Features

- Wide Input Voltage Range：3V~28V
- Adjustable 0.8V~20V Output Range
- Wide output load range: 0 to 8A
- ±1% Output Voltage Accuracy over Line and Load
- Constant-on-time control scheme for fast transient and high Efficiency
- Programmable Operation Frequency from 100kHz to 600kHz
- Integrated 18 mΩ at LDO=5V N-Channel MOSFET For High Side
- Integrated 9.5 mΩ at LDO=5V N-Channel MOSFET For Low Side
- Selectable Forced PWM or automatic PFM/PWM mode
- Under-Voltage Protection
- Over-Voltage Protection
- FB Short Protection
- Internal 5V Pre-regulator
- External Adjustable Soft-Start and Soft-Stop
- Over Temperature Protection
- Programmable Over Current Protection
- TQFN23-4x4 package
- Green Product (RoHS, Lead-Free, Halogen-Free Compliant)

Applications

- Notebook computers
- CPU core/IO Supplies
- Chip/RAM Supplies

General Description

The GS92A3 is small size chip with a relative constant on-time synchronous buck switching converter suitable for applications in notebook computers and other battery operated portable devices. Features include wide input voltage range, high efficiency and fast dynamic response The GS92A3 has a unique power save mode, which can save battery power supply by decreasing frequency when load current falls down below preset critical current point.

The fast dynamic transient response means that buck converter applications based on GS92A3 will provide about 100ns-order response to load when output voltage falls down or rises up. The frequency will increase or decrease to meet the change in output load. Moreover, the GS92A3 will take the same method to regulate the output voltage when input voltage changes. When transient response regulated, the converter will maintain a new steady-state operation. Both the transient response state and the new state, the GS92A3 always has the same on-time width.

The GS92A3 is suitable for the solutions which have the output voltage between 0.8V and 20V. An external setting resistor and output voltage can set the on-time width, duty-cycle and frequency for the converter. The integrated gate drivers feature adaptive shoot-through protection, fast signal transmission. Additional features include current limit, soft-start, over-voltage and under-voltage protection and soft discharge upon shutdown. The GS92A3 is available in package TQFN23-4x4.

