

May 2008

SG6846C Highly Integrated Green-Mode PWM Controller

Features

- Low Start-up Current: 8µA
- Low Operating Current: 3.7mA
- Peak-current Mode Operation with Cycle-by-cycle Current Limiting
- PWM Frequency Continuously Decreasing with Burst Mode at Light Loads
- V_{DD} Over-Voltage Protection (OVP)
- AC Input Brownout Protection with Hysteresis
- Constant Output Power Limit (Full AC Input Range)
- Internal Latch Circuit for OVP, OTP, and OCP
- Two-level OCP Delay: 110ms
- Programmable PWM Frequency with Frequency Hopping
- OCP Threshold is Half Peak Current Limit
- Feedback Open-loop Protection with 110ms Delay
- Soft Start-up Time: 5ms

Applications

General-purpose switch mode power supplies and flyback power converters, including:

- Power Adapters
- Open-frame SMPS
- SMPS with Surge-current Output, such as for Printers, Scanners, Motor Drivers

Description

A highly integrated PWM controller, SG6846C provides several features to enhance the performance of flyback converters. To minimize standby power consumption, a proprietary green-mode function provides off-time modulation to continuously decrease the switching frequency under light-load conditions. Under zero-load conditions, the power supply enters burst-mode, which completely shuts off PWM output. Output restarts just before the supply voltage drops below the UVLO lower limit. This green-mode function enables power supplies to meet international power conservation requirements.

The SG6846C is designed for SMPS with surge-current output, incorporated with a two-level OCP function. Besides the cycle-by-cycle current limiting, if the switching current is higher than OCP threshold and lasts for 110ms, SG6846C shuts down immediately. SG6846C also integrates frequency-hopping function internally, which helps reduce EMI emission of a power supply with minimum line filters. The built-in synchronized slope compensation provides proprietary internal compensation for constant output power limit over a universal AC input range. The gate output is clamped at 18V to protect the external MOSFET from over-voltage damage.

Other protection functions include AC input brownout protection with hysteresis and V_{DD} over-voltage protection. For over-temperature protection, an external NTC thermistor can be applied to sense the ambient temperature. When OCP, V_{DD} OVP, or OTP are activated, an internal latch circuit latches off the controller. The latch resets when V_{DD} supply is removed.

SG6846C is available in 8-pin SOP and DIP packages.

Ordering Information

Part Number	Operating Temperature Range	OCP Latch	Package
SG6846CLSZ	-20 to +85°C	Yes	8-Pin Small Outline Package (SOP)
SG6846CLDZ	-20 to +85°C	Yes	8-Pin Dual Inline Package (DIP)



All standard Fairchild Semiconductor products are RoHS compliant and many are also "GREEN" or going green. For Fairchild's definition of "green" please visit: http://www.fairchildsemi.com/company/green/rohs_green.html.

Typical Application

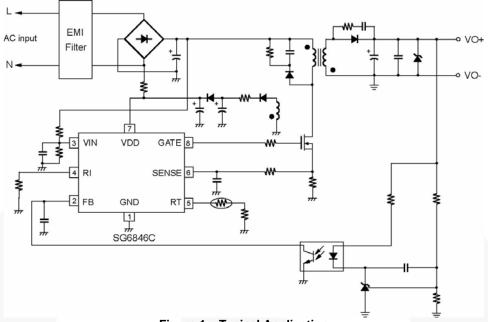
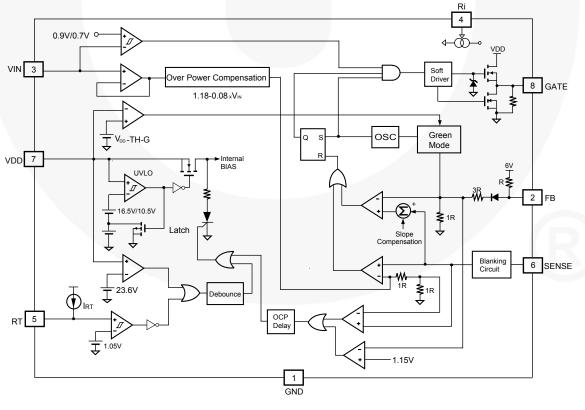


