

GENERAL DESCRIPTION

The CM3706 is a 1.5MHz constant frequency, slope compensated current mode PWM step-down converter. The device integrates a main switch and a synchronous rectifier for high efficiency without an external Schottky diode. It is ideal for powering portable equipment that runs from a single cell lithium-Ion (Li+) battery. The CM3706 can supply 600mA of load current from a 2.5V to 5.5V input voltage. The output voltage can be regulated as low as 0.6V. The CM3706 can also run at 100% duty cycle for low dropout operation, extending battery life in portable system. Idle mode operation at light loads provides very low output ripple voltage for noise sensitive applications. The CM3706 is offered in a low profile (1mm) 5-pin, thin TSOT package, and is available in an adjustable version.

FEATURES

- ◆ High Efficiency: Up to 96%
- ◆ 1.5Mhz Constant Switching Frequency
- ◆ 600mA Output Current at $V_{IN}=3V$
- ◆ Integrated Main switch and synchronous rectifier. No Schottky Diode Required
- ◆ 2.5V to 5.5V Input Voltage Range
- ◆ Output Voltage as Low as 0.6V
- ◆ 100% Duty Cycle in Dropout
- ◆ Low Quiescent Current: 300 μ A
- ◆ Slope Compensated Current Mode Control for Excellent Line and Load Transient Response
- ◆ Short Circuit Protection
- ◆ Thermal Fault Protection
- ◆ <1 μ A Shutdown Current
- ◆ Space Saving 5-Pin Thin TSOT23 package

APPLICATIONS

- ◆ Cellular and Smart Phones
- ◆ Microprocessors and DSP Core Supplies
- ◆ Wireless and DSL Modems
- ◆ PDAs
- ◆ MP3 Players
- ◆ Portable Instruments
- ◆ Digital Still and Video Cameras