Typical Application

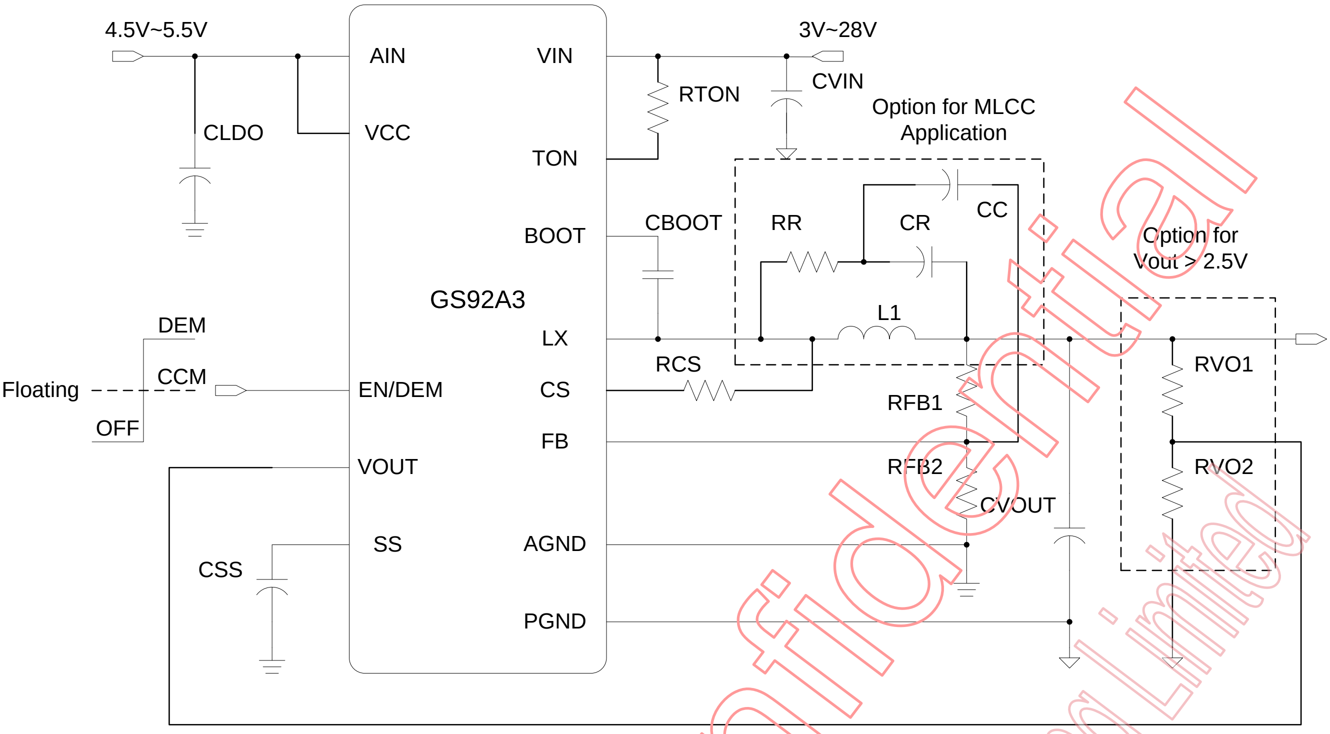


Figure 1a Typical Application of GS92A3

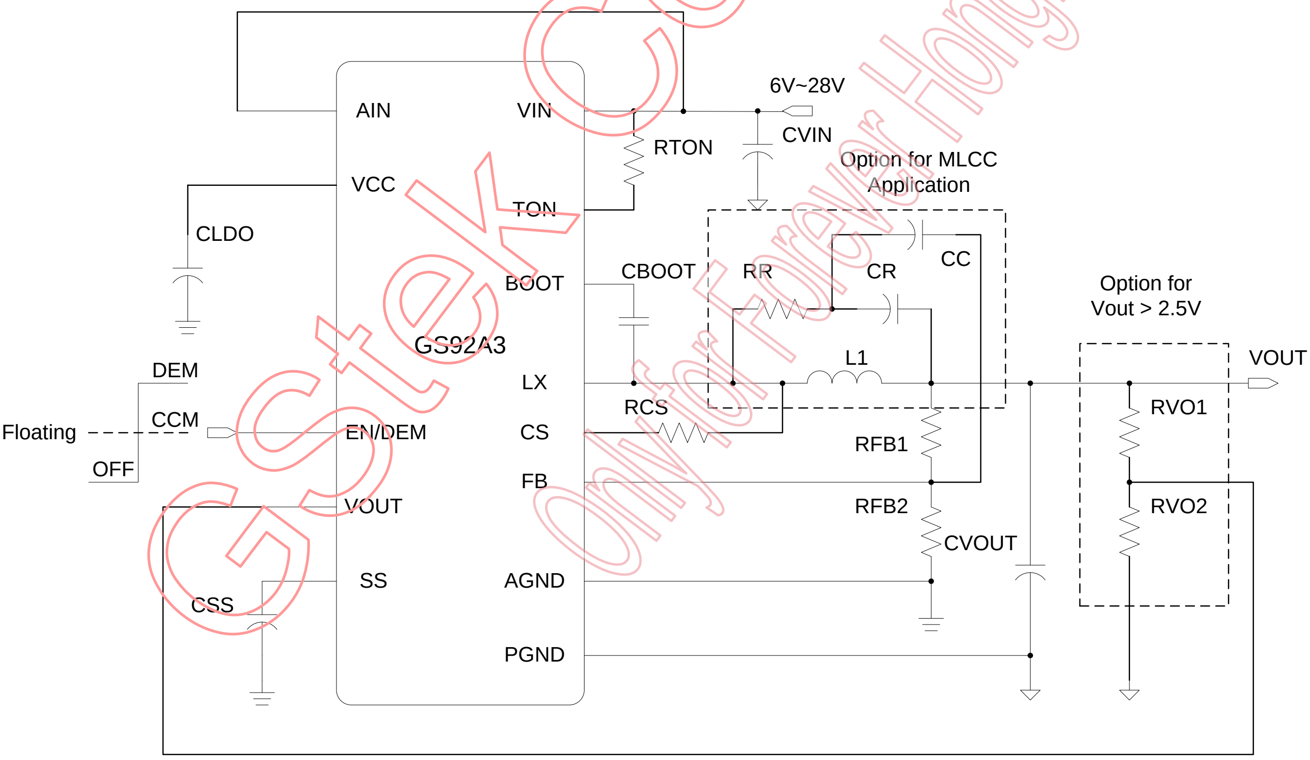


Figure 1b Typical Application of GS92A3

Function Block Diagram

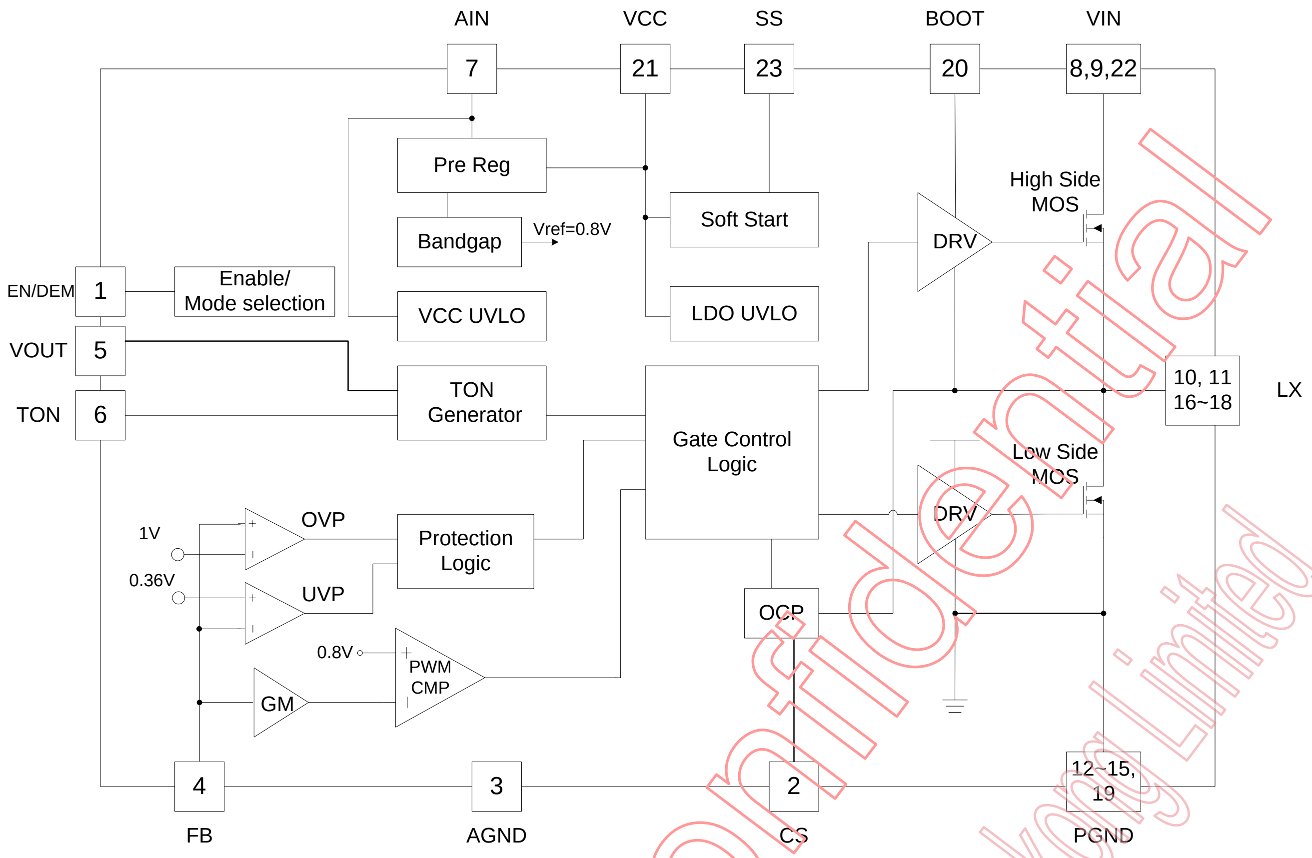
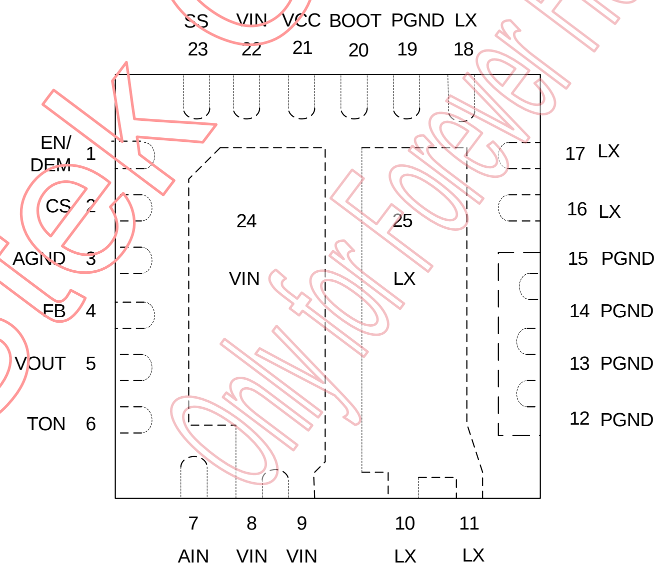


