DESCRIPTION

The AP8366 consists of a Low Standby-Power Quasi-Resonant (QR) Primary-Side controller and a avalanche-rugged smart power VDMOSFET (AP8366-A/B 700V, AP8366-C 800V), specifically designed for a high performance AC/DC charger or adaptor with minimal external components. AP8366 operates in primary-side sensing and regulation, so opto-coupler and A431 could be eliminated.
Because of internal HV Start-up circuit, the system with AP8366 can achieve less than 30mW standby power consumption (230VAC).
In CV mode, multi-mode and quasi resonant technique is utilized to achieve high efficiency, avoid audible noise and make the system meeting Energy star class VI. Good load regulation is achieved by the built-in cable drop compensation. In CC mode, the current and output power setting can be adjusted externally by the sense resistor R_{CS} at CS pin. AP8366 offers complete protections including Cycle-by-Cycle current limiting protection (OCP), over voltage protection (OVP), over temperature protection (OTP) and CS open or short protection (CSO/SP) etc.

The AP8366 is available in SOP7 package.

ORDERING INFORMATION

<table>
<tr><th>Package Type</th><th colspan="2">Part Number</th></tr>
<tr><td rowspan="2">SOP7
SPQ: 4,000pcs/Reel</td><td rowspan="2">M7</td><td>AP8366M7R-Y</td></tr>
<tr><td>AP8366M7VR-Y</td></tr>
<tr><td>Note</td><td colspan="2">Y: V_{BVDSS} & $R_{DS(ON)}$
A: 650V $R_{DS(ON)}$=13.5Ω
B: 650V $R_{DS(ON)}$=8Ω
C: 790V $R_{DS(ON)}$=10Ω
V: Halogen free Package
R: Tape & Reel</td></tr>
<tr><td colspan="3">AiT provides all RoHS products</td></tr>
</table>

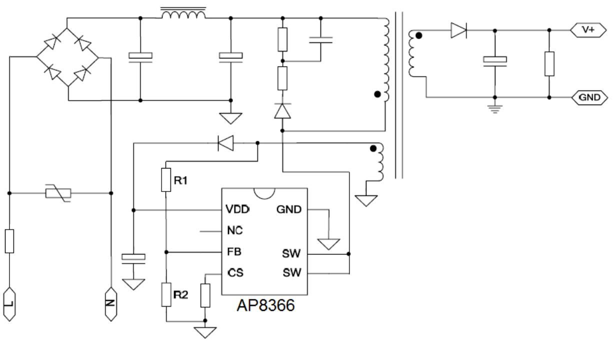
FEATURES

- Internal avalanche-rugged smart power VDMOSFET
- Internal HV Start-up Circuit, Standby power consumption < 30mW at 230VAC
- Multi-mode and Quasi-Resonant technique achieve high efficiency, meeting energy star class VI
- ±5% CC Regulation at Universal AC input
- Primary-side Sensing and Regulation without A431 and Opto-coupler
- Programmable Cable Drop Compensation
- No-need Control Loop Compensation Capacitance
- Excellent Protection Coverage:
  - Over Temperature Protection (OTP)
  - V_{DD} Under/Over Voltage Protection (UVLO&OVP)
  - Cycle-by-Cycle Current Limiting (OCP)
  - CS Short/Open Protection (CS O/SP)
- CV mode accurate: ±5%
- Available in SOP7 Package

APPLICATION

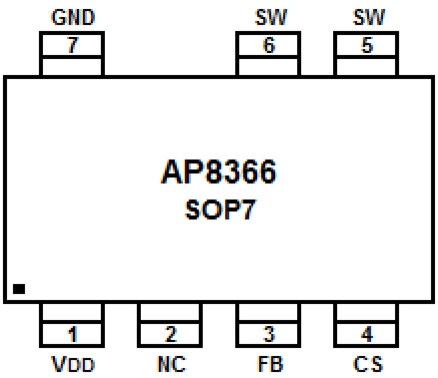
- Switch AC/DC Adaptor
- Battery Charger

TYPICAL APPLICATION



Component Parameter and Layout Considerations:
1. V_{DD} capacitor EC1 should be placed at the nearest place from the V_{DD} pin and the GND pin.

