Intelligent Digital Multi-Mode Flyback Controller Integrated with High Voltage MOSFET HYC1603C

Revision 0.4
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Contents

Intelligent Multi-Mode Flyback Controller Integrated with High Voltage MOSFET

Features

- Intelligent Digital Multi-Mode Control
- Peak Current Mode Control at Burst-Mode /PFM/DCM/CCM
- Continuous-Conduction Mode (CCM) under heavy load
- Integrated with High Voltage MOSFET
- Over-load Period up to 56mS
- Switching Frequency Dithering to Improve EMI
- Adaptive MOSFET Gate Drive to Balance Switching Loss and EMI
- Rich Protection Features
  - VCC OVP
  - Transformer Saturation Protection
  - Output Over Load Protection
  - Current Sensor Resistor Short Protection
  - Over Temperature Protection
- Power Consumption < 75mW
- Low Start-Up Current (<3μA)

Description

HYC1603C is an intelligent digital multi-mode Flyback controller integrated with 650V MOSFET. The newly developed architecture is inherent features to meet regulatory requirements from around the world.

HYC1603C integrates rich protections and features such as, slope compensation, VCC over voltage protection, transformer short protection, sense resistor short protection over-temperature protection.

HYC1603C is available with the SOP8 package.

Applications

- Offline Charger
- Programmable travel adapter
- USB PD Charger
- TV / Monitor Standby Power
- Notebook Adapter

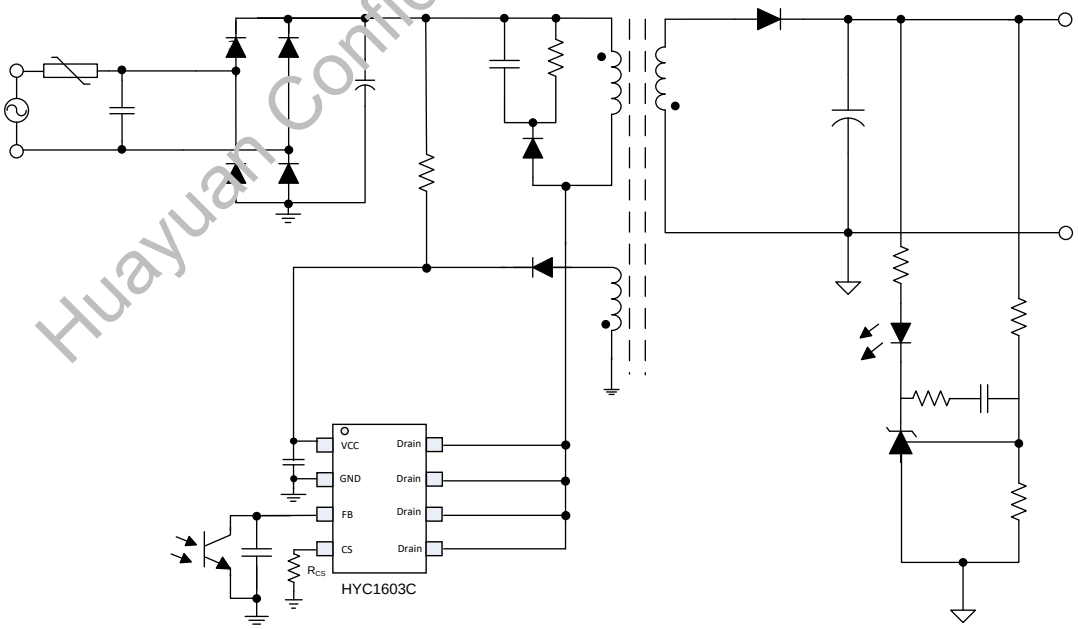
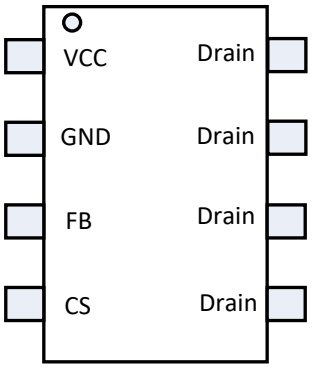


Fig 1.Typical Application Circuit

HYC1603C Pin Configuration

(TOP VIEW)



