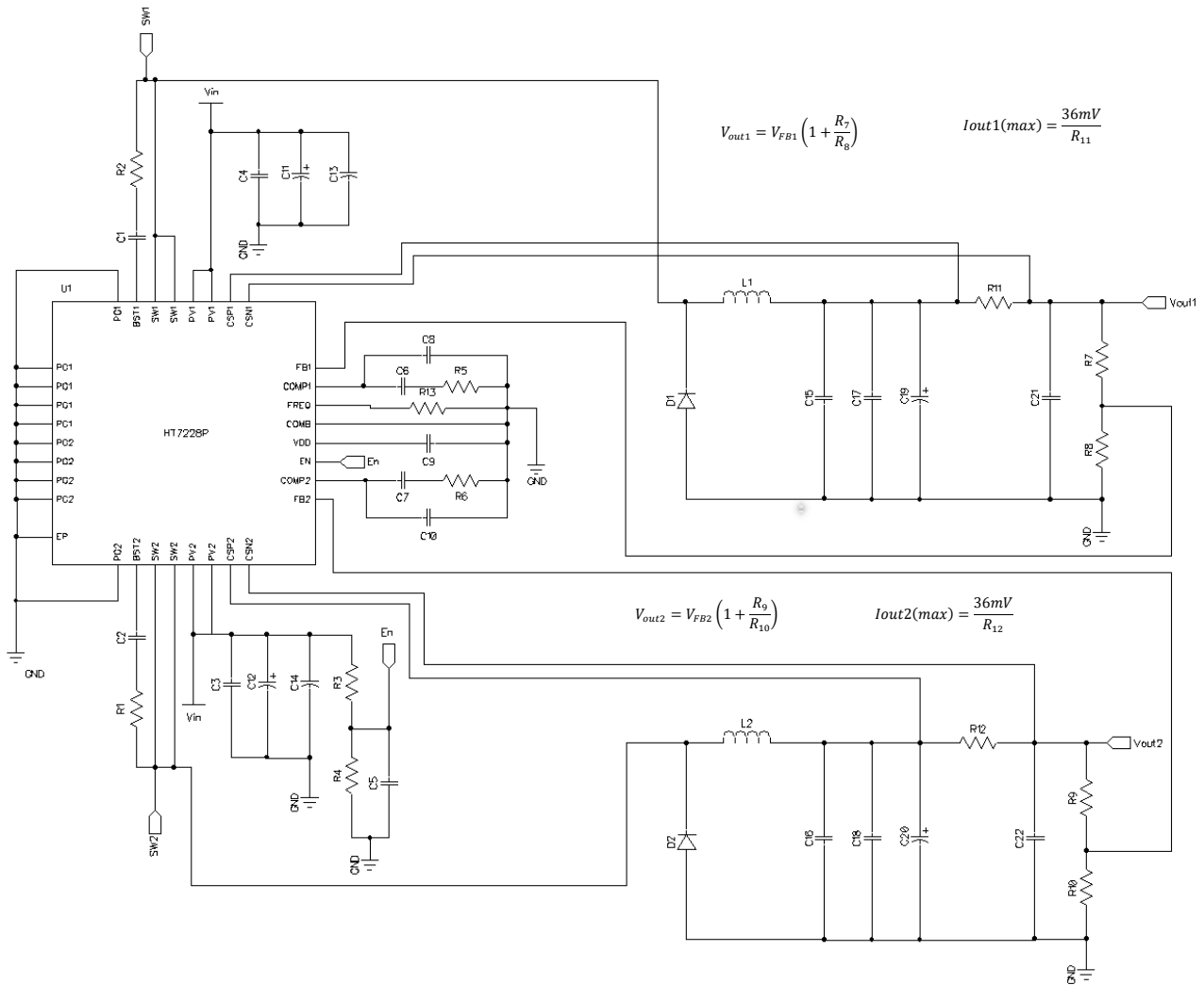


Fig. 9 - HT7228P simplified schematic (COMB = 0)

