MP1016

Full System Precision CCFL Driver

Monolithic Power Systems

General Description

The MP1016 is a Power IC that offers a true complete solution optimized for driving a Cold Cathode Fluorescent Lamp (CCFL). This Power IC converts unregulated DC voltage to a nearly pure sine wave required to ignite and operate the CCFL. Based on proprietary power topology and control techniques (patented), it greatly increases the power conversion efficiency. The MP1016 implements precision **burst mode** dimming without any additional external components. The MP1016 offers four distinct performance advantages:

1. More light for less power
2. Smallest board implementation possible
3. Low EMI emission
4. Low cost off the shelf components

Ordering Information

Part Number *	Package	Temperature
MP1016EF	TSSOP20 with Exposed Paddle	-20°C to +85°C
MP1016EM	TSSOP20	-20°C to +85°C

* For Tape & Reel use suffix – Z (e.g. MP1016EM-Z)

Features

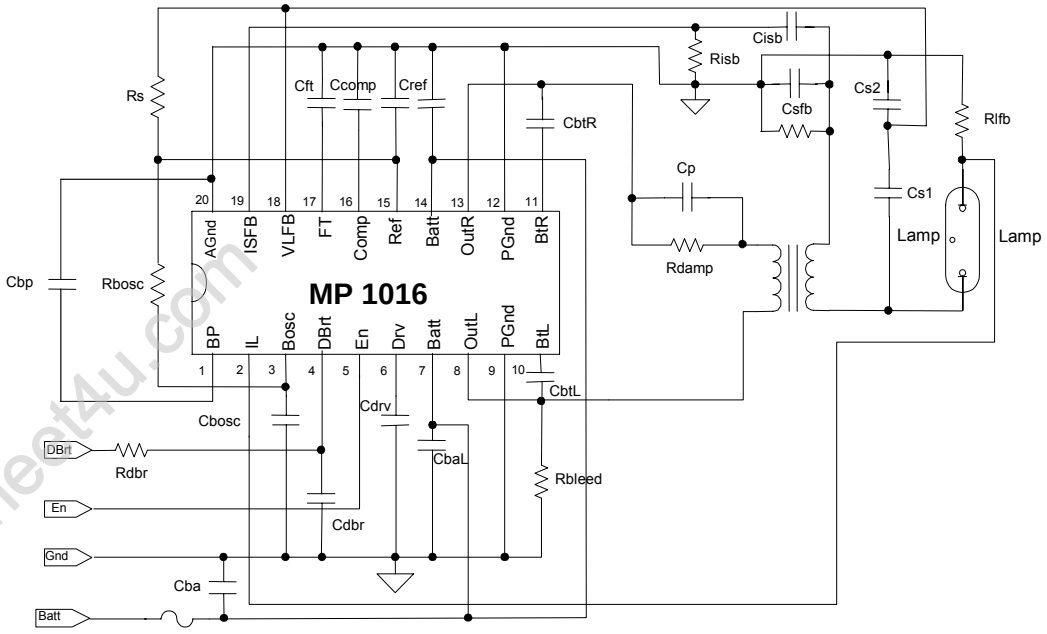
- Built-in Burst Mode Oscillator and Modulator
- Built-in Precision Burst Mode Dimming
- Built-in Open/Short Lamp Protection
- Built-in Dual Mode Fault Timer
- Built-in Soft-on/Soft-off Burst Mode
- Automatic Recovery from ESD Event
- Wide Range 6 to 22V Battery Voltage with Regulated Lamp Current
- Startup at All Voltages and Temperatures Without Additional Components
- Integrated 0.10Ω Power Switches
- Output Short Circuit Protected
- No High Voltage Ballast Capacitor

Applications

LCD Backlight Inverter for:

