1.8MHZ, 1A, SYNCHRONOUS SWITCHING BUCK REGULATOR

FEATURES

- **Up to 95% Efficiency**
- **2.5V to 5.5V Input Voltage Range**
- **1.8MHz Switching Frequency**
- **25µA Ultra Low Sleep Mode Quiescent**
- **<1µA Shutdown Current**
- **Internal Compensation Circuit**
- **500µs Soft Start Period**
- **160°C Built-in Thermal Shutdown Protection**

APPLICATIONS

- **Portable Navigation Device**
- **Digital Photo Frame**
- **Digital Still Camera**
- **E-Book**

GENERAL DESCRIPTION

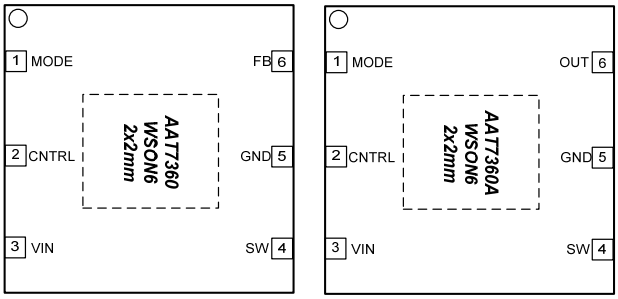
The AAT7360/7360A device is a 1.8MHz, high efficiency, synchronous buck regulator.

AAT7360/7360A incorporating both PFM and PWM mode operation. With an automatic Light Load Mode/PWM mode switching mechanism, the AAT7360/7360A device provides 80% efficiency under light load operation and up to 90% efficiency during heavy load condition.

The featured input voltage range of AAT7360/7360A provides flexibility for different applications.

The AAT7360/7360A is implemented in a 6-pin WSON6 package.

PIN CONFIGURATION

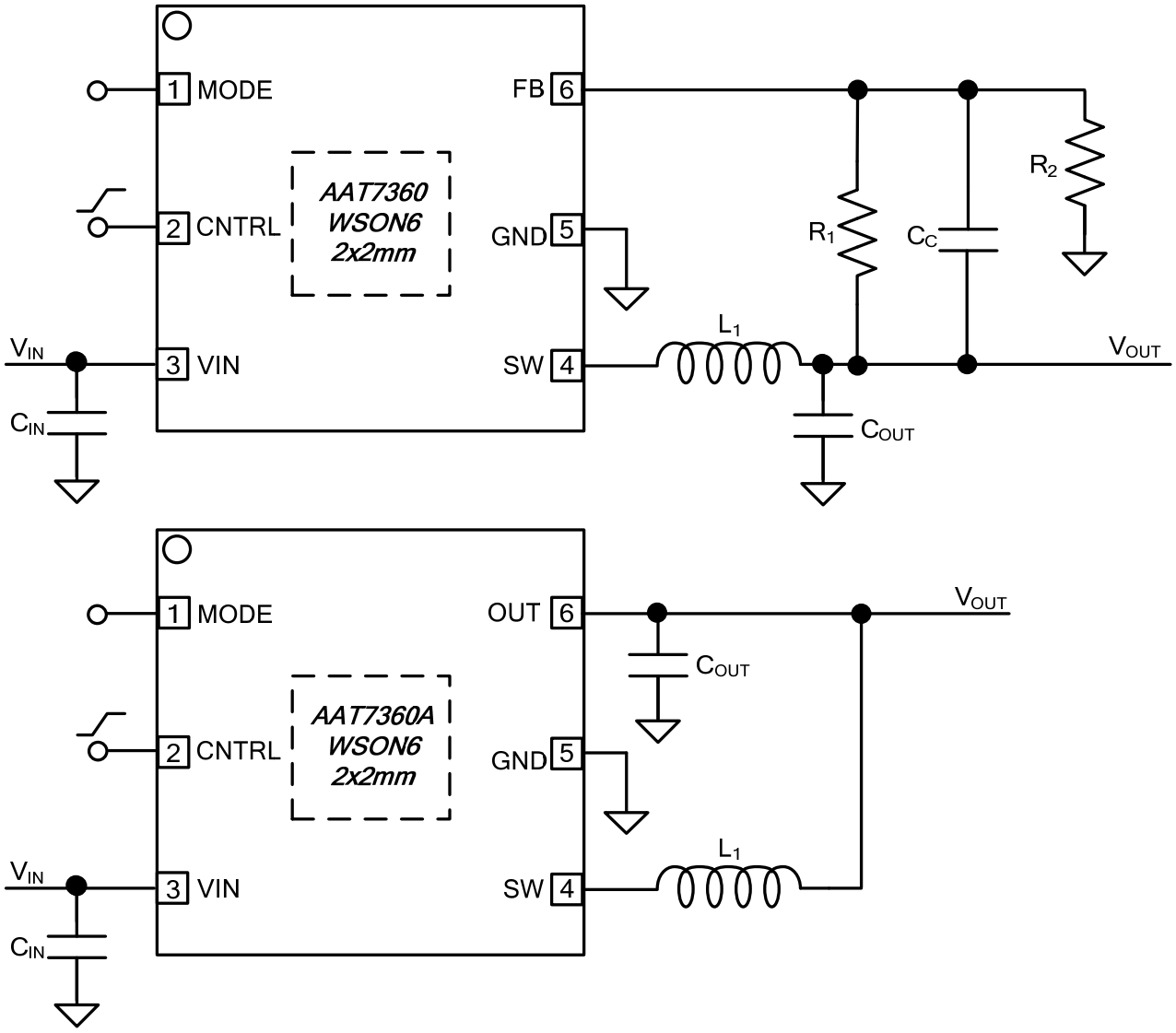


ORDERING INFORMATION

DEVICE TYPE	PART NUMBER	PACKAGE	PACKING	TEMP. RANGE	MARKING	MARKING DESCRIPTION
AAT7360	AAT7360-Q19-T	Q19 = WSON6-2x2	T: Tape and Reel	–40°C to +85°C	C08 XXX	C08= AAT7360, YYY = tracing code, AAA, AAB, AAC
AAT7360A	AAT7360A-Q19-T	Q19 = WSON6-2x2	T: Tape and Reel	–40°C to +85°C	C3X YYY	C3x = AAT7360A , x = Voltage Code, YYY = tracing code, AAA, AAB, AAC…

Note 1: All AAT products are lead free and halogen free.
Note 2: For the most current package and ordering information, please refer to our website at www.aatech.com.tw.
Note 3: The exposed pad beneath the ML package should be mounted to the PC board ground properly, cause damage otherwise.

