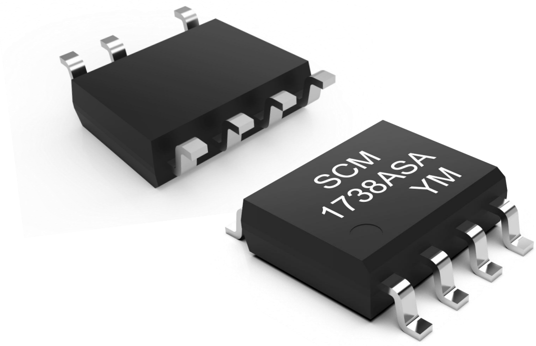
MORNSUN®

SCM1738ASA A High Precision CC/CV Primary Side Power Switch with Integrated MOSFET

Features

- Primary-side regulation Eliminates Opto-isolators
- High Precision Constant Voltage and Current Regulation at Universal AC Input
- Ultra Low Start-up Current
- Programmable CV and CC Regulation
- Programmable Cable Drop Compensation
- Integrated 650V MOSFET
- Integrated High Voltage Start up
- Extremely Low Standby Loss(<75mW)
- Built in Leading Edge Blanking(LEB)
- No External Compensation Required
- On-chip OTP
- VCC Over Voltage Protection
- Output Over Voltage Protection
- VCC Under Voltage Lockout with Hysteresis(UVLO)
- Cycle-by-Cycle Current Limiting
- Output Short Circuit Protection
- Over Current Protection
- Maximum on time protection

Package



Product optional package: SOP-7, Screen Printing information please see "Order Information"

Applications

- AC/DC Adapter
- Battery Chargers
- Standby power

Features Description

A high performance off-line primary-side power switch with integrating a 650V MOSFET. It operates in PFM (primary frequency modulation) to achieve a high stability and average efficiency by control accurate constant voltage/constant current (CV/CC).

Integrated high-voltage start-up with ultra low current. High-voltage start-up circuit replaces external start-up resistor.

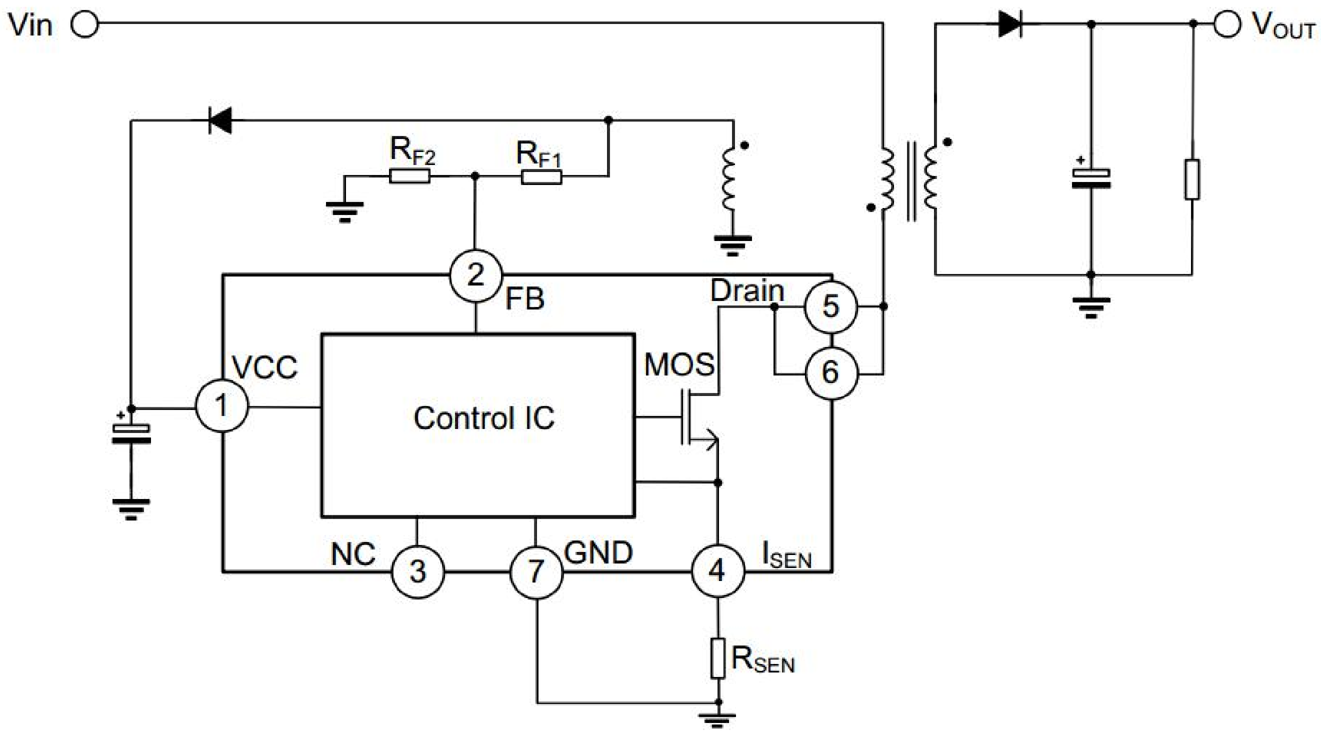
Be used for 8W power with loop compensation function and peak current compensation.