- Notebook Computers
- Tablet PCs
- Desktop Systems

Typical Application



Absolute Maximum Ratings

Input Voltage (V_{Batt})	25V
Power Dissipation	1.0W
Logic Inputs	-0.3 to 6.8V
IL, ISFB Input Voltages (V_{IL}, V_{ISFB})	± 6V
VLFB Input Voltage (V_{VLFB})	-0.3 to 12V
Junction Temperature	150°C
Lead Temperature (Solder)	260°C
Operating Frequency	150KHz
Storage Temperature	–55 to +150°C

Recommended Operating Conditions

Input Voltage (V_{Batt})	6 to 22V
Digital Brightness Voltage (V_{DBrt})	0 to 1.8V
En Enable Voltage (V_{En})	0 to 5V
Operating Frequency (Typical)	60KHz
Operating Temperature	-20 to +85°C

Thermal Characteristics

	θ_{JA}	θ_{JC}	
Thermal Resistance (TSSOP)	90°	25°	C/W
Thermal Resistance (TSSOPF)	40°	6°	C/W

Electrical Characteristics (Unless otherwise specified V_{Batt}=12V, T_A=25°C)

Parameters	Symbol	Condition	Min	Typ	Max	Units
Reference Voltage						
Output Voltage	V_{Ref}	I_{Ref} = 3mA	4.75	5.0	5.25	V
Reference Current	I_{Ref}		3.0			mA
Line Regulation		6V < V_{Batt} < 22V			30	mV
Load Regulation		0 < I_{Ref} < 3.0mA			30	mV
Battery Supply						
Supply Current (disabled)	I_{Batt}				10	µA
Supply Current (enabled)	I_{Batt}	6V < V_{Batt} < 22V		1.6	2.5	mA
Shutdown Logic						
Fault Timer Threshold	$V_{(TH)FT}$		1.1	1.2	1.3	V
Fault Timer Sink Current		V_{VLFB} > 0, V_{ISFB} < 1.2V		1		µA
Fault Timer Source Current						
Open Lamp		V_{VLFB} = 0, V_{ISFB} =1.2V		1		µA
Secondary Overload		V_{ISFB} = 1.2V		120		µA
Enable Voltage Low	$V_{(L)En}$				0.5	V
Enable Voltage High	$V_{(H)En}$		2.0			V
Output Drivers						
Switch On Resistance	$R_{(ON)OutL,OutR}$	**(Note 1)**		0.12		Ω
Short Circuit Current	I_{SC}			4		A
Ton(min)		V_{Comp}= 0V,V_{Batt} = 22V		435	550	ns
Ton(min)		V_{Comp}= 0V, V_{Batt} = 6V		1750	2100	ns
Brightness Control						
Sense Voltage	V_{IL}		360	379	400	mV
Lamp Current regulation		7V < V_{Batt} < 22V		2	5	%
Burst Oscillator Sink Current	I_{Bosc}			380		µA
Burst Oscillator Peak Voltage	V_{Bosc}		1.70	1.78	1.86	V
Digital Brightness Offset Voltage	$V_{(OS)DBrt}$		-50	5	50	mV
Fault Loop Control						
Open Lamp Threshold	$V_{(TH)VLFB}$			0		V
Secondary Current Threshold	$V_{(TH)ISFB}$			1.2		V
Fault Mode Comp Current	I_{Comp}	V_{VLFB} < 0V, V_{ISFB} > 1.2V		475		µA

Note 1: This parameter is guaranteed by design.
Note 2: It is recommended that power be applied to the MP1016, via the Batt pins (#7 and #14), a minimum of 3ms prior to the Enable pin En (#5) being switched high. DBRT is independent of Power on/off and Enable, therefore the DBRT control signal can be applied before or after the battery and enable signals.

