F72820

Synchronous Buck PWM DC-DC Controller

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F72820 Datasheet Revision History

Version	Date	Page	Revision History
0.21P	Mar/2005		Preliminary version
0.22P	Jun/2005	14	Update application circuit
0.23P	Mar/2006	15	Correct application circuit
0.24P	Jul 2007	13	Update company address

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1. General Description

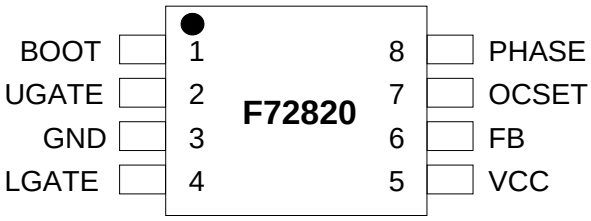
The F72820 is a single PWM DC-DC converter controller for application requiring high current such as motherboard, graphic card etc. The F72820 uses voltage mode PWM controller with fast transient response (driving two external N-channel MOSFETs in a synchronous rectified buck converter topology) and integrates some functions such as soft-start, over current and short circuit protections etc. Over current protection is achieved by monitoring the voltage drops across the high side MOSFET without the need for a current sensing resistor and short circuit condition is detected through FB pin. If fault conditions occur, the F72820 will initiate the soft start cycle. After three cycles and the fault conditions persist, the controller will go into shut down status. In shut down status, both gate drive signals will be low. To restart the controller, either recycling the Vcc supply or momentarily pulling OCSET pin below 1.25V. The F72820 is available in 8-SOP package.

2. Feature List

- Provides one synchronous rectified buck DC-DC PWM controller
  - Fast transient response (high bandwidth error amplifier; full 0~100% duty cycle)
  - Fixed operation frequency : 300KHz
  - Single loop voltage-mode control
  - Few external components
  - Output range adjustable down to 0.8V
- Operation is under 5V input
- Drives external N-channel MOSFETs
- Over current monitor is used by MOSFET $R_{DS(ON)}$
- 0.8V internal reference voltage
  - ±2% accuracy over line, load and temperature
- Internal soft-start (typically 3 ms)
- Internal loop compensation
- Under voltage fault monitoring and protection
- Over voltage protection
- 8-SOP package (150 mil)

