SLS (SRC/LLC+SR) Controller with 1 FM+2 PWMs

GENERAL DESCRIPTION

CM6901 is a SLS, SRC/LLC + SR resonant controller and it can operate at both SRC and LLC region with synchronous rectification to achieve high efficiency. Its unique features: FM + 2 PWMING modes. It is used for DC-DC conversion in offline application.

Light load regulation is accomplished by transitioning the controller from frequency modulation mode into **PWM mode**. To have the optimal balance performance between hold-up time and efficiency, its frequency range crosses fr1(resonant frequency).

CM6901 system has a constant voltage feedback loop with precision 2.5V VFB reference. The 1V ILIMIT can be latched when a standby converter is applied; otherwise, it is an auto-restart I limit.
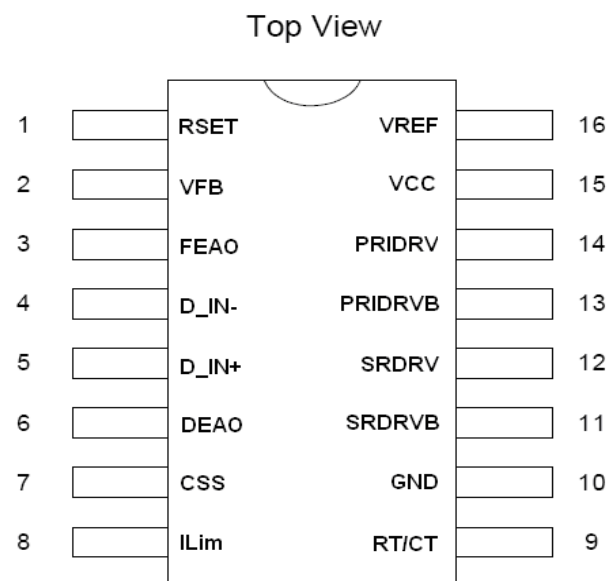
FEATURES

◆ 90+ Controller
◆ Smaller and Thinner Transformer
◆ 20ms with reasonable Bulk Cap(hold up time)
◆ SLS, SRC/LLC + SR resonant controller
◆ Supply Voltage Range : 10V to 20V.
◆ 2 Gate Drivers: Typical Peak Drive from 12V supply : (PMOS~200 ohm and NMOS~100 ohm).
◆ UVLO =11V with 1V Hystetesis.
◆ Reference OK Comparator.
◆ FM + 2 PWMING Mode Operation
◆ Light Load PWMING (light load regulation)
◆ SR Ideal Diode PWMING(cross resonant frequency application)
◆ GM FEAO, FM modulation Error Amplifier
◆ GM DEAO, PWM Error Amplifier
◆ Close Loop Soft start Capability with Shutdown Function.
◆ Auto-Restart during Current Limit .
◆ Precision 2.5V VFB threshold for constant voltage feedback loop.
◆ Precision 1V I limit threshold.

APPLICATIONS

◆ DC-DC power supply.
◆ Operates in FM/PWM mode.

CM6901 Pin Configuration

Top View

1 RSET	VREF 16
2 VFB	VCC 15
3 FEAO	PRIDRV 14
4 D_IN-	PRIDRVB 13
5 D_IN+	SRDRV 12
6 DEAO	SRDRVB 11
7 CSS	GND 10
8 ILim	RT/CT 9

ORDERING INFORMATION

Part Number	Temperature Range	Package
CM6901GIS*	-40℃ to 125℃	16-Pin SOP (S16)
CM6901GISTR*	-40℃ to 125℃	16-Pin SOP (S16)
CM6901GIP*	-40℃ to 125℃	16-Pin PDIP (P16)
CM6901XIS*	-40℃ to 125℃	16-Pin SOP (S16)
CM6901XISTR*	-40℃ to 125℃	16-Pin SOP (S16)
CM6901XIP*	-40℃ to 125℃	16-Pin PDIP (P16)

*Note : G : Suffix for Pb Free Product
    X : Suffix for Halogen Free and PB Free Product
    TR : Package is Typing Reel