Figure 1. Typical Application

Block Diagram



Marking Information

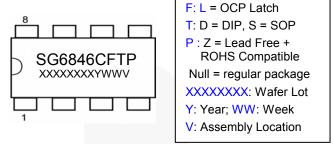


Figure 3. Top Mark

Pin Configuration

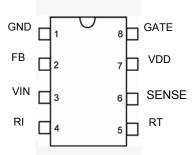


Figure 4. Pin Configuration

Pin Definitions

Pin#	Name	Function	Description			
1	GND	Ground	Ground.			
2	FB	Feedback	The signal from the external compensation circuit is fed into this pin. The PWM duty cycle is determined in response to the signal from this pin and the current-sense signal from pin 6.			
3	VIN	Line-voltage Detection	Line-voltage detection, used for brownout protection with hysteresis. Constant output power limit over universal AC input range is also achieved using this pin. Add a low-pass filter to filter out line ripple on bulk capacitor.			
4	RI	Reference Setting	A resistor from the RI pin to ground generates a reference current source that determines the switching frequency. Increasing the resistance reduces the switching frequency. Using a $26k\Omega$ resistor results in a $65kHz$ switching frequency.			
5	RT	Temperature Detection	For over-temperature protection, an external NTC thermistor is connected from this pin to the GND pin. The impedance of the NTC decreases at high temperatures. Once the voltage of the RT pin drops below a threshold, PWM output is disabled.			
6	SENSE	Current sense. The sensed voltage is used for peak-current-mode control cycle-by-cycle current limiting. If the switching current is higher than OCP threshold and lasts for 110ms, SG6846C turns off immediately. This two-lOCP feature is especially suitable for SMPS with surge current output.				
7	VDD	Power Supply	Power supply. If an open-circuit failure occurs in the feedback loop, the internal protection circuit disables PWM output as long as V_{DD} exceeds a threshold.			
8	GATE	Driver Output	The totem-pole output driver for the power MOSFET. It is internally clamped below 18V.			

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. All voltage values, except differential voltages, are given with respect to GND pin.

Symbol	Parameter	Parameter			Unit
V _{DD}	Supply Voltage			25	V
V _L	Input Voltage to FB, SENSE, VIN, RT,RI P	in	-0.3	7.0	V
D	Power Dissipation at T _A <50°C	DIP		800	mW
P _D	Power Dissipation at 1 _A <50 C	SOP		400	IIIVV
	Thermal Besistance (Juneties to Case)	DIP		67.1	°C/W
Θις	Thermal Resistance (Junction-to-Case)	SOP SOP		54.4	C/VV
TJ	Operating Junction Temperature		-40	+150	°C
T _{STG}	Storage Temperature Range		-65	+150	°C
TL	Lead Temperature, Wave Soldering, 10 Se		+260	°C	
ESD	Electrostatic Discharge Canability	Human Body Model		5.5	kV
ESD	Electrostatic Discharge Capability	Machine Model		250	V

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Min.	Max.	Unit
T _A	Operating Ambient Temperature	-20	+85	°C

Electrical Characteristics

 V_{DD} = 15V, T_A = 25°C, unless noted.