PIN DESCRIPTION



Top View

Pin #	Symbol	Function
1	V_{DD}	Power supply
2	NC	No connection
3	FB	The voltage feedback from auxiliary winding. Connected to resistor divider from auxiliary winding reflecting output voltage.
4	CS	Current Sense Input
5, 6	SW	Avalanche-rugged power MOSFET Drain pin. The Drain pin is connected to the primary lead of the transformer.
7	GND	Ground

ABSOLUTE MAXIMUM RATINGS

Supply Voltage Pin V_{DD}	-0.3V ~ 40V
High-Voltage Pin, SW (AP8366-A/B)	-0.3V ~ 650V
High-Voltage Pin, SW (AP8366-C)	-0.3V ~ 790V
Pin FB, CS	-0.3V ~ 5.5V
Operating Junction Temperature	-40℃ ~ 150℃
Storage Temperature Range	-55℃ ~ 150℃
Lead Temperature (Soldering, 10Secs)	260℃
ESD Protection (HBM, ESDA/JEDEC JDS-001-2014)	±4.0kV
Package Thermal Resistance $R_{θJC}$ (SOP7)	80°C/W
Maximum Pulse Drain Current (t_{PULSE}=100us)	1.0A

Stress beyond above listed “Absolute Maximum Ratings” may lead permanent damage to the device. These are stress ratings only and operations of the device at these or any other conditions beyond those indicated in the operational sections of the specifications are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

OUTPUT POWER TABLE

Part Number	Adapter NOTE
	85-265 V_{AC}
AP8366	6W

NOTE: Maximum output power is tested in an adapter at 45°C ambient temperature, with enough cooling conditions.

ELECTRICAL CHARACTERISTICS

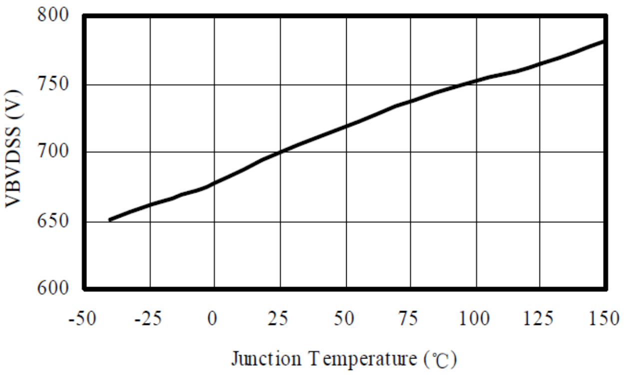
T_A = 25℃, V_{DD}= 21V, unless otherwise noted

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Power Section						
Break-Down Voltage -AP8366-A/B	BVDSS	I_{SW} = 250uA, T_J = 25℃	650	700	-	V
Break-Down Voltage -AP8366-C	BVDSS	I_{SW} = 250uA, T_J = 25℃	790	830	-	V
Drain-Source on State Resistance- AP8366-A	$R_{DS(on)}$	I_{SW} = 0.5A, T_J = 25℃	-	13.5	-	Ω
Drain-Source on State Resistance- AP8366-B	$R_{DS(on)}$	I_{SW} = 0.5A, T_J = 25℃	-	8	-	Ω
Drain-Source on State Resistance-AP8366-C	$R_{DS(on)}$	I_{SW} = 0.5A, T_J = 25℃	-	10	-	Ω
Off-State Drain Current	I_{OFF}	V_{SW} = 500V	-	-	100	uA
Start Up Threshold	V_{SW_START}	V_{DD}=V_{DDon} - 1V	-	30	-	V
Supply Voltage Section						
Operating Voltage Range	V_{DD}		8	-	30	V
V_{DD} Start Up Threshold	V_{DDon}		14.5	16.5	18.5	V
V_{DD} Under Voltage Shutdown Threshold	V_{DDoff}		7.5	8.5	9.5	V
V_{DD} Over Voltage Protect	V_{DDovp}		30	34	38	V
Supply Current Section						
V_{DD} Charge Current	I_{DD_CH}	V_{DD}=V_{DDon} - 1V, V_{SW}=100V	-	0.85	-	mA
Operating Current, Switching	I_{DD}	V_{DD} = V_{DDon} + 1V	0.3	0.5	0.7	mA
Operating Current After Fault	I_{DD_FAULT}	V_{DD} = 15V after fault	-	0.5	-	mA