SOP-7 lead-free package.

Selection Table

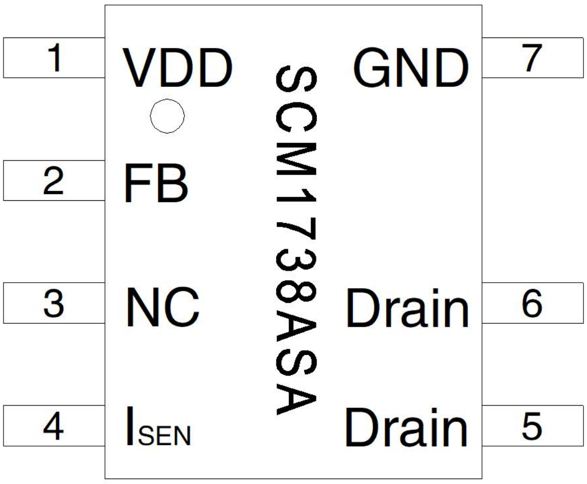
Model	Package	Topology	Control Mode	Protection Function	Power MOS	Power Range	Hazardous Substance control
SCM1738ASA	SOP-7	Flyback	Current Mode、SSR	OCP、OLP、OTP、SCP、UVLO、OVP	650V/1A/7.2Ω	8W Max	Halogen-free

Typical Application circuit

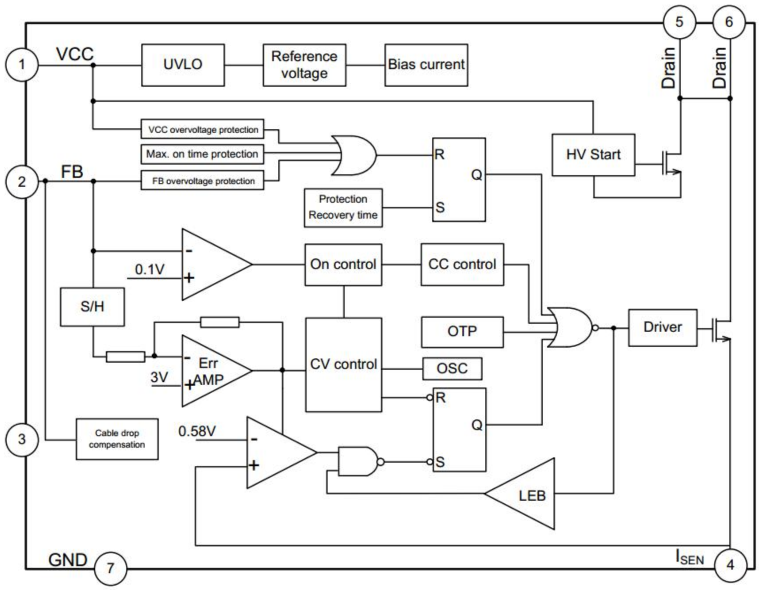


Contents

Pin Package



Block Diagram Circuit



Pin Descriptions

Name	Pin	Description
VDD	1	Power Supply
FB	2	The voltage feedback from auxiliary winding
NC	3	Not connected
I_{SEN}	4	Primary current sense
Drain	5、6	Drain of the internal power MOSFET
GND	7	GND