Pin Description

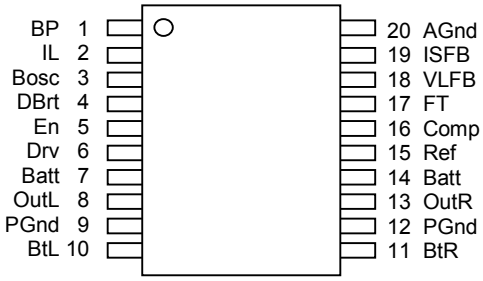


Table 1: Pin Designators

Pin Number	Pin Name	Pin Function
1	BP	Bypass Capacitor
2	IL	Lamp Current Feedback Sense Input
3	Bosc	Burst Oscillator Timing
4	DBrt	Burst Mode Dimming
5	En	Chip Enable. ***Do not float this pin***
6	Drv	Internally Generated MOSFET Gate Drive Supply Voltage (6V)
7	Batt	Power Supply Input
8	OutL	Output to Load (tank circuit)
9	PGnd	Power Ground
10	BtL	Regulated Output Voltage for Bootstrap Capacitor on Phase L
11	BtR	Regulated Output Voltage for Bootstrap Capacitor on Phase R
12	PGnd	Power Ground
13	OutR	Output to Load (tank circuit)
14	Batt	Power Supply Input
15	Ref	Internally Generated Reference Voltage Output (5V)
16	Comp	Loop Compensation Capacitor
17	FT	Fault Timer
18	VLFB	Open Lamp Detect (Lamp Voltage Feedback)
19	ISFB	Shorted Lamp Detect (Secondary Current Feedback)
20	AGnd	Small Signal Ground

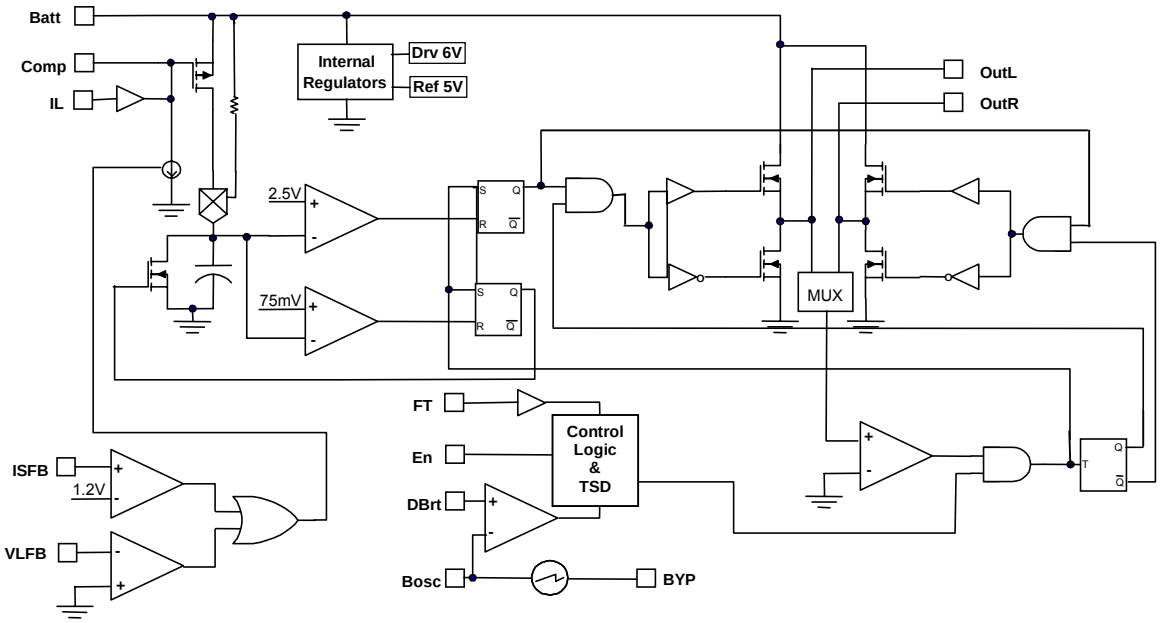


Figure 1: Functional Block Diagram

Feature Description

Brightness Control

The MP1016 can operate in two modes: Burst Mode with a DC input or Burst Mode with an external PWM. The two modes are dependent on the pin connections as per Table 1. Choosing the required burst repetition frequency can be achieved by an RC combination, as defined in component selection. The MP1016 has a soft on and soft off feature to reduce noise, when using burst mode dimming.

