A706

HIGH VOLTAGE BOOST DRIVER WITH 6 CHANNELS CONSTANT CURRENT REGULATORS

ADDtek
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DESCRIPTION

The A706 is a high voltage Boost driver with 6 channels adjustable constant current regulators for notebook LED backlight applications. Six regulated current ports are designed to provide uniform and pure DC constant current sinks for driving LEDs within a large range V_F variations. It can drive a number of LEDs in series/parallel configuration

Users may adjust the output current from 5mA to 40mA through an external resistor, R_{SET}, which gives users flexibility in controlling the light intensity of LEDs. It also could adjust LED brightness from 0% to 100% via enable pin (EN) with Pulse Width Modulation signal.

A feedback circuit is built in the between of Boost Driver and the Current Regulators. It could output the lowest dropout voltage among used channels to Boost Driver in order to maintain the output voltage in optimal level. An OVP circuit is built for open-loop protection when any string becomes open.

The thermal protection function protects IC from over temperature damage. Also, the exposed thermal pad enhances the package power dissipation.

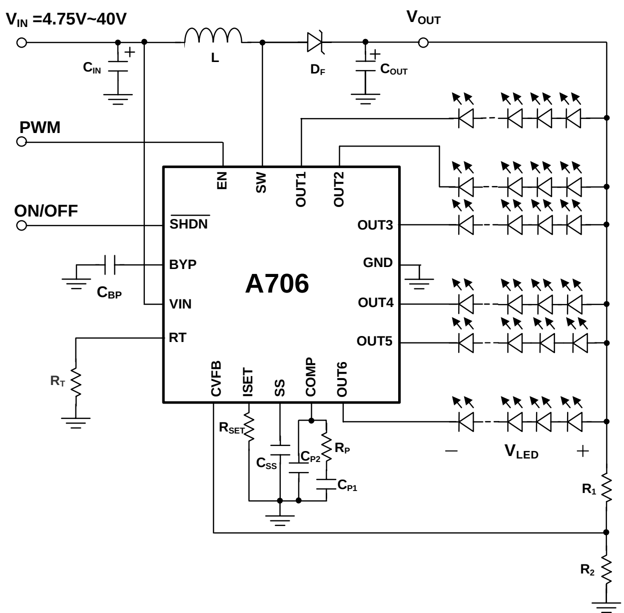
FEATURES

- **High frequency DC/DC converter for LEDs.**
- **Integrated 40V power MOSFET.**
- **4.5V ~ 25V wide input voltage range.**
- **6 constant-current output channels.**
- **Output current adjustable through external resistor.**
- **Constant output current range: 5mA~40mA.**
- **40V output sustaining voltage for up to 10 pcs of LEDs in series.**
- **LED open/short protection.**
- **1uA Shut-down current.**
- **2 types of pin-out available.**
- **Green Package.**

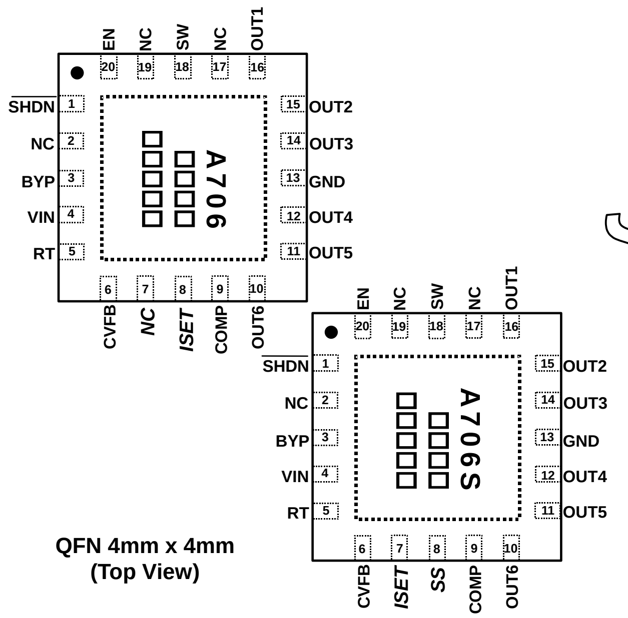
APPLICATIONS

- Automotive interior lighting
- LED backlight driver for NB and Monitors.

