FAIRCHILD SEMICONDUCTOR®

June 2008

FSEZ1016A
Primary-Side-Regulation PWM Integrated Power MOSFET

Features

- Constant-voltage (CV) and Constant-current (CC) Control Without Secondary-feedback Circuitry
- Green-mode Function: PWM Frequency Linearly Decreasing
- Fixed PWM Frequency at 42kHz with Frequency Hopping to Solve EMI Problem
- Cable Compensation in CV mode
- Low Start-up Current 10μA
- Low Operating Current 3.5mA
- Peak-current-mode Control in CV mode
- Cycle-by-cycle Current Limiting
- VDD Over-voltage Protection with Auto-Restart
- VDD Under-voltage Lockout (UVLO)
- Gate Output Maximum Voltage Clamped at 18V
- Fixed Over-temperature Protection with Latch
- DIP-7 and SOP-7 Package Available

Applications

- Battery chargers for cellular phones, cordless phones, PDA, digital cameras, power tools
- Best choice to replace linear transformer and RCC SMPS

Description

This highly integrated PWM controller, FSEZ1016A, provides several features to enhance the performance of low-power flyback converters. The patented topology of FSEZ1016A enables most simplified circuit design especially for battery charger applications. A low-cost, smaller and lighter charger is thus resulted when compared to a conventional design or a linear transformer. The start-up current is only 10uA, which allows use of large start-up resistance for further power saving.

To minimize the standby power consumption, the proprietary green-mode function provides off-time modulation to linearly decrease PWM frequency under light-load conditions. This green-mode function assists the power supply to easily meet the power conservation requirement.

By using FSEZ1016A, a charger can be implemented with fewest external components and minimized cost. A typical output CV/CC characteristic envelope is shown in Figure 1.

FSEZ1016A series controller are available in 7-pin DIP and 7-pin SOP packages.

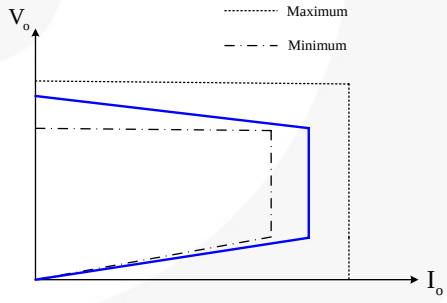


Figure 1. Typical output V-I characteristic

Ordering Information

Part Number	Operating Junction Temperature	Eco Status	Package	Packing Method
FSEZ1016ANY	-40°C to +125°C	Green	7-Lead, Dual Inline Package(DIP-7)	Tube
FSEZ1016AMY	-40°C to +125°C	Green	7-Lead, Small Outline Package (SOP-7)	Tape & Reel

For Fairchild's definition of "green" Eco Status, please visit: http://www.fairchildsemi.com/company/green/rohs_green.html.