TYPICAL APPLICATIONS

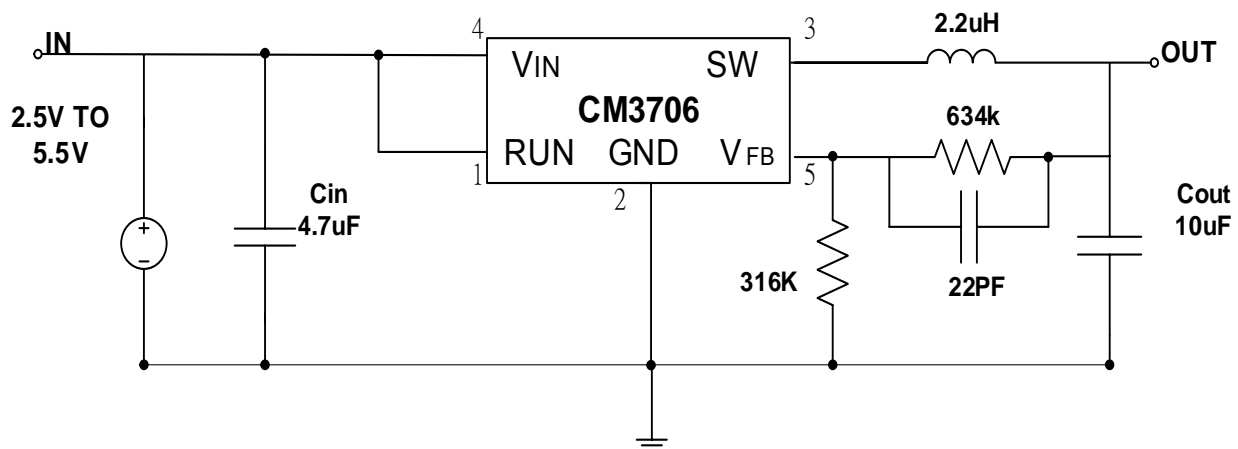
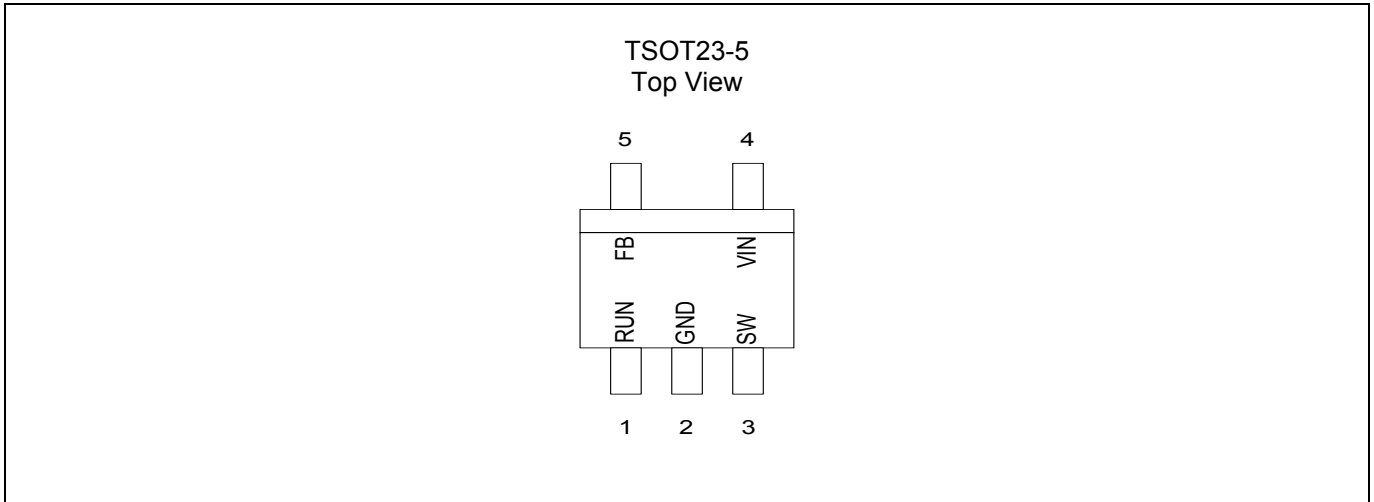
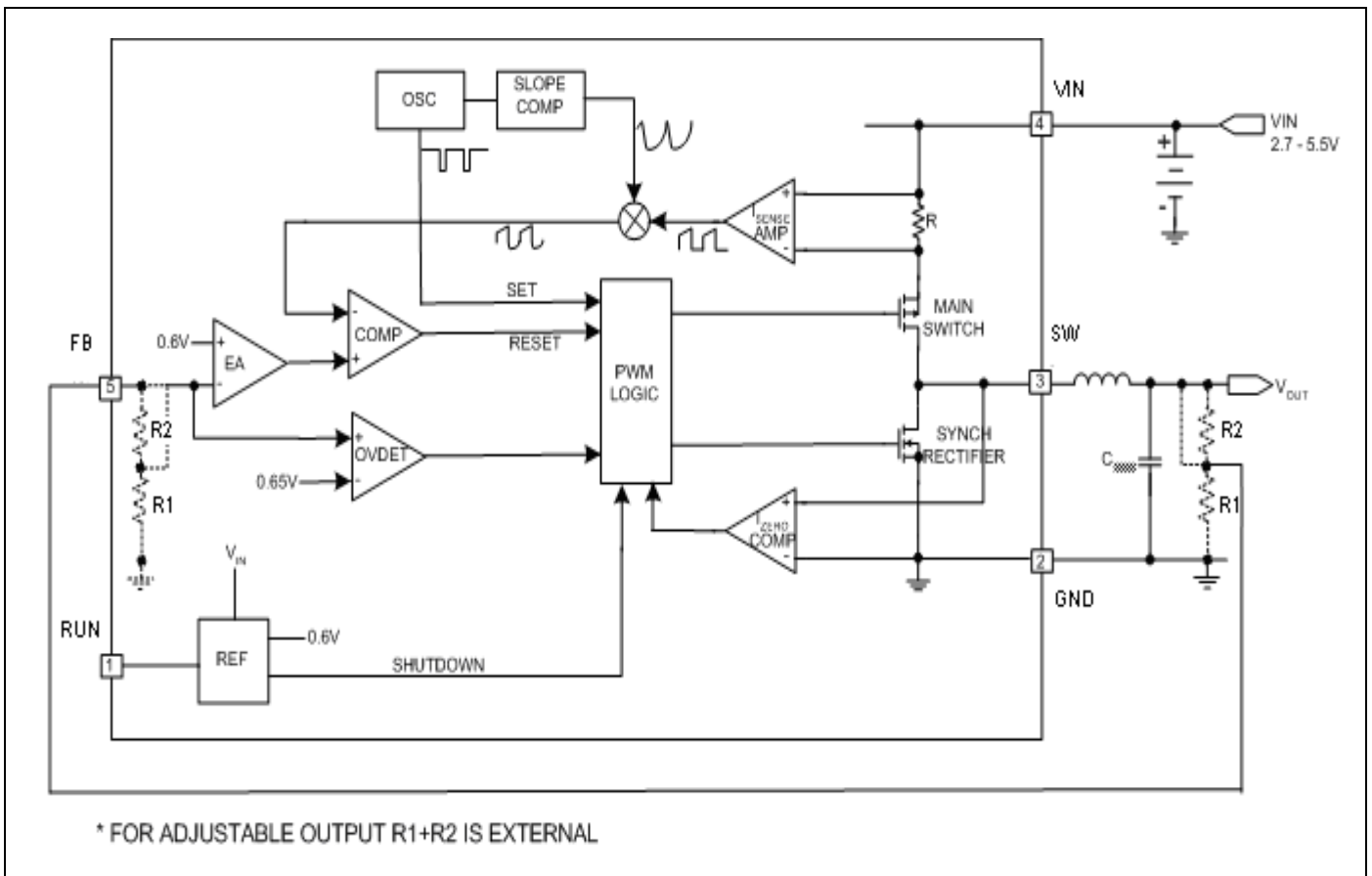