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3. Pin Configuration



4. Block Diagram

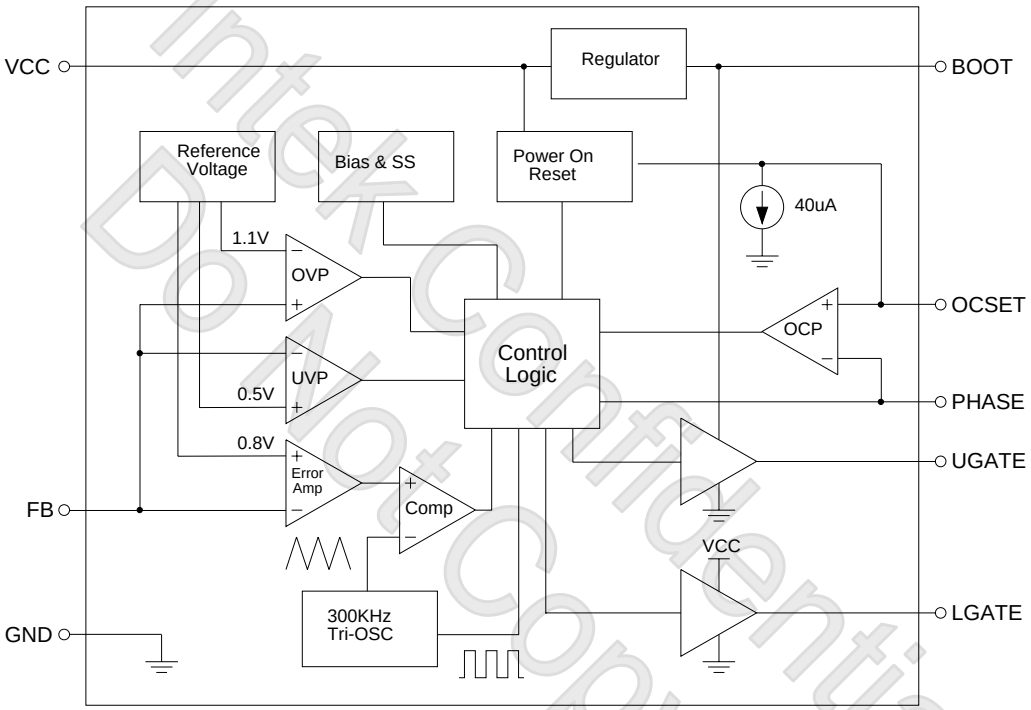


Figure 1: Block Diagram

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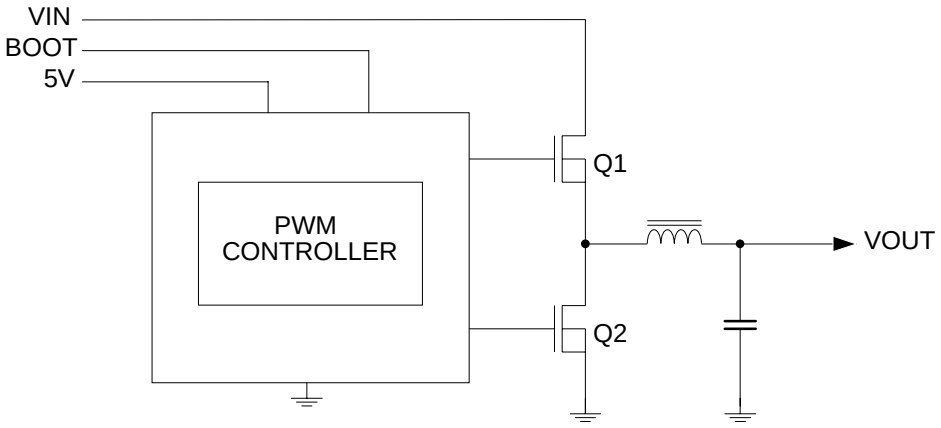


Figure 2: Simplified power system diagram

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5. Pin Description

AIN - Input pin(Analog)

AOUT - Output pin(Analog)

P - Power

Pin No	Pin Name	TYPE	PWR	Description
1	BOOT	P		Provide ground reference voltage for high side MOSFET by bootstrap circuit or ATX 12V.
2	UGATE	AOUT	BOOT	Higher gate drive output. Connect this pin to gate of the high side MOSFET
3	GND	P		Power ground pin for the chip
4	LGATE	AOUT	VCC	Lower gate drive output. Connect this pin to gate of the low side MOSFET
5	VCC	P		IC supply voltage. This voltage is monitored for power-on-reset purpose.
6	FB	AIN	VCC	Inverting input of the error amplifier used to compensate the feedback loop of the PWM controller.
7	OCSET/SD	AOUT/AIN	VCC	This is multi-function pin. Connecting a resistor from this pin to drain of high side MOSFET and an internal 40uA current source to ground. OCSET voltage is reference for over current detect. When OCSET voltage is under 1.25V, shut down function will be enabled.
8	PHASE	AIN	VCC	Connect to high side MOSFET source and monitor its voltage drop for over current protection.

6. Function Description

The F72820 is a single PWM DC-DC converter controller for application requiring high current such as motherboard, graphic card etc. The F72820 uses voltage mode PWM controller with fast transient response (driving two external N-channel MOSFETs in a synchronous rectified buck converter topology) and integrates some functions such as soft-start, over current and short circuit protections etc. Over current protection is achieved by monitoring the voltage drop across the high side MOSFET, eliminating the need for a current sensing resistor and short circuit condition is detected through the FB pin. If fault conditions occur, the F72820 would initiate the soft start cycle. After three cycles and the fault condition persist, the controller will go into shut down status. In shut down, both gate drive signals will be low. To restart the controller, either recycle the Vcc supply or momentarily pull the OCSET pin below 1.25V.

6.1 Bootstrap Operation

In single power supply system, the UGATE is powered by an external bootstrap circuit as Fig 3. The Boot capacitor, C_{BOOT} is charged and generated a floating reference voltage at phase pin. Typically a 0.1uF C_{BOOT} is enough for the most of applications. The C_{BOOT} capacitor is refreshed and charged to a voltage of "VCC – Diode Drop" while low side power MOS turning on.

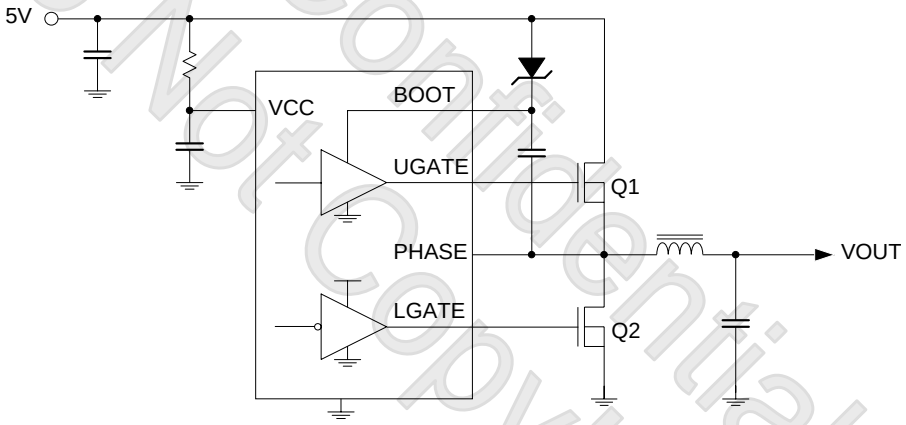


Fig 3. Single 5V Power Supply Operation.