SOP8

HYC1603C Functional Pin Definitions

No.	Name	Description
1	**VCC**	VCC is the supply of IC. The controller is enabled when VCC voltage reaches V_{CC_ON} and disabled when VCC drops below V_{CC_UVLO}.
2	**GND**	Ground.
3	**FB**	Voltage loop feedback input. Connect an opto-coupler from the FB pin.
4	**CS**	Current sensing pin. Connect pin CS with the external current sensing resistor with PCB trace as short as possible. Another side lead of sensing resistor connects with GND with PCB trace as short as possible.
5, 6, 7, 8	**Drain**	Drain of internal high voltage MOSFET. Connect pin Drain to the flyback transformer winding terminal lead with PCB trace as short as possible.

IC Functional Diagram

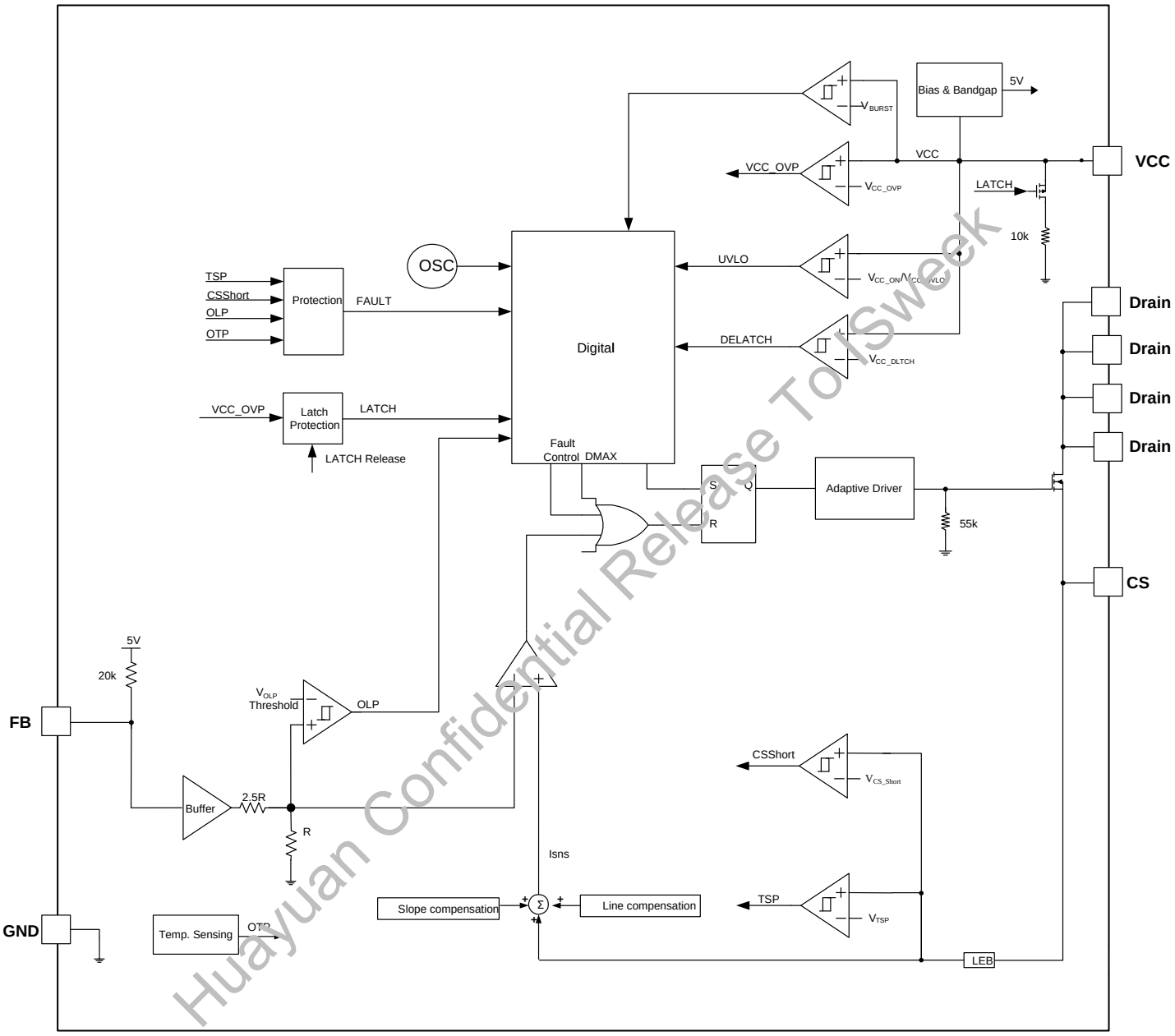


Fig 2. HYC1603C Simplified Functional Block Diagram

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Min.	Max.	Unit
VCC	VCC	-0.3	40.0	V
Drain	Drain	-0.3	725	V
CS, FB	CS, FB	-0.3	6.5	V
T_{jct}	Operating junction temperature	–40	150	℃
T_{stg}	Storage temperature	–40	150	℃

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device.

ESD Ratings

Item	Description	Value	Unit
Electrostatic Discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001	±4000	V
	Charged device model (CDM), per JEDEC specification JESD22-C101	±1000	V

Thermal Specification

Item	Value	Unit
RθJA Junction-to-ambient thermal resistance	132	℃/W
RθJC(top) Junction-to-case (top) thermal resistance	39	℃/W