TYPICAL APPLICATION CIRCUIT



PACKAGE PIN OUT



QFN 4mm x 4mm
(Top View)

ORDER INFORMATION

	K	QFN 4mm x 4mm
		20 pin
Without SS pin		A706KGT
With SS pin		A706KGT-SS

Note: The letter "G" is marked for Green parts, and letter "T" is marked for Tape & Reel.

ABSOLUTE MAXIMUM RATINGS (Note)	
Supply Voltage, V_{DD}	4.5V to 29V
Output Current, I_{OUTn}	40mA
SW Pin Voltage, V_{SW}	43V
Sustaining Voltage, OUTn	40V
Maximum Operating Junction Temperature, T_J	125°C
Operating Temperature, T_{opr}	-40°C to 85°C
Storage Temperature Range	-55°C to 150°C
Lead Temperature (Soldering, 10 seconds)	260°C

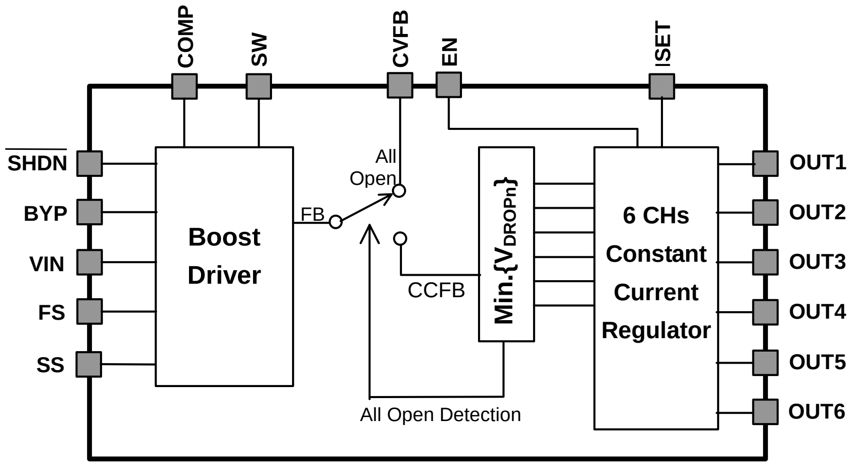
Note: Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of the specified terminal.

PIN DESCRIPTION

Pin Number		Pin Name	Pin Function
A706	A706S		
1	1	SHDN	Chip Shutdown pin, Low active. The supply current less than 10uA when shutdown. Internal pull-high.
3	3	BYP	Bypass de-coupling capacitor.
4	4	VIN	Power Supply pin.
5	5	RT	High Frequency Oscillator Timing Resistor for operation frequency.
6	6	CVFB	Constant Voltage Mode Feedback pin, feedback reference voltage is 1.20V.
8	7	ISET	Output Current Setting and Analog Dimming input. 1.20V used to connect an external resistor R_{SET} between ISET pin and GND pin for setting up output current for all output channels. $I_{SET} = 1.2V/R_{SET}$. $I_{OUTn} = I_{SET} \times 54$.
-	8	SS	Soft-Start pin.
9	9	COMP	Compensation pin.
10~12, 14~16	10~12, 14~16	OUT1 ~ OUT6	Constant Current Output terminals. Sink current is decided by the current on R_{SET} connected to I_{SET}.
13	13	GND	Ground terminal for control logic and current sink.
18	18	SW	Power Switch input.
20	20	EN	Output Enable Control pin. “High” active.
2, 7, 17, 19	2, 17, 19	NC	No Connection.
Exposed Pad		Heat Pad (PGND)	Heat pad. Connect to power ground. Must be soldered to electrical ground on PCB.

Note: The thermal pad is suggested connect to GND on PCB. And thermal conductivity will be improved, if a copper foil on PCB is soldered with thermal pad.