BLOCK DIAGRAM
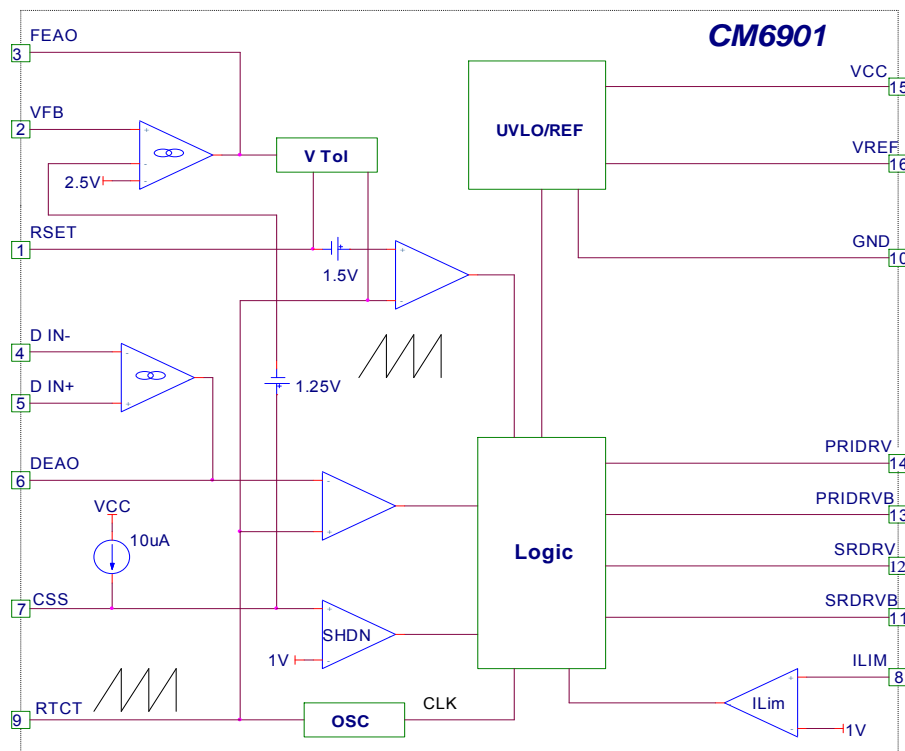
PIN DESCRIPTION

Pin No.	Symbol	Description	Operating Voltage			
			Min.	Typ.	Max.	Unit
1	RSET	External resistor which convert FEAO voltage signal into current signal for frequency modulation. SR is PWMing Control , when RSET lower than 1.5V.	0		5.5	V
2	VFB	Non-inverting input into resonant error amplifier .	0	2.5	3	V
3	FEAO	Resonant error amplifier output and compensation node for frequency modulation control.	0		5.5	V
4	D_IN-	Inverting input into PWM error amplifier.	0		6	V
5	D_IN+	Non-inverting input into PWM error amplifier.	0		6	V
6	DEAO	PWM error amplifier output and compensation node for PWM control.	0		4.5	V
7	CSS	Soft start for FM/PWM operation with 1V enable threshold. Also, use for auto-restart operation during current limit.	0		5.5	V
8	ILIM	Input to current comparator with 1V threshold.	0	1	1.25	V
9	RTCT	Oscillator timing components which set the minimum frequency.	1.2		3	V
10	GND	Ground				
11	SDRVB	Synchronous MOSFET driver output.	-0.3		VCC	V
12	SDRV	Synchronous MOSFET driver output.	-0.3		VCC	V
13	PRIDRVB	Primary side MOSFET driver output.	-0.3		VCC	V
14	PRIDRV	Primary side MOSFET driver output.	-0.3		VCC	V
15	VCC	Positive supply for the IC	10	15	20	V
16	VREF	Buffered output for the 7.5V voltage reference		7.5		V

ABSOULTE MAXIMUM RATINGS (TA=25℃, unless otherwise specified.)

The following ratings designate persistent limits beyond which damage to the device may occur.

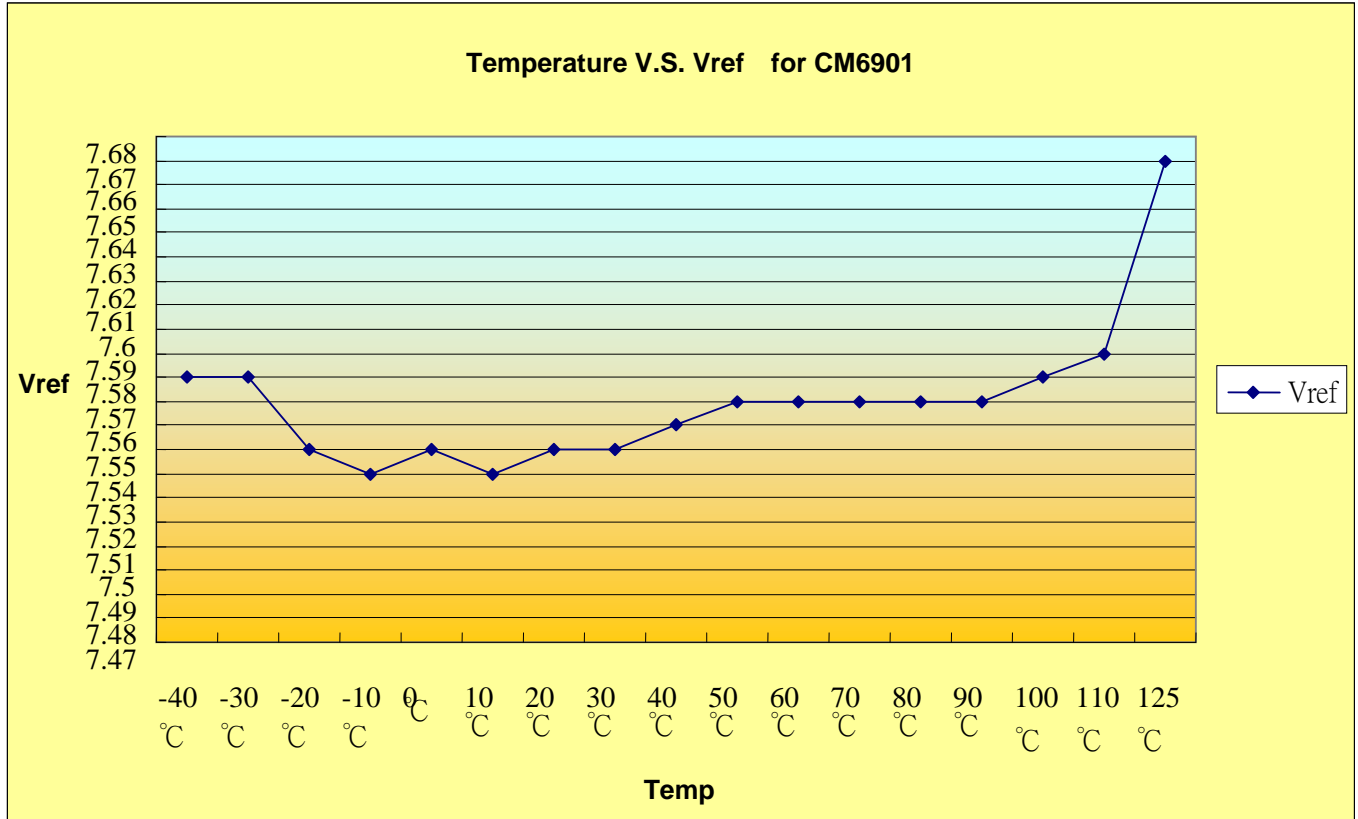| Symbol	Parameter	Value	Unit
VCC	DC Supply Voltage	-0.3 to 20	V
SRDRV	SRDRV Voltage	-0.3 to VCC+0.3	V
SRDRVB	SRDRVB Voltage	-0.3 to VCC+0.3	V
PRIDRV	PRIDRV Voltage	-0.3 to VCC+0.3	V
PRIDRVB	PRIDRVB Voltage	-0.3 to VCC+0.3	V
VREF	VREF Voltage	-0.3 to 7.5	V
RTCT	RTCT Voltage	-0.3 to VREF+0.3	V
VILIM	VILIM Voltage	-0.3 to VREF+0.3	V
CSS	CSS Voltage	-0.3 to VREF+0.3	V
DEAO	PWM Error Amplifier Output Voltage	-0.3 to VREF+0.3	V
D_IN+	Non-Inverting Input Into PWM Error Amplifier Voltage	-0.3 to VREF+0.3	V
FEAO	Resonant Error Amplifier Output Voltage	-0.3 to VREF+0.3	V
VFB	Non-Inverting Input Into Resonant Error Amplifier Voltage	-0.3 to VREF+0.3	V
RSET	V to I Voltage	-0.3 to VREF+0.3	V

ELECTRICAL CHARACTERISTICS

(VCC=12V, RT=43K±1%, CT=820pF±1%, Freq. = 80 KHz, Duty Cycle=48% , Temp= -40 ~ 125 ℃, unless otherwise specified.)