TYPICAL APPLICATION



List of Components:

- L_1 = 2.2µH
- C_{IN} = C_{OUT} = 10µF
- R_1 = R_2 = 100kΩ (For V_{OUT} = 1.2V)
- C_C = 20pF

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	VALUE	UNIT
Power Supply Voltage (VIN)	V_{IN}	–0.3 to +7.0	V
Switch Point Voltage (SW)	V_{SW}	–0.3 to +7.0	V
Output Voltage (VOUT)	V_{OUT}	–0.3 to (V_{IN}+0.3)	V
Logic Input Voltage (EN)	V_{CTL}	–0.3 to (V_{IN}+0.3)	V
Feedback Voltage (FB)	V_{FB}	–0.3 to (V_{IN}+0.3)	V
Ground (GND)	V_{PGND}	–0.3 to +0.3	V
Junction Temperature	T_J	150	°C
Operating Temperature Range	T_C	–40 to +85	°C
Storage Temperature Range	$T_{STORAGE}$	–65 to +150	°C
Lead Temperature (Soldering 10 sec)	T_{SOLDER}	300	°C

Note 1: Stresses above those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the devices.
Note 2: Exposure to ABSOLUTE MAXIMUM RATINGS conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	MIN	MAX	UNIT
Operating Ambient Temperature	T_C	–40	+85	°C
Power Supply Voltage	V_{IN}	2.5	5.5	V

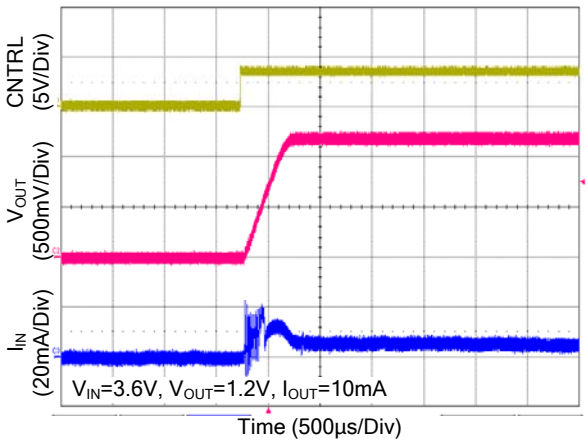
ELECTRICAL CHARACTERISTICS

(V_{IN} = 3.6V, V_{OUT} = 1.2V, T_C = –40°C to 85°C .Unless Otherwise Specified. Typical values are tested at 25°C ambient temperature.)

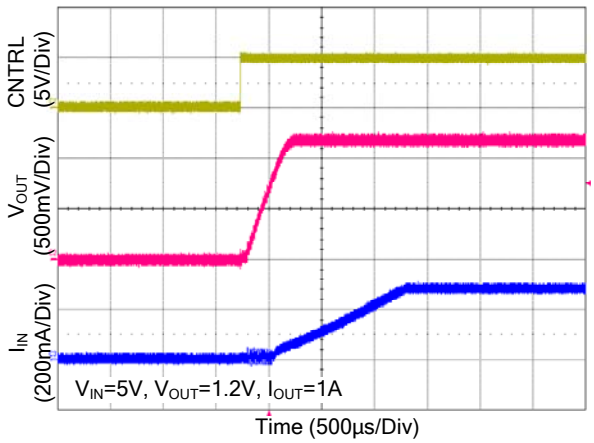
PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Supply Voltage	V_{IN}		2.5	-	5.5	V
Feedback Voltage	V_{FB}	Load = 300mA, T_C = 25°C (AAT7360)	0.588	0.600	0.612	V
Output Voltage Accuracy	V_{OUT}	Load = 300mA, T_C = 25°C (AAT7360A)	–2	-	+2	%
Supply Quiescent Current	I_{PWM}	V_{FB} = 0.5V, Mode = High, I_{LOAD} = 0A	-	-	300	µA
	I_{PFM}	V_{FB} = 0.7V, Mode = Low, I_{LOAD} = 0A	-	-	30	µA
	I_{SD}	V_{EN} = 0V, V_{IN} = 5.5V	-	0.01	1.00	µA
Peak Inductor Current	I_{PK}		-	1.5	-	A
Output Temperature Variation		T_C = –40°C to +85°C Load = 300mA	–2	-	+2	%
Reference Voltage Line Regulation	ΔV_{FB}	V_{IN} = 2.5V to 5.5V	-	-	0.4	%/V
Output Voltage Load Regulation	$V_{LOADREG}$		-	0.5	-	%/A
P Channel Power FET ON Resistance	R_{PDSON}	I_{SW} = 100mA	-	0.25	-	Ω
N Channel Power FET ON Resistance	R_{NDSON}	Guaranteed by Design	-	0.25	-	Ω
Switching Frequency	f_{OSC}		1.45	1.80	2.20	MHz
Enable Input Rising Voltage Threshold	V_{EN}		0.3	1.0	1.5	V
Enable Input Current	I_{EN}		-	±0.01	±1.00	µA
ISW Leakage Current	I_{LSW}	V_{EN} = 0V, V_{SW} = 0V or 5.5V, V_{IN} = 5.5V	-	±0.01	±1.00	µA
Soft Start Period	$t_{SOFTSTART}$		-	500	-	µs
Thermal Shutdown	T_{SD}		140	160	180	°C
Thermal Shutdown Hysteresis	T_{HYS}		10	20	35	°C