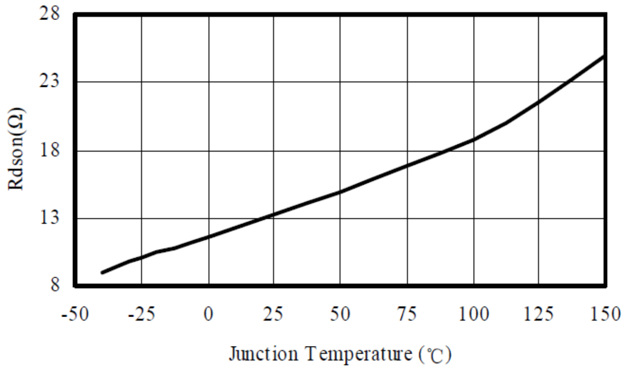
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Current Sense Section						
Current Sense Threshold	V_{TH_OC}		485	500	515	mV
Maximum Current Sense Threshold	$V_{TH\_OC\_MAX}$		-	560	-	mV
Minimum CS Threshold	V_{cs_min}		-	170	-	mV
Leading Edge Blanking Time	t_{LEB}		-	300	-	ns
Maximum t_{on}	t_{onmax}		-	50	-	us
OCP Propagation Delay	t_{D_OC}		-	100	-	ns
FB Section						
Reference Voltage for Feedback Threshold	V_{REF_CV}		2.475	2.5	2.525	V
Output Over Voltage Protection Threshold	V_{FBOVP}		2.85	3	3.15	V
Output Under Voltage Threshold	V_{UVP}		-	1.55	-	V
Maximum Cable Compensation Current	I_{cable}	V_{FB}=0V	22	24	26	uA
Minimum t_{off}	t_{offmin}		-	5	-	us
Maximum t_{off}	t_{offmax}		-	2.2	-	ms
Output Under Voltage Protection Blanking Time	t_{UVP}	f_{SW}= 50kHz	40	-	64	ms
Thermal Section						
Thermal Shutdown Temperature Threshold	T_{SD}		135	150	-	°C
Thermal Shutdown Hysteresis	T_{HYST}		-	30	-	°C