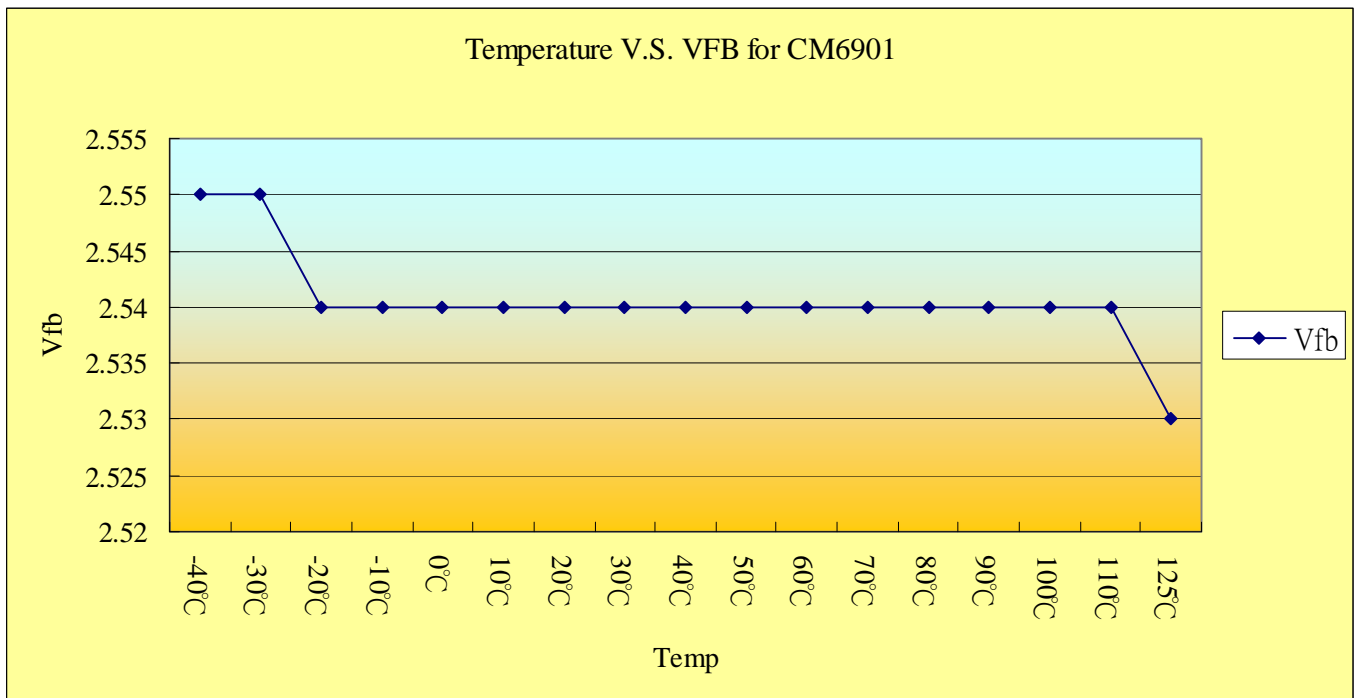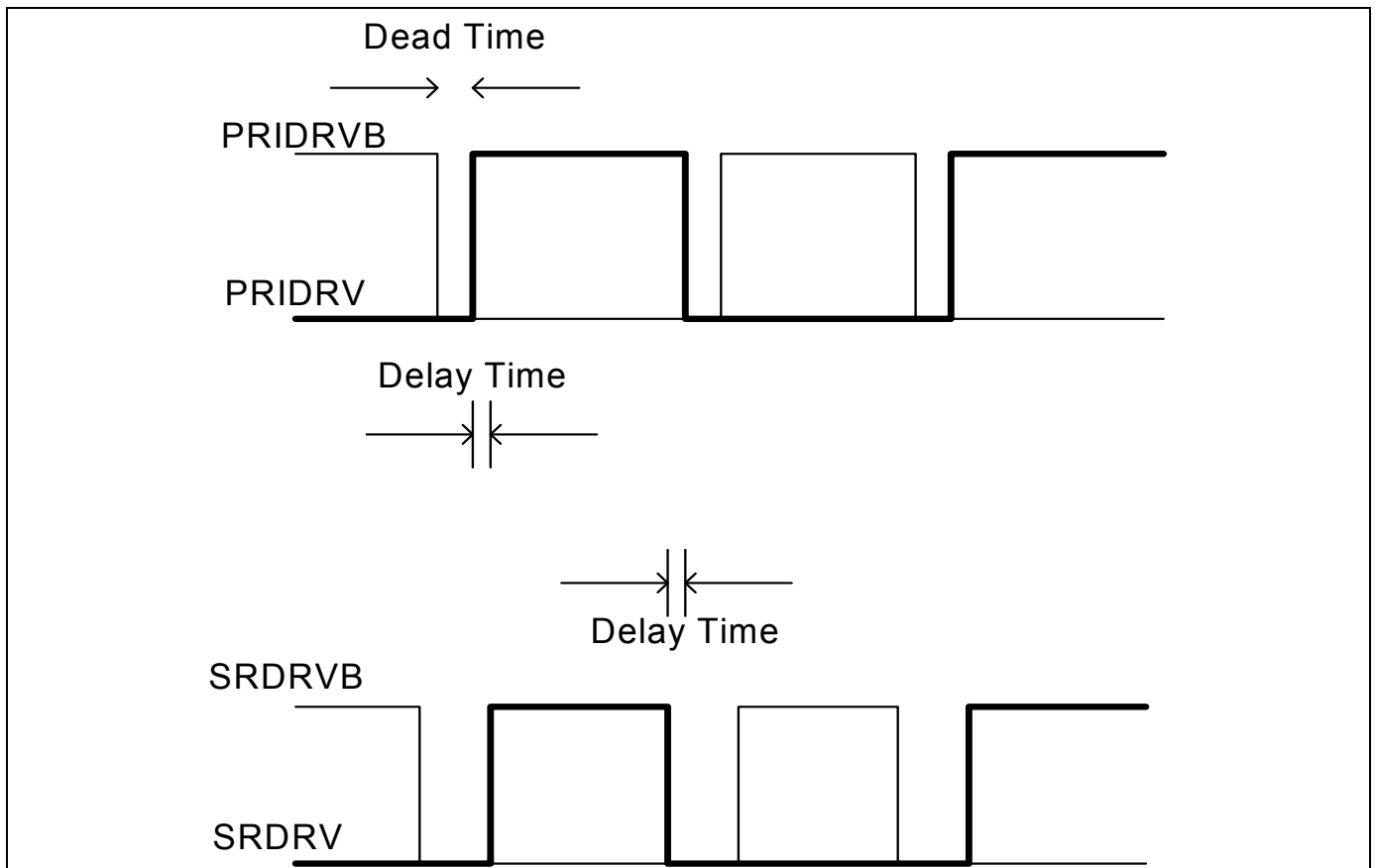| Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
VREF (pin 16)						
Reference Voltage (**note1**)	VREF	TA=25℃; Iref=1mA	7.41	7.5	7.59	V
	VREF	TA=-40℃; Iref=0mA	7.44	7.53	7.62	V
	VREF	TA=125℃; Iref=0mA	7.53	7.67	7.7	V
Line Regulation		11.5V < Vcc < 16.5V		10	25	mV
Load Regulation		0mA < Iref < 5mA	0	10	25	mV
VCC (pin 15)						
VCC Start up voltage	Vstart		10.5	11	11.5	V
VCC Turn off voltage			9.5	10	10.5	V
VCC Start up current			63.5	74.5	85.5	uA
UVLO Hysteresics	Hys		0.95	1	1.05	V
Operating Current	ICC			1		mA
SRDRVB , SRDRV , PRIDRVB , PRIDRV (pin 11,12,13,14)						
Output Low Voltage	Vol	Isrdrv=-6mA		0.6	1.2	V
Output High Voltage	Voh	Isrdrv=+6mA	9.6	10.8		V
Iout peak source current	Iout			0.12		A
Iout peak sink current	Iout			0.12		A
PMOS Rdson	Rout	TA=25℃		200	250	Ohm
NMOS Rdson	Rout	TA=25℃		100	150	Ohm
Dead Time between PRIDRV and PRIDRVB	TDead	TA=25℃		650		ns
Rising Edge Delay Between PRIDRV and SRDRV	TDelay	TA=25℃	175	217.5	260	ns
Falling Edge Delay Between SRDRV and PRIDRV	TDelay	TA=25℃	178	222.5	267	ns
Duty Cycle Range			0		50	%
ILIM (pin 8)						
Threshold Voltage	Vth	TA=25℃	1.45	1.65	1.75	V
SS Voltage Hi		TA=25℃	0.95	1	1.05	V
SS Voltage Low		TA=25℃	1.31	1.64	1.97	V