Absolute Maximum Ratings

T_A = 25℃, unless otherwise noted

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	DC supply voltage range (pin 1)	-0.3	29.5	V
V_I	Input voltage (pin 2,pin 4)	-0.3	6	V
I_{IN}	Input current	-10	10	mA
T_J	Maximum junction temperature	--	+150	℃
T_{amb}	Operating temperature	-40	+125	℃
T_{STG}	Storage temperature	-40	+125	℃
ESD	ESD(HBM)	--	2500	V

Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum-rated conditions for extended period may affect device's reliability.

Pin Configurations and Functions

Symbol	Parameter	Min.	Max.	Unit
V_{DD}	DC Supply Voltage	10	26	V
T_J	Operating Junction Temperature	-40	125	℃
P_{OMAX}	Output Power@90~264V Input	--	8	W

Maximum practical continuous power in an open frame design with sufficient drain pattern as a heat sink, at 45℃ ambient.Higher output power is possible with extra added heat sink or air circulation to reduce thermal resistance.

Electrical Characteristics

T_A = 25℃, V_{DD}=18V, unless otherwise noted

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
HV star						
I_{HVC}	Charging current	V_{CC}=0V, V_{Drain}=100V	--	1000	--	μA
I_{HVS}	Shunt down leakage current	V_{CC}=18V, V_{Drain}=650V	--	3	--	μA
Supply Voltage						
I_{OP}	Quiescent operating current	I_{SEN} =0,FB=0	--	600	--	uA
I_{ST}	Start-up current	V_{CC} =14V	--	1	3	μA
V_{ST}	UVLO(on)		16.5	18	19.5	V
V_{SP}	UVLO(off)		7.5	8.5	9.5	V
V_{cc_ovp}	VCC OVP level		25.5	28.0	29.5	V
V_{CC_CLP}	VCC clamp voltage	I_{VCC} =10mA	--	30.0	--	V
Feedback						
V_{CV}	CV reference voltage		2.90	3	3.10	V
V_{FB_OVP}	Output voltage protection		3.4	3.6	3.8	V
V_{FB_UVP}	Under voltage protection		--	1.9	--	V
I_{COMP_CABLE}	Load compensation current		42	48	54	μA
F_{min}	Minimum frequency		630	740	850	Hz
Current Sensing						
T_{LEB}	Leading edge blanking time		0.4	0.5	0.6	μs
V_{ISEN_MAX}	Maximum I_{SEN} threshold		--	580	--	mV
V_{ISEN_MIN}	Minimum I_{SEN} threshold		--	160	--	mV
T_{ON_MAX}	Maximum Ton		--	50	--	μs
On Chip OTP(Over Temperature)						
T_{OTP}	OTP level		140	150	155	℃
T_{OTP_hys}	OTP hysteresis		--	30	--	℃
MOSFET Section						
BV_{DSS}	MOSFET drain-source breakdown voltage		650	--	--	V
$R_{DS(ON)}$	Static drain to source on resistance		--	7.2	--	Ω