Figure 2 Function Block Diagram

Pin Configuration



(Top view)

Figure 3 TQFN23-4x4 Package

Pin Descriptions

No.	Name	I/O	Description
1	EN/DEM	I	Buck Enable Control Pin. EN=Low, Shutdown; EN=High, Auto-DEM Mode; EN=Floating, Forced CCM.
2	CS	I/O	Current Limit Detecting Input Pin. Connect LX Pin though an external resistor to set the current limit threshold.
3	AGND	O	Signal GND.
4	FB	I	Feedback Input. Adjust the output voltage with a resistive voltage-divider between the regulator's output and AGND.
5	VOUT	I	VOUT Pin offers the output information to the chip, in order to make the frequency setting more accuracy. When OVP condition occurs, through this pin discharge the energy of vout capacitor.
6	TON	I/O	On-Time Setting Input. Connect a resistor between VIN and TON to set the on time width.
7	AIN	I/O	Supply Input for internal analog circuitry.
8, 9, 22,24	VIN	I	Supply Input. VIN is the regulator input. All VIN pins must be connected together.
10, 11, 16~18,25	LX	I/O	Upper Driver Floating Ground for Buck Controller. Connect to an external inductor.
12~15, 19	PGND	O	Power Ground.
20	BOOT	I	Bootstrap Capacitor Connection. Connect a capacitor between BOOT and LX Pin.
21	VCC	I/O	Internal Linear Regulator Output.
23	SS	I/O	Soft-Start Time Setting Pin. Connect a capacitor between SS and AGND to set the soft-start time.

Ordering Information

GS92A3TQ-R

1. Package ← TQ
2. Shipping ← R

No	Item	Contents
1	Package	TQ:TQFN23-4x4
2	Shipping	R: Tape & Reel

Example: GS92A3 TQFN23-4x4 Tape & Reel ordering information is "GS92A3TQ-R"

Absolute Maximum Rating (Note 1)

Parameter	Symbol	Limits	Units
VIN, AIN to GND	V_{IN}, V_{AIN}	-0.3 ~ 30	V
TON to GND	V_{TON}	-0.3 ~ 30	V
VCC to GND	V_{CC}	-0.3 ~ 6	V
EN/DEM to GND	$V_{EN/DEM}$	-0.3 ~ 30	V
VOUT, FB to GND	V_{OUT}, V_{FB}	-0.3 ~ 6	V
BOOT Voltage	$V_{BOOT-GND}$	-0.3 ~ 40	V
BOOT to LX Voltage	$V_{BOOT-LX}$	-0.3 ~ 6	V
LX to GND DC <200ns	V_{LX}	-0.7 ~ 30 -8 ~ 32	V
Package Power Dissipation at $T_A \leqq 25°C$	$P_{D\_TQFN23-4x4}$	3546	mW
Junction Temperature	T_J	- 45 ~ 150	°C
Storage Temperature	T_{STG}	- 55 ~ 150	°C
Lead Temperature (Soldering) 10S	T_{LEAD}	260	°C
ESD (Human Body Mode) (Note 2)	V_{ESD_HBM}	2K	V
ESD (Machine Mode) (Note 2)	V_{ESD_MM}	200	V

Thermal Information (Note 3)

Parameter	Symbol	Limits	Units
Thermal Resistance Junction to Ambient	$\theta_{JA\_TQFN23-4x4}$	28.2	°C/W

Recommend Operating Condition (Note 4)

Parameter	Symbol	Limits	Units
VIN to GND (Note 5)	V_{IN}	3~28	V
AIN to GND (Note 5)	V_{AIN}	6~28	V
VCC to GND	V_{VCC}	4.5~5.5	V
EN/DEM to GND	$V_{EN/DEM}$	$V_{EN/DEM} = V_{AIN}$	V
Junction Temperature	T_J	-40 ~ 125	°C
Ambient Temperature	T_A	-40 ~ 85	°C