ELECTRICAL CHARACTERISTICS

(VCC=12V, RT=43K±1%, CT=820pF±1%, Freq. = 80 KHz, Duty Cycle=48% , Temp=-40 ~ 125℃, unless otherwise specified.)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
CSS (pin 7)						
Soft Start Current	Iss	TA=25℃	-8.7	-7.5	-6.3	uA
Enable Voltage	Ven	TA=25℃	0.9	1.0	1.1	V
Enable Hysteresis	Vhys	TA=25℃		100		mV
Auto-restart Upper Threshold	Vup		4.85	5.0	5.15	V
Auto-restart Lower Threshold	Vlw			1-Vhyst		V
FEAO Resonant Error Amplifier (pin 3)						
Input Voltage Range					6	V
Transconductance	Gm	VFB±50mV, TA=25℃	37	46.5	56	umho
VFB (Pin2)						
Feedback Reference Voltage (**note 2)**		TA=25℃	2.475	2.5	2.525	V
		TA=125℃	2.485	2.51	2.535	V
		TA=-40℃	2.465	2.49	2.515	V
Input Bias Current			-1	-0.5		uA
Output High Voltage				5.5+VBE		V
Output Low Voltage				0.1	0.4	V
Sink Current		VFB =250mV , TA=25℃	-20.4	-17	-13.6	uA
Source Current		VFB = -250mV , TA=25℃	12.4	15.6	18.8	uA
Open Loop Gain				60		dB
DEAO PWM Error Amplifier (pin 6)						
Input Voltage Range					6	V
Reference Voltage			0.96	1.01	1.06	V
Transconductance	Gm	TA=25℃	95	120	145	umho
Input Bias Current			-1.0	-0.5		uA
Output Voltage High				3+VBE		V
Output Voltage Low				0.1	0.4	V
Sink Current				-5		uA
Source Current				7		uA
Open Loop Gain				60		dB

ELECTRICAL CHARACTERISTICS

(VCC=12V, RT=43K±1%, CT=820pF±1%, Freq. = 80 KHz, Duty Cycle=48% , Temp=-40 ~ 125 ℃, unless otherwise specified.)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
RTCT Oscillator;RT=43K±1%;CT=820pF±1%, (pin 9)						
Initial Accuracy		TA=25℃	72	80	88	Khz
Voltage Stability		11.5V < Vcc < 16.5V		1		%
Temperature Stability				2		%
Ramp Valley to Peak Voltage				2		V
CT Discharge Time				350		nS
Maximum Duty cycle		DEAO > 3.0V		48		%
Minimum Duty Cycle		DEAO < 1.2V		0		%
SR Ideal Diode (pin12)						
Maximum Duty cycle		TA=25℃	35	40	45	%
Middle Duty cycle		TA=25℃	22	24.5	27	%
Minimum Duty cycle		TA=25℃	2.5	4.65	6.8	%
Frequency at Minimum Duty cycle		TA=25℃	36	39	42	KHz