6.2 Dual Power Operation

The F72820 Power-on-reset monitors VCC supply voltage and input voltage at the OCSET pin. POR level is 3.8V with 0.5V hysteresis at VCC voltage and 1.25V at OCSET voltage, The POR function initiates soft-start operation and reset control logic after these supply voltages exceed their POR threshold voltages.

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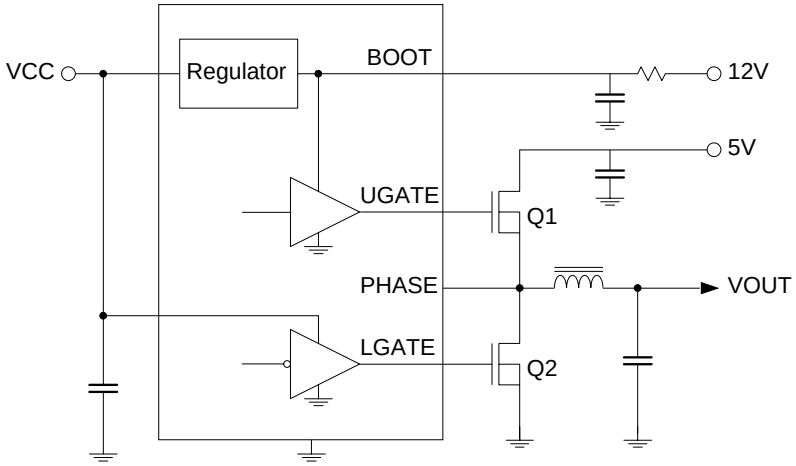


Figure 4

6.3 Soft-Start

The POR function initiates the digital soft-start sequence; the soft start function is used to prevent surge current from power supply input during power on. When soft start event, PWM error amplifier reference inputs are forced to track a voltage level proportional to the soft-start voltage. As the soft-start voltage slews up, the PWM comparator regulates the output relative to the tracked soft-start voltage, slowly charging the output capacitor(s), the soft start duration is 3mS in typical case.

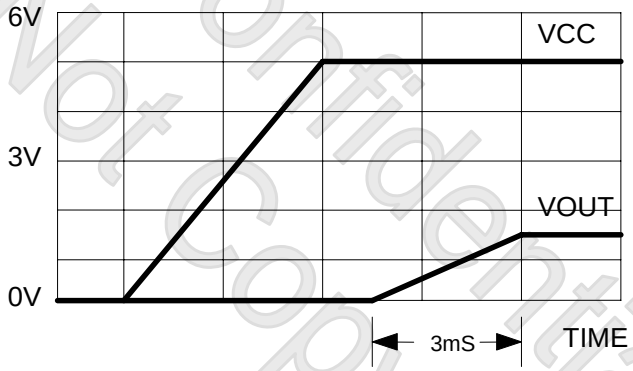


Figure 5

6.4 Over-current Protection

The over current protection function of the F72820 is trigger when the voltage across the $R_{DS\ (ON)}$ of upper side MOSFET the developed by drain current exceeds over-current tripping level. An external resistor (R_{OCSET}) programs the over-current tripping level of the PWM converter. As show on Figure 6, the internal 40uA current sink develops a voltage across R_{OCSET} that is reference to VIN. The over current comparator detect over current event when UGATE is high and PHASE voltage is under OCSET voltage. When OC be detected, over current protect function will soft start three times and check over current again. If over current event is true, the F72820 will be shut down.

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OVER-CURRENT TRIP:

$V_{DS} > V_{SET}$

$I_D \times R_{DS(ON)} > I_{OCSET} \times R_{OCSET}$

$V_{PHASE} = V_{IN} - V_{DS}$

$V_{OCSET} = V_{IN} - V_{SET}$

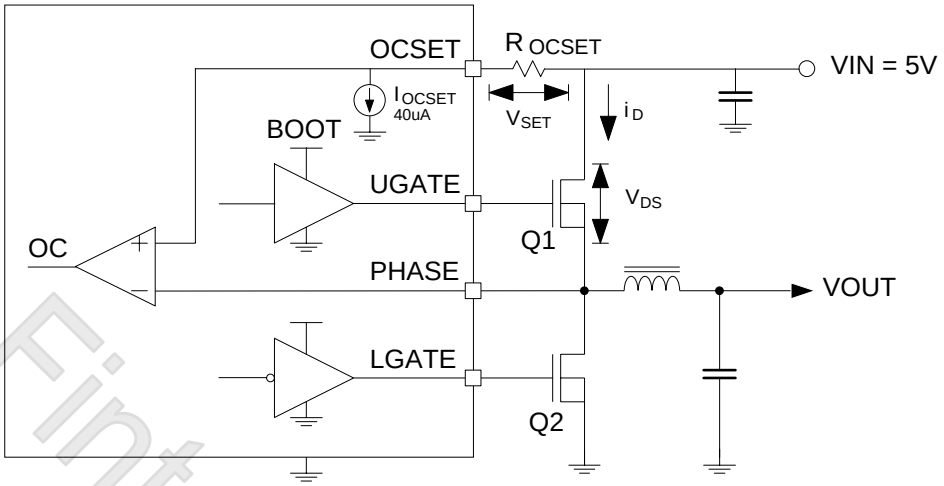


Figure 6

6.5 Under-voltage Protection

Pins FB are monitored during converter operation by under-voltage (UV) comparators. If the FB voltage drops below 0.5V, a fault signal is generated. The internal fault logic shut down regulator simultaneously when the fault signal triggers a restart. At time t0, VOUT has dropped below 0.5V of the nominal output voltage. Output is quickly shut down and the internal soft-start function begins producing soft-start ramps. The delay interval, t0 to 3*tss, seen by the output is equivalent to three soft-start cycles. After a short delay interval of 10.5ms, the fourth internal soft-start cycle initiates a normal soft-start ramp of the output, at time 3*tss. Both outputs are brought back into regulation by time 4*tss, as long as the UV event has cleared. When the cause of the UV still been present after the delay interval. A fault signal could then be generated and the outputs once again shutdown.

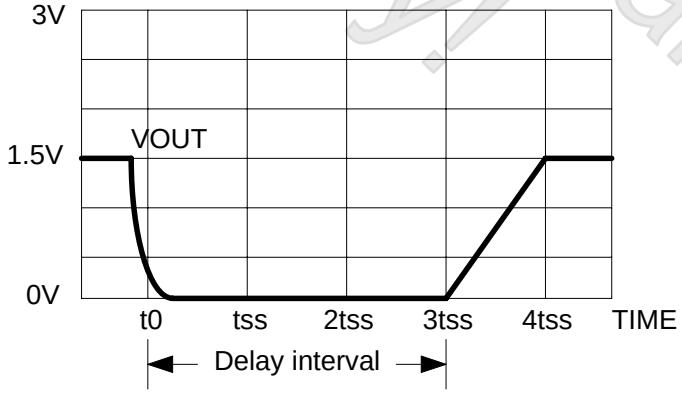


Figure 7

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6.6 Output Voltage Selection

The output voltage of the PWM converter can be programmed to any level between VIN (i.e. 5+V) and the internal reference, 0.8V. An external resistor divider is used to scale the output voltage relative to the reference voltage and feed it back to the inverting input of the error amplifier, see Figure 8. Depending on the value chosen for R1 (the resistor connected between VOUT1 and FB), R4 (the resistor connected from FB to GND) can be calculated based on the following equation:

$$R4 = \frac{R1 \times 0.8V}{VOUT - 0.8V} \qquad \text{(EQ1)}$$

If the desired output voltage is 0.8V, simply route VOUT back to FB through R1, but do not populate R4.

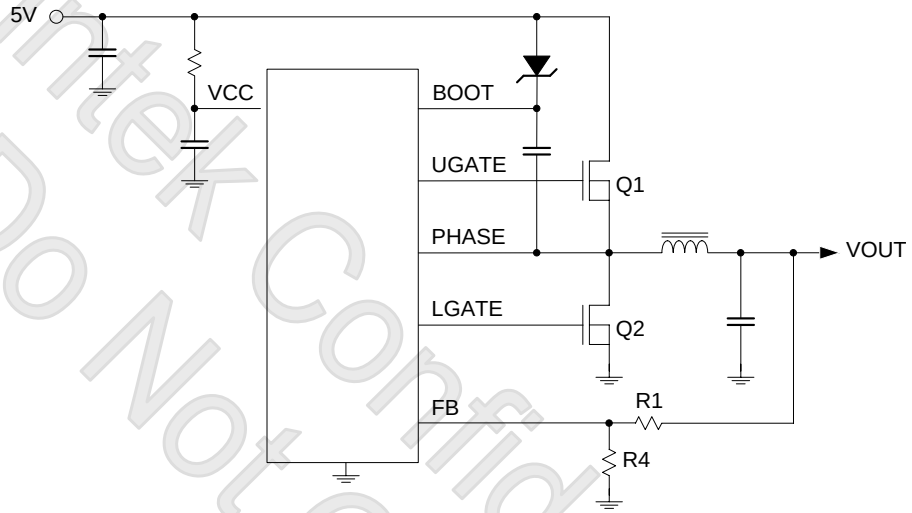


Figure 8: Output voltage selection

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6.7 Converter Shut Down

Pulling low the OCSET pin by a small signal transistor can shutdown the F72820 PWM controller as show is typical application circuit.