BLOCK DIAGRAM



THERMAL DATA

Thermal Resistance from Junction to Ambient, θ_{JA}	°C /W
Junction Temperature Calculation: $T_J = T_A + (P_D \times \theta_{JA})$. The θ_{JA} numbers are guidelines for the thermal performance of the device/pc-board system. Connect the ground pin to ground using a large pad or ground plane for better heat dissipation. All of the above assume no ambient airflow.	

Maximum Power Calculation:

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_{A(MAX)}}{\theta_{JA}}$$

T_J (°C): Maximum recommended junction temperature

T_A (°C): Ambient temperature of the application

θ_{JA} (°°C /W): Junction-to-Ambient thermal resistance of the package, and other heat dissipating materials.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min	Typ	Max	Unit
Supply Voltage	V_{IN}	4.5	12	25	V
SW Pin Voltage	V_{SW}	0		40	V
Output Voltage Over Voltage Protection (CV Mode) [Note 1, 2]	$V_{OUT, OVP}$	V_{LED}+1.6		39.5	V
Continuous Output Voltage (CC Mode) [Note 3]	V_{OUT}	V_{IN}		38.5	V
LED String Total Forward Voltage	V_{LED}	V_{IN}		38	V
Output Sink Current	I_{OUTn}	5		40	mA
Operation Frequency	f	650	750	1000	KHz
Operating free-air temperature range	T_A	-20		+85	°C

Note 1: For OVP function and CV mode, please refer to "Application Information" Section
Note 2: The difference between maximum V_{SW} and maximum $V_{OUT, OVP}$ is reserved for the forward voltage of Schottky diode.
Note 3: There should be guard band between Continuous Output Voltage and OVP voltage.

ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, T_A=25°C. (Unless otherwise noted)

System

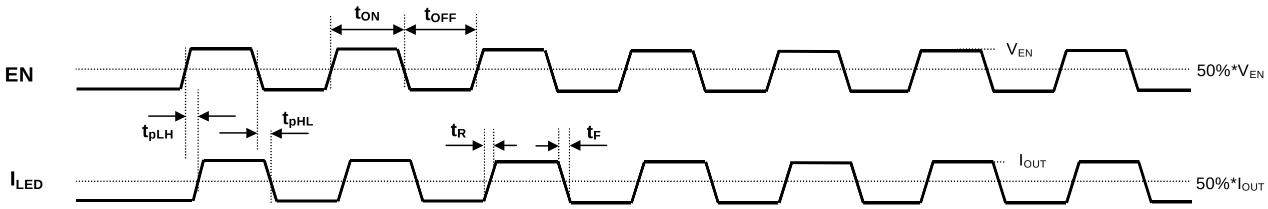
Parameter		Symbol	Conditions	Min	Typ	Max	Unit
Supply Current	"ON"	$I_{IN(ON)}$	R_{SET}=3.24kΩ; EN = "High"		7	10	mA
	"OFF"	$I_{IN(OFF)}$	R_{SET}=Open; EN = "Low"		6	9	mA
			R_{SET}=3.24kΩ; EN = "Low"		7	10	mA
	Shutdown	$I_{IN(SD)}$	$\overline{SHDN}$= "Low"		10		uA
EN Input Voltage	"H" level	V_{IH}		1.7		5	V
	"L" level	V_{IL}		GND		0.8	V
EN Input Hysteresis					200		mV
Pull-up Resistor, EN		R_{IN} (up)		0.5	1	1.5	MΩ
Thermal Protection Temperature		T_X	When T_J approaches T_X and OUT is shut off		160		°C
Thermal Protection Temperature Hysteresis					25		°C