Symbol	Parameter	Test Condition	Min.	Тур.	Max.	Unit
V _{DD} Section	1	•				
$V_{DD\text{-}OP}$	Continuously Operating Voltage				20	V
$V_{DD\text{-}ON}$	Turn-on Threshold Voltage		15.5	16.5	17.5	V
V_{DD-OFF}	Turn-off Voltage		9.5	10.5	11.5	V
$V_{DD\text{-}LH}$	Threshold Voltage for Latch-off Release		3	4	5	V
I _{DD-ST}	Start-up Current	V _{DD-ON} – 0.16V		8	30	μΑ
I _{DD-OP}	Operating Supply Current	GATE Open		3.7	5.0	mA
$V_{\text{DD-OVP}}$	V _{DD} Over-Voltage Protection (Latch off)		22.6	23.6	24.6	V
t _{D-VDDOVP}	V _{DD} OVP Debounce Time	$R_i = 26k\Omega$	60	100	140	μs
I _{DD-OVP}	V _{DD} OVP Latch-off Holding Current	V _{DD} = 5V	30	50	70	μA
V _{IN} Section			•	•		
V _{IN-OFF}	PWM Turn-off Threshold Voltage		0.65	0.70	0.75	V
$V_{\text{IN-ON}}$	PWM Turn-on Threshold Voltage		V _{IN-} OFF+0.1	V _{IN-} OFF+0.2	V _{IN-} OFF+0.2 2	V
Feedback I	nput Section					
A_V	Input-Voltage to Current-Sense Attenuation		1/3.5	1/4.0	1/4.5	V/V
Z _{FB}	Input Impedance		4.0	5.5	7.0	kΩ
V_{FBO}	FB Pin Open Voltage			6.2		V
V_{FB-OLP}	Threshold Voltage of Open-loop Protection		4.7	5.2	5.7	V
t _{D-OLP}	Open-loop Protection Delay Time	$R_1 = 26k\Omega$	100	110	120	ms
Current Se	nse Section					
Z _{SENSE}	Input Impedance			12		kΩ
t _{PD}	Delay to Output		1	100	250	ns
t _{LEB}	Leading-edge Blanking Time		270	360		ns
V _{SLOPE}	Slope Compensation	Duty = DCY _{MAX}	0.30	0.33	0.36	V
V _{STH1V}	Threshold Voltage for Current Limit	V _{IN} = 1V	1.07	1.10	1.13	V
V _{STH3V}	Threshold Voltage for Current Limit	V _{IN} = 3V	0.91	0.94	0.97	V
V _{STH1V-1/2}	OCP Threshold Voltage for Current Limit	V _{IN} = 1V	0.52	0.55	0.58	V
V _{STH3V-1/2}	OCP Threshold Voltage for Current Limit	V _{IN} = 3V	0.44	0.47	0.50	V
t _{D-OCP}	Delay Time for Over-Current Protection	$R_1 = 26k\Omega$	100	110	120	ms
t _{SS-65KHz}	Pariod During Start up Time	$R_1 = 26k\Omega$	4.5	5.0	5.5	ms
t _{SS-130KHz}	Period During Start up Time	$R_I = 13k\Omega$	2.25	2.50	2.75	ms

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Electrical Characteristics (Continued)

 V_{DD} = 15V, T_A = 25°C, unless noted.

Symbol	Parameter			Test Condition	Min.	Тур.	Max.	Unit		
Oscillator Section										
fosc	Normal PWM Frequer	ncy	Center Frequency	$R_{I} = 26k\Omega, V_{FB} > V_{N}$	62	65	68	kHz		
	·	,	Jitter Range	7	±3.7	±4.2	±4.7			
f _{OSC,MAX}	Maximum PWM		Center Frequency	$R_{I} = 13k\Omega, V_{FB} > V_{N}$	124	130	136	kHz		
,	Frequency		Jitter Range		±7.4	±8.4	±9.4			
f _{OSC,MIN}	Minimum PWM Frequency Fre		Center Frequency	$R_{I} = 36k\Omega, V_{FB} > V_{N}$	44.8	47.0	49.2	kHz		
			Jitter Range		±2.54	±2.90	±3.26			
t _{hop-1}	Jitter Period			$R_I = 26k\Omega, V_{FB} \ge V_N$	3.9	4.4	4.9	ms		
t _{hop-3}	Jitter period			$R_I = 26k\Omega$, $V_{FB} = V_G$	10.2	11.5	12.8	ms		
f _{OSC-G}	Green-mode Minimum	Fred	luency	$R_1 = 26k\Omega$	18.0	22.5	25.0	kHz		
V	FB Pin Frequency	Pin,	FB voltage	$R_{I} = 26k\Omega$, $V_{FB} = V_{N}$	1.9	2.1	2.3	V		
$V_{\text{FB-N}}$	Reduction Threshold	Jittei	Range	- 20K12, VFB - VN	3.7	4.2	4.7	KHz		
V_{FB-G}	ED Voltage at f	Pin,	FB voltage	$R_I = 26k\Omega$, $V_{FB} = V_G$	1.4	1.6	1.8	V		
V FB-G	FB Voltage at f _{OSC-G}	Jittei	Range	- 20K12, V _{FB} - V _G	1.27	1.45	1.62	KHz		
S _G	Slope for Green-Mode	e Modulation		$R_i = 26k\Omega$		85		Hz/mV		
f_{DV}	Frequency Variation v	s. V _{DI}	Deviation	V _{DD} = 11.5V to 20V			5	%		
f _{DT}	Frequency Variation v Deviation	s. Tei	mperature	T _A = -30 to 85°C		1.5	5.0	%		