6.8 PWM Controller Feedback Compensation

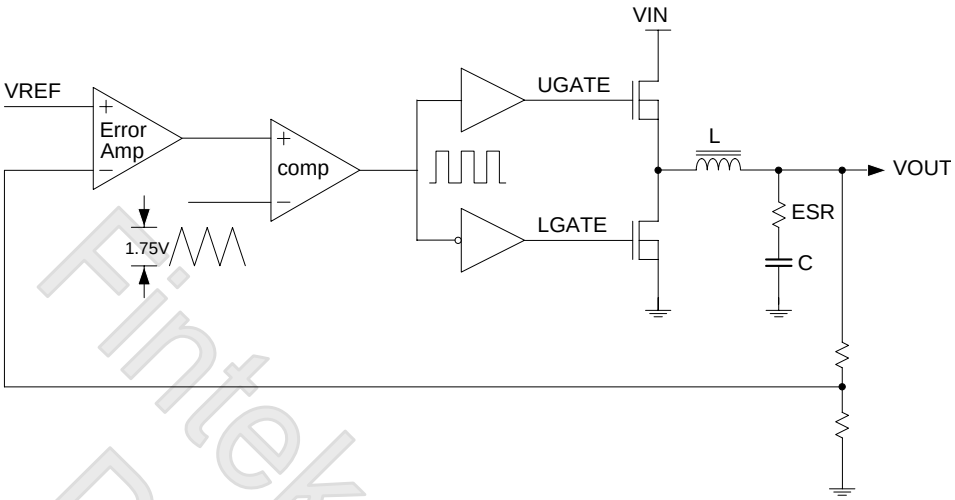
The F72820 is a voltage mode step down PWM controller. The gain of error amp is fixed at 34dB for simplified design and saving external components. The amplitude of internal Tri-wave OSC is 1.75V. The loop gain and loop Zero/Pole are calculated as follow equations.

$$DC_Loop_Gain = 34dB \times \frac{5}{1.8} \times \frac{0.8}{Vout}$$

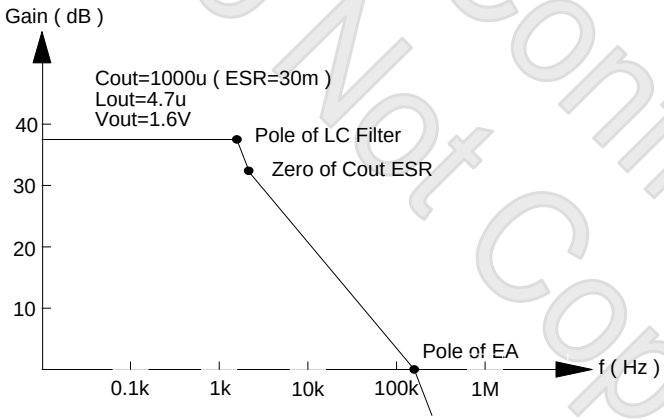
$$Pole_of_LC_Filter = \frac{1}{2\pi\sqrt{LC}}$$

$$Pole_of_EA = 130kHz$$

$$Zero_of_Output_Cap_ESR = \frac{1}{2\pi \times ESR \times C}$$



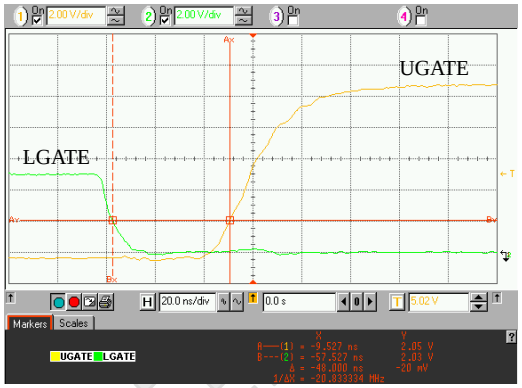
The F72820 Bode plot as shown Figure 9



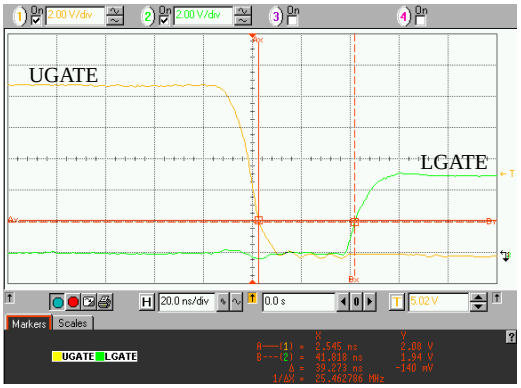
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6.9 Typical Characteristic

