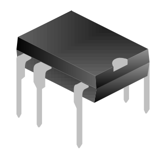
Primary Side Control SMPS with Integrated MOSFET

General Description

GG6005 is a primary side control PSR SMPS with an integrated MOSFET. It features a programmable cable drop compensation function, PFM technology, and a CV/CC control loop with high reliability and average efficiency.

With the GG6005, the opto coupler and Y capacitor, secondary feedback control, and the loop compensation circuit can be eliminated to reduce cost.

In a certain output voltage range, the output voltage can be set through feedback resistors, and output current also can be set through a peak current sense resistor. Setting the cable drop compensation and peak current compensation are also available for optimized output voltage/current regulation.



DIP-8A-300-2.54

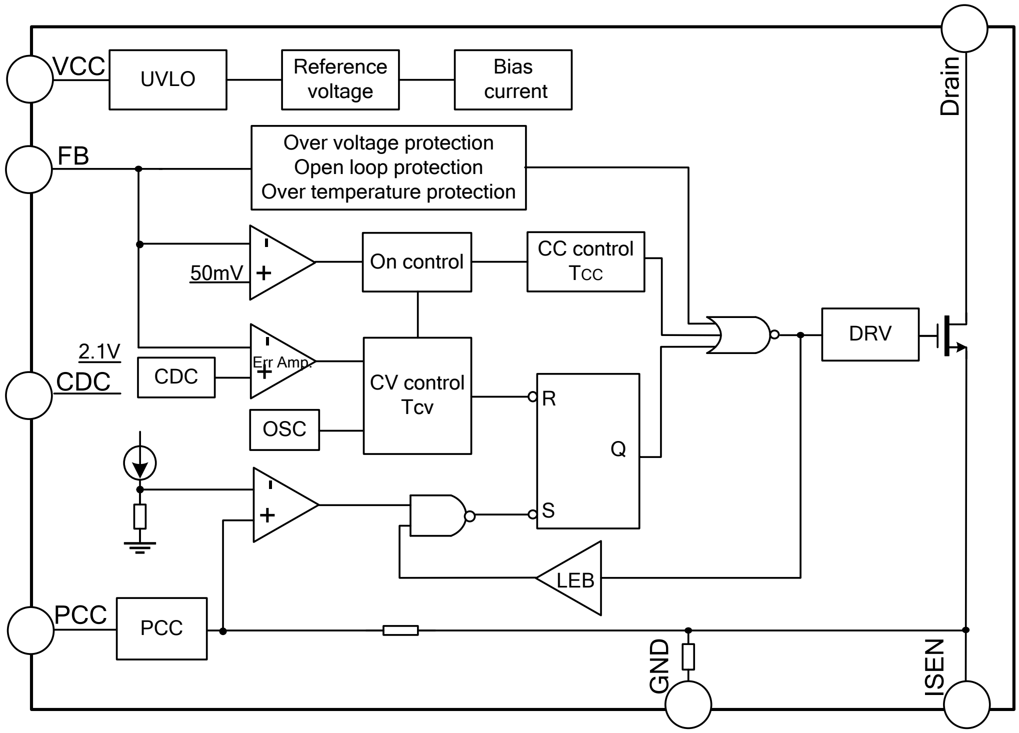
Features

- Built-in high voltage MOSFET
- Primary side control
- Low start-up current
- Leading edge blanking
- Pulse-Frequency Modulation(PFM)
- Overvoltage protection
- Undervoltage lockout
- Over temperature protection
- Cycle by cycle current limiting
- Open loop protection
- Cable drop compensation
- Peak current compensation

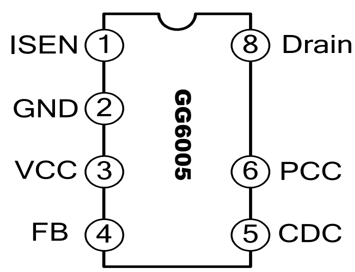
Applications

- Mobile Charger
- Low Power Adaptor
- Charger for MP3 and other portable apparatus
- Stand-by power supply

Block Diagram



Pin Configuration



Pin Description

Pin No	Pin Name	I/O	Function description
1	ISEN	I	Peak current sense pin
2	GND	–	Ground
3	VCC	–	Power supply
4	FB	I	Feedback voltage input pin
5	CDC	I	Cable drop compensation resistor connect pin
6	PCC	I	Peak current compensation resistor connect pin
7	--	--	No pin
8	Drain	O	Drain pin of high voltage MOSFET