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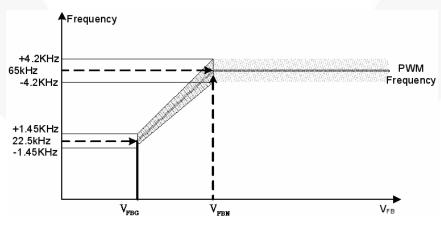


Figure 5. PWM Frequency

Electrical Characteristics (Continued)

 V_{DD} = 15V, T_A = 25°C, unless noted.

Symbol	Parameter	Test Condition	Min.	Тур.	Max.	Unit
PWM Outpo	ut Section					
DCY _{MAX}	Maximum Duty Cycle		80	85	90	%
V _{OL}	Output Voltage Low	$V_{DD} = 15V, I_{O} = 50mA$			1.5	V
V _{OH}	Output Voltage High	$V_{DD} = 12V, I_{O} = 50mA$	8			V
t _R	Rising Time	GATE = 1nF		350		ns
t _F	Falling Time	GATE = 1nF		50		ns
V_{CLAMP}	Gate Output Clamping Voltage	V _{DD} = 20V			18	V
Over-Temp	erature Protection (OTP) Section ⁽¹⁾					
I _{RT}	Output Current of RT Pin	$R_I = 26k\Omega$	64	70	76	μΑ
V _{RTTH}	Threshold Voltage for OTP		1.00	1.05	1.10	V
t _{DOTP-LATCH}	Over-Temperature Latch-off Debounce	$R_1 = 26k\Omega$		100		μs
R _{RT-OFF}	Equivalent Impedance of RT for OTP ⁽¹⁾	$R_l = 26k\Omega$	14	15	16	kΩ
R _I Section						
RI _{NOR}	R _I Operating Range		13		36	kΩ
RI _{MAX}	Maximum R _I Value for Protection		10			ΜΩ
RI _{MIN}	Minimum R _I Value for Protection				6	kΩ

Note:

1. The relationship between R_{RT-OFF} and R_I is: $R_{RT-OFF} = V_{OTP-LATCH-OFF} / I_{RT} = V_{RT} / (70 \mu A \times 26 / R_I (K\Omega))$ (1)

Typical Performance Characteristics

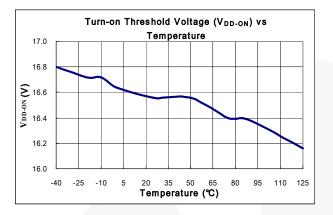


Figure 6. Turn-on Threshold Voltage ($V_{DD\text{-}ON}$) vs. Temperature

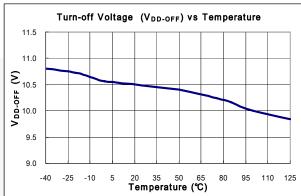


Figure 7. Turn-off Threshold Voltage (V_{DD-OFF}) vs. Temperature

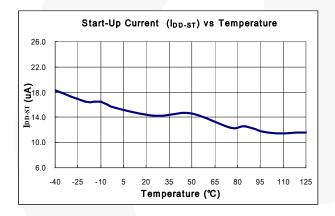


Figure 8. Start-up Current (I_{DD-ST}) vs. Temperature

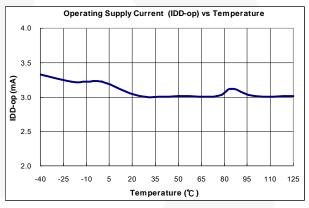


Figure 9. Operating Supply Current (I_{DD-OP}) vs. Temperature

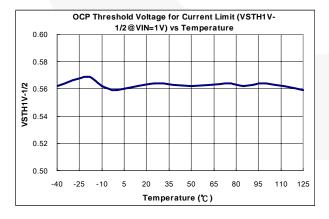


Figure 10. OCP Threshold Voltage for Current Limit $(V_{STH1V^-1/2} \text{ at } V_{IN} = 1V) \text{ vs. Temperature}$