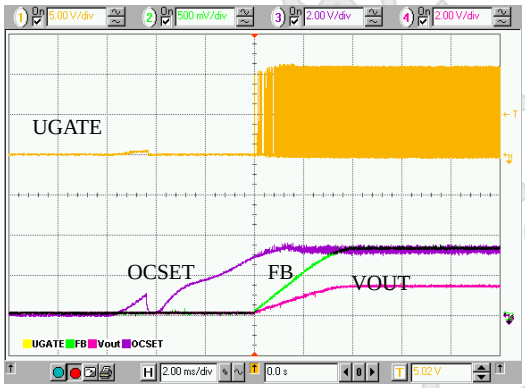
Dead time



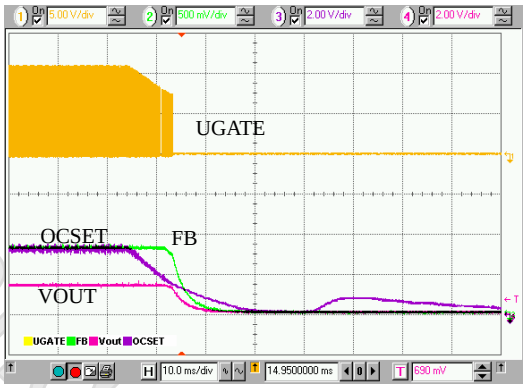
Dead time



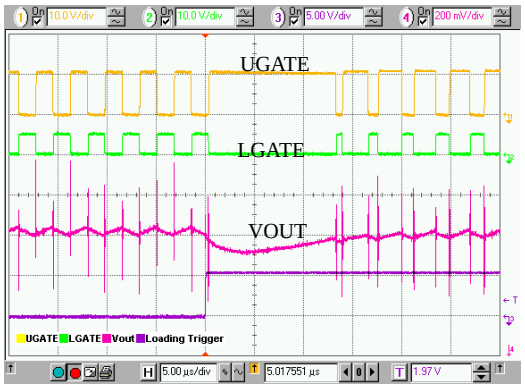
Power up



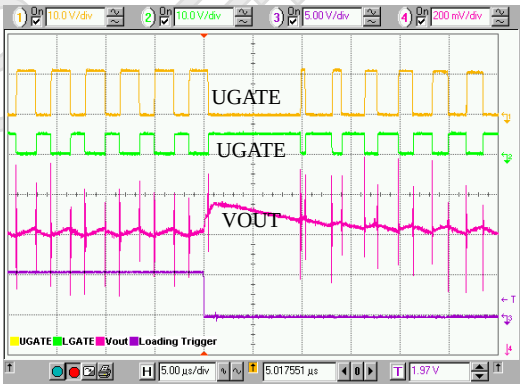
Power off



Load transient response

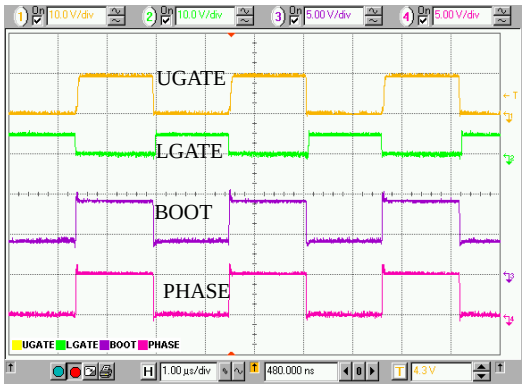


Load transient response

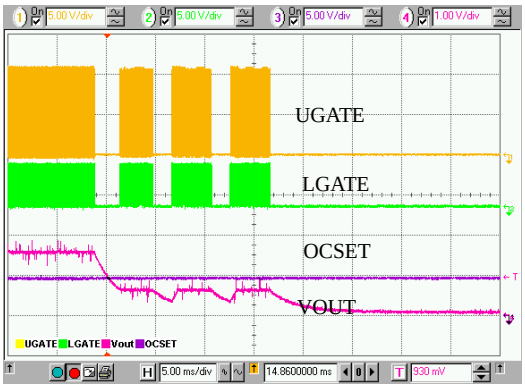


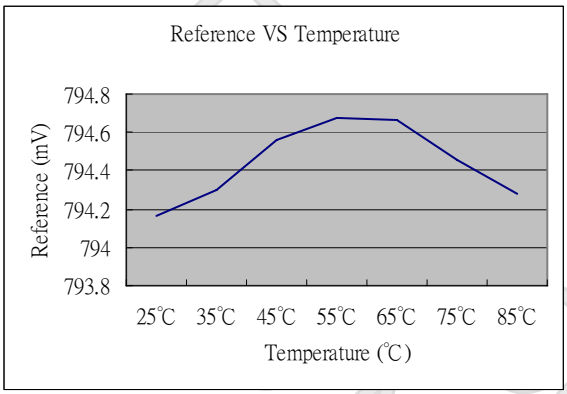
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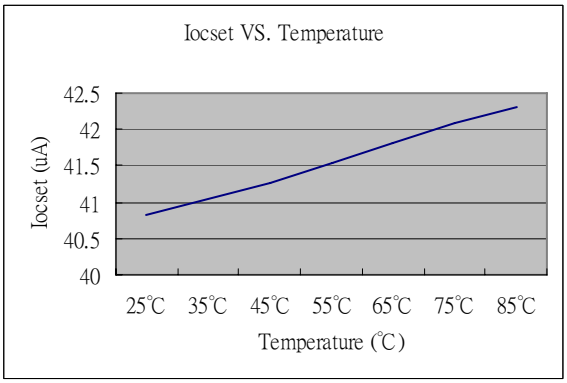
Bootstrap Wave Form