Boost Driver						
Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Under Voltage Lockout Threshold “OFF”	$UVLO_{OFF}$	Lock out		3.2		V
Under Voltage Lockout Threshold “ON”	$UVLO_{ON}$	Resume		3.4		V
BYP Voltage	V_{BYP}	$5V \leqq V_{IN} \leqq 25V$		5		V
SW Breakdown Voltage	BV			40		V
SW Current Limit	I_{LIMIT}		1.35			A
SW Turn-on Resistance	$R_{DS(ON)}$	I_{SW}=100mA		300	500	mΩ
Feedback Voltage	V_{FB}			1.2		V
Maximum Duty Cycle	D_{MAX}	f = 750KHz		93		%
Minimum Duty Cycle	D_{MIN}	f = 750KHz		5.5		%
Operation Frequency	f	R_{RT} = 50KΩ		750		KHz
Adjustable Constant Current Regulators						
Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Sustaining Voltage	V_{DS}	OUT1 ~ OUT6			40	V
Output Leakage Current	I_{OH}	V_{OH}=36V		0.5		uA
Output Current	I_{OUT}	V_{DS}=0.6V, R_{SET}=2.16kΩ, Rank A	29.1	30.0	30.9	mA
		V_{DS}=0.6V, R_{SET}=2.16kΩ	27.9	30.0	32.1	mA
		V_{DS}=0.6V, R_{SET}=3.24kΩ, Rank A	19.4	20.0	20.6	mA
		V_{DS}=0.6V, R_{SET}=3.24kΩ	18.6	20.0	21.4	mA
Output Current Skew	$\triangle I_{OUTn}$	V_{DS}=0.6V, R_{SET}=2.16kΩ, Rank A			±3	%
		V_{DS}=0.6V, R_{SET}=2.16kΩ			±7	%
		V_{DS}=0.6V, R_{SET}=3.24kΩ, Rank A			±3	%
		V_{DS}=0.6V, R_{SET}=3.24kΩ			±7	%
Regulation of Output Current vs. Sustaining Voltage	$\%/\triangle V_{DS}$	V_{DS} =0.6V ~ 3.0V		±0.1	-	%/V
Regulation of Output Current vs. Supply Voltage	$\%/\triangle V_{IN}$	V_{IN} = 5V ~ 25V		±1		%