Electrical Characteristics

(R_{TON}=300KOhm, V_{IN}=12V, V_{OUT}=1.2V, EN/DEM=V_{IN}, T_A =25°C, unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Voltage (V_{AIN})						
Under voltage lock out (Rising)	V_{AIN_UVLO}			5.5		V
UVLO Hysteresis	$V_{AIN\_UVLOHYS}$			0.2		V
5V Pre-regulator (V_{VCC})						
Output Voltage	V_{VCC}			5.15		V
Under voltage lock out	V_{VCC_UVLO}			4.15		V
(Rising) UVLO Hysteresis	$V_{VCC\_UVLOHYS}$			0.3		V
Reference Voltage						
FB Reference Voltage	V_{FB}	V_{VCC}=5V		0.8		V
Enable Logic						
EN Logic Low Voltage	V_{EN_L}	EN Falling			0.6	V
EN Floating Voltage	V_{EN_F}	VIN Power On, Stable State(Forced CCM)		2.2		V
EN Logic High Voltage	V_{EN_H}	EN Rising(DEM)	3.1			V
Current Parameters						
Quiescent	I_Q	FB=0.85V, VIN=12V		830		uA

Soft start current	I_{SS}	Vss=0		10		uA
Shutdown Current	I_{SHTDN}	EN=0, I(VIN)		4		uA
		EN=0, I(TON)			0.01	uA
		EN=0, I(EN)	-2	-1		uA
Logic Input Current	I_{EN}	EN=12V		13		uA
		EN=0V	-2	-1		uA
System Time & Driver On-Resistance						
On-Time	T_{ON}	V_{IN}=12V, V_{FB}=0.79V, R_{TON}=300K, V_{OUT}=1.2V		300		ns
Minimum On-Time	T_{ON_Min}	V_{IN}=12V, V_{FB}=0.79V, R_{TON}=1K, V_{OUT}=1.2V		100		ns
Minimum Off-Time	T_{OFFMIN}	V_{IN}=12V, V_{FB}=0.79V, R_{TON}=300K		440		ns
High Side MOS RDSON	R_{DSH}	BOOT-LX=5V		18		mohms
High Side Leakage	I_{LEAKH}			10		uA
Low Side MOS RDSON	R_{DSL}	VCC-GND=5V		9.5		mohms
Low Side Leakage	I_{LEAKL}			10		uA
Current Sensing						
CS Set Source Current	I_{CS}	V_{CS}=1V		20		uA
ICS current temperature coefficient	TCS	On the bias of TA=25°C		4900		ppm/°C
Current Limit 1 (Rising)	I_{LIM1}	GND-LX, RCS=18K	324	360	396	mV
Current Limit 2 (Rising)	I_{LIM2}	GND-LX, RCS=10K	180	200	220	mV
Current Limit 3 (Rising)	I_{LIM3}	GND-LX, RCS=2.5K	35	50	65	mV
Zero Crossing Threshold	V_{T_0}	GND-LX	-10		10	mV
Voltage Fault Protection						
UVP Threshold	V_{UV_TH}	Measure at V_{FB}, with respect to reference voltage		45		%
UVP Blank Time	T_{UV_B}	From Enable to UVP $80mV < V_{FB} <$ UVP Threshold		$1.6x10^8$ xC_{SS}		ms
UVP Fault Delay	T_{UV_D}	Force V_{FB} below UVP threshold		20		us

OVP Threshold	V_{OV_TH}	Measure at V_{FB}, with respect to reference voltage		125		%
OVP Fault Delay	T_{OV_D}	Force V_{FB} above OVP Threshold		20		us
Over Temperature Shutdown						
Thermal Shutdown Threshold	T_{TSDN}			150		°C
Thermal Shutdown Hysteresis	T_{HYS_TSDN}			20		°C
Bootstrap Diode						
Internal Boost Charging Switch On-Resistance	R_{BT_D}	VCC to BOOT, 10mA			120	ohms

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2. Devices are ESD sensitive. Handling precaution recommended.

Note 3.θ_{JA} is measured in the natural convection at T_A=25°C on a high effective thermal conductivity test board (4 Layers, 2S2P) of JEDEC 51-7 thermal measurement standard.

Note 4. The device is not guaranteed to function outside its operating conditions.

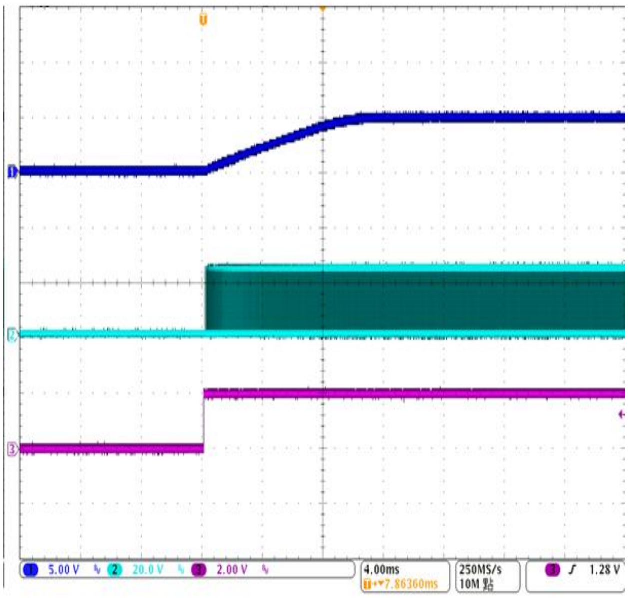
Note 5 Recommend the Pulse time<100ns when VIN over than 30V.

Note 6 If V(BOOT)-V(LX)<4V, a boot diode is recommended.

Typical Characteristics

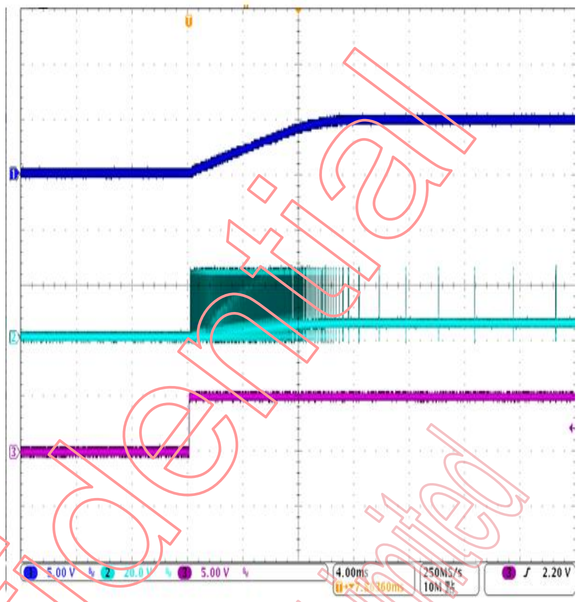
Power on from EN (CCM Mode, No Load)