TYPICAL OPERATING CHARACTERISTICS

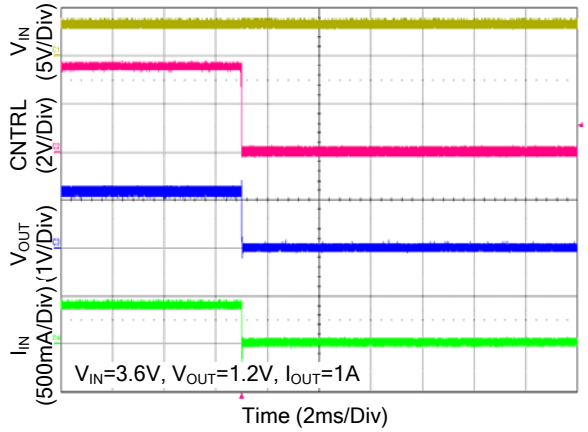
Power on with CNTRL



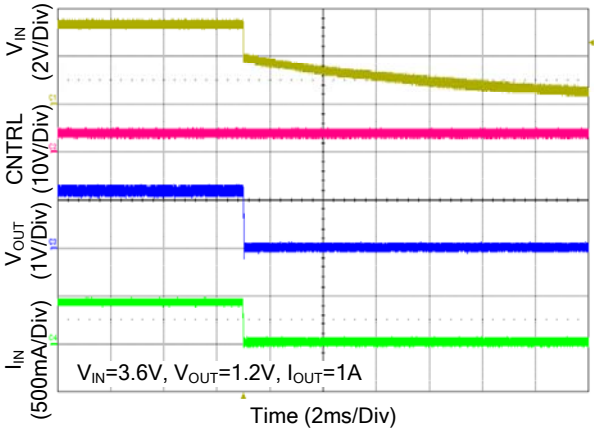
Power on with CNTRL



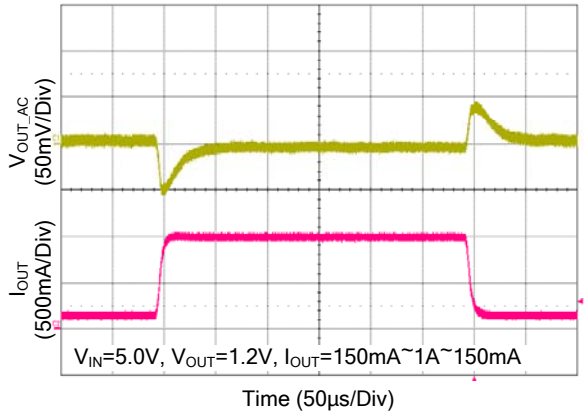
Power off with CNTRL



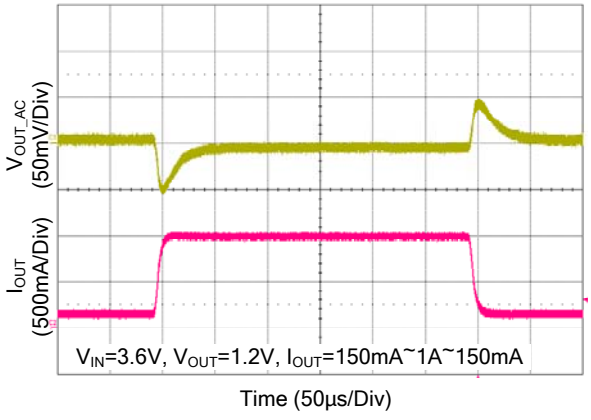
Power off with V_{IN}



Load Transient Response

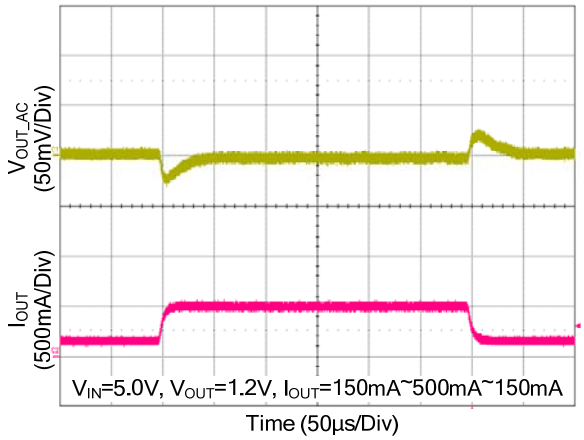


Load Transient Response

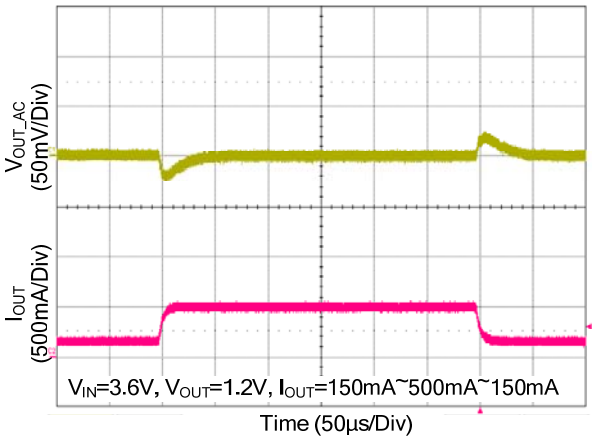


TYPICAL OPERATING CHARACTERISTICS