Application Diagram

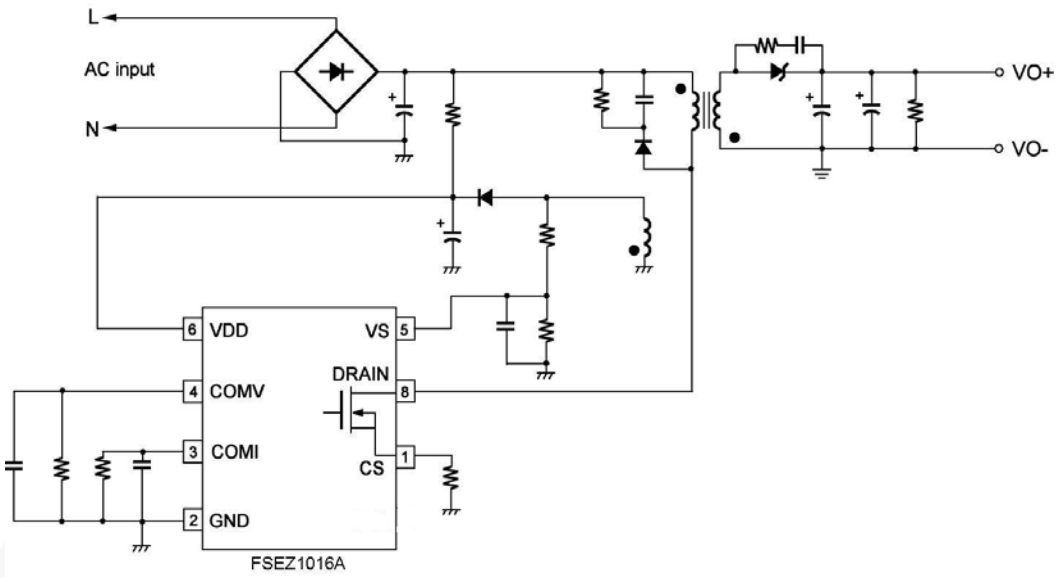


Figure 1. Typical Application

Internal Block Diagram

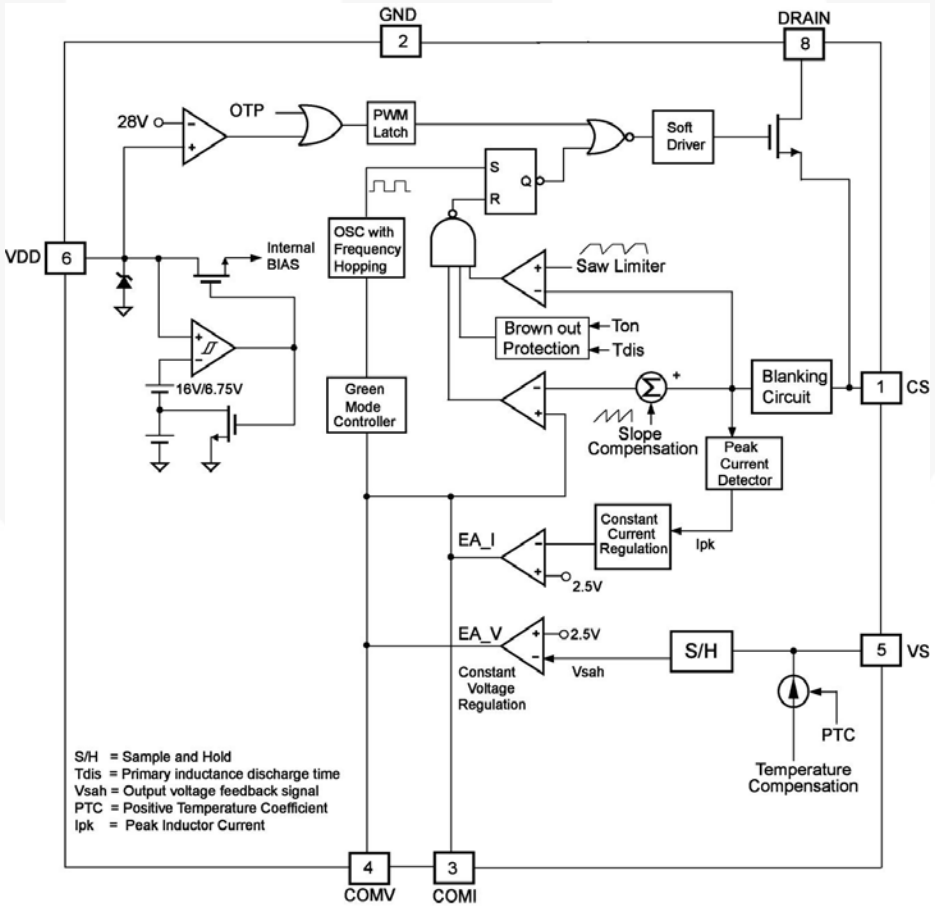
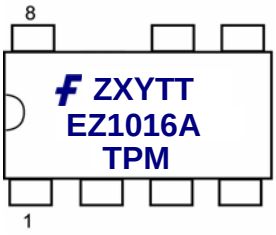


Figure 2. Functional Block Diagram

Marking Information



F- Fairchild logo
Z- Plant Code
X- 1 digit year code
Y- 1 digit week code
TT: 2 digits die run code
T: Package type (N=DIP, M=SOP)
P: Z: Pb free, Y: Green package
M: Manufacture flow code