TYPICAL CHARACTERISTICS

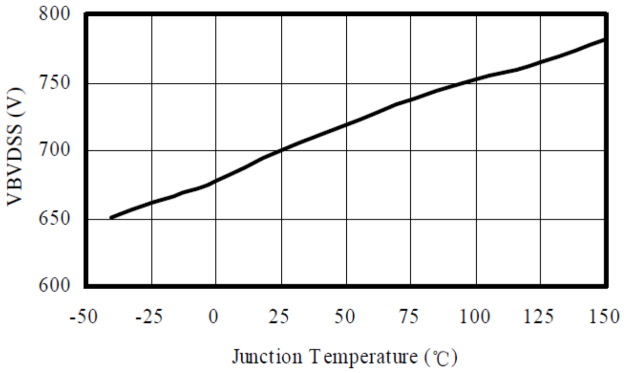
1. AP8366-A BV vs. T_J



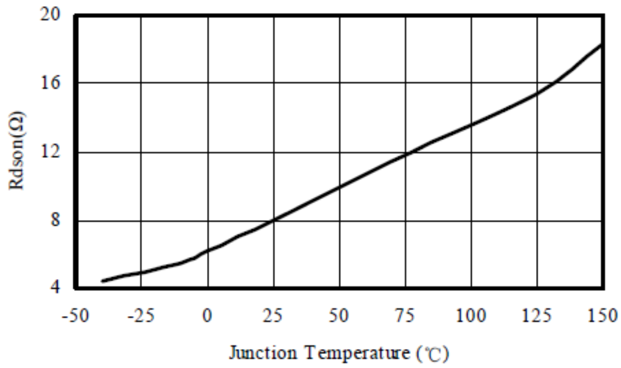
2. AP8366-A Rdson vs. T_J



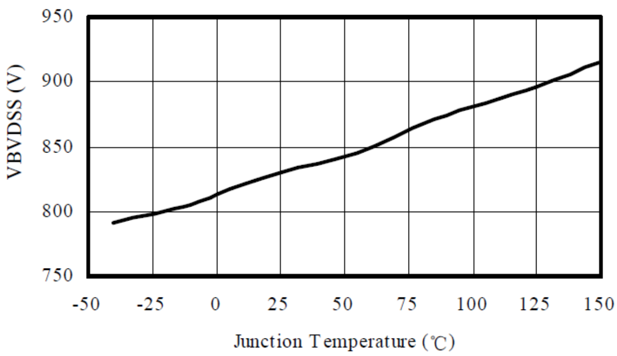
3. AP8366-B BV vs. T_J



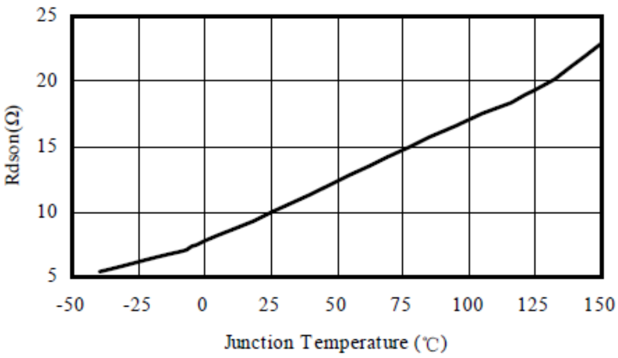
4. AP8366-B Rdson vs. T_J



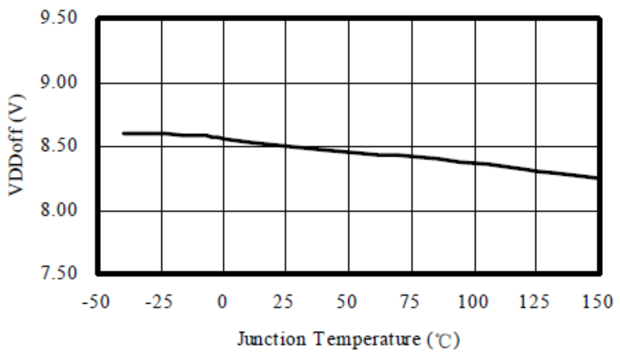
5. AP8366-C BV vs. T_J



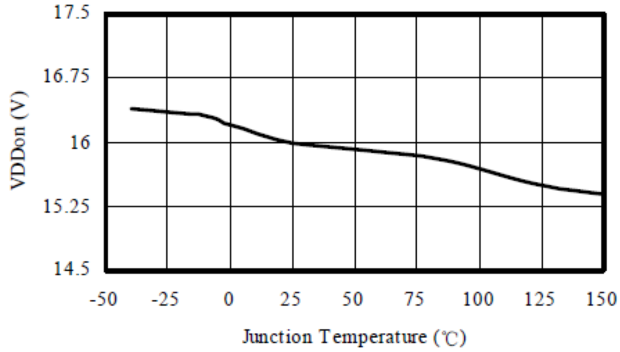
6. AP8366-C Rdson vs. T_J



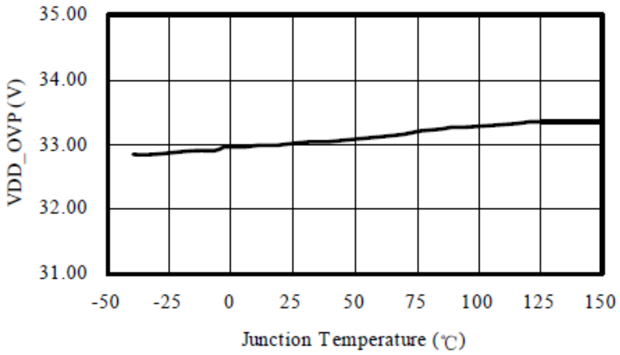
7. V_{DDoff} vs. T_J



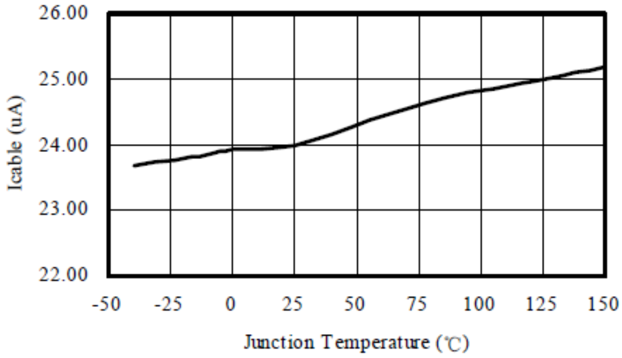
8. V_{DDon} vs. T_J



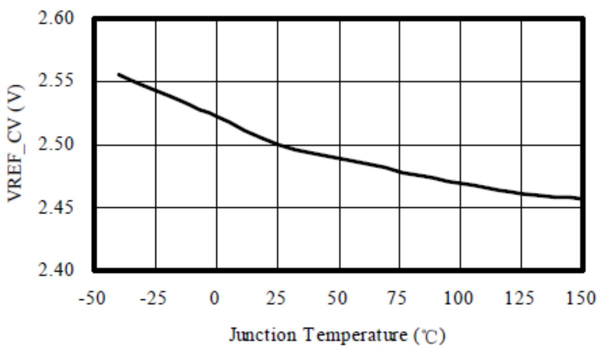
9. V_{DD_OVP} vs. T_J