Note1: Output dropout voltage: 90% x I_{OUT} @ V_{OUT}=600mV

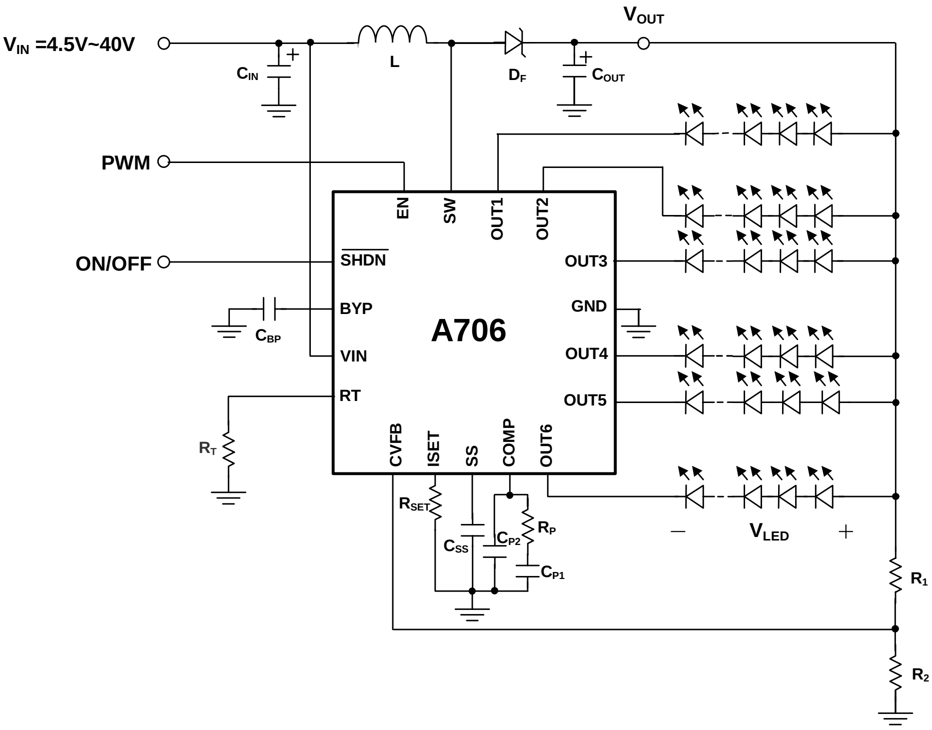
PWM SWITCHING CHARACTERISTICS

Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Propagation Delay Time (Output Current from “L” to “H”)	t_{pLH}	V_{IN} = 12.0V V_{DS} = 1.0V V_{IH} = 5.0V V_{IL} = GND R_{SET} = 3.24kΩ	0.1	0.3	0.6	us
Propagation Delay Time (Output Current from “H” to “L”)	t_{pHL}		0.05	0.1	0.4	us
Shutdown Recover Delay Time				50		us
EN Minimum Pulse Width	t_{ON}		4	-	-	us
Output Current Rising Time (Rising from 10% to 90%)	t_R		0.5	1	2	us
Output Current falling Time (Falling from 90% to 10%)	t_F		0.5	1	2	us



APPLICATION INFORMATION

Typical Application Circuit



CC Mode and CV Mode

There are two working mode for Boost driver of A706: CC Mode (Constant Current mode) and CV mode (Constant Voltage mode).

CC mode is used in usual operation that at least one channel of the six channels is connected. In CC mode, the internal detecting circuit detects the dropout voltage of used channels and the internal selection circuit selects the lowest dropout voltage of the used channels as feedback signal to Boost driver for adjusting output voltage. In addition, the selection circuit will neglect the channels not used.

If all channels are open circuited, A706 will enter CV mode. The CVFB pin is used for setting the output voltage when A706 is in CV mode. CV mode is designed for OVP (Over Voltage Protection). When all of the six channels are open circuited, the output voltage of the Boost driver is fixed at a predetermined value.

Setting the Output Voltage of CV Mode

CVFB pin is used to set the output voltage of CV mode. By using the resistor divider, R1 and R2, to divide the output voltage to the CVFB pin as feedback signal, the output voltage of CV mode is determined by:

$$V_{CVFB} = V_{OUT} \cdot \frac{R_2}{R_1 + R_2}$$

$$V_{OUT} = V_{CVFB} \cdot \left(1 + \frac{R1}{R2}\right) = 1.2V \cdot \left(1 + \frac{R1}{R2}\right)$$

Where, the feedback pin voltage, V_{CVFB}, is always at 1.2V.

Over Voltage Protection (OVP)

The CV mode output voltage should be designed to be higher than ($V_{LED,MAX}$+V_{DROP}+1V). Where, $V_{LED,MAX}$ is the possible maximum forward voltage of all of the 6 LED string, and V_{DROP} is the minimum dropout voltage needed by OUT1 ~ OUT6 pins, which is about 0.6V.

Setting LED Current

An external resistor R_{SET} connected to I_{SET} pin sets the sink current of each channel. The value of R_{SET} is calculated by the following formula:

$$I_{OUTn} = I_{SET} \cdot 54 = \frac{1.2V}{R_{SET}} \cdot 54 \quad \text{(in mA)}$$