Absolute Maximum Rating (Unless Otherwise Specified, T_{amb}=25°C)

Characteristics	Symbol	Rating	Unit
Supply voltage	V_{CC}	-0.3~28	V
Internal voltage reference	V_{REF5V}	-0.3~5.5	V
Input voltage on pin FB	V_{FB}	-30~30	V
Input voltage on other pins	V_{IN}	-0.3~ 5.3	V
Input current	I_{IN}	-10~10	mA
Drain-source breakdown voltage	BV_{DSS}	650	V
Gate-Source Voltage	V_{GS}	±30	V
Drain Current	I_D	2.5	A
Drain Current Pulsed	I_{DM}	10	A
Power Dissipation	P_D	1.5	W
Single Pulsed Avalanche Energy	E_{AS}	135	mJ
Operating junction temperature	T_J	+160	°C
Operating temperature range	T_{amb}	-20~ +85	°C
Storage temperature range	T_{STG}	-40~+125	°C
ESD(HBM)	ESD	2500	V

Thermal Characteristics

Characteristics	Symbol	Conditions	Rating	Unit
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$		16	°C/W
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$		74	°C/W

MOSFET Electrical Characteristics (unless otherwise specified, T_{amb}=25°C)

Characteristics	Symbol	Conditions	Min.	Typ.	Max.	Unit
Static Drain-source on-state Resistance	$R_{DS(ON)}$	V_{GS}=10V, I_D=1.25A	--	3.8	4.8	Ω
Forward transconductance	G_{fs}	V_{DS}=50V, I_D=0.5A	1.5	--	--	S
Input Capacitance	C_{iss}	V_{GS}=0V, V_{DS}=25V, f=1MHz	--	450	--	pF
Output Capacitance	C_{oss}		--	35	--	
Reverse Transfer Capacitance	C_{rss}		--	8.4	--	
Turn-on Delay Time	$t_{d(ON)}$	V_{DS}=0.5B_{VDSS}, I_D=25mA	--	12.6	--	nS
Rise Time	t_r		--	31	--	
Turn-off Delay Time	$t_{d(OFF)}$		--	17.6	--	
Fall time	t_f		--	20	--	

Electrical Characteristics (unless otherwise specified, V_{CC}=18V, T_{amb}=25°C)

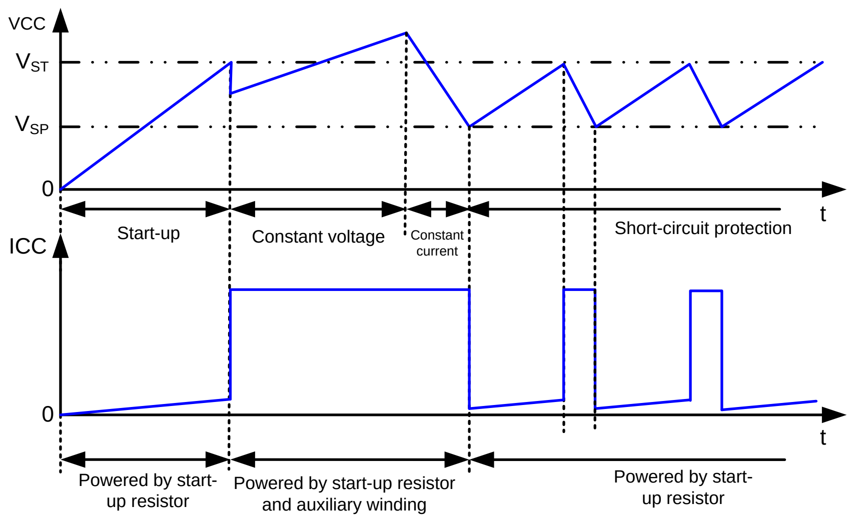
Characteristics	Symbol	Test conditions	Min	Typ	Max	Unit
Supply voltage						
Start-up current	I_{ST}	V_{CC} =14V	--	3	10	µA
Quiescent current	I_{OP}		--	300	450	µA
Start threshold voltage	V_{ST}		13	14.5	16	V
Shutdown threshold voltage	V_{SP}		5.5	6.5	7.5	V
Reference power supply	V_{REF5V}		4.75	5.0	5.25	V
VCC Overvoltage protection	V_{CCOVP}		24	25	26	V
Feedback						
Enable turn on voltage	V_{EN}		20	50	80	mV
FB Overvoltage protection	V_{FBOVP}		4.8	5.0	5.2	V
Loop open voltage	V_{BLANK}		-1.4	-1.2	-1.0	V
Constant voltage threshold	V_{CV}		2.0	2.1	2.2	V
Dynamic Characteristics						
Leading-edge blanking time	T_{LEB}		0.3	0.6	0.9	µS
CV loop control off time	T_{CVmin}		1.0	--	2.8	µS
	T_{CVmax}	$V_{FB} > V_{CV}$+0.2V	12	18	24	mS
Maximum duty of constant-voltage loop	D_{Smax}		50	57	64	%
PFM frequency range	f_S		100	--	200k	Hz
Over voltage recover time	T_{OVP}		12	18	24	mS
Current Limit						
Peak current detecting threshold voltage	V_{PK}	I_{PCC}=0	500	700	900	mV
Peak current compensation	ΔI_{PK}	I_{PCC}=-1µA	2.2	2.5	2.8	mA
Cable Drop Compensation						
Cable drop compensation voltage	V_{CDC}	R_{CDC}=100k , D_S=50%	180	200	220	mV
Over Temperature Protection						
Over temperature detection	T_{sd}		125	140	--	°C
Over temperature hysteresis	T_{sdhys}		20	35	55	°C