Figure 1. Basic Application Circuit with CM3706 adjustable version

PIN CONFIGURATION



BLOCK DIAGRAM

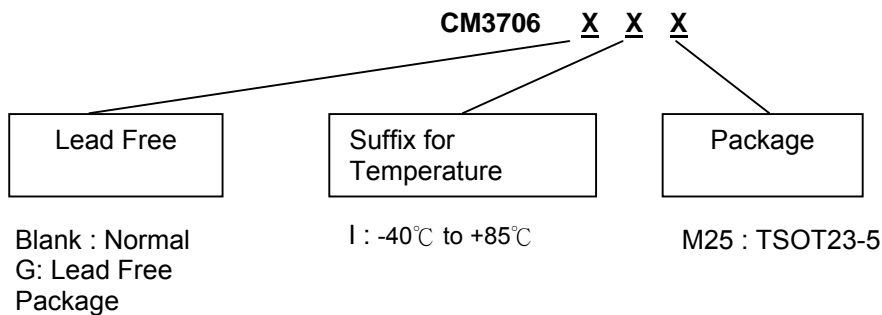


PIN DESCRIPTION

| Pin No. | Symbol | Description |
|---------|--------|--|
| 1 | RUN | Regulator Enable control input. Drive RUN above 1.5V to turn on the part. Drive RUN below 0.3V to turn it off. In shutdown, all functions are disabled drawing <math><1\mu\text{A}</math> supply current. Do not leave RUN floating. |
| 2 | GND | Ground Pin. |
| 3 | SW | Power Switch Output. It is the Switch node connection to Inductor. This pin connects to the drains of the internal P-CH and N-CH MOSFET switches. |
| 4 | VIN | Supply Input Pin. Must be closely decoupled to GND, Pin 2, with a 2.2 μF or greater ceramic capacitor. |
| 5 | FB | VFB (CM3706): Feedback Input Pin. Connect FB to the center point of the external resistor divider. The feedback threshold voltage is 0.6V. |

ORDERING INFORMATION

| Part Number | Voltage | Temperature Range | Package |
|-------------|---------|-------------------|----------|
| CM3706IM25 | Adj | -40°C to +85°C | TSOT23-5 |
| CM3706GIM25 | Adj | -40°C to +85°C | TSOT23-5 |



ABSOLUTE MAXIMUM RATINGS (Note 1)

Absolute maximum ratings are those values beyond which the device could be permanently damaged.

| | | | |
|----------------------------------|------------------------|---|-----------------|
| Input Supply Voltage..... | -0.3V to 6.0V | Peak SW Sink and Source Current..... | 1.5A |
| RUN, VFB Voltages | - 0.3V to (VIN + 0.3V) | Junction Temperature (Note 2) | 125°C |
| SW Voltage..... | - 0.3V to (VIN + 0.3V) | Storage Temperature Range | - 65°C to 150°C |
| Operating Temperature Range..... | -40°C to +85°C | Lead Temperature (Soldering, 10 sec)..... | 300°C |

OPERATING CONDITIONS

| | |
|---------------------------|---------------|
| Temperature Range | -40°C to 85°C |
| Vin Operating Range | 2.5V to 5.5V |

Thermal Resistance (Note 3):

| Package | Θ_{JA} | Θ_{JC} |
|----------|---------------|---------------|
| TSOT23-5 | 250°C/W | 110°C/W |

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula:

$$CM3706: T_J = T_A + (P_D) \times (\Theta_{JA})$$

Note 3: Thermal Resistance is specified with approximately 1 square of 1 oz copper.

ELECTRICAL CHARACTERISTICS (Unless otherwise stated, these specifications apply $T_A=25^\circ\text{C}$; $V_{IN}=+3.6\text{V}$) maximum ratings are stress ratings only and functional device operation is not implied.