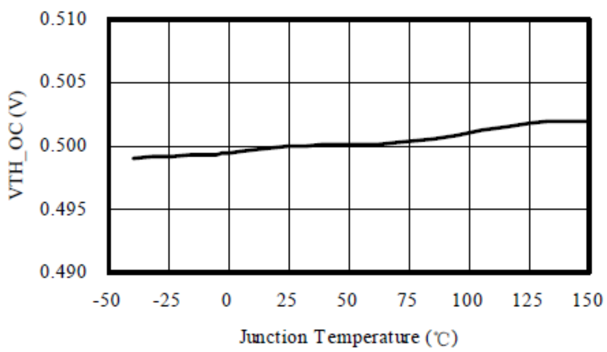
10. Icable vs. T_J



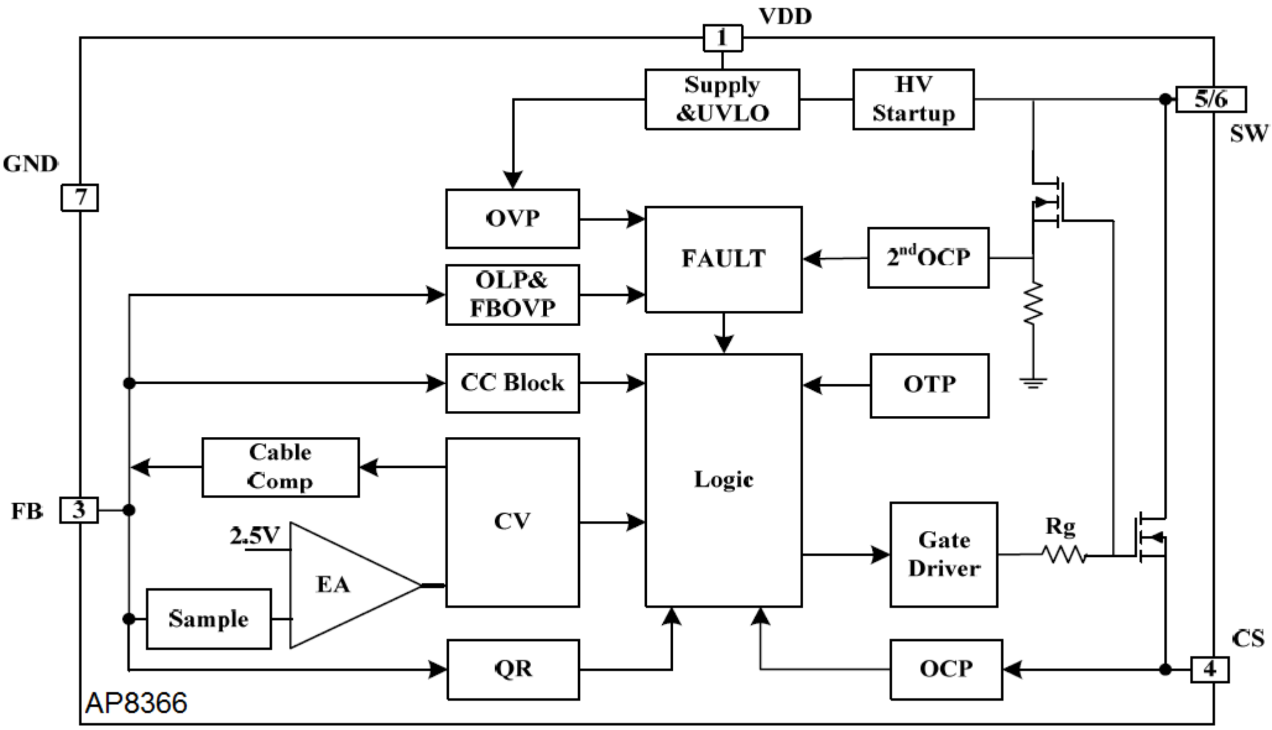
11. V_{REF_CV} vs. T_J



12. V_{TH_OC} vs. T_J



BLOCK DIAGRAM



DETAILED INFORMATION

Functional Description

The AP8366 is a high performance CC/CV primary-side controller. AP8366 operates in primary-side sensing and regulation, so opto-coupler and A431 could be eliminated. Proprietary built-in CV and CC control can achieve high precision CC/CV control meeting most charger and adaptor application requirements. Internal HV Start-up circuit and the chip's low consumption help the system to meet strict standby power standard.