Note 2: The maximum allowable power dissipation is a function of the maximum junction temperature T_J(MAX), the junction-to-ambient thermal resistance $R_{\theta JA}$, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D(MAX)=(T_J(MAX)- T_A)/$R_{\theta JA}$. Exceeding the maximum allowable power dissipation produces an excessive die temperature, causing the regulator to go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.

Electrical Characteristics

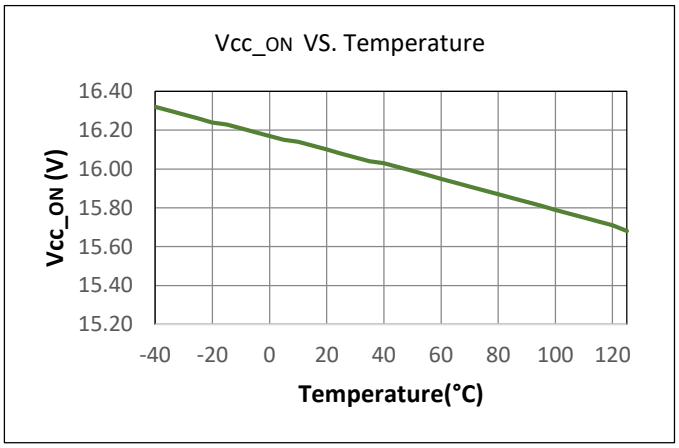
VCC = 12V, T_{AMB}= 25℃, unless otherwise specified.

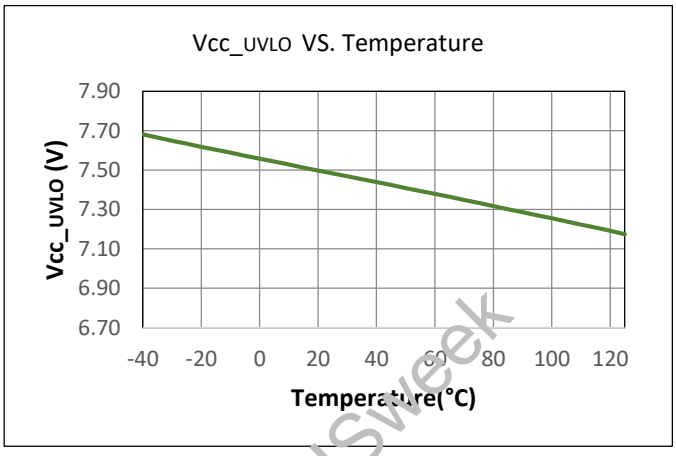
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
VCC Section						
V_{CC}	Bias Power Supply				39.5	V
V_{CC_OVP}	VCC OVP Threshold		36	38	39.5	V
V_{CC_ON}	Power-On Threshold	V_{CC} Rising	15	16.5	17.5	V
V_{CC_UVLO}	UVLO Threshold	V_{CC} Falling	6.7	7.50	8.3	V
V_{CC_DLTCH}	Delatch Threshold	V_{CC} Falling		4.50		V
I_{CC_NGT}	Quiescent Current	DRV Pin Open			700	μA
I_{CC_WGT}	Operating Current with Load	fs=65kHz, 1nF Load on DRV Pin		2		mA
I_{CC_ST}	Start_up Current	V_{CC}< V_{CC_ON} During Start_up			3	μA
CS Section						
V_{CS_Limit}	Current Limit		0.76	0.80	0.84	V
V_{CS_Short}	Current Sensing Short Threshold		0.06	0.10	0.14	V
V_{TSP_REF}	Transformer Saturation Protection Threshold		1.425	1.50	1.575	V
LEB	Leading Edge Blanking Time			300		ns
FB Section						
V_{FB}	FB Pin Pull-Up Voltage	FB Pin Open		5.0	5.5	V
V_{FB_OLP}	Open Loop Protection Reference		4.0	4.2	4.4	V
V_{OLP_HYS}	Open Loop Protection Hysteresis			40		mV