CH1:VOUT CH2:LX 3:EN



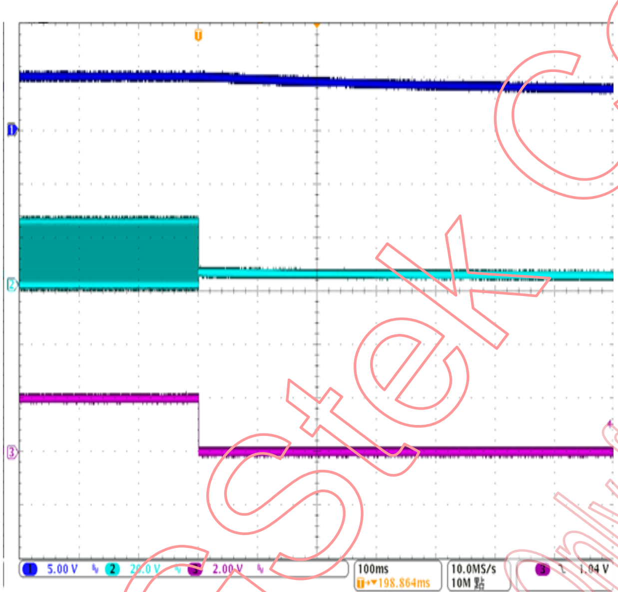
Power on from EN (DEM Mode, No Load)

CH1:VOUT CH2:LX 3:EN



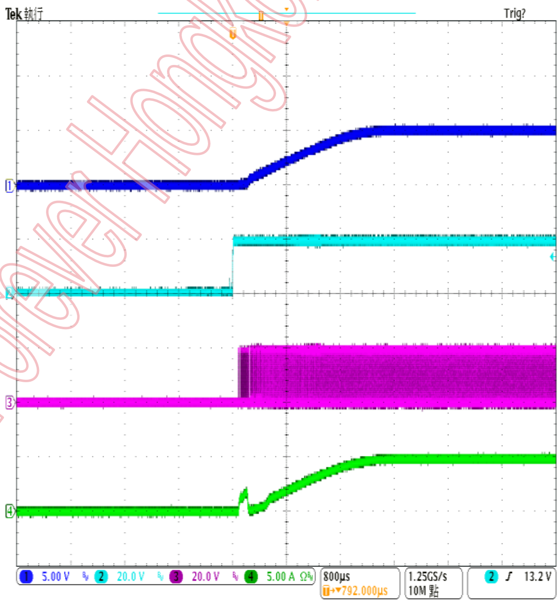
Power Off From EN

CH1:VOUT CH2:LX 3:EN



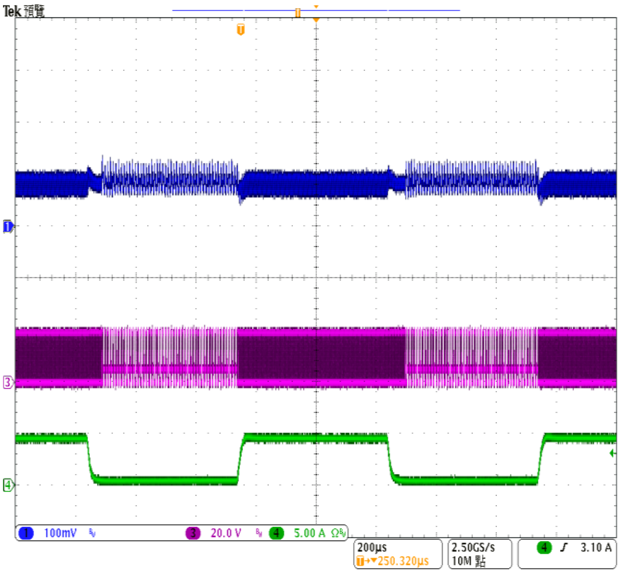
Power on from EN (load=5A)