HV Start up Control

At start up, the internal high-voltage start-up circuit provides the internal bias and charges the external V_{DD} capacitor, so that AP8366 starts up quickly. When V_{DD} reaches V_{DDon}, the device starts switching and the internal high-voltage current source stops charging the capacitor. The device keeps in normal operation provided as long as V_{DD} keeps above V_{DDoff}. After startup, the bias is supplied from the auxiliary transformer winding, the current of HV start-up circuit is designed to be very low so that the power consumption is very low.

CC Operation Mode

In CC operation mode, the AP8366 captures the auxiliary flyback signal at FB pin through a resistor dividing-network.

The pulse width of the auxiliary flyback signal determines the AP8366 oscillator frequency. The higher the output voltage is, the shorter the pulse width is, and the higher the chip oscillator frequency is, thus the constant output current can be achieved.

The current waveform of DCM mode is shown in Figure 1. During MOSFET turn-on time, the current in the primary winding (Ipri) ramps up. When MOSFET turns off, the energy stored in the primary winding is transferred to the secondary side, so the peak current in the secondary winding is

$$I_{sec\text{-}pk} = I_{pri\_pk} \times N_{ps} \qquad (1)$$

The output current is

$$I_O = \frac{I_{sec\_pk}}{2} \times \frac{T_{demag}}{T_p} = \frac{1}{2} N_{ps} \frac{V_{CS}}{R_{sense}} \frac{T_{demag}}{T_p} \qquad (2)$$

Because Vipk is constant and Tp is equal to tow times Tdemag, the output current Io is constant.

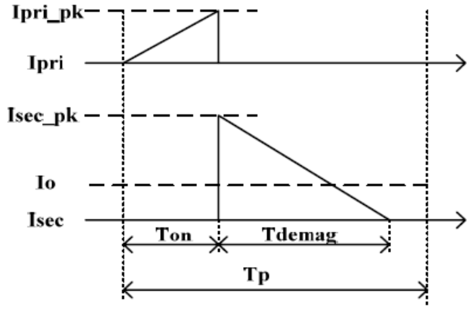


Figure 1. The current waveform of DCM mode

CV Operation Mode

In CV mode , AP8366 uses a pulse to sample V_{FB} and it is hold until the next sampling. The sampled voltage is compared with V_{REF_CV} and the error is amplified. The error amplified output reflects the load condition and controls the switching off time to regulate the output voltage, thus constant output voltage can be achieved.

The relationship between the output voltage and V_{REF_CV} is

$$V_O = (V_{REF\_CV} \times \frac{R1+R2}{R2}) \times \frac{Ns}{N_{AUX}} \qquad (3)$$

N_S means Secondary winding, N_{AUX} means Auxiliary winding

The AP8366 operates in PFM_QR mode during full load mode, since the peak current (Ipeak) of MOSFET is constant, the chip frequency decreases while the output current decreases. When the switching frequency approaches to 25kHz, the AP8366 enters PWM_QR mode, the chip frequency decreases slowly while the output current decreases, the Ipeak decreases while the output current decreases. Therefore the AP8366 can avoid audible noise, while achieving high efficiency at 25% load conditions. When Vcs decreases to 170mV, the AP8366 enters Standby mode. In this mode, Ipeak keeps around constant, the chip oscillator frequency decreases while the output current decreases. Figure 2 illustrates the relations of the switching frequency, Ipeak and Loading for AP8366.

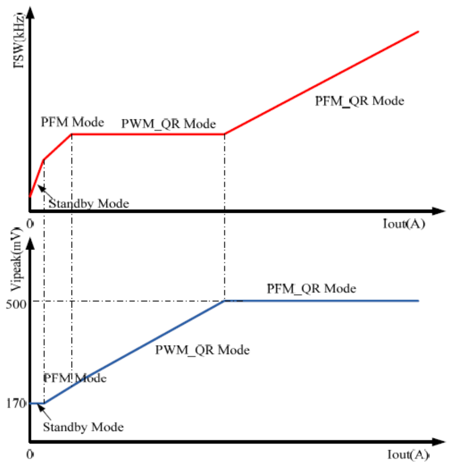


Figure 2. The Switching Frequency, Vipeak vs. LOAD

Current Sensing and Leading Edge Blanking

Cycle-by-Cycle current limiting is offered in AP8366. The switch current is detected by a sense resistor at CS pin. The CC set-point and maximum output power can be externally adjusted by external current sense resistor at CS pin. An internal leading edge blanking circuit chops off the sensed voltage spike at initial power MOSFET on-state so that the external RC filtering on sense input is no longer needed.