Functional Description

GG6005 is an off-line SMPS controller. It features a built-in MOSFET, cable drop compensation, and peak current compensation. CV/CC is obtained through output voltage/current controlled through detecting the feedback voltage of the auxiliary winding and peak current of the primary winding.
The whole operating period consists of peak current detection and feedback voltage detection.
When the MOSFET is on, the primary current is detected by a sense resistor and the voltage at pin FB is negative, the load is powered by the output capacitor and the output voltage V_O decreases. When the primary current exceeds the limit, the MOSFET is off and the voltage at pin FB is detected. The output capacitor and the load are powered by secondary current and V_O increases. The transistor is on again after stopping for T_{CV} and holding for T_{CC}, and then, it comes to peak current detect again.

1. Start-up and under voltage lockout

At the beginning, the capacitor connected to pin V_{CC} is charged via the start resistor by the high voltage DC bus and the circuit starts to work if the voltage at V_{CC} is 14.5V. The circuit is powered by the start resistor and auxiliary winding for normal operation. The whole control circuit enters undervoltage lockout if V_{CC} is decreased to 6.5V, the capacitor connected to pin V_{CC} is charged through the start resistor and the IC only restarts when V_{CC}=14.5V.



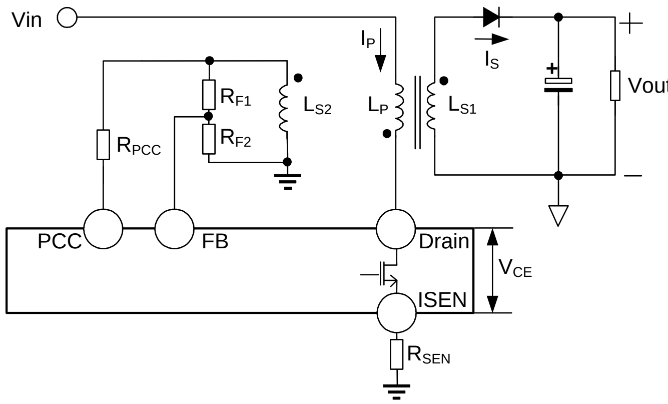
2. Peak current detection

When V_{DRIVE}=1, the MOSFET is on, the linearly increased primary current is detected by the sense resistor. When this current increases to the threshold value (peak value), the MOSFET is off and the driving voltage V_{DRIVE}=0.
There is a burr when the MOSFET is on, and MOSFET will be off by error if its voltage is up to the threshold value V_{PK} for the peak current. So the leading edge blanking time T_{LEB}=0.6μs is set to avoid this error.

3. Peak current compensation

The detected peak current value will be increased following the input AC voltage due to the off delay. The output current is deeply affected by the peak current and therefore the voltage regulation is worse without peak current compensation.
Peak current compensation is available in the GG6005 through pin PCC by AC input voltage detecting. With the compensation, the detected peak current is hold with different input AC voltages for better line regulation.

The threshold value $V_{PK}=0.7V$ is set by the circuit, that is, this value can be adjusted by R_{SEN}. The peak current compensation ability is decided by R_{PCC}, the lower resistance, the higher compensation.