Note1

Temperature V.S. Vref for CM6901

Note2

Temperature V.S. VFB for CM6901

Timing Diagram

Oscillator

The oscillator frequency is determined by the values of RT and CT.

f_{osc} = 1 / (t_{RAMP} + t $_{DEADTIME}$)

t_{RAMP} = RT * CT * ln((V_{REF} + I_{CHG}*RT -1.25)/(V_{REF} + I_{CHG}*RT -3)) where I_{CHG} = 4*(F_{EAO}-V_{BE})/R_{SET}

$t_{DEADTIME}$ = 2.5V/2.5mA * CT = 850 * CT

Resonant Section
FM Modulator

Frequency modulation of the resonant controller section is accomplished by controlling the charging current of the oscillator through resonant error amplifier. The frequency of the resonant section is ½ of the oscillator frequency. Compensation is accomplished by connecting R and C in series to the FEAO pin.

I_{CHG} = 4*(F_{EAO}-V_{BE})/R_{SET}

$I_{CHG(max)}$ = 20V/R_{SET}
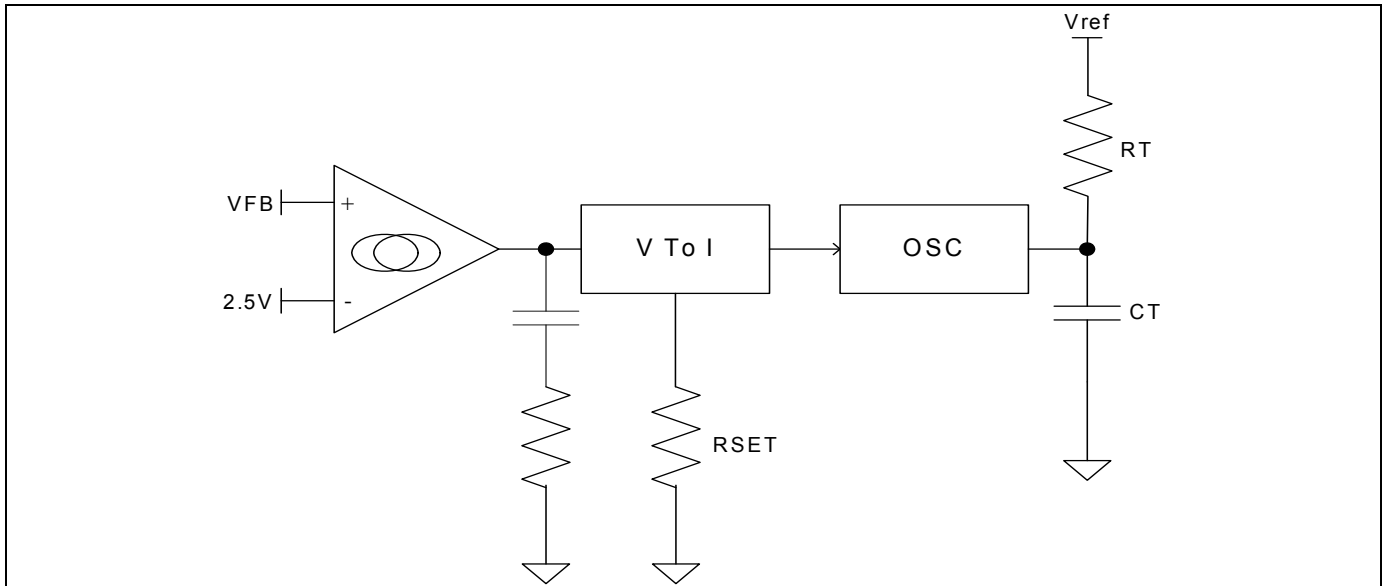
2 PWMings:

SR Ideal Diode PWMing (Synchronous Outputs)

SR Ideal Diode PWMing for synchronous drivers is accomplished by comparing the voltage signal at the RSET pin to RTCT ramp. The pulse-width reduction happens when the voltage at the RSET is lower than 1.5V. This allows safe operation of the power converter with synchronous rectification when the switching frequency is below the highest resonant point frequency fr1.
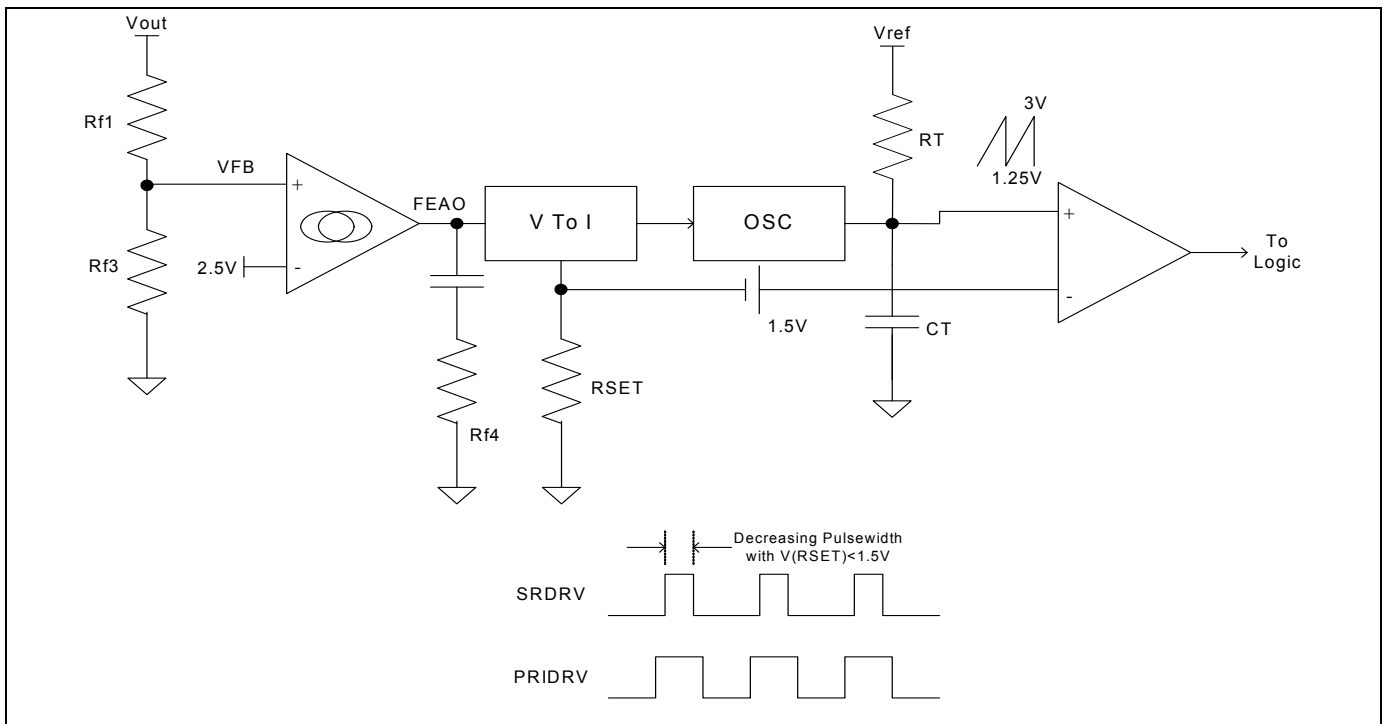
Light Load PWMING