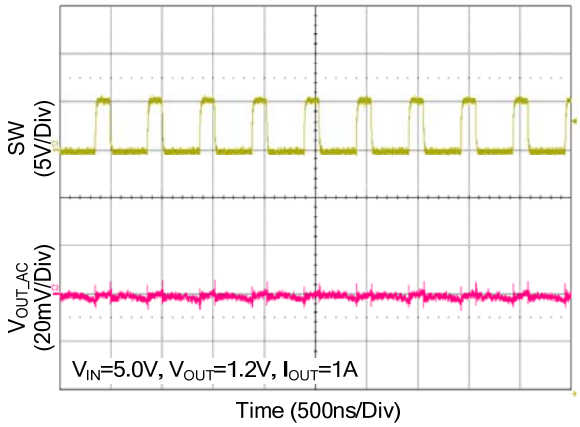
Load Transient Response



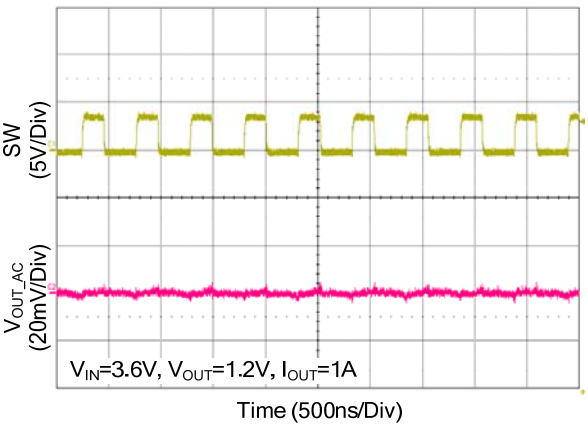
Load Transient Response



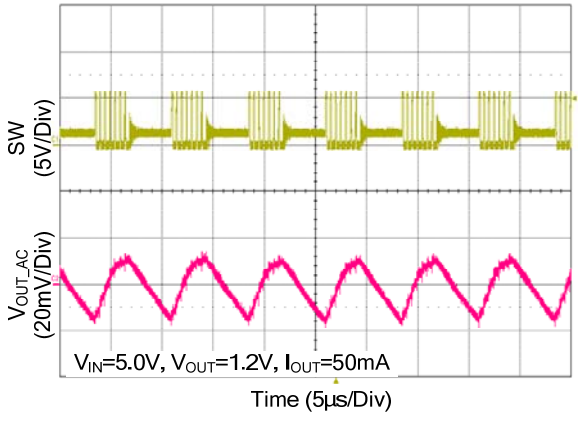
Output Ripple Voltage



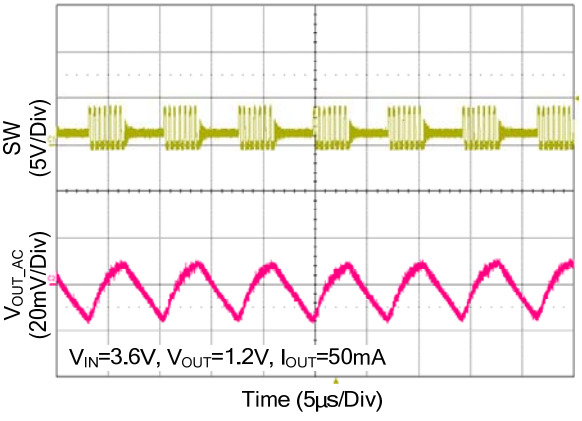
Output Ripple Voltage



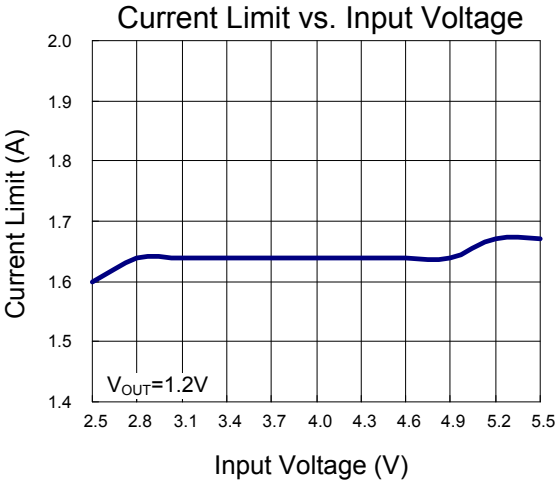
Output Ripple Voltage

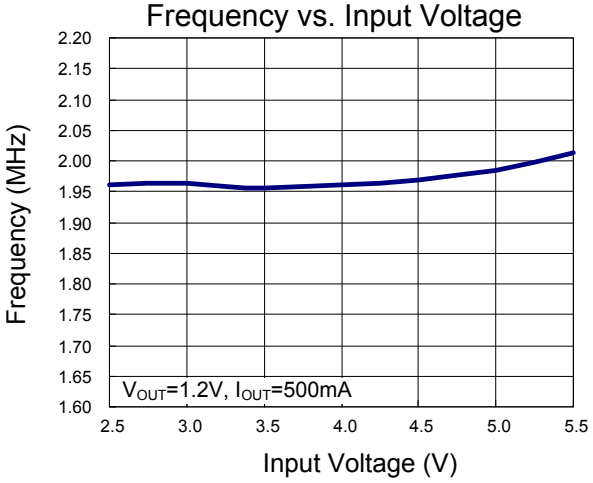


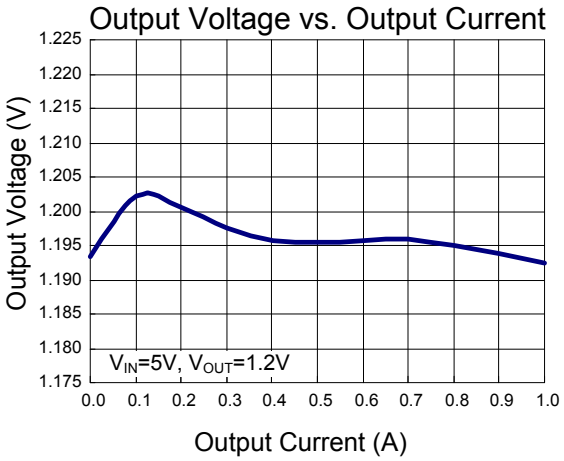
Output Ripple Voltage