Typical Performance Characteristics

T_{amb} = 25℃, V_{cc}=18V, unless otherwise noted

Figure 1. Vcc Supply Start-up Current vs. Temperature

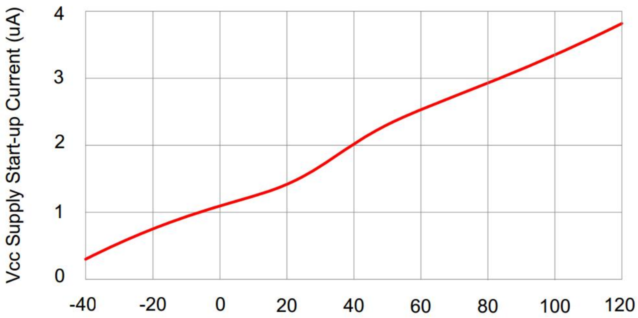


Figure 2. UVLO(on) vs. Temperature

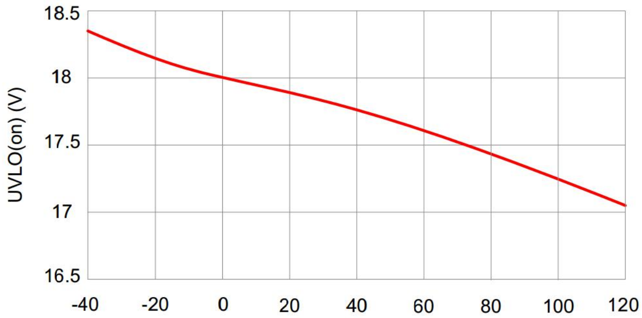


Figure 3. UVLO(off) vs. Temperature

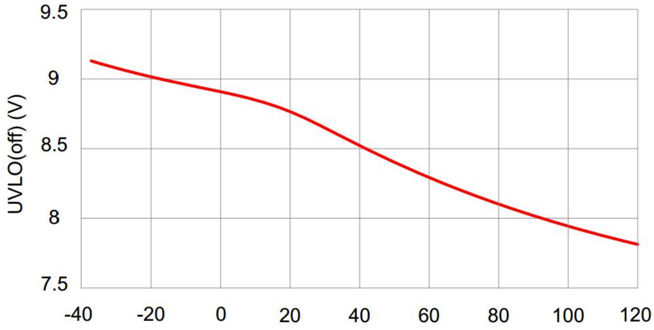


Figure 4. Load Compensation Current vs. Temperature

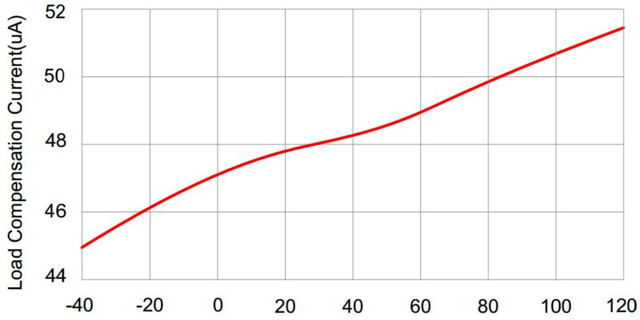
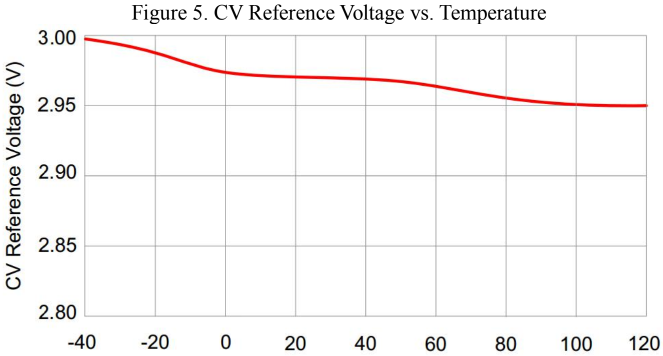


Figure 5. CV Reference Voltage vs. Temperature



Functional Description

SCM1738ASA is an excellent Primary-side regulation controller with constant current and constant voltage regulation. It removes the for secondary feedback circuits while achieving excellent line and load regulation. It integrates with more functions to reduce the external components counts and size.