4. Feedback Voltage Detection

When the MOSFET is off, the voltage at pin FB is positive and voltage is sensed at 2/3 duration of this positive voltage, this sensed voltage is used for T_{CV} control after compared with V_{CV}, amplified and held. CV is available by T_{CV} controlling. Without consideration of voltage drop on cable and rectifier diode, the equation is shown as:

$$V_{OUT}\frac{n_{S2}}{n_{S1}}\cdot\frac{R_{F2}}{R_{F1}+R_{F2}}=V_{CV}$$

T_{OFF1}, T_{OFF2}, and T_{ON} are counted at the same time which indicates durations of positive FB voltage, FB damping oscillation and FB negative voltage respectively. Positive FB voltage indicates there is current delivered to the secondary side of transformer, while negative and FB damping oscillation indicate there is no current delivered to the secondary side of transformer.

The duty factor is expressed as:

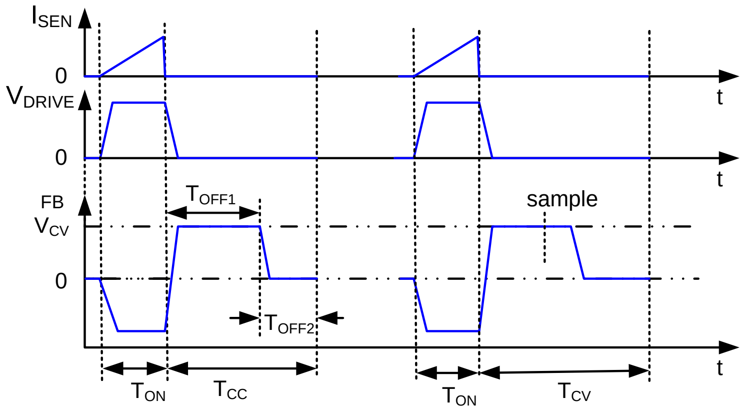
$$D_S=\frac{T_{OFF1}}{T_{OFF1}+T_{OFF2}+T_{ON}}=\frac{T_{OFF1}}{T};$$

Output current, also the average current in secondary winding:

$$I_{OUT}=\frac{I_{SP}\cdot T_{OFF1}}{2T}=\frac{nD_S}{2}I_{PK};$$

I_{SP}—peak current in secondary winding, I_{PK}—peak current in primary winding, n—turns ratio of primary/secondary windings.

Hence, with constant peak current, when $D_S=D_{Smax}=0.57$ (this value is determined by internal circuit), the circuit enters constant-current mode and output current is kept constant.

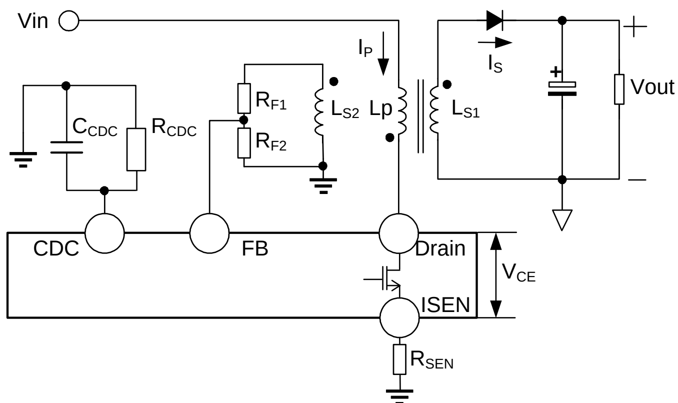


5. Cable Drop Compensation

In the actual design, the cable voltage drop V_{CAB} should be taken into consideration:

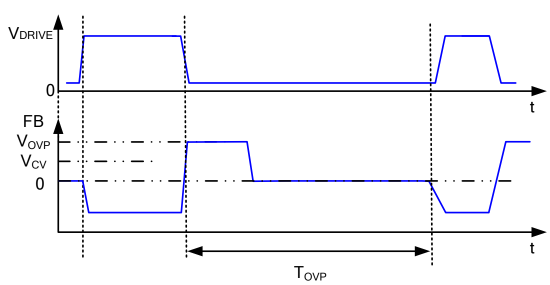
V_D is almost constant with different currents, and cable voltage drop V_{CAB} is proportional to output current, which is needed to be compensated to get better voltage regulation.

For cable compensation, R_{CDC} is used for an equivalent cable resistor and a different R_{CDC} is needed for different cable.



6. Over Voltage Protection

The output is shutdown if voltage at FB exceeds the threshold V_{OVP} and this state is kept for 18ms, then the circuit restarts.