Programmable Cable Drop Compensation

In AP8366, an offset voltage is generated at FB pin by an internal current flowing into the divider resister, as shown in Figure 3. The Cable Drop Compensation block compensates the voltage drop across the cable. As the load current decreases from full load to no load, the voltage drop across the cable decreases. It can be programmed by adjusting the external resistor R2 or R1 at FB pin. The maximum compensation is

$$\frac{V_{cable}}{V_o} = \frac{I_{cable} \times (R2//R1)}{2.5V} \quad (4)$$

Because of the influence of the chip's sampling position and devices of the system, the actual maximum compensation is less than theoretical value.

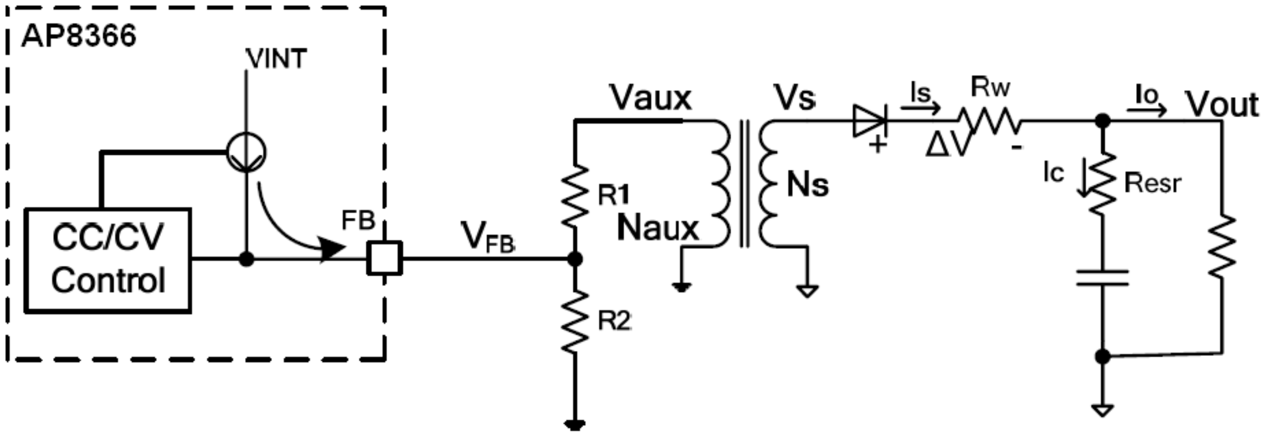


Figure 3. Icable

Reference Negative Temperature Compensation

As shown in Figure 3, the voltage of FB pin is

$$V_{FB} = K(V_o+\Delta V), K = \frac{R2 \times N_{AUX}}{(R1+R2) \times Ns} \quad (5)$$

Where ΔV has a negative temperature coefficient, K is a constant.

In AP8366, the voltage reference uses the negative temperature compensation technology. At room temperature, the voltage reference is 2.5V. The voltage reference (V_{REF_CV}) decreases while the temperature of chip increases. The reference negative temperature compensation block compensates the ΔV, thus the output voltage keeps constant at full range of temperature. The reference negative temperature compensation improves output precision.

Quasi-Resonant Switching

The AP8366 incorporates a unique proprietary quasi-resonant switching scheme that achieves valley-mode turn on for every switching cycle in CV mode. This unique feature greatly reduces the switching loss. The actual switching frequency can vary slightly cycle by cycle, providing the additional benefit of reducing EMI.