Table 2: Function Mode

Function	Pin Connection	
	Pin 4	Pin 3
	DBrt	Bosc
Burst Mode with DC input voltage	0 - 1.8V	Rbosc Cbosc
Burst Mode from external source	PWM	1.5V

Brightness Polarity: Burst: 100% duty cycle is at 2V

Fault Protection

Open Lamp: The VLFB pin (#18) is used to detect whether an open lamp condition has occurred. During normal operation the VLFB pin is typically at 5V DC with an AC swing of +/- 2V. If an open lamp condition exists then the AC voltage on the VLFB line swings below zero volts. When that occurs, the IC regulates the VLFB voltage to 10V p-p and a 1µA current source will inject into the FT pin. If the voltage at the FT pin exceeds 1.2V, then the chip shuts down.

Excessive Secondary Current (Shorted Lamp and UL safety specs): The ISFB pin (#19) is used to detect whether excessive secondary current has occurred. During normal operation the ISFB voltage is a 1V p-p AC signal centered at zero volts D.C. If a fault condition occurs that increases the secondary current, the voltage at ISFB increases above 1.2V. When that occurs, the IC regulates the ISFB voltage to 2.4V p-p and a 120µA current source injects into the FT pin. If the voltage at the FT pin exceeds 1.2V, the IC shuts down.

Fault Timer: The timing for the fault timer depends on the sourcing current, as described in the previous section, and the capacitor on the FT pin. This capacitor programs the time for the voltage to rise before the chip detects a "real" fault. When a fault is triggered, then the internal drive voltage (V_{Drv}) will collapse from 6.2V to 0V. The reference voltage will stay high at 5.0V.

Lamp Startup

The strike voltage of the lamp is always guaranteed at any temperature because the MP1016 uses a resonant topology for switching the outputs. The device continues to switch at the resonant frequency of the tank until the strike voltage is achieved. This eliminates the need for external ramp timing circuits to ensure startup.

Chip Enable

The chip has an on/off function, which is controlled by the En pin (#5). The En drives a Schmitt trigger. The chip turns ON with En=High and OFF with En=Low. It is recommended that power be applied to the MP1016, via the Batt pins (#7 and #14), a minimum of 3ms prior to the En pin (#5) being switched high.

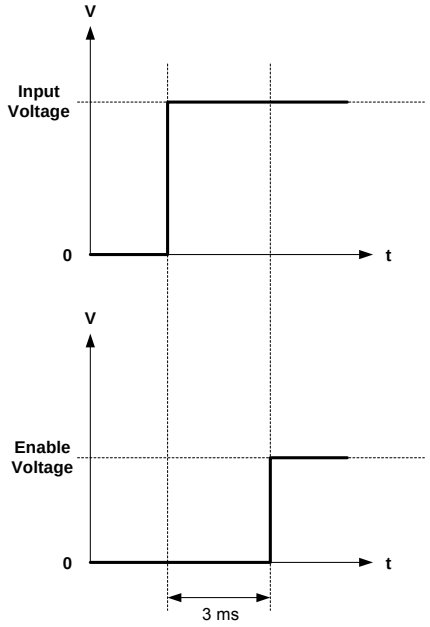


Figure 2: Input Voltage vs. Enable Sequence

Application Information

Pin 19 (ISFB) : Rsfb, Csfb , Risb, Cisb,
(Secondary Short Protection)

The Rsfb and Csfb combination is used for feedback to the ISFB pin to detect excessive secondary current. *These resistors have to be +/- 5% tolerance components*. The value for Rsfb is 1.7KΩ and for Csfb is 82nF. This ensures that the voltage at the Isfb pin is typically 1.0V during steady state operation. The maximum value for Csfb is 93nF to ensure that the chip will meet the UL1950 specification. Risb and Cisb components form a high pass filter.