7. Over Temperature Protection

If the circuit is over temperature, the output is shut down to prevent the circuit from damage. The hysteresis of over temperature protection is used to avoid frequent changes between normal and protection modes. The over protection threshold value is 140°C and hysteresis value is about 35°C. Hence, the circuit is only functions normally when the temperature is 105°C below.

8. Open Loop Protection

When MOSFET is on, if V_{FB}>－1V, the loop is open and open loop protection is active to shutdown the output, which stays on for 18ms and then the circuit restarts

9. PFM Frequency Setting

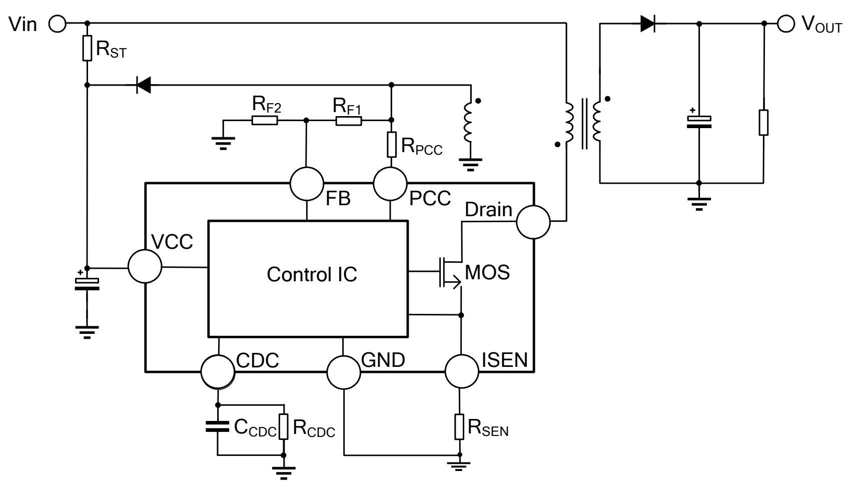
PFM frequency range is determined by the constant on time T_{ON} and constant-voltage loop off time. When the off time is T_{CVmax}, the circuit works with no load and the operating frequency value is at minimum; when the off time is T_{CVmin}, the circuit works with full load and operating frequency value is at maximum.

According to the formula: $P_O = V_O \cdot I_O = \frac{1}{2} L_m I_{PK}{}^2 \cdot f_S \cdot \eta$

Where, Lm—primary inductance, I_{PK}—peak current in primary side, fs—operating frequency, η—efficiency.

Hence, $f_S = \frac{2V_O \cdot I_O}{L_m I_{PK}{}^2 \cdot \eta}$

Typical Application Circuit



Note: The circuit and parameters are for reference only; please set the parameters of the real application circuit based on actual testing.

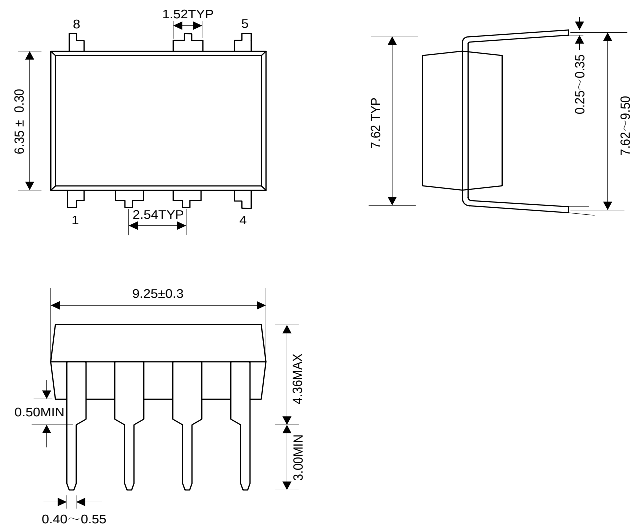
Ordering Information

Part No	Package	Marking	Material	Packing
GG6005	DIP-8A-300-2.54	GG6005	Pb free	Tube
GG6005G	DIP-8A-300-2.54	GG6005G	Pb free	Tube

Package Outline

DIP-8A-300-2.54

UNIT: mm



MOS Devices Operation Notes:

Electrostatic charges may exist in many things. Please take the following preventive measures to prevent effectively the MOS electric circuit as a result of the damage which is caused by discharge:

- The operator must put on wrist strap which should be earthed to against electrostatic.
- Equipment cases should be grounded.
- All tools used during assembly, including soldering tools and solder baths, must be grounded.
- MOS devices should be packed in antistatic/conductive containers for transportation.

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