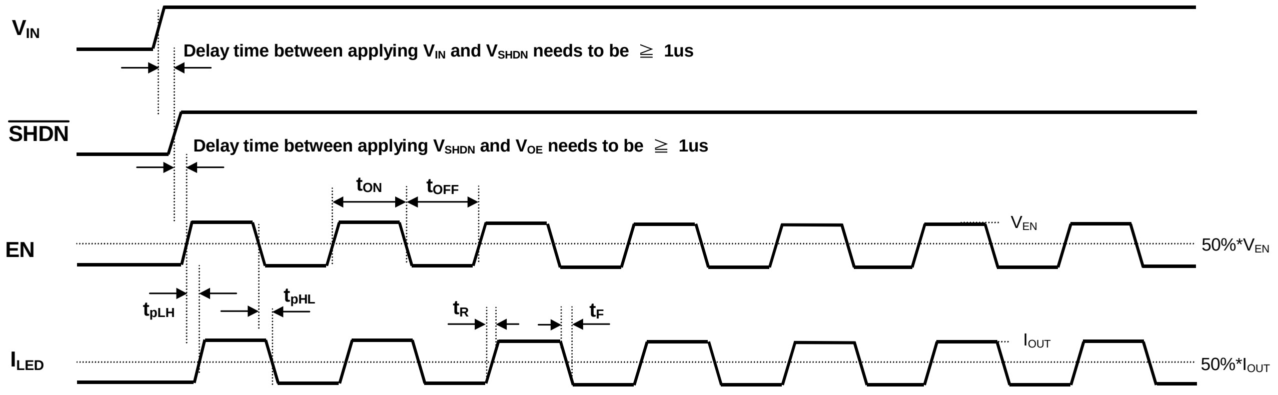
Operation Frequency

A706 is operated under a fixed frequency, which is set by external resistor R_{RT} connected to R_T pin. Resistor R_{RT} sets the charging current for the internal oscillator. The approximate operation frequency can be calculated by the equation:

$$f_S \cong \frac{3.75 \cdot 10^4}{R_{RT}\,(K\Omega)} \quad \text{(in KHz)}$$

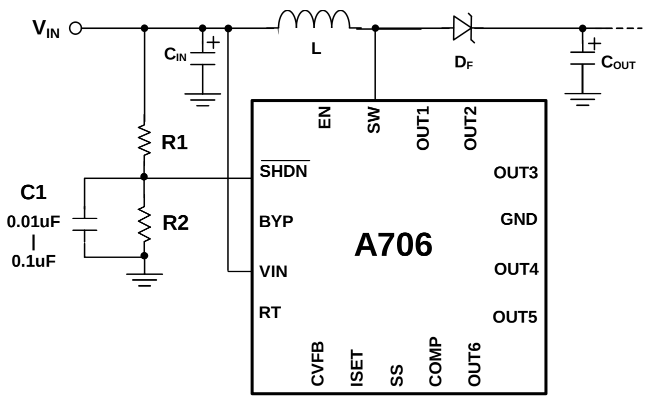
Power Sequence and Timing Chart

The chip is recommended not to be enabled before V_{IN} is applied. Please follow the proper power sequence in the below timing chart.



Characteristic	Symbol	Min	Typ	Max	Unit
LED “ON” Period	t_{ON}	4			us
LED “OFF” Period	t_{OFF}	4			us
Propagation Delay Time (Output Current from “L” to “H”)	t_{pLH}	0.1	0.3	0.6	us
Propagation Delay Time (Output Current from “H” to “L”)	t_{pHL}	0.05	0.1	0.4	us
Output Current Rising Time (Rising from 10% to 90%)	t_R	0.5	1	2	us
Output Current falling Time (Falling from 90% to 10%)	t_F	0.5	1	2	us

When the A706 is operated in a real system, make sure the shutdown signal connected to $\overline{SHDN}$ pin be applied after V_{IN} is applied by at least 1us. However, if there is no shutdown signal from controller be applied to $\overline{SHDN}$ pin of A706 during evaluating stage, add an RC circuit to the system, as shown in the following figure. That means, don’t left $\overline{SHDN}$ pin floating.



R1 and R2 are used to divide the V_{IN} voltage to a suitable level for $\overline{SHDN}$ pin and C1 is used to filter out the noise so that A706 won’t be interfered. 0.01uF ~ 0.1uF of C1 is recommended.

PWM Dimming Control

A706 provides PWM dimming control function through EN pin. Basically, by changing the duty cycle of the PWM control signal, the ratio of LED ON-time to OFF-time can be changed. Consequently, larger duty cycle results in larger average current for driving LED and thus higher luminance.

Ideally, the average LED driving current is in linear proportion to the duty cycle of the PWM control signal in spite of the frequency. However, due to the inherent propagation delay of the chip and the rising/falling time of the driving current, the deviation of the actual current from theoretical value will become larger when the PWM frequency gets higher.

That is, if the PWM frequency exceeds certain recommended value, the effect of the fixed propagation delay and the rising/falling time of LED current on the linear relationship between the duty cycle and the average current will become more apparent. On the other hand, if the PWM frequency is too low, lower than 180Hz for instance, the flicker will become visible. Therefore, it is important to choose a suitable frequency for the PWM signal.