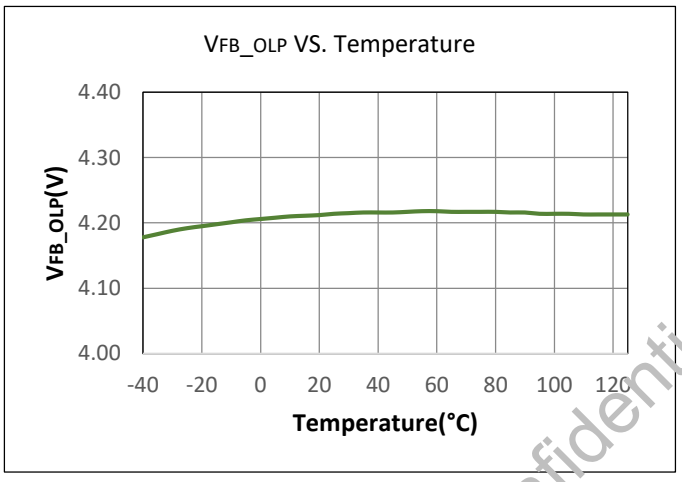
V_{BURST}	Burst Mode Entry Threshold		1.15	1.2	1.25	V
V_{BURST_HYS}	Burst Mode Threshold Hysteresis			0.1		V
R_{FB}	FB Pin Pull_up Resistance		14	20	26	kΩ
Drain Section						
V_D	Operating Drain Voltage	V_{GS}=0, I_D=100uA	650			V
I_D	Continuous Drain Current @25℃				4.0	A
	Continuous Drain Current @100℃				2.5	A
R_{DS_ON}	Drain-source On-state Resistance		0.6		2.2	Ω
PWM Section						
f_{SW}	Base Switching Frequency			65		kHz
Δf	Frequency Jittering Range			±5%		
OTP Section						
T_{OTP}	Over Temp Protection	(Note 3)	140			℃
T_{OTP_Hys}	OTP Hysteresis	(Note 3)		50		℃

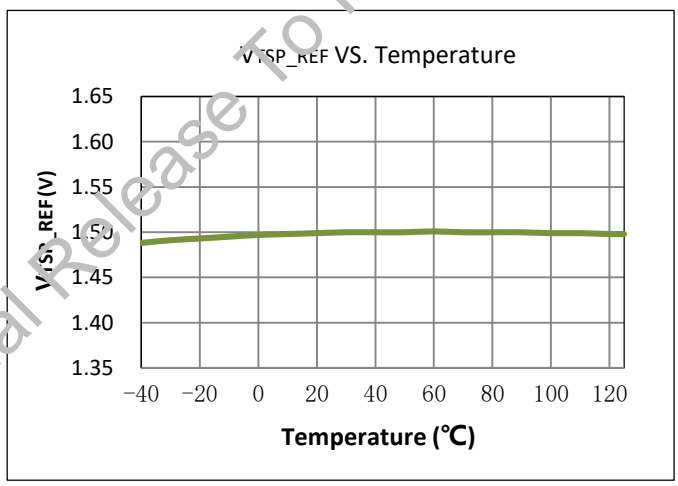
Note 3. Guaranteed by design.