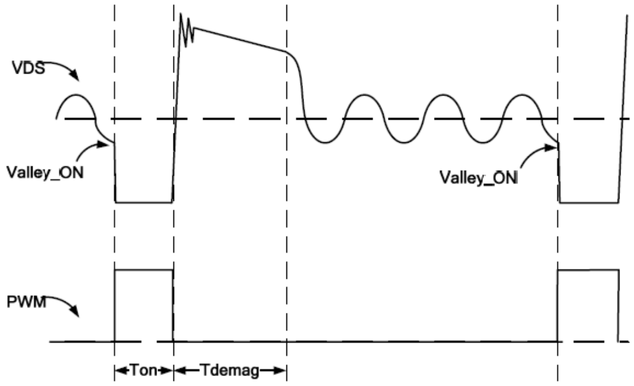
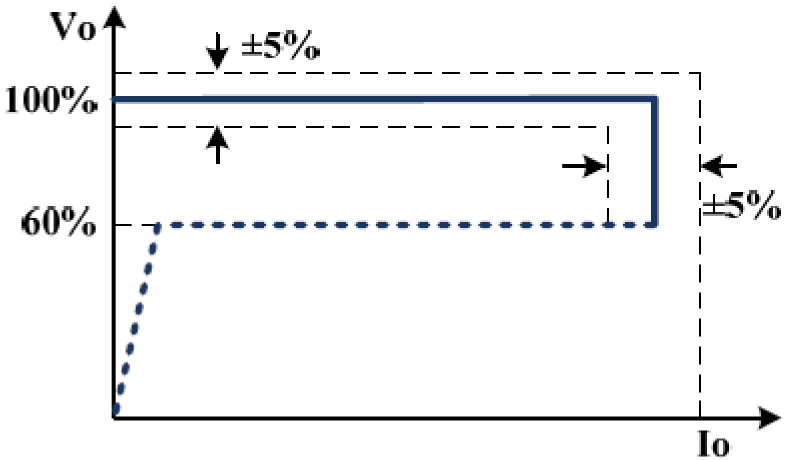


Figure 4. QR Mode

Protection Control

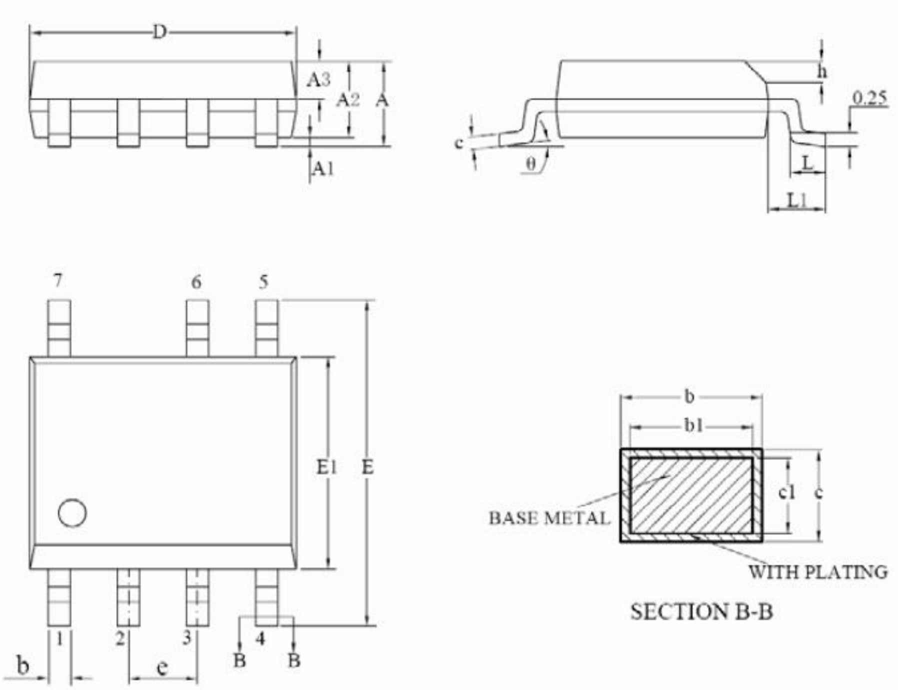
The AP8366 has several self-protection functions, such as Cycle-by-Cycle current limiting (OCP), Over-Voltage Protection, Over-Temperature Protection, Feedback Loop open Protection, Output short circuit Protection, CS resistor open/short circuit Protection and Under Voltage Lockout on V_{DD}. All protections are self-recovered.

OUTPUT FEATURES



PACKAGE INFORMATION

Dimension in SOP7 (Unit: mm)



Symbol	Min	Max
A	-	1.75
A1	0.10	0.225
A2	1.30	1.50
A3	0.60	0.70
b	0.39	0.48
b1	0.38	0.43
c	0.21	0.26
c1	0.19	0.21
D	4.70	5.10
E	5.80	6.20
E1	3.70	4.10
e	1.27 BSC	
h	0.25	0.50
L	0.50	0.80
L1	1.05 BSC	
θ	0°	8°

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