In Application , low gain configuration accomplished by connecting R_{f4} and R_{f5} in the closed loop configuration . The gain for the PWM is determined by R_{f4} and R_{f5} where the gain is equal to $-R_{f5}/R_{f4}$. The voltage of VR_{set} at which the controller goes into FM and PWM simultaneously is equal to :

$VRset = D\_IN+ \times (1+R_{f4}/R_{f5}) - (R_{f4}/R_{f5}) \times 3$ where 3 is the peak voltage of RTCT

Varyin R_{set} from VR_{set} to $VR_{set} + 1.75 \times R_{f4}/R_{f5}$ will cause the duty cycle to vary from 50% to 0% while the frequency will vary propotionally according to $1.75*R_{f4}/R_{f5}$ where 1.75 is the peak-to-peak voltage of the RTCT ramp. For proper operation, select R_{f5} value so that the current through R_{f5} $\{((D\_IN+) - 1.2)/R_{f5}\}$ should be less than 5uA.
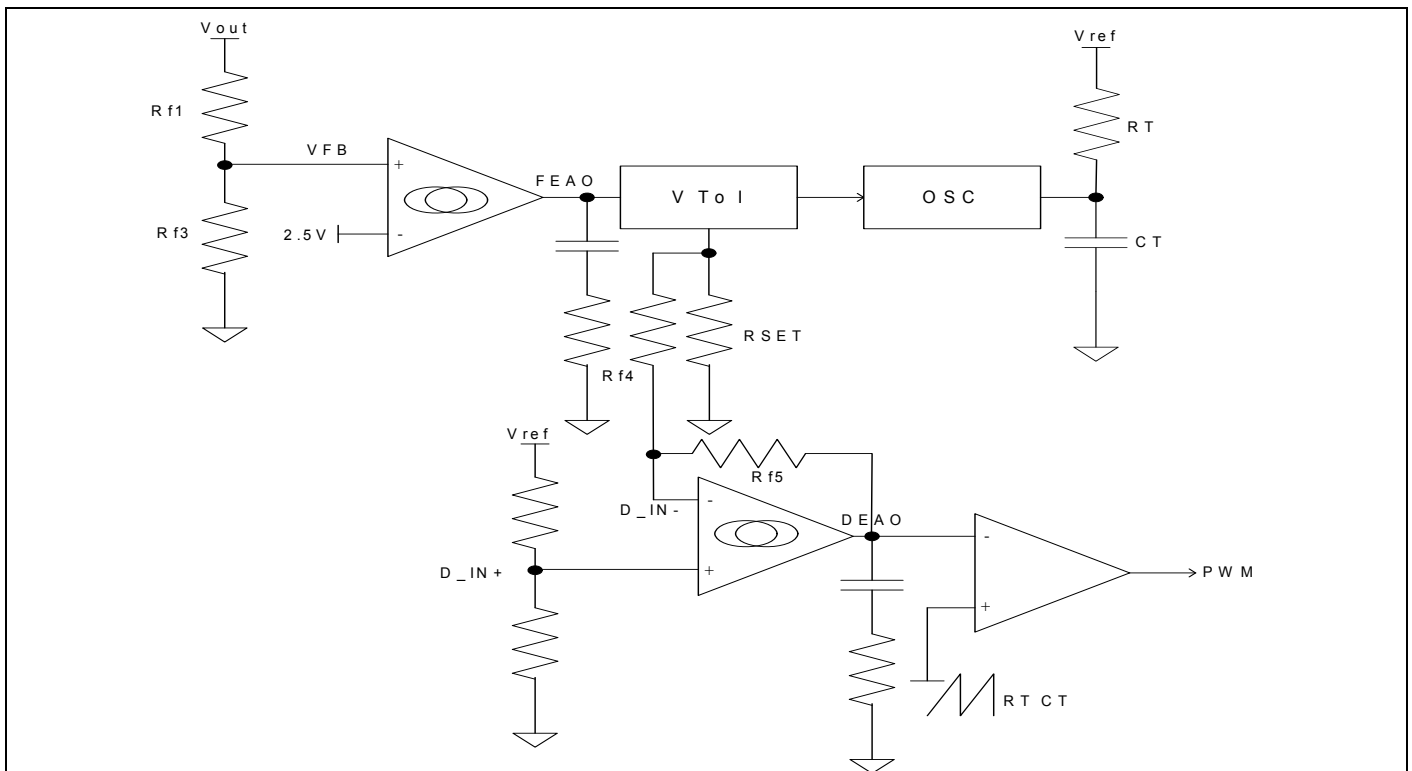
Soft Start and Enable

Soft start of the FM and PWM is controlled by the selection of the external capacitor at CSS pin.   A current source of 7.5uA supplies the charging current for the capacitor. Soft start of the FM and PWM begins at 1.25V. The soft start pin CSS also serves as an enable function. The output drivers are enabled when CSS pin reached 1V.