| Parameter | Conditions | MIN | TYP | MAX | unit |
|-----------------------------------|--|--------|------------|----------|------------------|
| Input Voltage Range | | 2.5 | | 5.5 | V |
| Input DC Supply Current | | | | | |
| Active Mode | $V_{FB}=0.5\text{V}$ | | 270 | 400 | μA |
| Shutdown Mode | $V_{FB}=0\text{V}$, $V_{IN}=4.2\text{V}$ | | 0.08 | 1.0 | μA |
| Regulated Feedback Voltage | $T_A = +25^\circ\text{C}$ | 0.5880 | 0.6000 | 0.6120 | V |
| | $T_A = 0^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ | 0.5865 | 0.6000 | 0.6135 | V |
| | $T_A = -40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ | 0.5850 | 0.6000 | 0.6150 | V |
| V_{FB} Input Bias Current | $V_{FB} = 0.65\text{V}$ | | | ± 30 | nA |
| Reference Voltage Line Regulation | $V_{IN} = 2.5\text{V}$ to 5.5V , | | 0.11 | 0.4 | %/V |
| Regulated Output Voltage | CM3706-1.2, $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ | 1.164 | 1.200 | 1.236 | V |
| | CM3706-1.5, $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ | 1.455 | 1.500 | 1.545 | V |
| | CM3706-1.8, $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ | 1.746 | 1.800 | 1.854 | V |
| Output Voltage Line Regulation | $V_{IN} = 2.5\text{V}$ to 5.5V , $I_{OUT}=10\text{mA}$ | | 0.11 | 0.40 | %/V |
| Output Voltage Load Regulation | I_{OUT} from 10 to 600mA | | 0.0015 | | %/mA |
| Peak Inductor Current | $V_{IN}=3\text{V}$, $V_{FB}=0.5\text{V}$ or $V_{OUT}=90\%$ Duty Cycle <35% | | 1.2 | | A |
| Oscillator Frequency | $V_{FB}=0.6\text{V}$ or $V_{OUT}=100\%$ | 1.2 | 1.5 | 1.8 | MHz |
| $R_{DS(ON)}$ of P-CH MOSFET | $I_{SW} = 300\text{mA}$ | | 0.3 | 0.50 | Ω |
| $R_{DS(ON)}$ of N-CH MOSFET | $I_{SW} = -300\text{mA}$ | | 0.2 | 0.45 | Ω |
| SW Leakage | $V_{RUN} = 0\text{V}$, $V_{SW} = 0\text{V}$ or 5V , $V_{IN} = 5\text{V}$ | | ± 0.01 | ± 1 | μA |
| RUN Threshold | $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ | 0.3 | 0.45 | 1.5 | V |
| RUN Leakage Current | | | ± 0.1 | ± 1 | μA |
| Thermal Shutdown Trip Threshold | | | 150 | | $^\circ\text{C}$ |
| Output over voltage lockout | $\Delta V_{OVL} = V_{OVL} - V_{FB}$ | | 60 | | mV |

Note 4: 100% production test at $+25^\circ\text{C}$. Specifications over the temperature range are guaranteed by design and characterization.

FUNCTIONAL DESCRIPTION

Operation

CM3706 is a monolithic switching mode Step-Down DC-DC converter. It utilizes internal MOSFETs to achieve high efficiency and can generate very low output voltage by using internal reference at 0.6V. It operates at a fixed switching frequency, and uses the slope compensated current mode architecture. This Step-Down DC-DC Converter supplies 600mA output current at $V_{IN} = 3V$ with input voltage range from 2.5V to 5.5V.

Current Mode PWM Control

Slope compensated current mode PWM control provides stable switching and cycle-by-cycle current limit for excellent load and line responses and protection of the internal main switch (P-Ch MOSFET) and synchronous rectifier (N-CH MOSFET). During normal operation, the internal P-Ch MOSFET is turned on for a certain time to ramp the inductor current at each rising edge of the internal oscillator, and switched off when the peak inductor current is above the error voltage. The current comparator, I_{COMP} , limits

the peak inductor current. When the main switch is off, the synchronous rectifier will be turned on immediately and stay on until either the inductor current starts to reverse, as indicated by the current reversal comparator, I_{ZERO} , or the beginning of the next clock cycle. The $OVDDET$ comparator controls output transient overshoots by turning the main switch off and keeping it off until the fault is no longer present.

Dropout Operation

When the input voltage decreases toward the value of the output voltage, the CM3706 allows the main switch to remain on for more than one switching cycle and increases the duty cycle (Note 5) until it reaches 100%. The output voltage then is the input voltage minus the voltage drop across the main switch and the inductor. At low input supply voltage, the $R_{DS(ON)}$ of the P-Channel MOSFET increases, and the efficiency of the converter decreases. Caution must be exercised to ensure the heat dissipated not to exceed the maximum junction temperature of the IC.

Idle Mode Operation

At very light loads, the CM3706 automatically enters Idle Mode. In the Idle Mode, the inductor current may reach zero or reverse on each pulse. The PWM control loop will automatically skip pulses to maintain output regulation. The bottom MOSFET is turned off by the current reversal comparator, I_{ZERO} , and the switch voltage will ring. This is discontinuous mode operation, and is normal behavior for the switching regulator.

Maximum Load Current

The CM3706 will operate with input supply voltage as low as 2.5V, however, the maximum load current decreases at lower input due to large IR drop on the main switch and synchronous rectifier. The slope compensation signal reduces the peak inductor current as a function of the duty cycle to prevent sub-harmonic oscillations at duty cycles greater than 50%. Conversely the current limit increases as the duty cycle decreases.