Figure 3. Top Mark

Pin Configuration

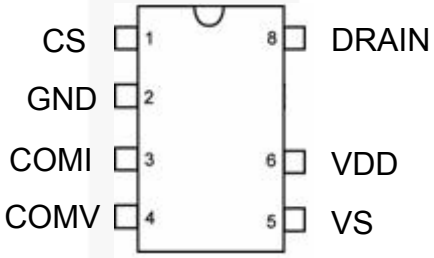


Figure 4. Pin Configuration

Pin Definitions

Pin #	Name	Description
1	CS	Analog input, Current sense. Connected to a current-sense resistor for peak-current-mode control in CV mode. The current-sense signal is also provided for output-current regulation in CC mode.
2	GND	Voltage Reference, Ground.
3	COMI	Analog output, Current compensation. Output of the current error amplifier. Connecting a capacitor between COMI pin and GND for frequency compensation.
4	COMV	Analog output, Voltage compensation. Output of the voltage error amplifier. Connecting a capacitor between COMV pin and GND for frequency compensation.
5	VS	Analog input, Voltage sense. Output-voltage-sense input for output-voltage regulation.
6	VDD	Power Supply.
7	N.C	
8	DRAIN	Power MOSFET Drain. This pin is the high voltage power MOSFET drain

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.

Symbol	Parameter		Min.	Max.	Unit
V_{VDD}	DC Supply Voltage[1, 2]			30	V
V_{VS}	VS Pin input voltage		-0.3	7	V
V_{CS}	CS Pin input voltage		-0.3	7	V
V_{COMV}	Voltage Error amplifier output voltage		-0.3	7	V
V_{COMI}	Voltage Error amplifier output voltage		-0.3	7	V
V_{DS}	Drain-Source Voltage			600	V
I_D	Continuous Drain Current	T_C=25°C		1	A
		T_C=100°C		0.6	A
I_{DM}	Pulsed Drain Current			4	A
E_{AS}	Single Pulse Avalanche Energy			33	mJ
I_{AR}	Avalanche Current			1	A
P_D	Power Dissipation (T_A＜50°C)	DIP-7		800	mW
		SOP-7		660	
$R_{\theta JA}$	Thermal Resistance (Junction to Air)	DIP-7		113	°C /W
		SOP-7		153	
$R_{\theta JC}$	Thermal Resistance (Junction to Case)	DIP-7		67	°C /W
		SOP-7		39	
T_J	Operating Junction Temperature			150	°C
T_{STG}	Storage Temperature Range		-55	150	°C
T_L	Lead Temperature (Wave soldering or IR, 10 seconds)			260	°C
ESD	ESD Capability, Human Body Model			2.5	KV
	ESD Capability, Machine Model			200	V

Notes:
1. Stresses beyond those listed under ”absolute maximum ratings” may cause permanent damage to the device.
2. All voltage values, except differential voltages, are given with respect to GND pin.

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	Conditions	Min.	Typ.	Max.	Unit
T_J	Operating Junction Temperature		-40		125	°C