Pin 18 (VLFB): Cs1, Cs2 and Rs
(Open Lamp protection)

The regulated open lamp voltage is proportional to ratio of the Cs1 and Cs2 capacitances. Cs1 has to be rated at 3KV and is typically between 5 to 22pF. Choose the value of Cs1, typically 15pF, for a specified maximum frequency. The value of Cs2 is

set to achieve the required open lamp voltage detection value, typically 4nF.

$$Cs2 = Cs1 * V(max)rms / 3.5Vrms)$$

The value of Rs is typically 12KΩ (not critical).

Pin 17 (FT): Cft

The Cft cap is used to set the fault timer. This capacitor will determine when the chip reaches the fault threshold value. Choose the capacitor value to set the time out value.

Open Lamp Time

$$Cft\ (nF) = T(\text{open lamp})\ (1\mu A) / 1.2\ V$$

Cft= 820nF, sets the open lamp time-out to 0.98 sec.

Pin 16 (Comp): Ccomp

The compensation capacitor connects between Comp and V_{Ref} and compensates the system. Use a 1.5nf or 2.2nF capacitor. This capacitor should be X7R ceramic dielectric with a voltage rating sufficient for 5V biasing. The value of Ccomp affects the soft-on rise time and soft-off fall time.

Pin 15 (Ref):

Cref is the bypass capacitor for the internal 5.0V supply. It must be placed as close as possible to the pin. A maximum of 100 mils is recommended between the capacitor and the IC. The value of the capacitor is typically 0.47µF

Pin 14, Pin 7 & Pin 9 (Batt & PGnd): CbaR/L, Cba

These capacitors are used as the bypass caps for the battery voltage supply line. These capacitors absorb most of the input switching current of the inverter and require adequate ripple rating. Typically the current rating for Cba is > 500mArms. Typically CbaR and CbaL are 1µF and Cba is equal to 2 caps of 2.2µF.

Pin 13 & Pin 8 (OutL, OutR): Cp1, Rdamp, Rbleed

The primary transformer current flows through Cp1. Its value is typically 1µF and its voltage rating is sufficient for a 5V bias. The capacitor should be ceramic and have a ripple current rating greater than the primary current (typically 0.8Arms).

Rdamp and Rbleed ensure that the bridge outputs are at 0V prior to startup. Typically Rbleed = 4.3KΩ and Rdamp = 1KΩ.

Pin 11 and Pin 10 (BtL and BtR): Cbtl and Cbtr

Cbtl and Cbtr are the reservoir capacitors for the upper switches' gate drive. They should be 10nF, X7R ceramic dielectric and have a voltage rating for 6.6V
biasing.

Pin 6 (Drv): Cdrv

Cdvr bypasses the 6.2V gate supply for the lower switches. Use a 100nF ceramic Y5V or X7R dielectric capacitor.

Pin 5 (En): Enable Pin

The En pin enables and disables the IC. Do not float the En pin.

Pin 4 (DBrt) : Rdbr and Cdbr

The DBrt pin controls the burst brightness. The DC voltage on the DBrt pin controls the burst percentage on the output. Filter the signal for optimal operation. The active range is approximately 0.1V to 1.8V. The value of Rdbr and Cdbr is not critical.