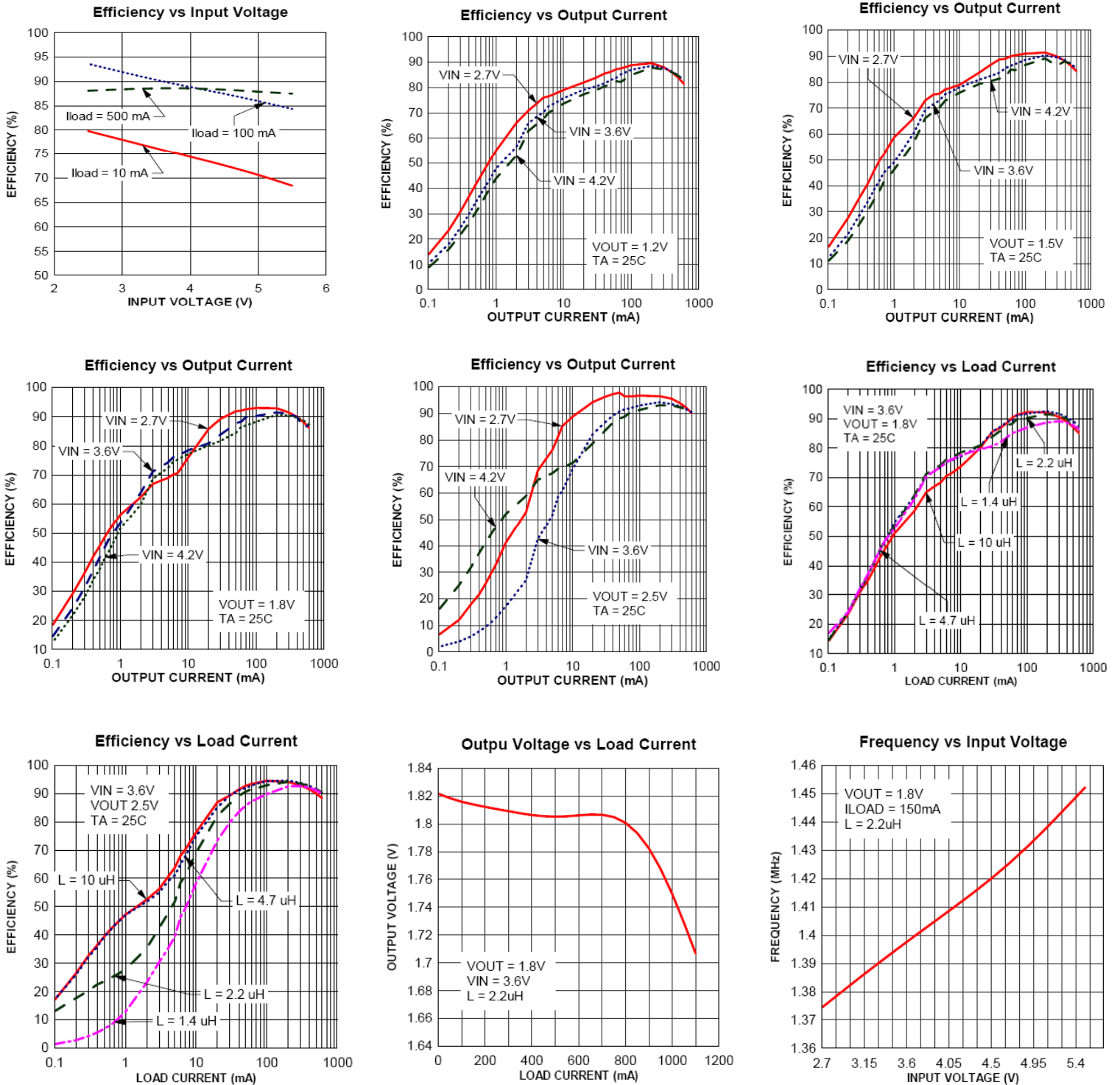
Note 5: The duty cycle D of a step-down converter is defined as:

$$D = T_{ON} \times f_{OSC} \times 100\% \approx \frac{V_{OUT}}{V_{IN}} \times 100\%$$

where T_{ON} is the main switch on time, and f_{OSC} is the oscillator frequency (1.5Mhz).

Typical Performance Characteristics

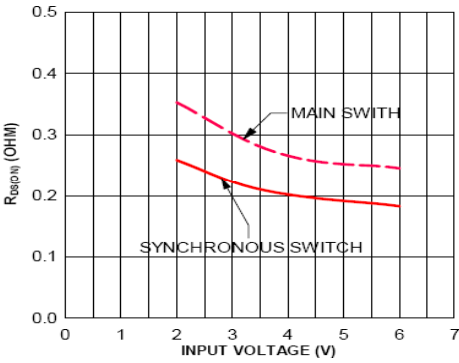
(Test Figure 1 above unless otherwise specified)