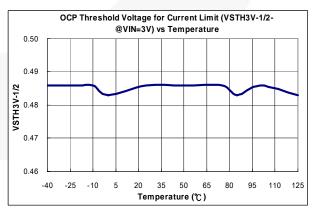


Figure 11. OCP Threshold Voltage for Current Limit ($V_{STH3V^-1/2}$ at V_{IN} = 3V) vs. Temperature

Typical Performance Characteristics (Continued)

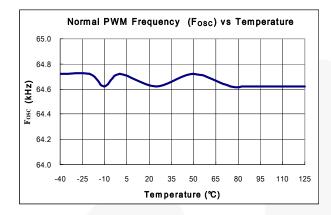


Figure 12. Normal PWM Frequency (fosc) vs. Temperature

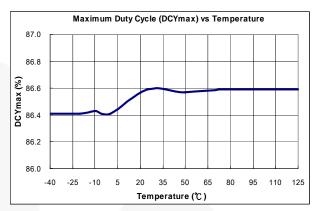


Figure 13. Maximum Duty Cycle (DCY_{MAX}) vs. Temperature

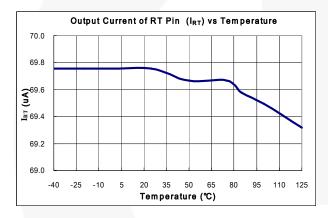


Figure 14. Output Current of RT Pin (I_{RT}) vs. Temperature

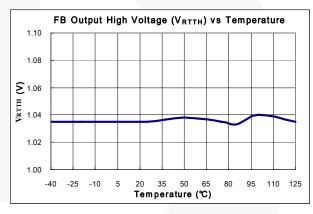


Figure 15. FB Output High Voltage (V_{RTTH}) vs. Temperature

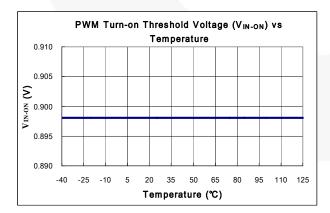


Figure 16. PWM Turn-on Threshold Voltage ($V_{\text{IN-ON}}$) vs. Temperature

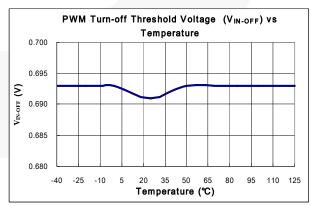


Figure 17. PWM Turn-off Threshold Voltage (V_{IN-OFF}) vs. Temperature

Operation Description

Start-up Operation

The turn-on/turn-off thresholds are fixed internally at 16.5V/10.5V. To enable the SG6846C during start-up, the hold-up capacitor must first be charged to 16.5V through the start-up resistor.

The hold-up capacitor continues to supply V_{DD} before energy can be delivered from the auxiliary winding of the main transformer. The V_{DD} must not drop below 10.5V during this start-up process. This UVLO hysteresis window ensures that the hold-up capacitor can adequately supply V_{DD} during start-up.

The typical start-up current is only 8µA, which allows a high-resistance, low-wattage start-up resistor to be used to minimize power loss. A 1.5M Ω /0.25W start-up resistor and a 10µF/25V V_{DD} hold-up capacitor are sufficient for a universal input range.

The required operating current has been reduced to 3.7mA, which enables higher efficiency and reduces the V_{DD} hold-up capacitance requirement.

Green-Mode Operation

The proprietary green-mode function provides off-time modulation to continuously decrease the switching frequency under light-load conditions. Maximum on-time is limited to provide protection against abnormal conditions. To further reduce power consumption under zero-load condition, the PWM oscillator is completely turned off and the power supply enters burst-mode. This green-mode function dramatically reduces power consumption under light-load and zero-load conditions. Power supplies using the SG6846C can meet even the most restrictive international regulations regarding standby power consumption.