Pin 3 (Bosc): Cbosc and Rbosc

Cbosc and Rbosc sets the burst repetition rate and the minimum Ton. Set T_{min} to achieve the minimum required system brightness. Ensure that T_{min} is long enough that the lamp does not extinguish. These values are determined by the following steps:

1) Select a Minimum Duty Cycle (D_{MIN}). This is the ratio T_{FALL} / (T_{FALL} + T_{RISE}) for the burst oscillator. For example: 10%

2) Determine Rbosc by the formula:

$$Rbosc = (1.68*(1/D_{MIN} – 1) / 0.42 + 4) / 380e\text{-}6$$

3) Select a burst frequency and find T_{TOTAL} where T_{TOTAL} = 1/burst frequency. Then determine Cbosc by the formula:

$$Cbosc = T_{TOTAL}*(1\text{-}D_{MIN})/(0.42*Rbosc)$$

Where:

f_{bosc}= burst frequency rate in Hz
T_{min}= Minimum burst time in sec

Pin 1 & Pin 20: (BP, AGnd) Cbp

Place a 0.1µF bypass capacitor Cbp between pin 1 (BP) and pin 20 (AGnd).

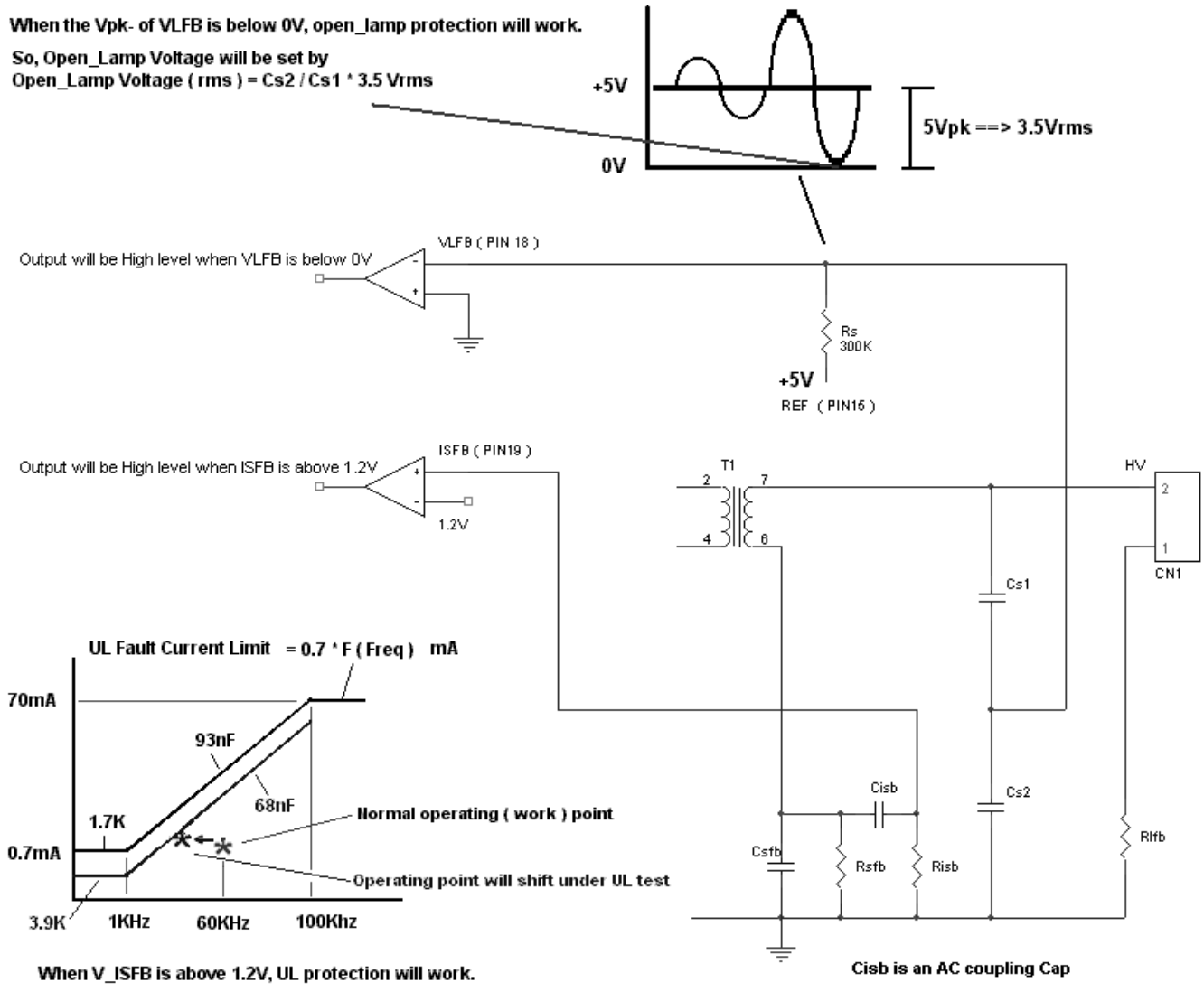


Figure 3: Open_Lamp Voltage Setup and UL Test Protection Application Information

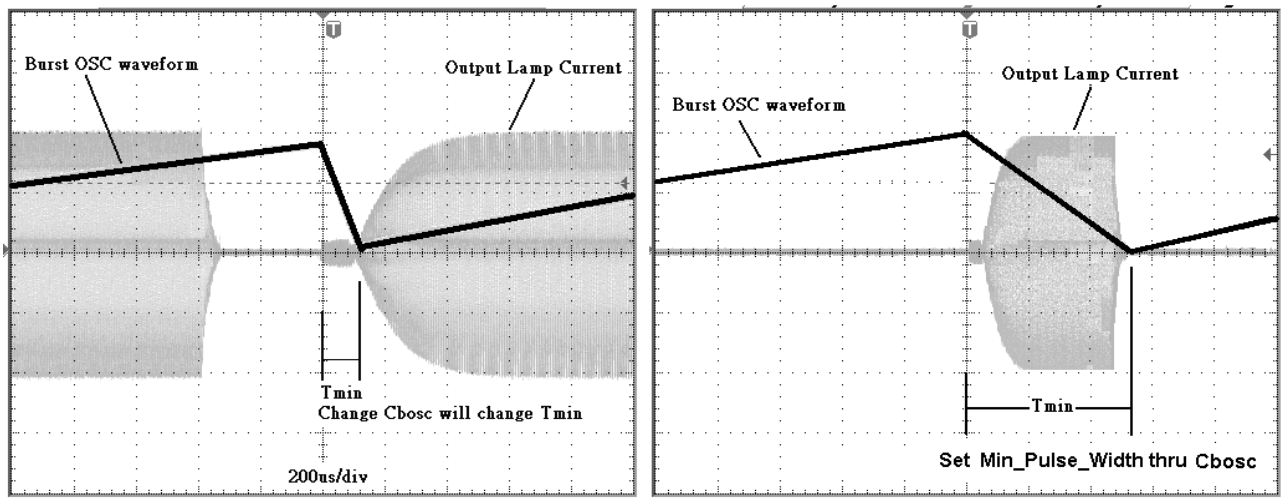


Figure 4: Burst Oscillator Waveform versus Output Lamp Current

Packaging Information

TSSOP20 or TSSOP20F (Exposed Paddle **)