CH1:VOUT CH2:EN CH3:LX CH4:IOUT



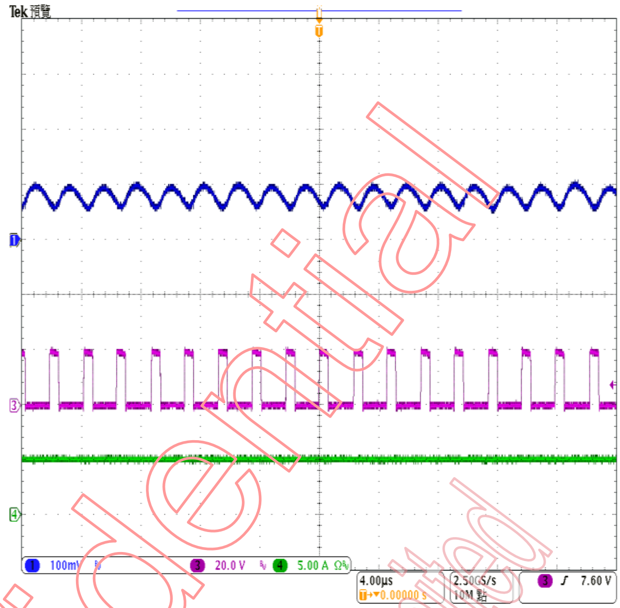
Load transient

CH1:VOUT CH2:LX CH3::IOUT



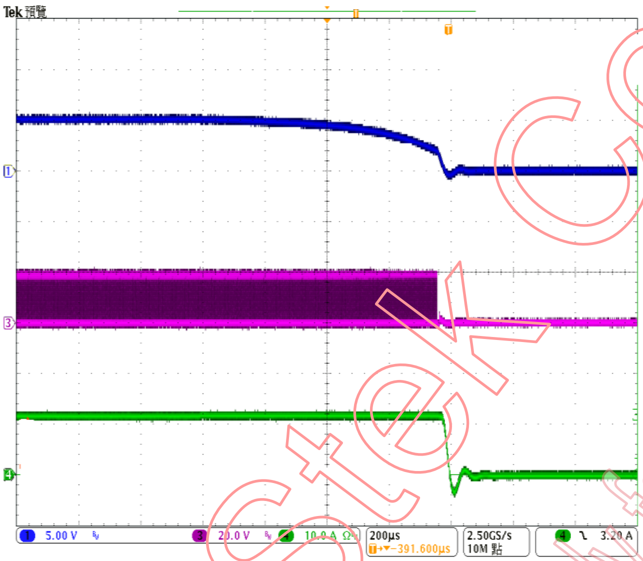
Vout ripple

CH1:VOUT CH2:LX CH3:IOUT



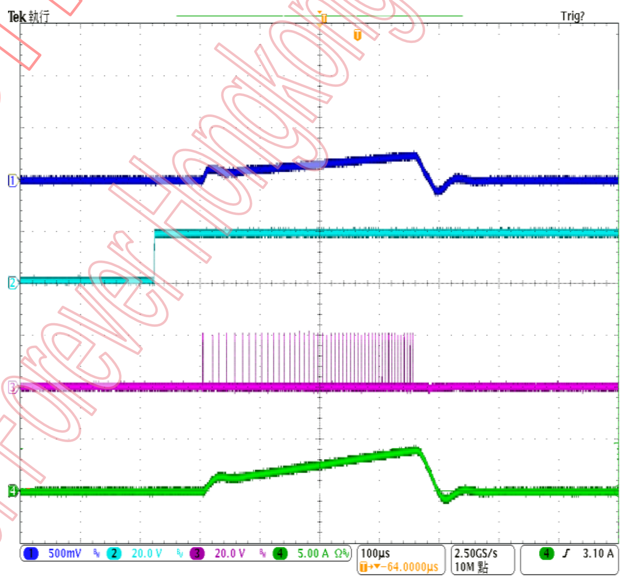
OCP

CH1:VOUT CH2:LX CH3:IOUT



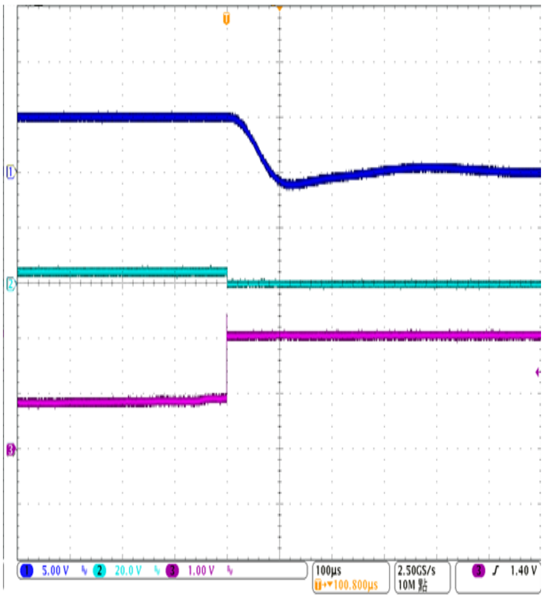
Power On in short condition

CH1:VOUT CH2:EN CH3:LX CH4 IOUT



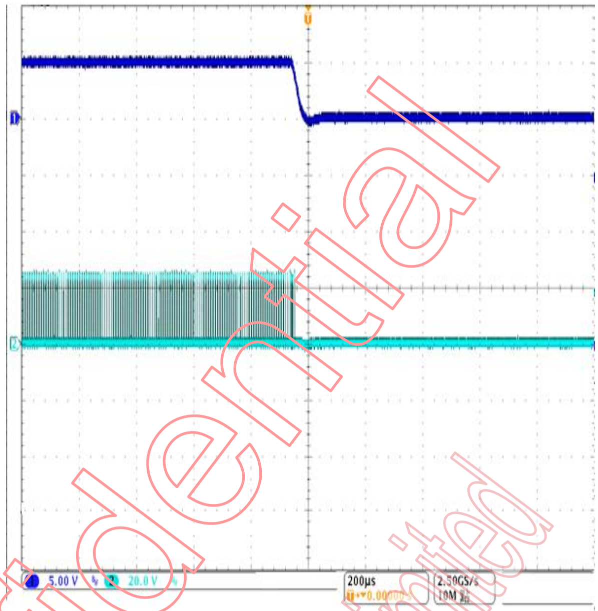
OVP (FB Trigger)

CH1:VOUT CH2:LX CH3:FB



UVP

CH1:VOUT CH2:LX CH4 IOUT



Application Information

The GS92A3 is small size chip with a relative constant on-time synchronous buck switching converter suitable for applications in notebook computers and other battery operated portable devices. Features include wide input voltage range, high efficiency and fast dynamic response.

System Clock Generator and PWM Control

The on-time of GS92A3 can be set by an external setting resistor from input voltage to TON Pin. The converter maintains the on-time width as loop feedback path exists between the GS92A3 converter, low pass filter and voltage divider. For a given input voltage buck application, the feedback maintains the constant on-time width. Due to the constant resistor and input voltage, the GS92A3 based buck converter has the relative constant frequency. Moreover, the GS92A3 can increase the duty-cycle automatically as input voltage falls down. Because of the constant on-time in each switching period, the converter maintains the relative frequency when the input voltage changes

At the beginning of each switching cycle, upper power MOSFET is turned on, after typical fixed on-time, the upper MOSFET is turned off, and then lower power MOSFET is turned on after internal dead time. The upper MOSFET will not be turned on at the beginning of next cycle until output voltage falls down below the preset voltage and the dead time passes. The same events repeat the following switching cycles. To avoid the surge inductor current during large load transient, a minimum Off-time is added. Typical minimum off-time is around 440ns. The too small on-time can affect soft-start and anti-noise ability, so in order to avoid the on-time too small to be eliminated; a minimum on-time is set to around 110ns. This should to be noted in the small duty applications.