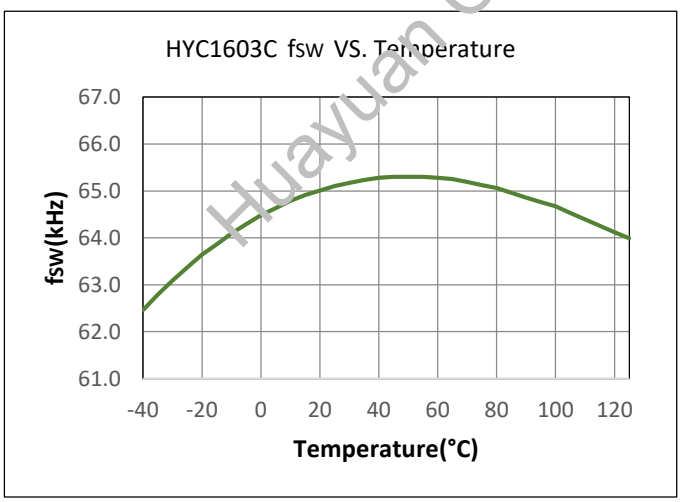
Typical Characteristics











Detailed Function Description

HYC1603C is a high performance, high integration, secondary side feedback AC/DC Flyback PWM controller integrated with high voltage MOSFET. It implements the advanced digital control scheme to achieve high efficiency, better EMI and high performance at low total system cost. HYC1603C operates under peak current control. It operates CCM under heavy load condition in order to improve efficiency and reduce bulk capacitance.

Multi-Mode

HYC1603C is a digital multi-mode PWM controller. It operates Burst/PWM/PFM/DCM/CCM control alternately based on feedback voltage, as shown in 0. HYC1603C operates with peak current control under both high line and low line condition. Under heavy load condition, it operates under CCM with switching frequency at 65kHz. As the load decreases, it enters into DCM operation. The switching frequency is decreased from 65kHz to 25 kHz following the frequency profile. At light load, the controller operates under the burst mode.

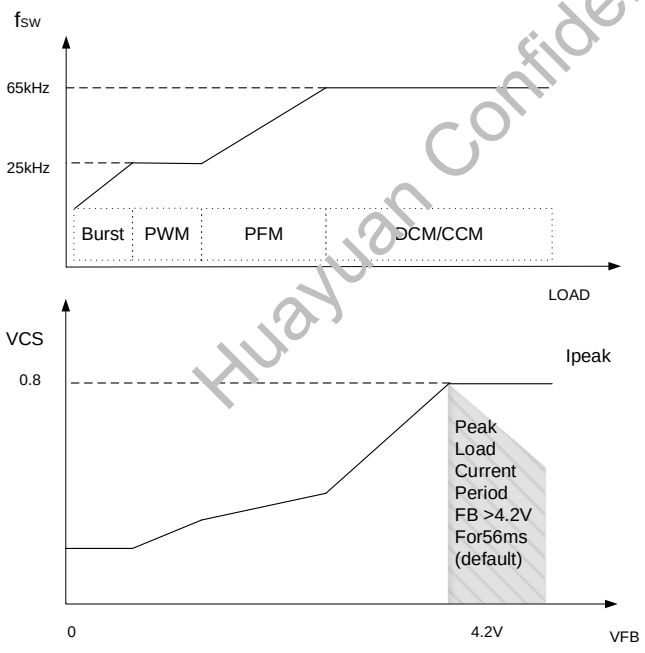


Fig 3. Load Profile

Start-up

The start-up time specification of adapter is generally less than 3 seconds. The V_{CC} voltage of the HYC1603C generated from start-up resistors and the bias winding after start-up. HYC1603C consumes less than 3μA current (I_{CC_ST}) till V_{CC} reaches the threshold of V_{CC_ON}. It enables all internal block bias based on power sequence and MOSFET driver. As the output voltage is ramping up, the bias winding voltage is going up accordingly. The V_{CC} voltage is going down from V_{CC_ON} once the normal operation begins till the bias voltage takes over to charge the V_{CC} capacitor.