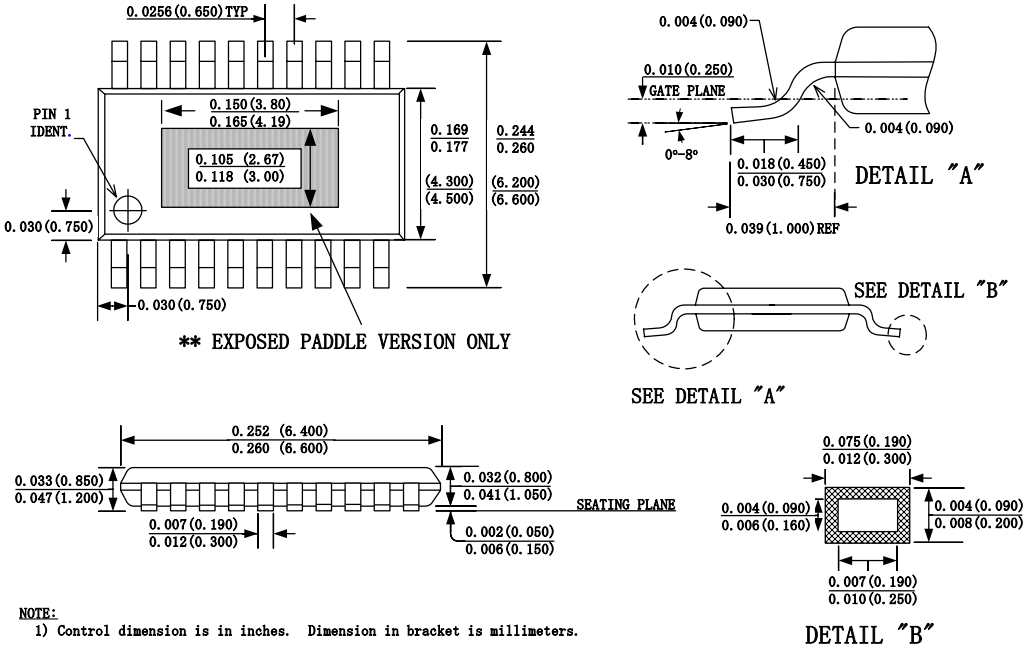


TABLE OF MATERIAL DECLARATION

This table is used for part such as: Leadframe, Die attach material, Gold Wire, Solder, Mold Compound, Coating Material, Marking Ink.

PACKAGE : 20 TSSOP-LF
CUSTOMER :

No.	Part Name	Material Name	Component wt (mg)	Material Content (Element)	CAS Number	Element Wt [A] (%)	Element Wt (mg)	Wt % Of Total Unit Wt	ppm
1	Leadframe 401075	Spot Ag Copper C7025	25.3002	Cu	7440-50-8	96.2	24.3388	34.5841	345840.87
				Ni	7440-02-0	3	0.7590	1.0785	10785.06
				Si	7440-21-3	0.65	0.1645	0.2337	2336.76
				Mg	7439-95-4	0.15	0.0380	0.0539	539.25
			0.6686	Ag [B]	7440-22-4		0.6686	0.9501	9500.64
2	Die attach material	Epoxy Ablebond 84-1 LMISR4	0.7923	Silver (70 - 85)	7440-22-4	77.5	0.6140	0.8725	8725.07
				Epoxy Resin (5 - 25)	Proprietary	15	0.1188	0.1689	1688.72
				Aromatic Amine (1 - 10)	Proprietary	5.5	0.0436	0.0619	619.20
3	Gold Wire	Gold	0.8930	Au	7440-57-5	99.99	0.8929	1.2688	12688.18
				Ag	7440-22-4	1 ppm			0.013
				Cu	7440-50-8	1ppm			0.013
				Fe	7439-89-6	2 ppm			0.025
				Mg	7439-95-4	1 ppm			0.013
				Ca	7440-70-2	1 ppm			0.01
				Be	7440-41-7	5 ppm			0.06
4	Tin Plate	Pure Tin	0.8903	Sn	7440-31-5	100	0.8903	1.2651	12650.68
5	Mold Compound	EME7351LS	38.7961	Silica Fused (80 - 95)	60676-86-0	87.5	33.9466	48.2362	482362.33
				Epoxy resin (3 - 8)	-	5.5	2.1338	3.0320	30319.92
				Phenol resin (3 - 8)	-	5.5	2.1338	3.0320	30319.92
				Antimony trioxide (0.2 - 1.5)	1309-64-4	0.85	0.3298	0.4686	4685.81
6	Die	Silicon Chip	3.0352						
	Total unit weight =		70.3757						

Note:
(A) Element Wt Composition is derived from MSDS and/or material C of C from Vendors
(B) Wt of silver spotted on leadframe is estimated.
(C) Component Weight is based on assembly of generic parts.