For the maximum dimming frequency, please refer to the timing chart & table in above. It is determined by the minimum duty ratio, D_{MIN}, and the minimum LED “ON” time, $t_{ON,MIN}$. The maximum dimming frequency, f_{PWM}, can be calculated by the following formula:

$$\frac{1}{f_{PWM,MAX}} = \frac{t_{ON,MIN}}{D_{MIN}}$$

For Example, if the minimum duty ratio of PWM dimming control signal is 10%, then the maximum dimming frequency can be up to 25KHz. However, if the minimum duty ratio of PWM dimming control signal is 20%, the maximum dimming frequency can be up to 50KHz. Usually, 2KHz ~ 20KHz is avoided in order to prevent noise.

LAYOUT GUIDELINE

It is very important to keep the loop of the SW pin, Schottky diode, output capacitor, and the GND pin of A706 as small as possible, and also minimize the length of the traces between these components, as shown in the following Fig. 1 and Fig. 2. This is because the *di/dt* at these traces is very high and according to the formula of

$$v = L \cdot \frac{di}{dt}$$

the related voltage spikes will be very high if the trace inductance is high. Such voltage spikes not just cause EMC problems, but may interfere or even damage the IC sometimes.

The most important is, DON'T use via holes in the loop described above, because via holes have high inductance.

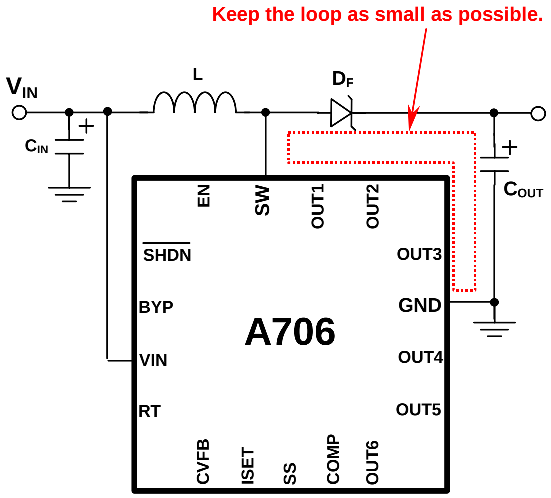


Fig. 1

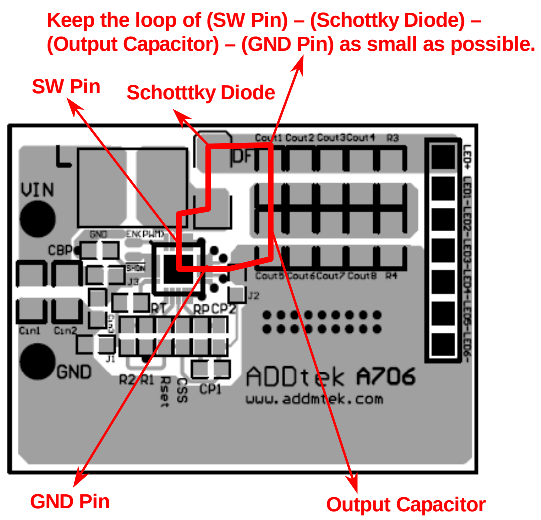


Fig. 2

A big ground plane (form input to out put) can help almost all the performance of the chip. Beside the ground trace on the top layer, please use another layer as the ground layer. Put several vias on the thermal pad of A706 to connect to this big ground can help to conduct the heat to the whole ground layer. This can reduce the temperature of A706 a lot more than just using Thermal Pad along.

About analog ground (the ground for feedback resistors, soft start capacitor, CVFB sensing resisters, compensation components, R_T resistor, R_{SET} resistor, and Bypass capacitor), it is recommended to use short traces to connect these ground points and then directly connect these traces to the GND pin of A706. Please refer to Fig. 3 and Fig. 4.