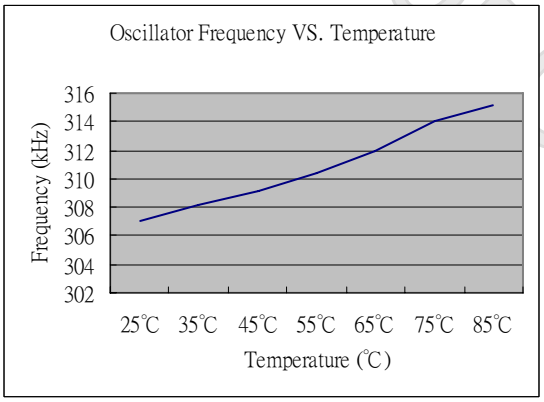


Over-Current Protect









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7. Electrical Characteristic

Absolute Maximum Ratings

PARAMETER	SYMBOL	RATINGS	UNIT
IC supply voltage	VCC	7	V
Gate drivers supply voltage	12VCC	15	V
PWM controller outputs	UGATE, LGATE		V
Feedback voltages of both regulators	FB, FB2, COMP	GND - 0.3-17	V
ESD classification	HBM	2	kV
Maximum junction temperature (plastic package)	T_j	150	°C
Maximum storage temperature	T_{STO}	-65 ~ 150	°C
Maximum lead temperature (soldering 10s)		260	°C

Note: **If ICs are stressed beyond the limits listed in the "absolute maximum ratings", they may be permanently destroyed. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.**

Package thermal information

PARAMETER	SYMBOL	SOIC	UNIT
Thermal resistance junction-ambient	Rth_ja	133	°C/W

DC and AC electrical characteristics

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
VCC SUPPLY CURRENT/Regulated Voltage						
Nominal supply current 5VCC	I_{CC}	UGATE, LGATE and DRIVE2 open		2	4	mA
Regulated Voltage from BOOT	V_{CC}	V_{BOOT} = 12V	5.0	5.5	6	V
POWER-ON RESET						
Rising VCC threshold		VOCSET = 4.5V		3.8	4.0	V
Falling VCC threshold		VOCSET1 = 4.5V	3.1	3.3		V
Rising V_{OCSET} Threshold			0.8	1.25	2.0	V
OSCILLATOR AND Protection						
Free running frequency	F_{OSC}	V_{CC}=5V	250	300	350	kHz
Ramp Amplitude	$\triangle V_{OSC}$			1.75*		V_{P-P}
FB Over Voltage Trip		FB Rising	1.0	1.1	1.2	V

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PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
FB Under Voltage Trip		FB Falling	0.4	0.5	0.6	V
OCSET Current Source	I_{OCSET}	V_{OCSET} = 4.5V	35	40	45	uA
Soft-start interval	T_{SS}		1	3	6	ms
REFERENCE VOLTAGE						
Reference voltage	V_{REF}		0.784	0.8	0.816	V
PWM CONTROLLER GATE DRIVERS						
Upper Drive Source	R_{UGATE}	BOOT = 12V ; BOOT – V_{UGATE} = 1V		8	12	Ω
Upper Drive Sink	R_{UGATE}	V_{UGATE} = 1V		4	6	Ω
Lower Drive Source	R_{LGATE}	VCC – V_{LGATE} = 1V		3	4.5	Ω
Lower Drive Sink	R_{LGATE}	V_{LGATE} = 1V		2	3	Ω
Error Amplifier						
DC Gain				34*		dB

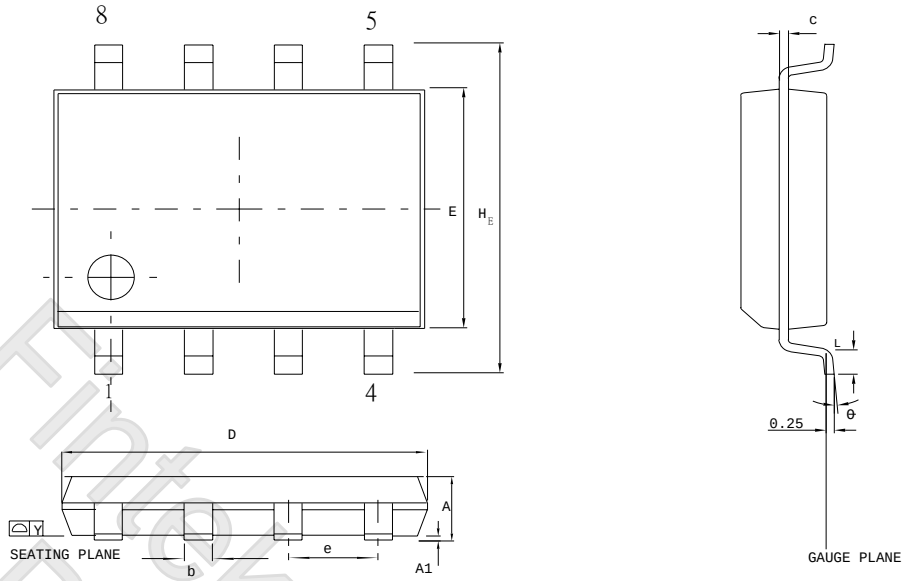
Note: **Design Guarantee**

8. Ordering Information

Part Number	Package Type	Production Flow
F72820 SG	8-SOP (Green Package)	Commercial, 0°C to +70°C

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9. Package Dimensions (8-SOP/150 mil)



Control demensions are in milmeters .