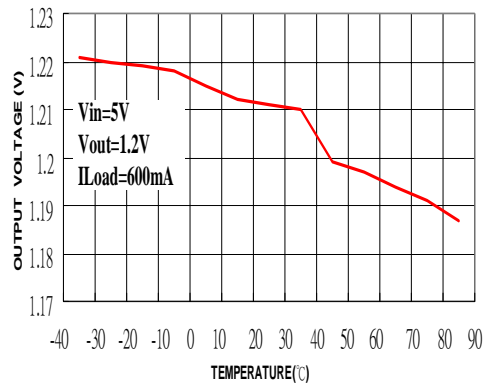
CM3706

1.5MHz, 600mA Synchronous Step-Down Regulator

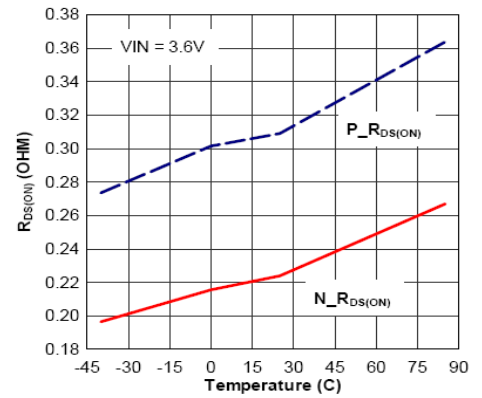
R_{DS(ON)} vs Input Voltage



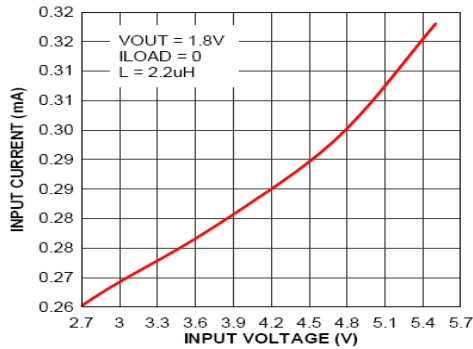
Output Voltage vs Temperature



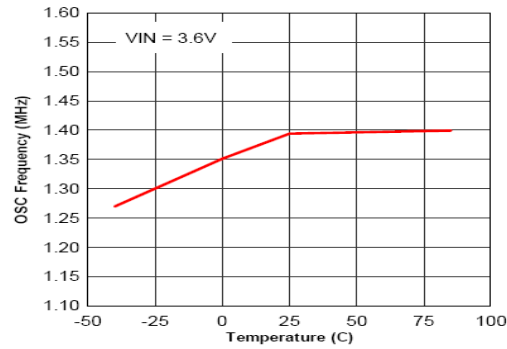
R_{DS(ON)} vs Temperature



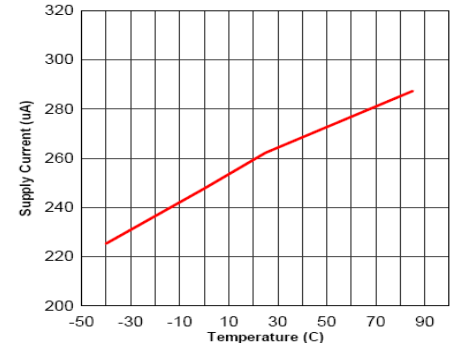
Input Voltage vs Input Current



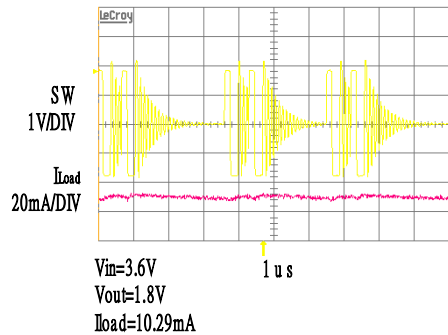
Frequency vs Temperature



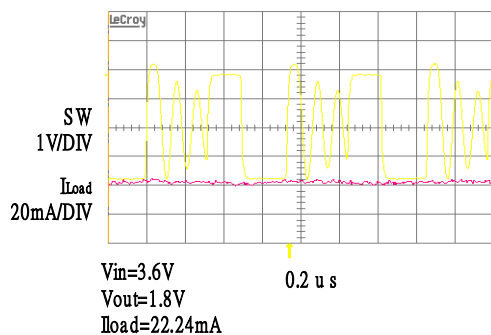
Supply Current vs Temperature



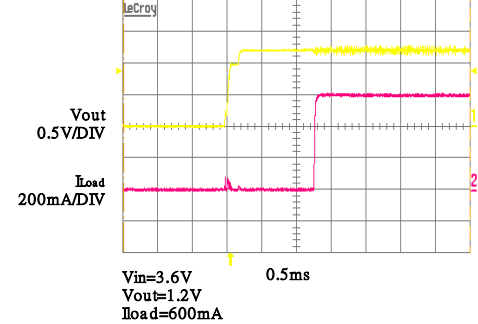
Pulse Skipping Mode Operation



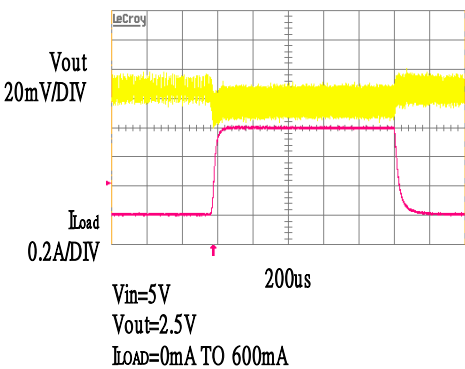
Discontinuous Operation



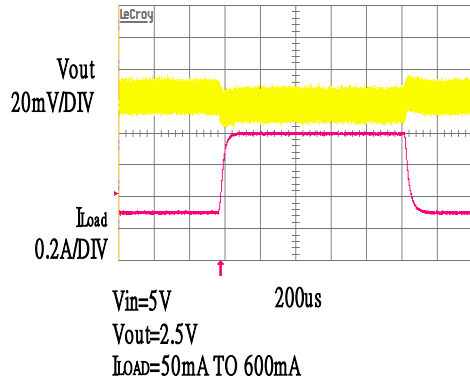
Start-Up from shutdown



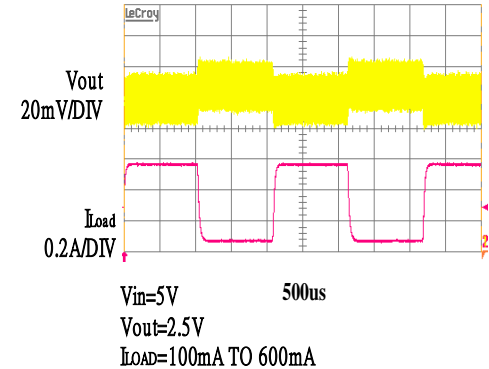
Load step



Load step



Load step



APPLICATIONS INFORMATION

Setting the Output Voltage

Figure 2 above shows the basic application circuit with CM3706 adjustable output version. The external resistor sets the output voltage according to the following equation:

$$V_{OUT} = 0.6V \left(1 + \frac{R2}{R1} \right)$$

R1=316KΩ ; R2= 316KΩ ; V_{OUT}=1.2V

R1=316KΩ ; R2= 470KΩ ; V_{OUT}=1.5V

R1=316KΩ ; R2= 630KΩ ; V_{OUT}=1.8V

R1=316KΩ ; R2= 1MΩ ; V_{OUT}=2.5V

R1=316KΩ ; R2= 1.42MΩ ; V_{OUT}=3.3V.

Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency shall be less than input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. A 4.7μF ceramic capacitor for most applications is sufficient.

Inductor Selection

For most designs, the CM3706 operates with inductors of 1μH to 4.7μH. Low inductance values are physically smaller but require faster switching, which results in some efficiency loss. The inductor value can be derived from the following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where ΔI_L is inductor Ripple Current. Large value inductors lower ripple current and small value inductors result in high ripple currents. Choose inductor ripple current approximately 35% of the maximum load current 600mA, or $\Delta I_L = 210mA$.

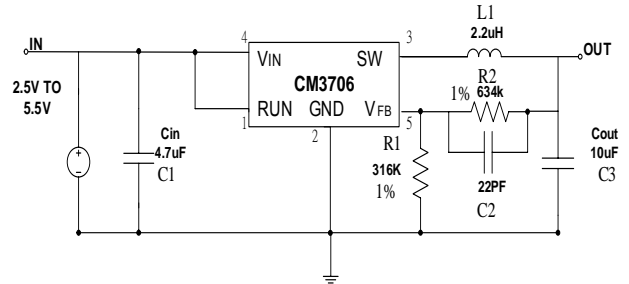


Figure2 Application Circuit with adjustable output versions

For output voltages above 2.0V, when light-load efficiency is important, the minimum recommended inductor is 2.2μH.

For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 50mΩ to 150mΩ range. For higher efficiency at heavy loads, or minimal load regulation (but some transient overshoot), the resistance should be kept below 100mΩ. The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation (600mA+105mA).

Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended due to their low ESR and high ripple current. The output ripple V_{OUT} is determined by:

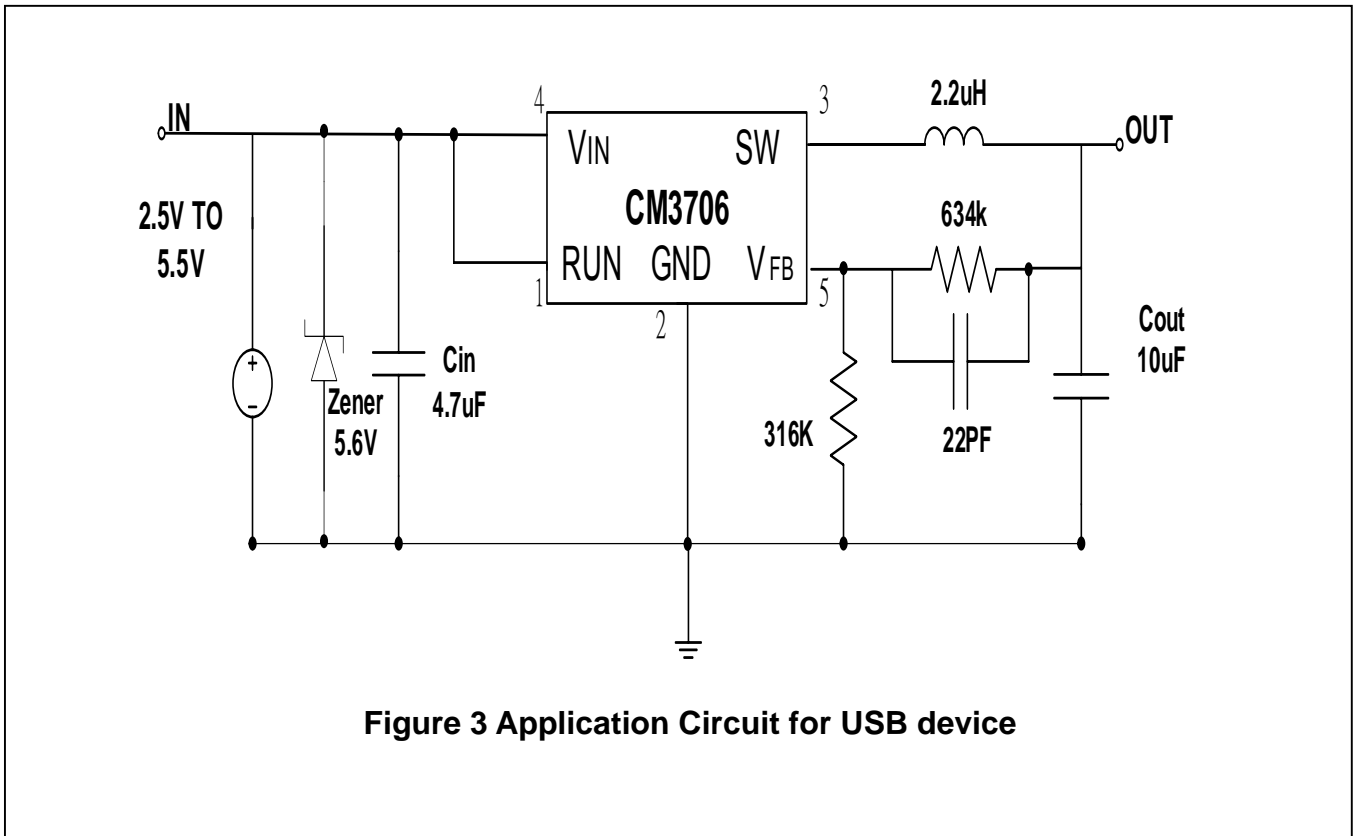
$$\Delta V_{OUT} \leq \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times f_{OSC} \times L} \times \left(ESR + \frac{1}{8 \times f_{osc} \times C3} \right)$$

Input Zener Selection

In USB device application, we will add zener. The zener can be reduced the surge voltage when device plug in and plug out. Application circuit is show in Figure3.

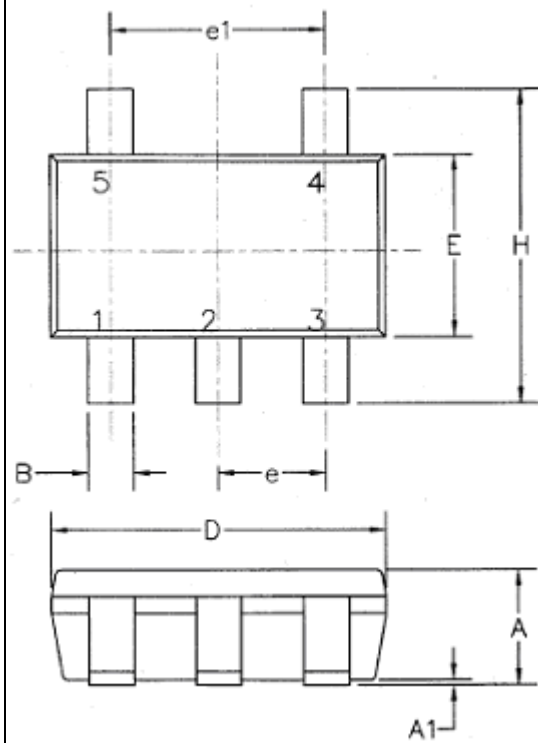
APPLICATION CIRCUIT

Application Circuit for USB device



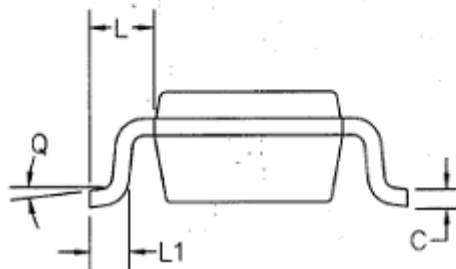
PACKAGE DIMENSION

Package Description



5LD SOT-23 PACKAGE OUTLINE DIMENSIONS
ALL DIMENSIONS IN MM.

| Dimension | Min. | Max. |
|-----------|-----------|------|
| A | 0.9 | 1.20 |
| A1 | 0.01 | 0.13 |
| B | 0.3 | 0.5 |
| C | 0.09 | 0.2 |
| D | 2.8 | 3.0 |
| H | 2.5 | 3.1 |
| E | 1.5 | 1.7 |
| e | 0.95 REF. | |
| e1 | 1.90 REF. | |
| L1 | 0.2 | 0.55 |
| L | 0.35 | 0.8 |
| Q | 0° | 10° |



Note5: Package outline exclusive of mold flash and metal burr.



CM3706

1.5MHz, 600mA Synchronous Step-Down Regulator

IMPORTANT NOTICE

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