Soft Start

After V_{CC} reaches V_{CC_ON} threshold, HYC1603C begins the soft start. The HYC1603C soft start threshold and timing is show in Fig 4.

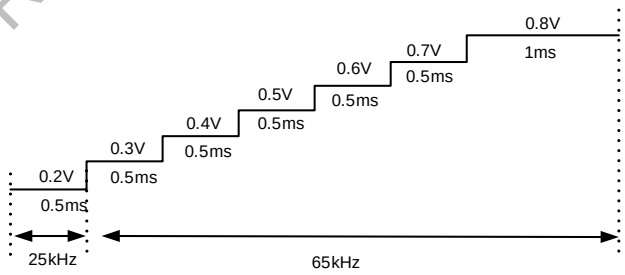


Fig 4. Soft-Start with 4ms Timing and Threshold

In HYC1603C, the soft start is implemented as a predetermined peak current control within 4ms. For first 0.5ms, the switching frequency is 25kHz and the predetermined peak current control voltage command across sensing resistor is 0.2V in order to achieve the transformer demagnetizing. The next level is the peak current control voltage as 0.3V for 0.5ms under 65kHz switching frequency. The following peak current control voltage step is increasing 0.1V for every 0.5ms to 0.8V following the incremental pattern. The duration of 0.8V step is 1ms instead of 0.5ms. During the soft start, the feedback voltage and the peak current control are decoupling. The soft start will be terminated once the feedback voltage is lower than the predetermined peak current level.

Protections

HYC1603C achieves various protections as listed in below table, including VCC OVP, RCS Short Protection, Transformer-Short Protection (TSP), Over Load Protection (OLP), Over-Temperature Protection (OTP).

Protection	**Response**
VCC OVP	Latch
R_{CS} Short Protection	Auto restart
Transformer Saturation Protection TSP	Auto restart
Over Load Protection	Auto restart
On Chip OTP	Auto restart

VCC OVP

When VCC pin voltage reaches threshold, V_{CC_OVP}, HYC1603C performs VCC OVP protection function. VCC_OVP is a latch type protection. If the voltage level is over the OVP threshold, it shuts down and enters into the latch mode.

The latch is released with AC power off and V_{CC} voltage discharge below V_{CC_DLTCH}.

RCS Short Protection

If R_{CS} is shorted, the system might damage. To prevent the damage, HYC1603C implements the scheme to detects R_{CS} short and shut down the PWM.

Transformer Saturation Protection (TSP)

TSP is performed when there is a transformer saturation. It could happen when both secondary rectifier and primary MOSFET turns on overlap. It is implemented through the comparator with V_{TSP_REF} threshold. The current slew rate is very high under the transformer saturation as only leakage inductance limits the transformer current rate. If current sensing voltage signal triggers TSP threshold after LEB. IC performs TSP to shut down the PWM signal once the TSP threshold is triggered. HYC1603C keeps as off state till next power reset event.

Over Load Protection (OLP)

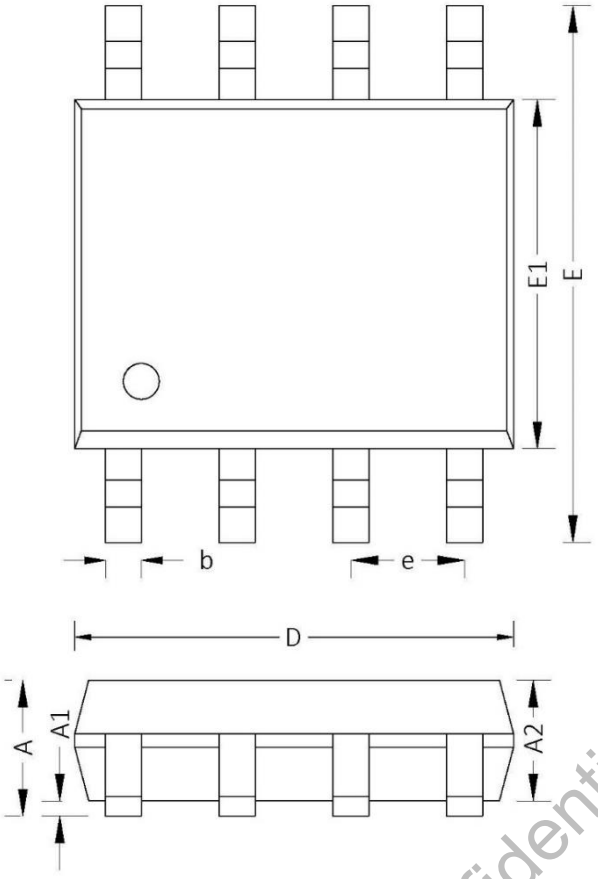
The maximum current sense voltage is limited at V_{CS_LIMIT}. When the current sense voltage reaches at V_{CS_LIMIT}, and the switching frequency also reaches the f_{SW}, the maximum output power is limited. If the output load keeps increasing, the output voltage keeps dropping and the feedback voltage V_{FB} keeps increasing. When the V_{FB} reaches the V_{FB_OLP}, HYC1603C counts to 56ms and then shuts down. The OLP function is enable after the soft-start.