Start up and Under Voltage Lockout(UVLO)

After AC supply or DC BUS is powered on, the VCC capacitor could be charged up above UVLO(on) threshold by HV start and start up quickly. When VCC is higher than the UVLO(on) threshold V_{ST} , the SCM1738ASA turns off depletion-mode MOSFET and the internal blocks start to work.Auxiliary winding of flyback could supply enough energy to maintain VCC above UVLO(off).

If at any time the VCC voltage drops below UVLO(off) threshold V_{SP} then all the logic is reset. At this time depletion-mode MOSFET turns on so that the VCC capacitor can be charged up again towards the UVLO(on) threshold.

Current Sensing and Leading-edge Blanking

The SCM1738ASA detects the primary current from I_{SEN} pin, which is not only for peak current mode control but also for the pulse-by-pulse current limit.

A leading-edge blanking (LEB) time is included in input of I_{SEN} pin to prevent the false-trigger from the current spike.

The peak current voltage is depended on the load conditions. The maximum is 0.58V and the minimum is 0.16V as shown in Figures 6.

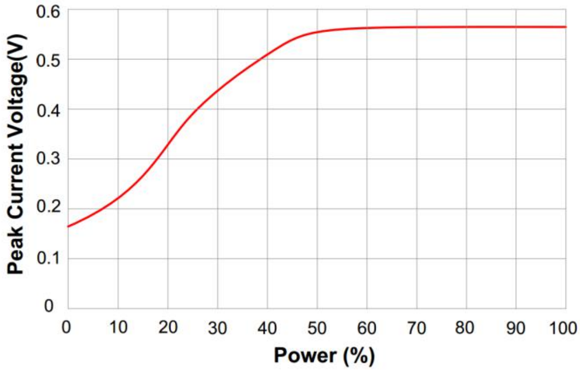


Figure 6. Peak current sensing threshold

Principle of C.V. Operation

In order to tightly regulate the output voltage, the information about the output voltage and load current needs to be accurately sensed. In the DCM Fly-back converter, this information can be read via the auxiliary winding. Assuming the secondary winding is master and the auxiliary winding is slave.

The auxiliary voltage is auxiliary is given by:

$$V_A = \frac{N_A}{N_S}(V_O + \Delta V_O)$$

Where ΔV_0 indicates the voltage drop of the output Diode and Cable Drop Voltage; N_A is the turns of auxiliary winding; NS is the turns of secondary winding.

Via a resistor divider connected between the auxiliary winding and FB (pin 2), the auxiliary voltage is sample at the 2/3~1/2 of the demagnetization and it is hold until the next sample. The sample voltage is compared with reference voltage and the difference is amplified. The error amplifier output reflects the load condition and controls the switching off time to regulate the output, thus constant output voltage can be achieved.

Principle of C.C. Operation

The primary side control is applied to eliminate secondary feedback circuit or opto-coupler, which will reduce the system cost. The output current I_0 can be expressed as:

$$I_0 = \frac{I_{SPK} \cdot T_{OFF1}}{2T_{SW}} = \frac{n \cdot D_S}{2} \cdot I_{PK}$$

Where I_{SPK} indicates peak current of secondary winding;The n indicates the turn ratio of primary and secondary winding; And the duty cycle of secondary side diode is given by:

$$D_s = \frac{T_{OFF1}}{T_{OFF1} + T_{OFF2} + T_{ON}} = \frac{T_{OFF1}}{T_{SW}}$$

Where T_{ON} indicates the time when the primary side MOSFET is ON; T_{OFF1} indicates the time when the secondary side diode is ON; T_{OFF2} indicates the time when neither primary side MOSFET nor secondary side diode is ON; T_{SW} indicates the switching period.

When the sampled voltage is below reference voltage (V_{CV}), SCM1738ASA fixes D_S to a constant value 0.5, thus the constant output current can be achieved.