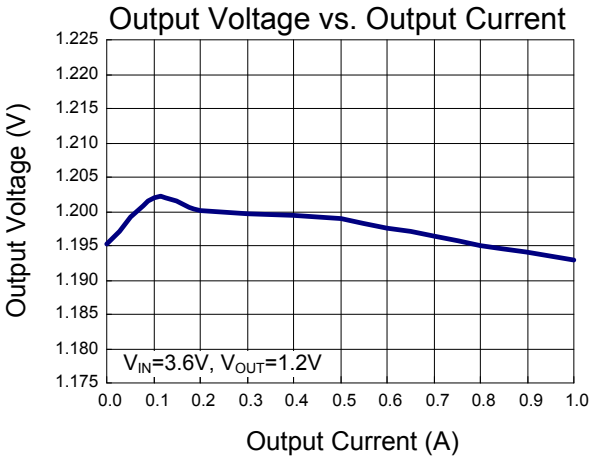


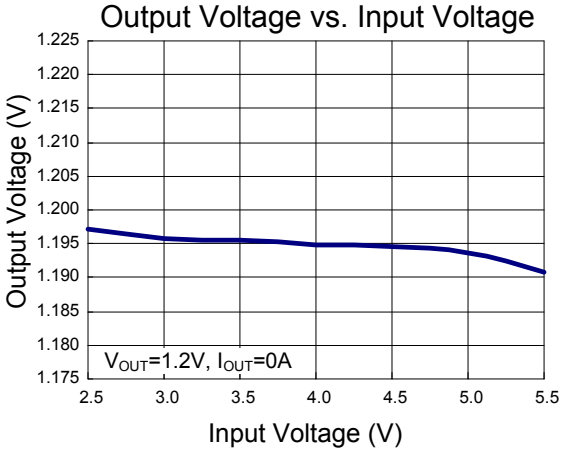
TYPICAL OPERATING CHARACTERISTICS

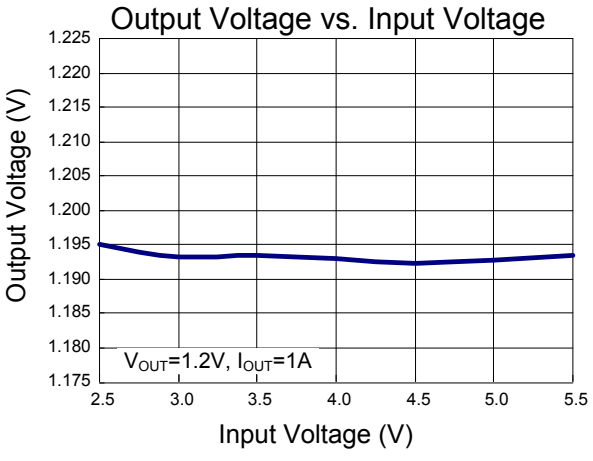












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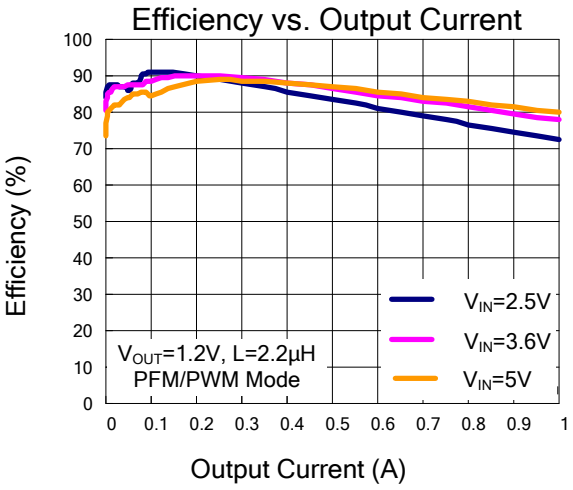
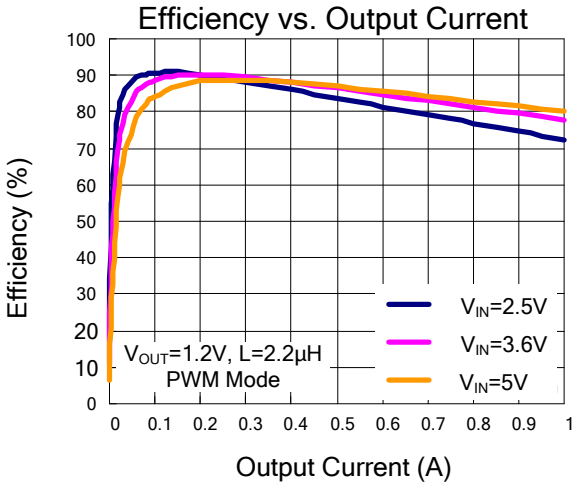
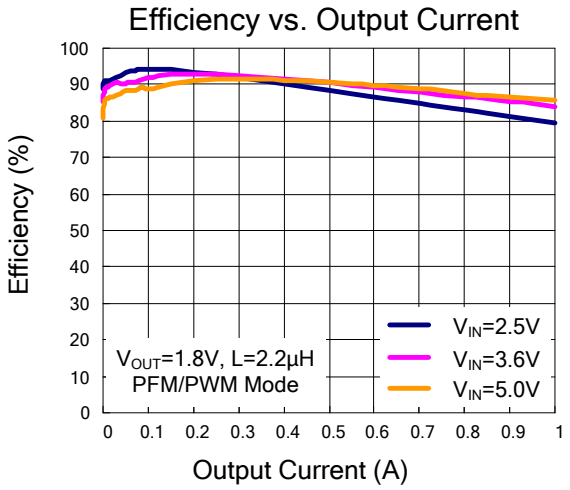
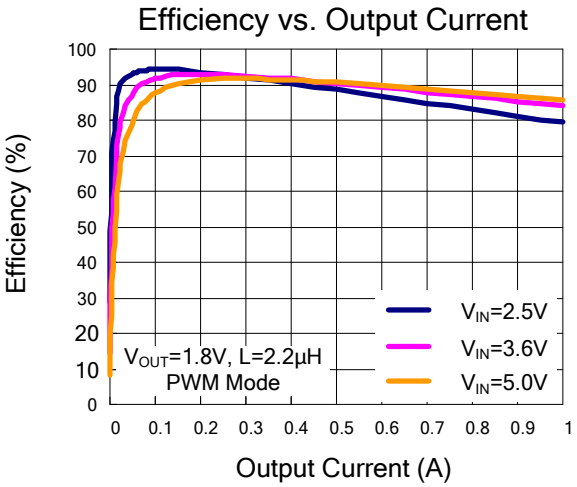
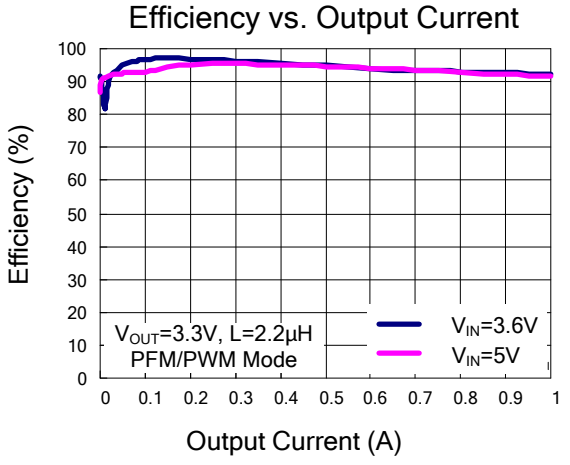
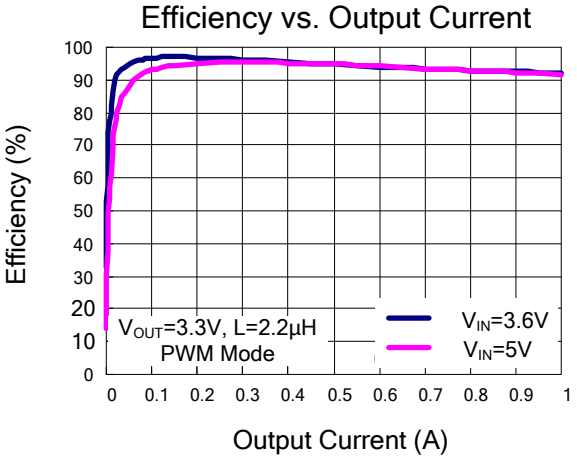