## HT7228P (Preliminary)

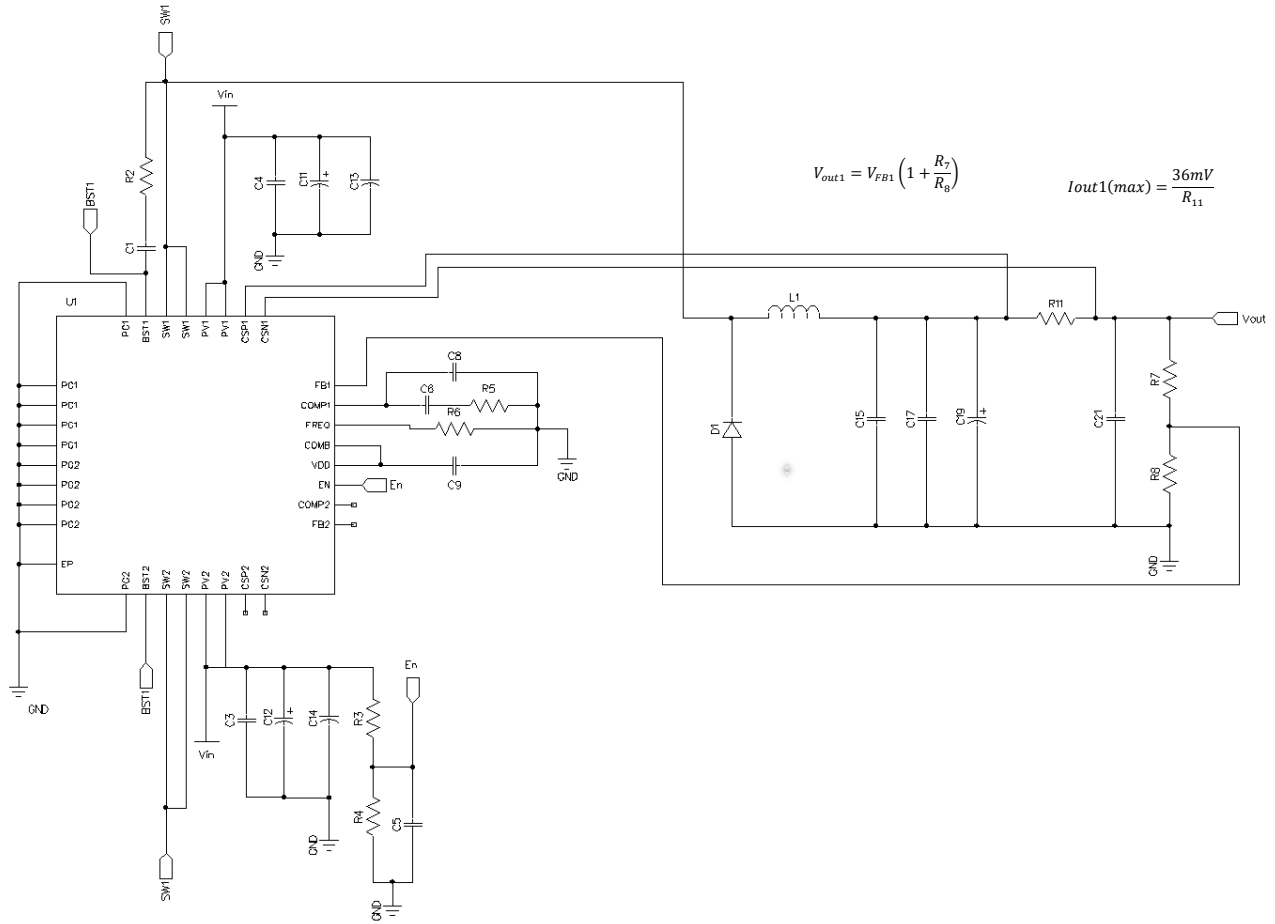
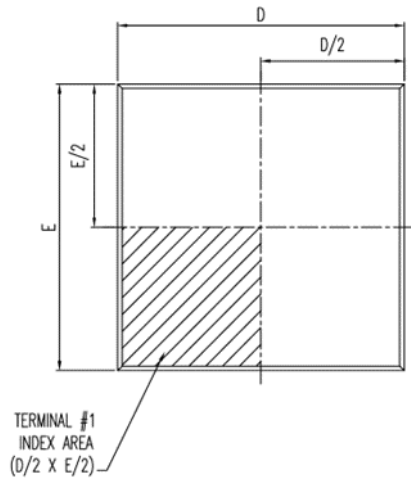


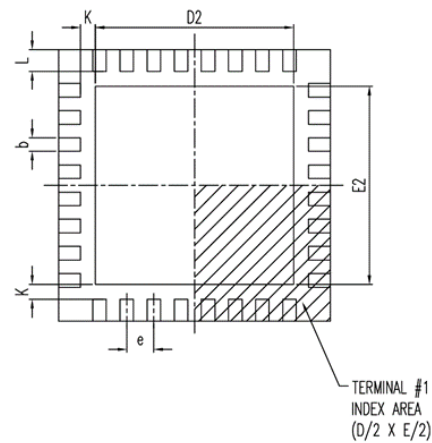
Fig. 10 - HT7228P simplified schematic (COMB = 1)

## 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		
$\theta$	0°		14°
JEDEC	MO-220 (Variation WHHD-4)		

NOTES :

- ALL DIMENSIONS ARE IN MILLIMETERS.
- DIMENSION b APPLIES TO METALIZED 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.
- BILATERAL COPLANARITY ZONE APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.

Dual Ports 

**HT6000 Series**

Fast Charging is just a Breeze



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