Oscillator Operation

A resistor connected from the RI pin to GND generates a reference current source, inside the SG6846C, used to determine the PWM frequency. Increasing the resistance decreases the amplitude of the current source and reduces the PWM frequency. Using a $26 k\,\Omega$ resistor results in a corresponding 65kHz switching frequency. The relationship between RI and the switching frequency is:

$$f_{\text{PWM}}(kHz) = \frac{1690}{R_{\text{L}}(k\Omega)}$$
 (2)

If an open-circuit or short-circuit to ground occurs at the RI pin, the internal protection circuit immediately shuts down the controller.

Two-level Over-current Protection (OCP)

The cycle-by-cycle current limiting shuts down the PWM immediately when the switching current is over the peak-current threshold. Additionally, when the switching current is higher than half of the peak-current threshold, the internal counter counts down. When the total accumulated counting time is more than ~110ms (R_I = $26k\Omega$), the controller is latched off and the internal counter counts up. When the switching current is lower than half of the peak current threshold, the internal counter will count down. When the total accumulated counting time is more than ~110ms (R_I = $26k\Omega$), the controller is latched off.

This two-level OCP protection and up/down counter are especially designed for SMPS with surge current output, such as those for printers, scanners, and motor drivers.

Constant Output Power Limit

For constant output power limit over a universal input-voltage range, the peak-current threshold is adjusted by the voltage of the VIN pin. Since the VIN pin is connected to the rectified AC input line voltage through the resistive divider, a higher line voltage generates a higher V_{IN} voltage. The threshold voltage decreases as the V_{IN} increases, making the maximum output power at high line input voltage equal to that at low line input. The value of R-C network should not be so large it affects the power limit (shown in Figure 18). R and C should put on less than $300\,\Omega$ and 1000pF respectively.

Brownout Protection

Since the VIN pin is connected through a resistive divider to the rectified AC input line voltage, it can also be used for brownout protection. If the $V_{\rm IN}$ voltage is less than 0.7V, the PWM output is shut off. As the $V_{\rm IN}$ over 0.9V, the PWM output is turned on again. The hysteresis window for ON/OFF is ~0.2V.

V_{DD} Over-voltage Protection (OVP)

 V_{DD} over-voltage protection is built in to prevent damage. When V_{DD} is over 23.6V, the SG6846C is latched off.

Over-temperature Protection (OTP)

An external NTC thermistor can be connected from the RT pin to GND. The impedance of the NTC decreases at high temperatures. When the voltage of the RT pin drops below 1.05V, the SG6846C is turned off. For protection-mode options, see Ordering Information.

Operation Description (Continued)

Noise Immunity

Noise from the current sense or the control signal may cause significant pulse-width jitter, particularly in continuous-conduction mode. Slope compensation helps alleviate this problem. Good placement and layout practices should be followed. Avoid long PCB traces and component leads. Compensation and filter components should be located near the SG6846C.

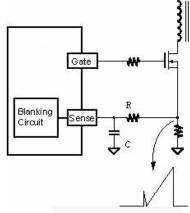


Figure 18. Current Sense R-C Filter

Reference Circuit

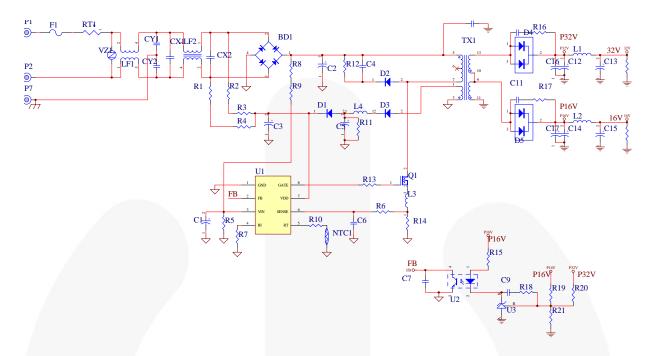
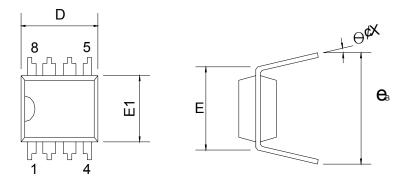