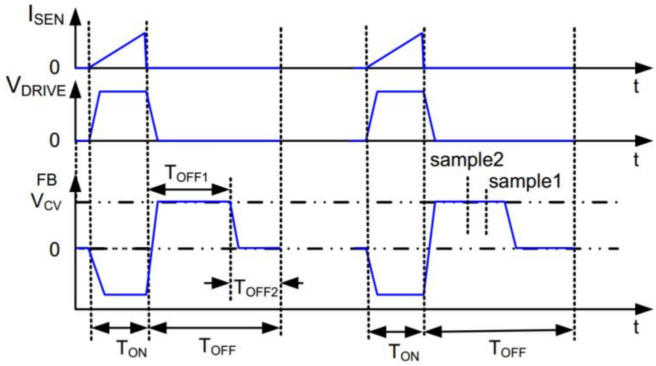


Figure 7. Principle of C.C. Operation

AC line compensation

The variation of max output current in CC mode can be rather large if no compensation is provided. The OCP threshold is self adjusted higher at higher AC voltage.This OCP threshold slop adjustment helps to compensate the increased output current limit at higher AC voltage. The OCP threshold in SCM1738ASA is a function of the switching ON time. For the ON time between 1.2us to 5.5us, the OCP threshold changes linearly from 500mV to 580mV. The peak current compensation is as shown in the following diagram.

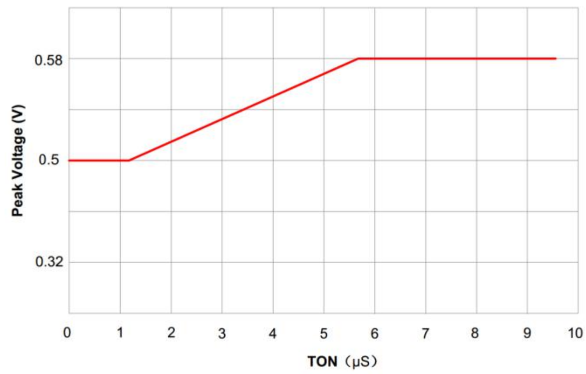


Figure 8. Peak Current Compensation

Programmable Cable Drop Compensation

In SCM1738ASA, cable drop compensation is implemented to achieve good load regulation. The offset voltage is created across FB by a current source which feeds out the FB during the sampling period. The current is proportional to the switch off times. As a result, the drop due to the cable loss can be compensated. So, the offset voltage increases as the current increases in condition from full-load to no-load. It can also be programmed by adjusting the resistance of the divider to compensate the drop for various cable lines used.

The percentage of maximum compensation is:

$$\frac{\Delta V_0}{V_0} = \frac{I_{COMP\_CABLE} \cdot (R1 // R2)}{3V} \times 100\%$$

Where ΔV_0 is load compensation voltage and ΔV_0 is output voltage. The load compensation is as shown in the following diagram.

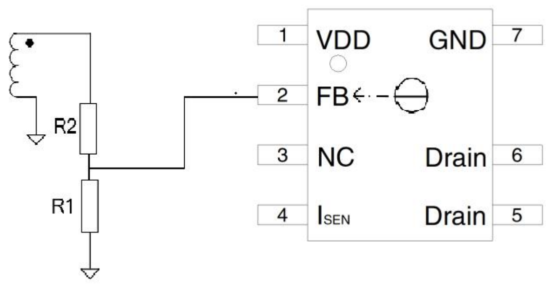


Figure 9. Schematic of Output Cable Compensation

Protection

The SCM1738ASA Integrates rich protection features including precise on-chip OTP, cycle-by-cycle current limiting (OCP), output over voltage protection, VCC over voltage protection, output short circuit protection, under voltage lockout on VCC (UVLO), over current protection, maximum on time 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 frequently change between normal and protection modes. The over protection threshold value is 150°C and hysteresis value is about 30°C. Hence, the circuit is only normal when the temperature is 120°C below.

If voltage at FB exceeds the threshold V_{FBOVP} =3.6V and this state is kept for three cycles, the protection will be activated to stop the switching of the power MOSFET until the next UVLO(on) arrives.

If VCC voltage rises over 28.0V, the protection will be activated to stop the switching of the power MOSFET until the next UVLO(on) arrives.