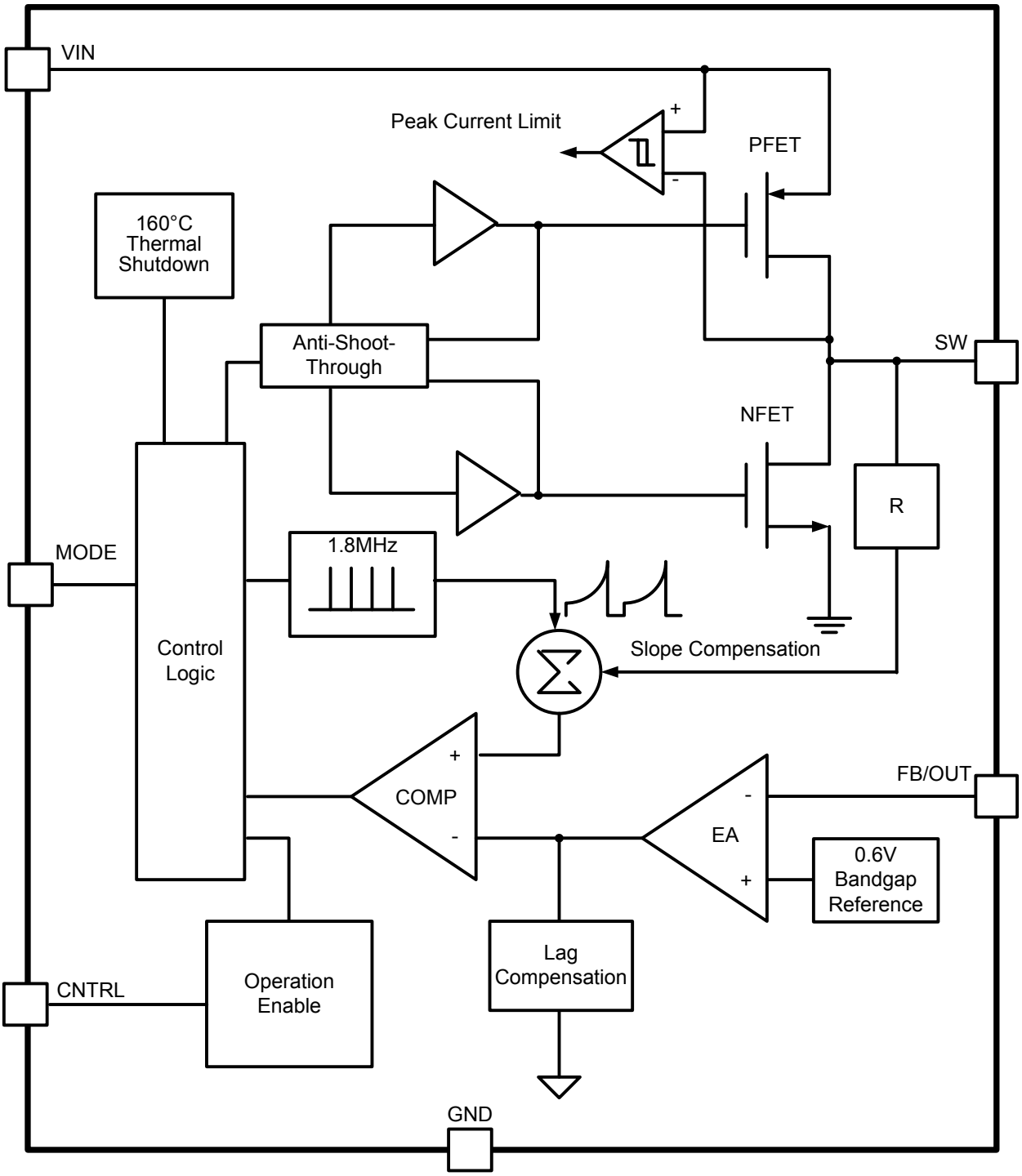




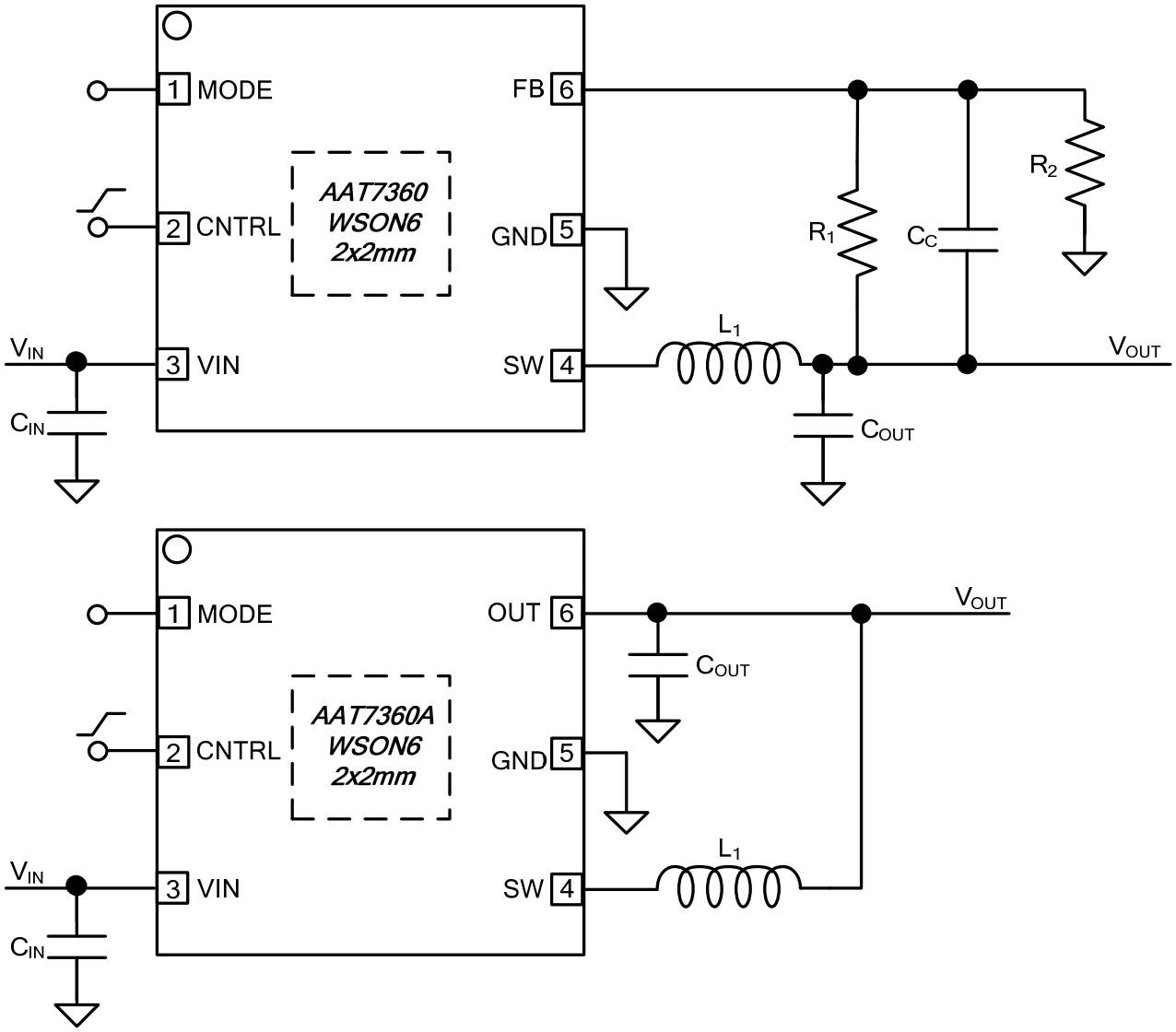
PIN DESCRIPTION

Pin No.	Name	I/O	Description
WSON6	AAT7360/7360A		
1	MODE	I	Mode Selection Pin. A forced PWM Mode can be Achieved by Pulling this Pin High
		-	Not Connected
2	CNTRL	I	Enable Logic Input Pin. Pull the Voltage at this Pin above V_{CTLH} to Enable the Device
3	VIN	I	Power Supply Input Pin. Connect this Pin to a Li^+–Lon Battery or an Equivalent Power Source. Connecting VIN to Ground through a 10µF Bypass Capacitor is Recommended
4	SW	O	Regulator Switching Output Pin. SW is Connected to the Drain Terminals of the Internal Power MOSFETs. Connect this Pin to the Regulated Output through a 2.2µH Inductor
5	GND	-	System/PWR Ground Pin. Connect this Pin to a Clean Ground
6	FB/OUT	I/O	Feedback Pin (Output pin). The Regulator Output Voltage can be Programmed with an External Resistor Feedback Loop Connected between this Pin and the Regulated Output (AAT7360)

FUNCTION BLOCK DIAGRAM



TYPICAL APPLICATION CIRCUIT



List of Components:

- L_1 = 2.2µH
- C_{IN} = C_{OUT} = 10µF
- R_1 = R_2 = 100kΩ (For V_{OUT} = 1.2V)
- C_C = 20pF

DETAILED DESCRIPTION

The AAT7360/7360A is a buck converter with current-mode operation. The AAT7360/7360A includes a high-side PFET and a low-side NFET which eliminate the need for an external Schottky diode and have low on-resistance to maximize efficiency. Moreover, the AAT7360/7360A is compensated internally so that no external compensation network is required.

PWM Mode Operation

AAT7360/7360A uses the peak current mode pulse width modulation PWM control scheme for fast transient response and cycle-by-cycle current limiting (Figure 1.). The PWM maintains a constant frequency and varies the duty ratio according to the output voltage and load current. This modulation scheme provides high efficiency at medium to heavy load conditions, and reduces the output ripple at light load conditions. In this operating mode, the PFET turns on each cycle for a minimum on-time of 25ns (typical), and turns off when an internal sawtooth signal exceeds the error amplifier output EO. The sawtooth signal is composed of the sensed inductor current and an artificial slope compensation ramp to prevent oscillation at duty ratios higher than 50%. After the high-side PFET is turned off, the low-side NFET is turned on until the next cycle begins. Figure 2 demonstrates the PWM mode control scheme.