High Side Switch On-Time Count

The on-time is decided by the external setting resistor, and the input voltage. Looking at the TON pin, the input voltage is converted to current which is inversely proportional to itself by dividing the external setting resistor. The input voltage-proportional current is used to charge an internal capacitor from zero volts. When the voltage between two terminals of the capacitor reaches to the internal setting voltage, on-time one-shot pulse is generated, and then upper power MOSFET is turned off and lower power MOSFET is turned on.

We can count the on-time and switching frequency according to the equations below:

$T_{ON}=(V_{OUT}\times R_{TON}\text{x}8p) / (V_{IN}-0.8)$ for VOUT<=2.5V

$T_{ON}=(R_{TON}\text{x}20p) / (V_{IN}-0.8)$ for VOUT>2.5V

Then, the switching frequency is:

$F_{SW}=V_{OUT}/ (V_{IN}\times T_{ON})$

R_{TON} is a resistor connected from the input supply (VIN) to the TON pin.

For heavy load (more than 8A) application, due to ground bounced and the high impedance of R_{TON}, the TON pin should always be bypassed to GND using a several nF-order ceramic capacitor for reliable system operation.

EN, PFM/PWM Mode and Shutdown Soft-Discharge

The EN/DEM pin enables the power supply. When EN/DEM is tied to high voltage (over V_{EN_H}) the GS92A3 is enabled and diode-emulated mode (DEM, which is power save mode) will be also enabled. When the EN/DEM is floating or tri-stated, an internal tri-stated judged logic module will activate the controller and the DEM Mode will be disabled.

In DEM mode, when the loads goes low, GS92A3 starts power save mode in order to maintain the on-time and decrease the system clock frequency to skip PWM pulses for better efficiency. If DEM Mode is enabled, the GS92A3 zero crossing comparator will sense the inductor current and judge its value by comparing the LX node (LX) to PGND. Once the LX node voltage is equal to the PGND node voltage, the converter will enter the DEM Mode and turn off the low side power MOSFET. As the load current is further decreased, it takes longer time to discharge the output capacitor to the level than required the next switching cycle. The on-time is kept the same as that in the heavy-load condition.

If the EN/DEM pin is pulled low, the GS92A3 internal logic will shutdown the switching clock and stop the buck converter, and Discharge Module works to discharge the related output voltage through the VOUT pin. This will ensure that the output is in a defined state next time when it is enabled. Since this is a soft discharge, that there are no dangerous negative voltage excursions to be concerned about. In order to maintain the correct function of the soft-discharge module, the chip power supply must be online.

Output Voltage Selection

The output voltage is set by the feedback resistors R_{FB1} and R_{FB2} of Figure1a and Figure1b. The internal reference is 0.8V, so the voltage at the feedback pin is also 0.8V. Therefore the output can be set by the equation below:

V_{OUT}= (1+R_{FB1}/R_{FB2}) ×0.8V

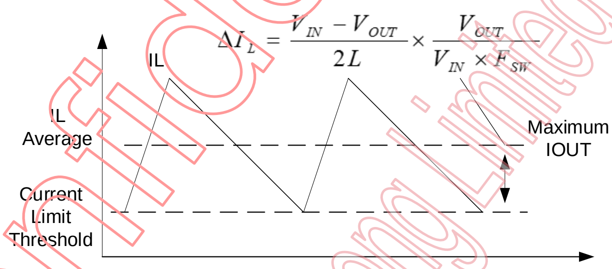
Current Limit

The GS92A3 uses the on-state resistance of the low-side power MOSFET as a current-sense resistor. In this case, the R_{CS} resistor between the LX pin and CS pin sets the over current threshold. This resistor R_{CS} is connected to a 20uA current source within the GS92A3 which is turned on when the low side power MOSFET turns on. When the voltage drop across the low side power MOSFET equals the voltage crossing the current limit resistor R_{CS}, positive current limit will activate. The high side Power MOSFET will not be turned on until both the voltage drop across the sense element (low side power MOSFET) falls below the voltage across the R_{CS} resistor and the output voltage falls to pre-set value. The current sensing circuit actually regulates the inductor valley current. This means that if the magnitude of the current-sense signal at CS pin is above the current-limit threshold, the PWM is not allowed to initiate a new switching cycle. The equation for the current limit threshold is as follows:

IL_LIMIT=20uA×R_{CS}/R_{DSL}

Where, R_{DSL} is the resistance of low side power MOSFET.

It is diagramed by the graph below:



Ensure that noise and DC errors do not corrupt the current-sense signal seen by CS and PGND. Mount the IC close t the low side power MOSFET and sense resistor with short, direct traces, making a Kelvin sense connection to the sense resistor.

Output Over-Voltage Protection

When the output voltage rises up to 125% of the preset voltage, the internal fault-logic module delays about 20us and turns on the low side Power MOSFET. It stays latched on and the GS92A3 is latched off until Power Reset or EN Reset.

Output Under-Voltage Protection

When the output voltage falls down to 45% of the preset voltage, the internal fault-logic module will delay about 20us and turns off both the high side and low side Power MOSFETs. Both switches stay latched off and the GS92A3 is latched off until Power Reset or EN Reset. During soft-start, the UVP will be blanked, until soft-start procedure finished. The blank time depended on the value of the capacitor connected to SS Pin. But if the output voltage rises up above the UVP threshold tolerance during the counter period, the UVP counter is released immediately.

UVLO and Soft-Start

An internal under voltage lockout (UVLO) module is used to sense the VCC power supply. The PWM converter is forbidden by the under voltage lockout module. When VCC rises about 4.15V, the GS92A3 will initial the control logic circuitries and soft-start ramping generator, and then allows switching to occur. When VCC falls down to about 3.85V, the PWM converter is forbidden again.

When VAIN rises about 5.5V, the LDO output voltage (VCC) of GS92A3 enables and regulates a 5.15V voltage. After VAIN falls down to 5.3V the LDO (VCC) will turn off.

After soft-start module starting, the GS92A3 converter will release the current limit threshold followed the soft-start ramp. After UVP blanking time, the output under voltage protection is enabled.