Figure 19. Application Circuit for 32V / 16V Output

BOM

Part No.	Value	Part No.	Value	Part No.	Value
R1, R2, R3, R4	470KΩ +/-5%	C4	103 P 630V	D3	FR103 1.0A 200V
R8, R9	S1MΩ +/-1%	C10,C11	102 P 1KV	BD1	DBL406G
R5	16K2Ω +/-1%	C6,C7	102 P 50V	D4	BYT28-300
R15	1K5Ω +/-5%	C9	222 P 50V	D5	BYV32-150
R13	10Ω +/-5%	C14,C17	470µ 25V	F1	250V4A QUICK
R18	4K7Ω +/-5%	C15	220µ 25V	L1,L2	1.8µH
R21	15ΚΩ +/-1%	C13,C16	220µ 50V	L4	10μH
R7	27ΚΩ +/-5%	C2	150µ 400V	U3	TL431 +/-1%
R6	330Ω +/-1%	C1	4μ7 50V	U1	SG 6846
R19	102ΚΩ +/-1%	C3	10μ 50V	U2	PC817
R14	0Ω22 +/-5%	CX1	X1 0.47μ 275V	Q1	7NB60
R16, R17	1W 20Ω +/-5%	C8	Y2 222P 250V	TX1	EI-33
R11	20ΚΩ +/-5%	C5	100μ 50V	RT1	SCK053
R12	100ΚΩ +/-5%	CX2	X2 0.1μF 275V	VZ1	14ψ 470V
R20	887ΚΩ +/-1%	D1	1N4148		
R22	10ΚΩ +/-1%	D2	BYV95C		

Physical Dimensions



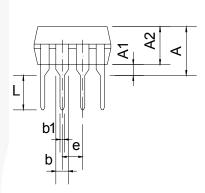


Figure 20. 8-Pin DIP

Symbol	Millimeter			Inch		
Symbol	Min.	Тур.	Max.	Min.	Тур.	Max.
A			5.334			0.210
A1	0.381			0.015		
A2	3.175	3.302	3.429	0.125	0.130	0.135
b		1.524			0.060	y y
b1		0.457			0.018	
D	9.017	9.271	10.160	0.355	0.365	0.400
E		7.620			0.300	/
E1	6.223	6.350	6.477	0.245	0.250	0.255
е		2.540			0.100	
L	2.921	3.302	3.810	0.115	0.130	0.150
ев	8.509	9.017	9.525	0.335	0.355	0.375
θ °	0°	7°	15°	0°	7°	15°

Package drawings are provided as a service to customers considering Fairchild components. Drawings may change in any manner without notice. Please note the revision and/or date on the drawing and contact a Fairchild Semiconductor representative to verify or obtain the most recent revision. Package specifications do not expand the terms of Fairchild's worldwide terms and conditions, specifically the warranty therein, which covers Fairchild products.

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Physical Dimensions

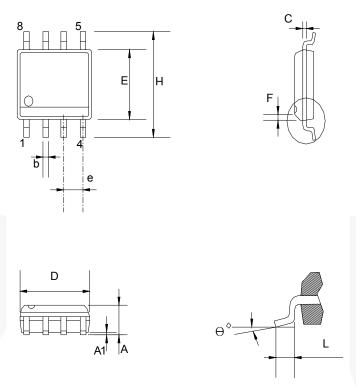


Figure 21. 8-Pin SOP

Cumbal	Millimeter			Inch	Inch		
Symbol	Min.	Тур.	Max.	Min.	Тур.	Max.	
A	1.346		1.752	0.053		0.069	
A1	0.101		0.254	0.004		0.010	
b		0.406			0.016		
С		0.203			0.008		
D	4.648		4.978	0.183	/	0.196	
E	3.810		3.987	0.150	/	0.157	
е	1.016	1.270	1.524	0.040	0.050	0.060	
F		0.381X45°			0.015X45°		
Н	5.791		6.197	0.228		0.244	
L	0.406		1.270	0.016		0.050	
θ°	0°		8°	0°		8°	

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