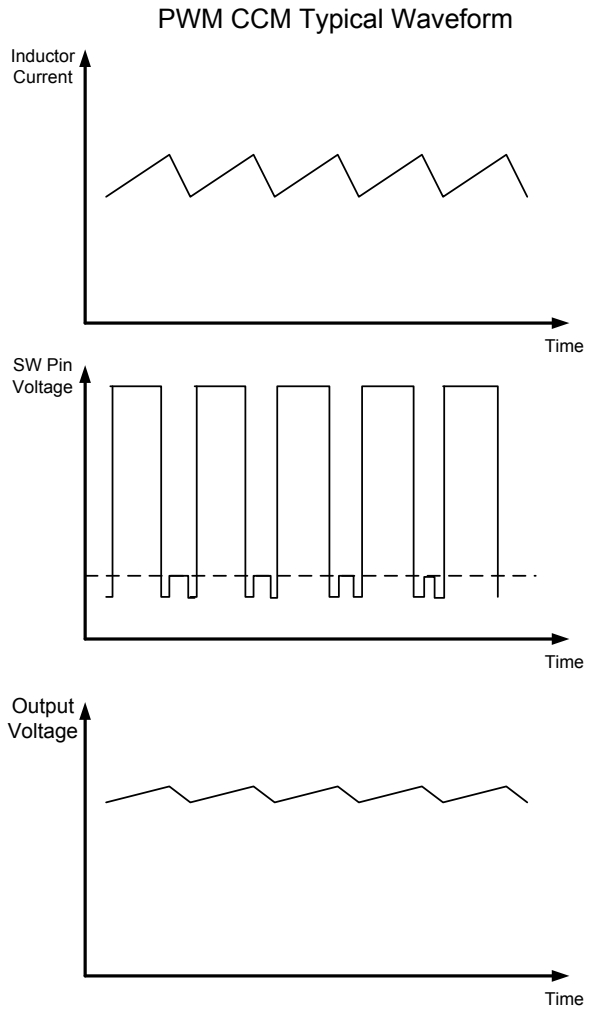


Figure 1. PWM Mode Operation Signal Waveforms

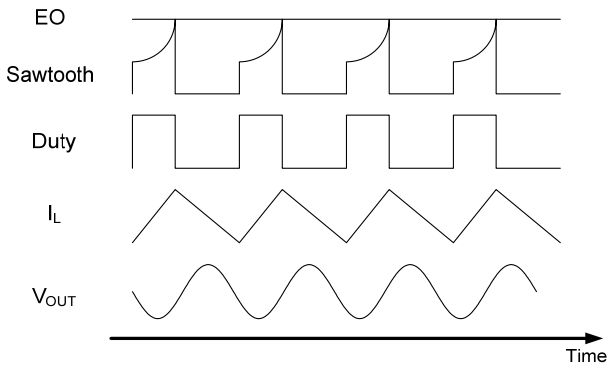


Figure 2. PWM Mode Control Signal Waveforms

Enable

The Control CNTRL pin allows user to enable and disable the converter for purposes such as power-up sequencing. When CNTRL is pulled above 1.5V, the converter is enabled, the internal reference circuit wakes up, and the system initiates the soft-start operation. When CNTRL is pulled below 0.3V, the converter is disabled, both the PFET and the NFET are turned off, and the output capacitor is discharged.

Soft-Start

The AAT7360/7360A has a built-in soft-start mechanism to minimize the inrush current during start-up. Once the voltage at the CNTRL pin rises above 1.5V, the device begins to charge the output capacitor with pulses of increasing duty cycle. The soft-start duration typically lasts 500µs and varies depending on V_{IN}, V_{OUT}, and the load. A typical output voltage waveform during soft-start is shown in Figure 3.

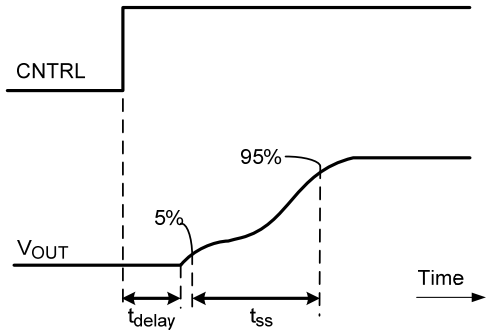


Figure 3. Soft-Start Waveform

Thermal Shutdown

The AAT7360/7360A provides a built-in thermal protection function. The thermal shutdown threshold temperature is 160°C (typical) with a 15°C (typical) hysteresis.

OCP and SCP

When the load current exceeds the typical operation threshold, the peak inductor current is clamped at 1.5A for over-current protection (OCP). If the OCP signal remains high and the voltage at the FB pin falls below 0.2V (typical), the short circuit protection (SCP) is triggered and the AAT7360/7360A is disabled to protect the device itself and its peripheral circuitry.

Once the SCP function is triggered, the device can be re-started by first pulling the CNTRL pin low then high again.

Light Load Mode Operation

The AAT7360/7360A is implemented with a highly efficient light load operation mode, which is activated during light load condition, typically at load current below 100mA (varies with V_{IN} and V_{OUT}). In a light load condition, the system is only awake temporarily to charge the output and maintain its level around the nominal value, while most circuits are usually turned-off to conserve energy. The precision comparator sets the system sleep/wake-up thresholds, and controls the output ripple to typically below 3% of the nominal value.

DESIGN PROCEDURE

Output Voltage Programming

The output voltage is set by the external voltage divider (refer to Typical Application Circuit):

$$V_{OUT} = \frac{R_1 + R_2}{R_2} \times V_{REF}$$

Where V_{REF} is the internal reference voltage of 0.6V.

Compensation Information

The parasitic capacitance at the FB pin forms a pole with the external voltage divider resistors. A feed forward capacitor C_C is recommended to cancel out this pole. The value of C_C can be determined by the following equation:

$$C_C = \frac{C_{PARASITIC} \times (R_1 // R_2)}{R_1 - (R_1 // R_2)}$$

Where $C_{PARASITIC}$ = 20pF (typical).

Inductor Selection

The typical value of inductor is 2.2µH. The selection of inductor affects system performance under different operating conditions. The inductor is rated by its equivalent series resistance ESR and saturation current. A lower ESR of the inductor results in higher efficiency for the buck converter. A lower inductance inductor results in larger inductor current ripple and output voltage ripple. The inductor current ripple and maximum output current under steady-state can be calculated by the following:

$$\Delta I_L = \frac{V_{IN} - V_{OUT}}{L} \times \frac{V_{OUT}}{V_{IN}} \times \frac{1}{f_S}$$

$$I_{L\_MAX} = I_{O\_MAX} + \frac{\Delta I_L}{2}$$

Where ΔI_L is the peak-to-peak inductor current ripple, I_{L_MAX} is the maximum inductor current, L is the inductor value, f_S is the switching frequency (1.8MHz typical), and I_{O_MAX} is the maximum output current. During heavy load transients, the maximum inductor current will rise above that calculated value, thus it is recommended to choose an inductor with rated saturation current larger than the calculated value.