Auto-retry Mode

During normal operation, CSS pin will be charged to 5.5V + VBE.   When VFB exceeds 2.93V due to ILIM exceeds 1V due to over current condition, output drivers are immediate set to low , and CSS begins to discharge with 0.75uA current source.   When CSS pin is below 0.9V, 7.5uA current source start charging the CSS pin.   When CSS pin reaches 1V, the output drivers are re-enable and the controller goes into soft start mode.   If over current condition still exists then, the outputs are immediately disabled, but CSS continues to charge toward 5V.   When CSS reaches 5V, 7.5uA charging current is disabled and 0.75uA current source begins to discharge the CSS, and the cycle repeat until over current condition is removed.
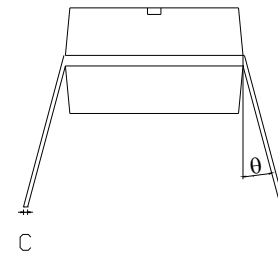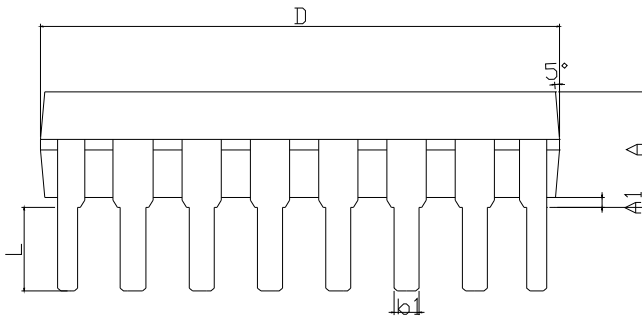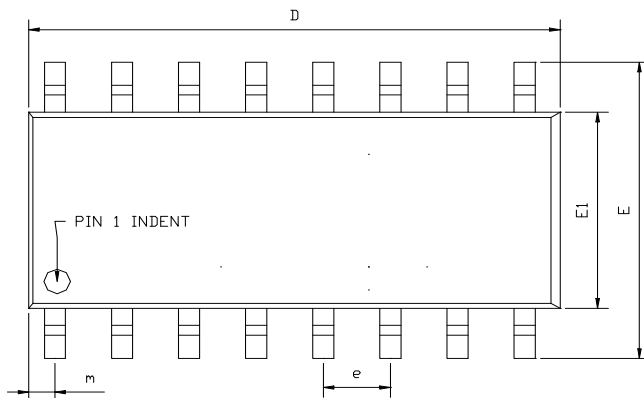
OCP Setting
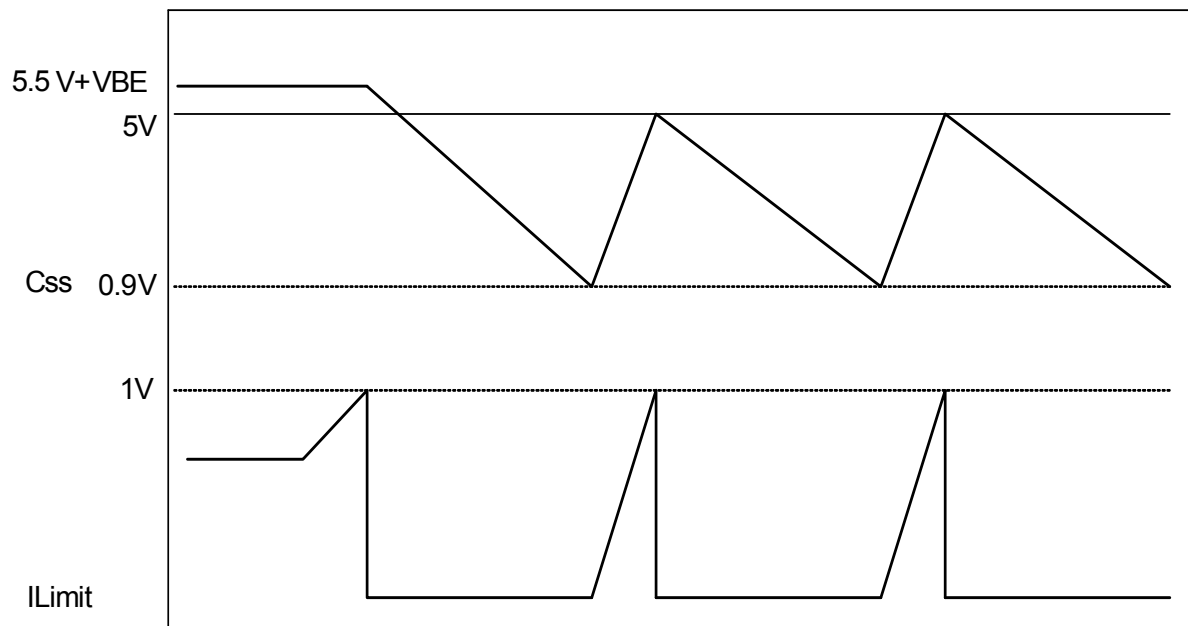
TYPICAL APPLICATION CIRCUIT
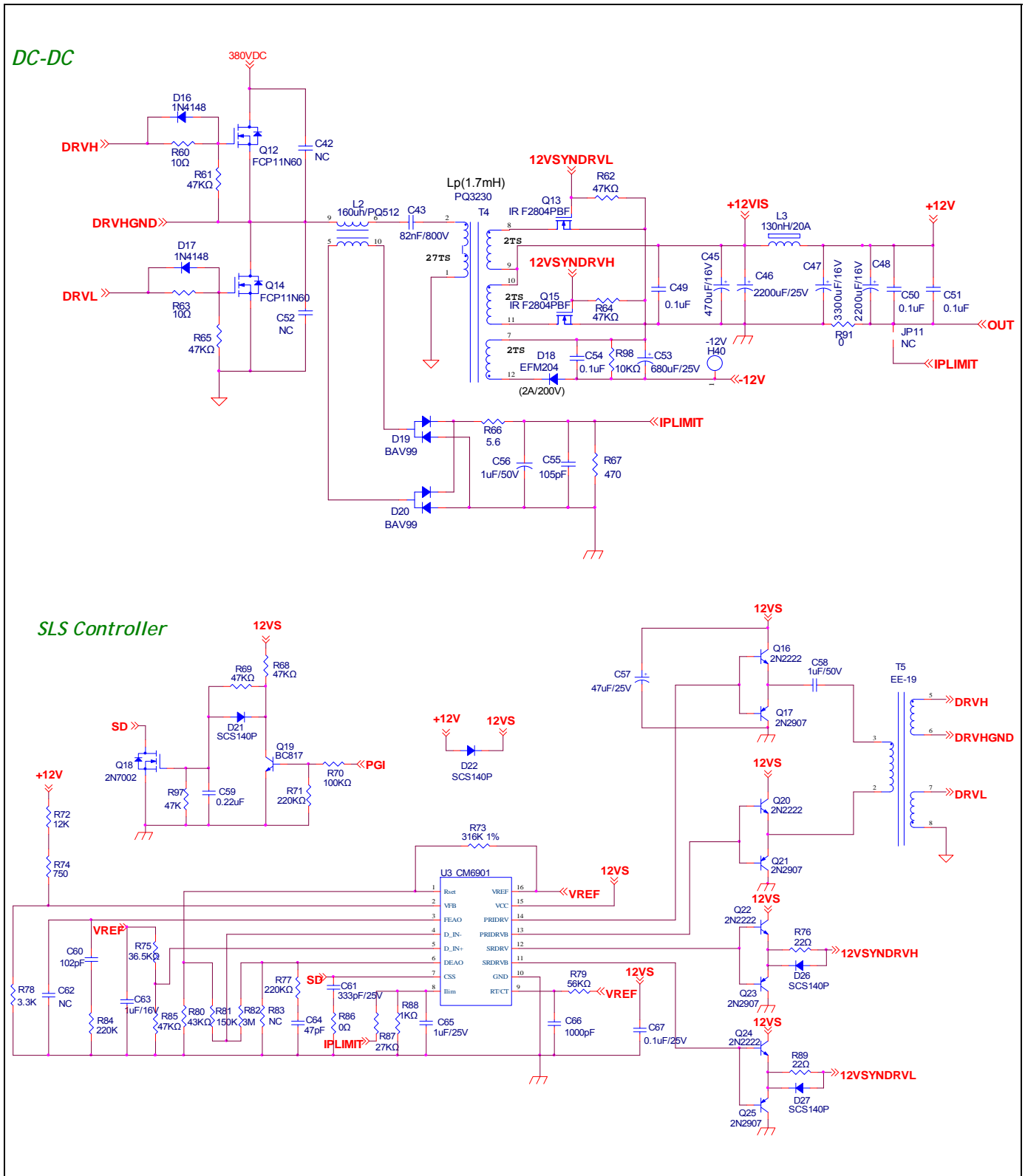
PACKAGE DIMENSION