SYMBOL	DIMENSION IN MM		DIMENSION IN INCH	
	MIN.	MAX.	MIN.	MAX.
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
b	0.33	0.51	0.013	0.020
c	0.19	0.25	0.008	0.010
E	3.80	4.00	0.150	0.157
D	4.80	5.00	0.188	0.196
e	1.27 BSC		0.050 BSC	
H_E	5.80	6.20	0.228	0.244
Y	——	0.10	——	0.004
L	0.40	1.27	0.016	0.050
θ	0	10	0	10

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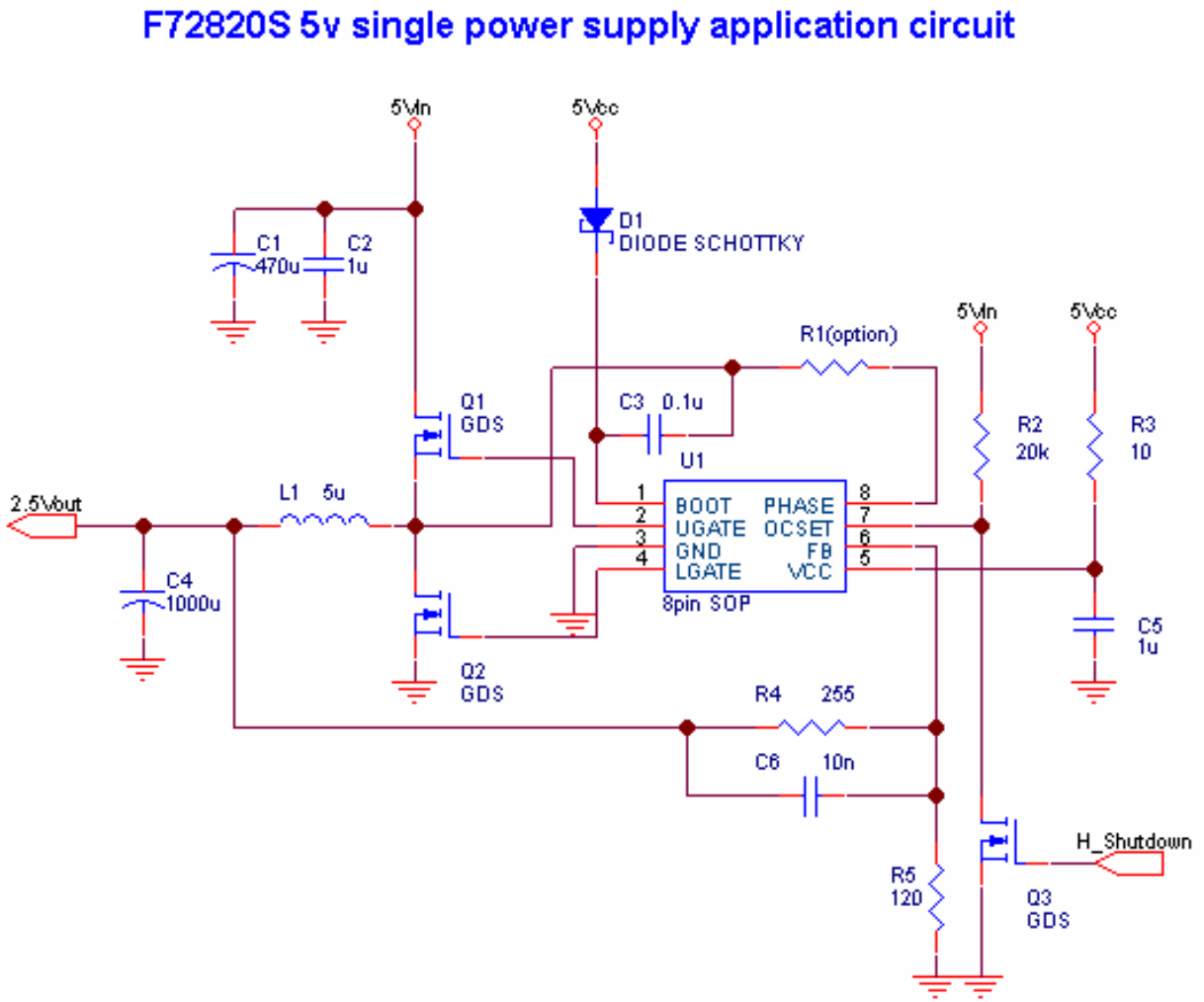
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10. Application Circuit



F72820S 12v single power supply application circuit