Input and Output Capacitor Selection

In PWM mode the supply current into high-side PFET is a square wave of duty cycle V_{OUT}/V_{IN}. A low ESR input capacitor with proper RMS current rating is required to prevent large voltage transients. The maximum RMS capacitor current is calculated as follows:

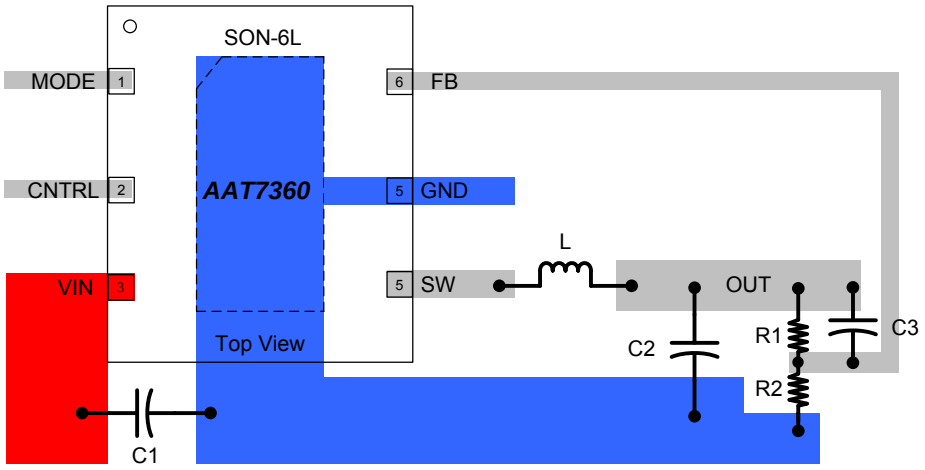
$$I_{RMS\_IN} \cong I_{O\_MAX} \times \frac{\sqrt{V_{OUT}(V_{IN} - V_{OUT})}}{V_{IN}}$$

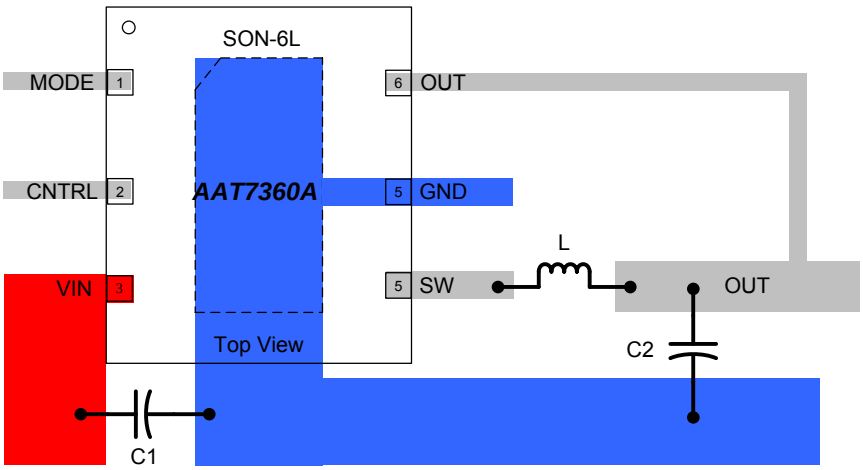
The typical value of the output capacitor is 10µF. A lower ESR and larger capacitance of the output capacitor results in a smaller output voltage ripple. The output voltage ripple consists of voltage spikes caused by the output capacitor ESR and voltage ripples from inductor current ripple that charges and discharges the output capacitor:

$$\Delta V_{OUT} \cong \Delta I_L \left(ESR + \frac{1}{8 \times f_S \times C_{OUT}} \right)$$

Ceramic capacitors are recommended due to their high ripple current rating, high voltage rating and low ESR. Typically the RMS current rating will meet the application requirement.

LAYOUT CONSIDERATION



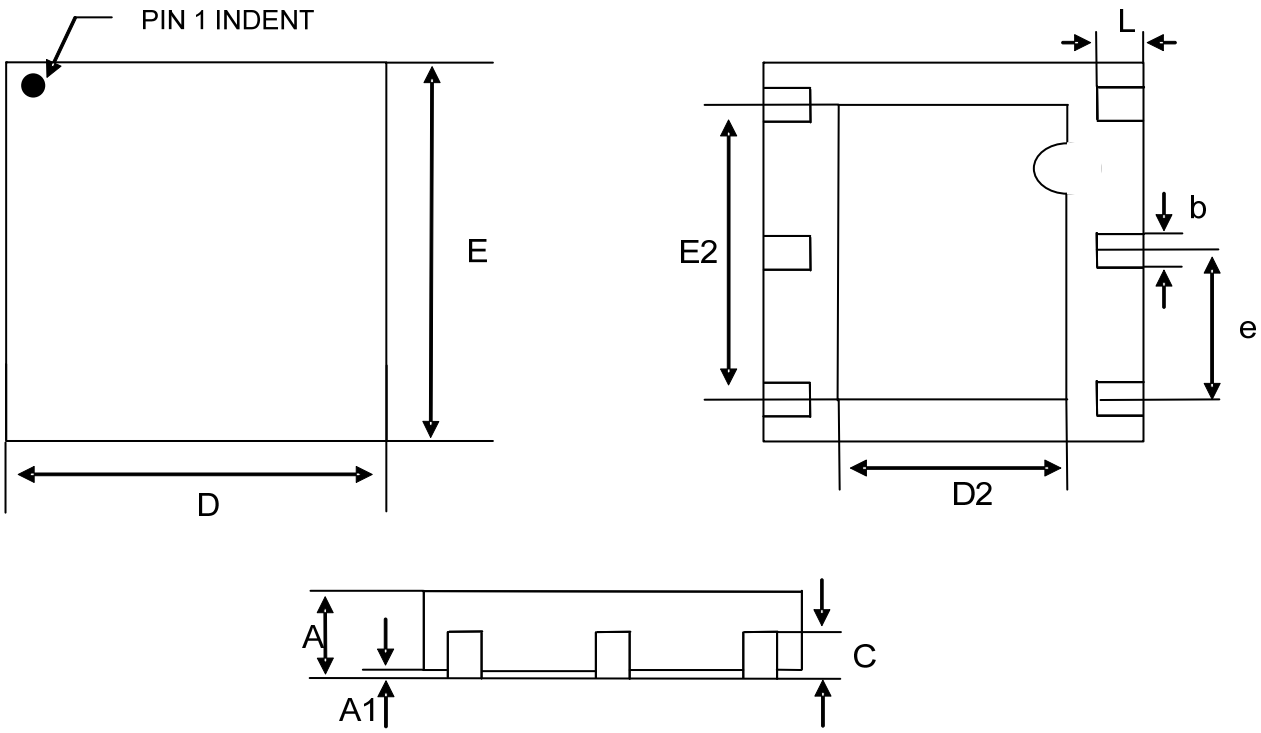


Layout Notes:

1. C1 (input) and C2 (output) should be placed near AAT7360/7360A/7360B/7360C.
2. Inductor should be placed near SW and sensitive component kept away from this trace.

PACKAGE DIMENSION

WSON6-2x2



Symbol	Dimensions In Millimeters		
	MIN	TYP	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.20	0.25	0.30
C	0.19	0.20	0.25
D	1.95	2.00	2.05
D2	0.75	0.80	0.85
E	1.95	2.00	2.05
E2	1.35	1.40	1.45
e	-----	0.65	-----
L	0.30	0.35	0.40