16-PIN PDIP (P16)
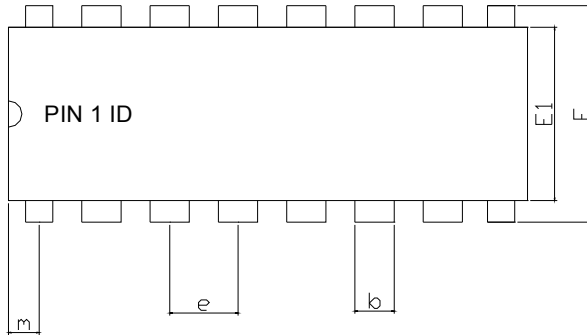
SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	---	---	4.32	---	---	0.170
A1	0.38	---	---	0.015	---	---
b	1.40	---	1.65	0.055	---	0.065
b1	0.40	---	0.56	0.016	---	0.022
C	0.20	---	0.31	0.008	---	0.012
D	18.79	---	19.31	0.740	---	0.760
E	7.49	---	8.26	0.295	---	0.325
E1	6.09	---	6.61	0.240	---	0.260
e	---	2.54	---	---	0.100	---
L	3.18	---	---	0.125	---	---
m	0.50	---	---	0.02	---	---
θ	0°	---	15°	0°	---	15°

16-PIN SOP (S16)

SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHS		
	MIN	NOM	MAX	MIN	NOM	MAX
A1	0.05	---	0.15	0.002	---	0.006
A2	1.40	---	1.55	0.055	---	0.061
b	0.30	---	0.51	0.012	---	0.020
C	0.15	---	0.26	0.006	---	0.010
D	9.80	---	10.06	0.386	---	0.396
E	5.79	---	6.20	0.228	---	0.244
E1	3.76	---	4.01	0.148	---	0.158
e	---	1.27	---	---	0.050	---
L	0.38	---	0.69	0.015	---	0.035
m	0.43	---	0.69	0.017	---	0.027
θ	0°	---	8°	0°	---	8°

EXPOSED PAD DIMENSION : (mm)
PAD SIZE: X=2.3 ; Y=2.8
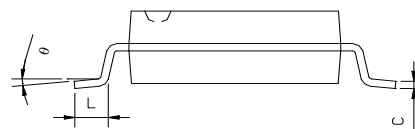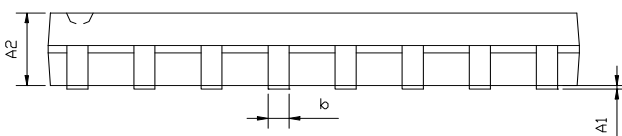
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HsinChu Headquarter	**Sales & Marketing**
5F, No. 11, Park Avenue II, Science-Based Industrial Park, HsinChu City, Taiwan T E L : +886-3-5679979 F A X : +886-3-5679909	21F., No. 96, Sec. 1, Sintai 5th Rd., Sijhih City, Taipei County 22102, Taiwan, R.O.C. T E L : +886-2-2696 3558 F A X : +886-2-2696 3559