FB Short Protection

Because the UVP protection is blanked during the soft-start period, if FB pin short to GND, the output voltage will increase continuously without OVP protection. It is a very dangerous condition. The GS92A3 build in a safety protection scheme to avoid this situation. When soft-start procedure begins, the GS92A3 monitors the SS Pin and FB Pin both, if the voltage of SS Pin is higher than 160mV and at the same time the voltage of FB Pin is lower than 80mV, after a few micro seconds delay, the fault logic will stop the switching cycle and latch on. Only Power on Reset and EN Reset can release this latch condition.

VOUT Pin

The Vout Pin offers feedback information of output voltage. This information makes the ton more accurate, so the switching frequency variation is very small even when the GS92A3 operates on very wide input voltage range. When any fault condition occurs, the Vout Pin provides a discharge path from output to gnd.

External Devices Selection

For loop stability, the 0 dB frequency (f0), defined in the follow equation:

$$f_0 = \frac{1}{2\pi \times RESR \times C_{OUT}} \le \frac{f_{SW}}{4}$$

The loop stability is determined by the output capacitor. Specialty polymer capacitors have C_{OUT} in the order of several 100uF and RESR in range of 10mohm is recommended. However, ceramic capacitors have f0 at more than 700 KHz, which is not recommended.

In order for the right regulate manner, the ripple voltage at the feedback pin (FB), should be approximately 15mV. This generates Vripple= (V_{OUT}/0.8) ×15mV at the output node. The output capacitor RESR should meet this equation.

The external device selection is list below:

Choose Feedback Voltage Divider Resistor

Set R_{FB2}=1K~20K ohm

$$R_{FB1} = \frac{(V_{OUT} - 0.8)}{0.8} \times R_{FB2}$$

Choose RTON

$$T_{ON(Max)} = \frac{1}{f_{SW}} \times \frac{V_{OUT}}{V_{IN(Min)}}$$

$$R_{TON(MAX)} = (V_{IN} - 0.8) \times 375K$$

Choose Inductor

Set the ripple current approximately 1/4 to 1/2 of the maximum output current. 1/3 is recommended. The recommended inductor can be calculated from the output current, indicated by formula below

$$L_{IND} = \frac{3}{I_{IOUT(max)} \times f} \times \frac{(V_{IN(max)} - V_{OUT}) \times V_{OUT}}{V_{IN(max)}}$$

For applications that require fast transient response with minimum VOUT overshoot, consider a smaller inductance than above. The cost of a small inductance value is higher steady state ripple, larger line regulation, and higher switching loss.

Choose Output Capacitors

$$RESR = \frac{1}{I_{ripple}} \times \frac{V_{OUT}}{0.8} \times 0.015$$

$$\approx \frac{3}{I_{OUT(max)}} \times \frac{V_{OUT}}{0.8} \times 0.015$$

$$RESR \approx \frac{V_{OUT}}{I_{OUT(max)}} \times 75(mohm)$$

Organic semiconductor capacitors are recommended.

Choose Soft-Start Capacitor

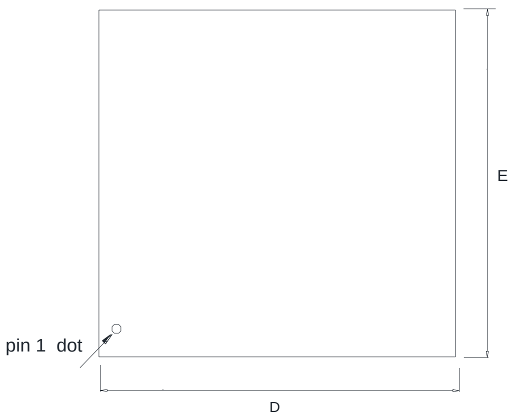
When SS ramp rise up to about 1.6V, the chip thinks the soft-start procedure is over, and then, release the UVP protection function. At the same time, the VOUT voltage will reach the target set by the FB resistor divider. So, the total soft-start time is defined by the formula below:

$$T_{SS} = \frac{1.6 \times C_{SS}}{I_{SS}} = 1.6 \times 10^{8} \times C_{SS}\ \text{(ms)}$$

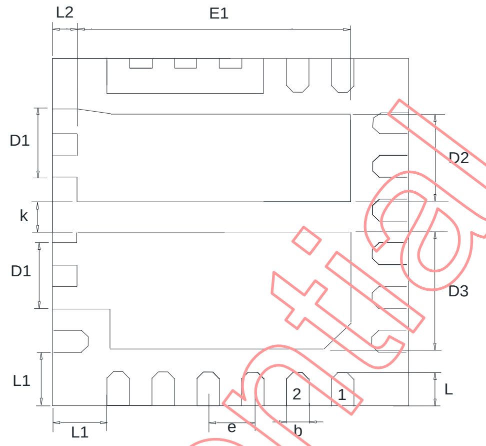
Where, the unit of Tss is mS.

For example, the typical Tss is equal to 1.6mS with 10nF C_{SS}.

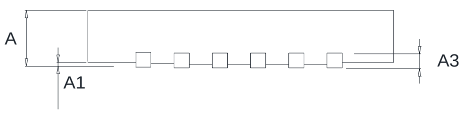
Package Dimensions, TQFN23-4x4



(Top view)



(Bottom view)



(Side view)

Symbol	Dimensions in Millimeters	
	Min.	Max.
A	0.70	0.80
A1	0.00	0.05
A3	0.203 REF.	
b	0.20	0.30
D	3.90	4.10
D1	0.65	0.85
D2	0.85	1.05
D3	1.24	1.44
E	3.90	4.10
E1	2.95	3.15
E2	2.60	2.70
E3	2.95	3.15
L	0.35	0.45
L1	0.57	0.67
L2	0.23	0.33
e	0.50 REF.	
k	0.33	0.37

Note

1. Min.: Minimum dimension specified.
2. Max.: Maximum dimension specified.
3. REF.: Reference. Normal/Regular dimension specified for reference.

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