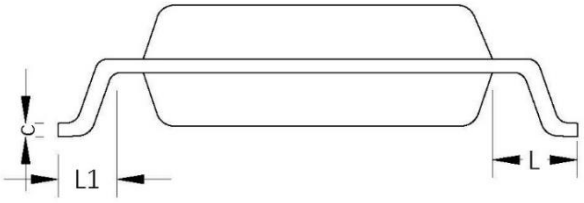
When the feedback circuit such as opto-coupler opens, V_{FB} pin is also pulled up to the internal 5V reference. HYC1603C also shuts down after 56ms.

Over Temperature Protection (OTP)

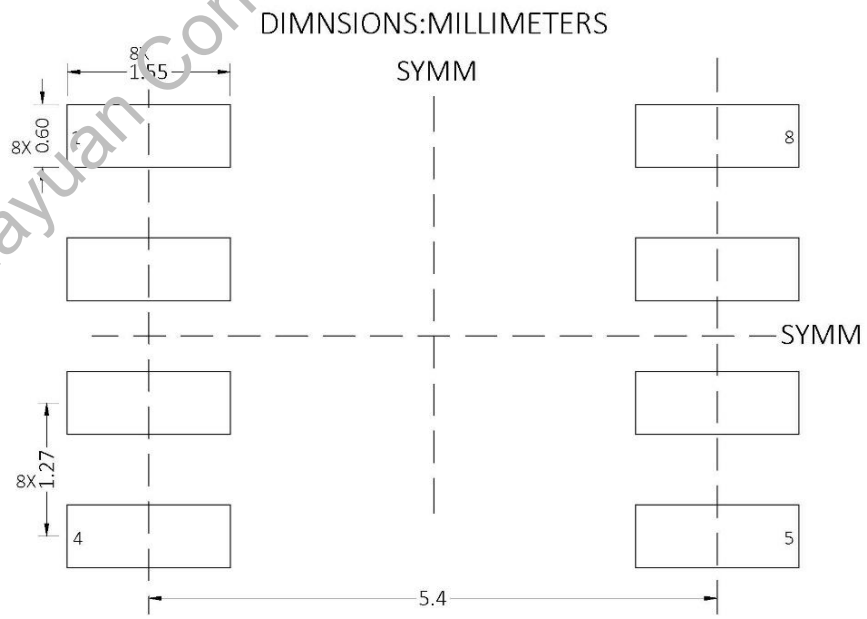
The internal die temperature is sensed to prevent from over-heat. The temperature reference for OTP is defined at 145 ℃ typical with 50 ℃ hysteresis. When OTP fault signal is detected, the OTP is activated to shut down PWM. HYC1603C try to power-up until the die temperature drops down to 95 ℃.

SOP8 Package





SOP8 COMMON DIMENSIOS(millimeter)			
SYMBOL	MIN	NOM	MAX
A	-	-	1.75
A1	0.10	-	0.25
A2	1.25	-	1.65
b	0.32	-	0.50
c	0.15	0.20	0.25
D	4.70	4.90	5.00
E	5.80	6.00	6.20
E1	3.70	3.90	4.00
e	1.27REF		
L1	0.40	-	0.80
L	1.00	1.05	1.10



Recommended Land Pattern

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