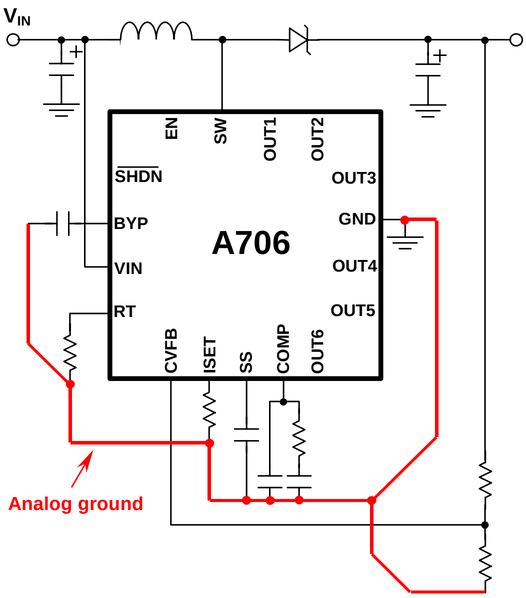


Fig. 3

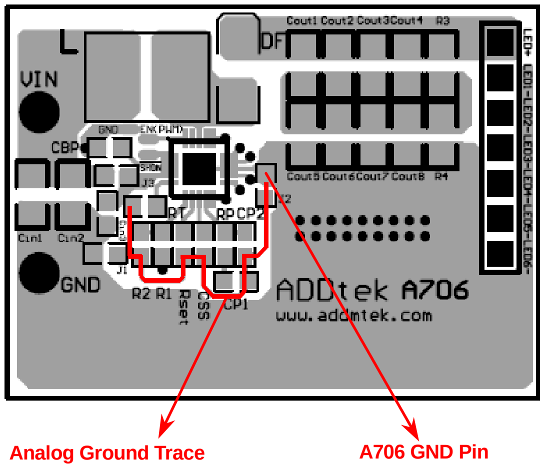
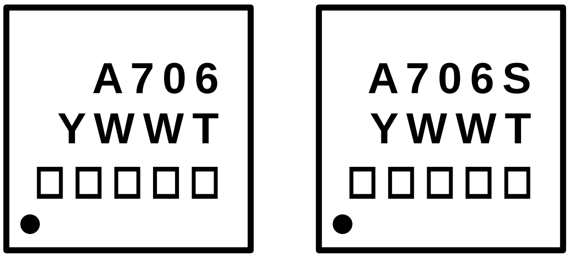


Fig. 4

About the input capacitors, ceramic caps of several uF or bigger are recommended to be used and it is better to be placed close to the IC.

PACKAGE

Top Marking for QFN 4mm x 4mm



S : Soft-Start Function Options

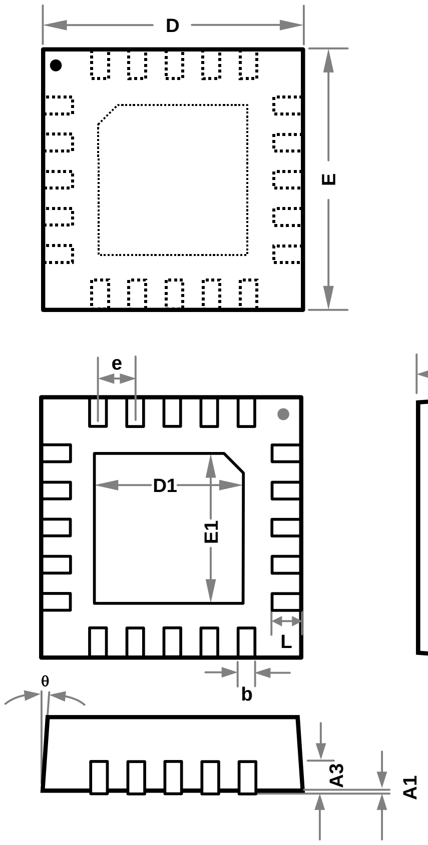
Y : Year Code

WW : Week Code

T : Trace Code

□□□□□ : Lot Number

QFN 4mm x 4mm – 20 pin



SYMBOLS	MIN.	NOM.	MAX.
A	0.800	0.850	1.000
A1	0	-	0.050
A3	0.195	0.203.	0.211
b	0.180	0.230	0.280
D	3.950	4.000	4.050
D1	2.450	2.500	2.550
E	3.950	4.000	4.050
E1	2.450	2.500	2.550
e	-	0.50BSC	-
L	0.350	0.400	0.450
θ°	-12	-	0

UNIT: MILLIMETERS

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