If the FB voltage falls below 1.9V for over the delay time of 160ms, the protection will be activated to stop the switching of the power MOSFET until the next UVLO(on) arrives.

If the primary peak current multiplied by the I_{SEN} sense resistor is greater than 0.6V over current is detected and the IC will immediately turn off the gate drive until the next cycle, and the switching pulse will continue if the OCP threshold is not reach or the switching pulse will turn off again if the OCP threshold is still reached.

If pin I_{SEN} is floating, the peak current can' t be detected, while system maybe damaged by actual abnormal peak current. Maximum on time is needed. When T_{ONMAX} =50us, it enters maximum on time protection and the drive is shutdown.

PFM frequency setting

PFM frequency range is determined by the on time T_{ON} and constant-voltage loop off time T_{OFF} . When off time is T_{OFFmax} , the circuit works with operating frequency value is minimum; when off time is T_{OFFmin} , the circuit works with operating frequency value is maximum.

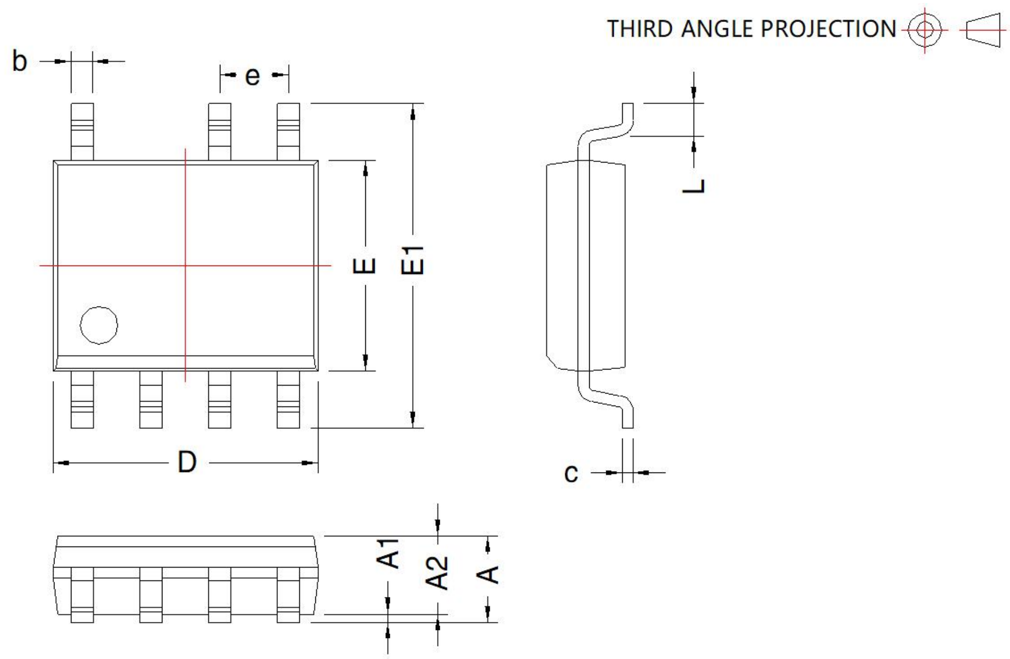
According to the formula:

$$P_0 = V_0 \cdot I_0 = \frac{1}{2} I_{PK}^2 \cdot L_P \cdot f_{SW} \cdot \eta$$

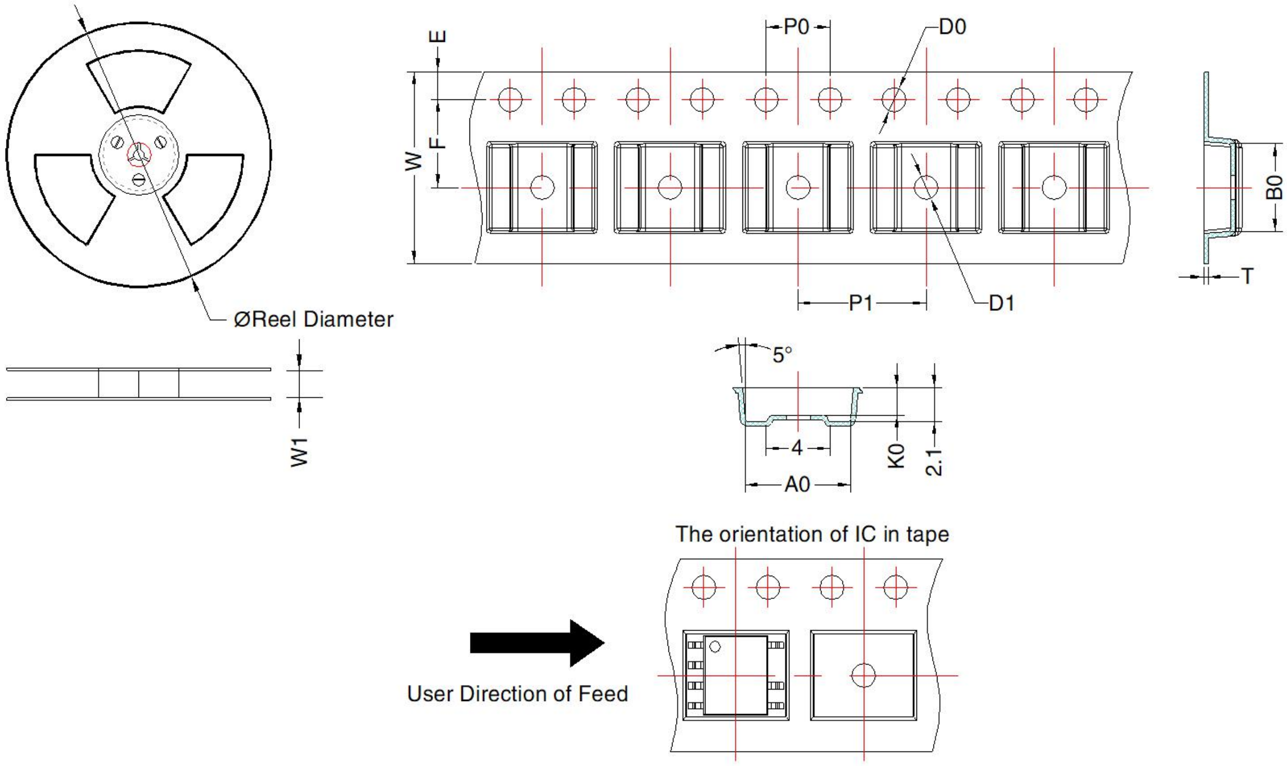
Where, L_P primary inductance, I_{PK} peak current in primary side, f_{SW} -operating frequency, η - efficiency.

Hence:

$$f_{SW} = \frac{2V_0 \cdot I_0}{I_{PK}^2 \cdot L_P \cdot \eta}$$



SOP-7				
Mark	Dimension(mm)		Dimension(inch)	
	Min	Max	Min	Max
A	1.30	1.8	0.051	0.071
A1	0.05	0.25	0.002	0.010
A2	1.25	1.65	0.005	0.065
D	4.70	5.10	0.185	0.201
E	3.70	4.10	0.146	0.162
E1	5.8	6.2	0.228	0.248
L	0.40	1.27	0.016	0.050
b	0.33	0.51	0.013	0.020
e	1.27TYP		0.05TYP	
c	0.17	0.26	0.007	0.010



Device	Package Type	MPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	T (mm)	W (mm)	E (mm)	F (mm)	P1 (mm)	P0 (mm)	D0 (mm)	D1 (mm)
SCM1738ASA	SOP-7	4000	330.0	12.4	6.6 ± 0.2	5.5 ± 0.2	1.8 ± 0.1	0.3 ± 0.1	12.0 ± 0.3	1.75 ± 0.1	5.5 ± 0.1	8 ± 0.2	4 ± 0.1	1.5 ± 0.1	1.5 ± 0.1

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