Electrical Characteristics

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

Symbol	Parameter		Conditions	Min.	Typ.	Max.	Units
VDD SECTION							
V_{OP}	Continuously Operating Voltage					25	V
V_{DD-ON}	Turn-on Threshold Voltage			15	16	17	V
V_{DD-OFF}	Turn-Off Threshold Voltage			4.5	5	5.5	V
I_{DD-ST}	Startup current		0< V_{DD} < V_{DD-ON}-0.16V		10	20	µA
I_{DD-OP}	Operating Current		V_{DD}=20V, Fs= F_{OSC}, V_{VS}=2V, V_{CS}=3V, C_L=1nF		3.5	5	mA
$I_{DD-GREEN}$	Green-mode Operating Supply Current		V_{DD}=20V, V_{VS} =2.7V Fs=$F_{OSC-N-MIN}$, V_{CS}=0V C_L=1nF, V_{COMV} = 0V		1	2	mA
V_{DD-OVP}	VDD Over-voltage-protection level		V_{CS}=3V, V_{VS}=2.3V V_{DD}=20V➔OVP	27	28	29	V
$t_{D-VDDOVP}$	VDD Over-voltage-protection Debounce Time		V_{CS}=5V, Fs= F_{OSC}, V_{VS}=2.3V,	100	250	400	µs
OSCILLATOR SECTION							
F_{OSC}	FSEZ1016A Frequency	Center Frequency	T_A = 25°C V_{VS}=2.3V, V_{CS}=5V	39	42	45	KHz
		Frequency Hopping Range	V_{CS}=1.5V, V_{VS}=2V;	±1.8	±2.6	±3.6	
t_{FHR}	Frequency Hopping Period		V_{CS}=1.5V, V_{VS}=2V;		3		ms
$F_{OSC-N-MIN}$	Min. frequency at No-Load		V_{VS} =2.7V, V_{COMV} = 0V		550		Hz
$F_{OSC-CM-MIN}$	Min. Frequency at CCM		V_{VS} =2.3V, V_{CS}=0.5V		20		KHz
F_{DV}	Frequency Variation Versus V_{DD} Deviation		V_{DD} = 10V to 25V			5	%
F_{DT}	Frequency Variation Versus Temp. Deviation		T_A = -40°C to 85°C			15	%
VOLTAGE-SENSE SECTION							
I_{VS-UVP}	Sink current for Brownout protection		R_{VS}=20KΩ		125		µA
Itc	IC Compensation Bias Current				9.5		µA
$V_{BIAS-COMV}$	Adaptive Bias voltage dominated by V_{COMV}		V_{COMV} =0V, T_A = 25°C, V_{CS}=5V, R_{VS}=20KΩ		1.4		V

Electrical Characteristics

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
CURRENT-SENSE SECTION						
t_{PD}	Propagation Delay to GATE Output			100	200	ns
t_{MIN-N}	Min. On Time at No-Load	V_{VS}= -0.8V, Rs=2KΩ , V_{COMV}=1V		1100		ns
t_{MINCC}	Min. On Time in CC mode	V_{CS}=5V V_{VS}=0V, V_{COMV}=2V		400		ns
D_{SAW}	Duty Cycle of SAW Limiter			40		%
V_{TH}	Threshold Voltage for Current Limit			1.3		V
VOLTAGE-ERROR-AMPLIFIER SECTION						
V_{VR}	Reference Voltage	V_{CS}=5V	2.475	2.5	2.525	V
V_N	Green-Mode Starting Voltage on COMV pin	V_{CS}=5V, F_S=F_{OSC}-2KHz V_{VS}=2.3V		2.8		V
V_G	Green-Mode Ending Voltage on COMV pin	V_{CS}=5V, F_S=1KHz		0.8		V
I_{V-SINK}	Output Sink Current	V_{VS}=3V, V_{COMV}=2.5V		90		μA
$I_{V-SOURCE}$	Output Source Current	V_{VS}=2V, V_{COMV}=2.5V		90		μA
V_{V-HGH}	Output High Voltage	V_{VS}=2.3V	4.5			V
CURRENT-ERROR-AMPLIFIER SECTION						
V_{IR}	Reference Voltage	V_{CS}=5V	2.475	2.5	2.525	V
I_{I-SINK}	Output Sink Current	V_{CS}=3V, V_{COMI}=2.5V		55		μA
$I_{I-SOURCE}$	Output Source Current	V_{CS}=0V, V_{COMI}=2.5V		55		μA
V_{I-HGH}	Output High Voltage	V_{CS}=0V	4.5			V

Electrical Characteristics

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
INTERNAL MOSFET SECTION						
DCY_{MAX}	Maximum Duty Cycle			75		%
BV_{DSS}	Drain-Source Breakdown Voltage	I_D=250μA, V_{GS}=0V	600			V
$\Delta BV_{DSS}/\Delta T_J$	Breakdown Voltage Temperature Coefficient	I_D=250μA, Referenced to 25 °C		0.6		V/°C
I_S	Maximum Continuous Drain-Source Diode Forward Current				1	A
I_{SM}	Maximum Pulsed Drain-Source Diode Forward Current				4	A
$R_{DS(ON)}$	Static Drain-Source On-Resistance	I_D=0.5A, V_{GS}=10V		9.3	11.5	Ω
I_{DSS}	Drain-Source Leakage Current	V_{DS}=600V, V_{GS}=0V, T_C=25 °C			1	μA
		V_{DS}=480V, V_{GS}=0V, T_C=100 °C			10	μA
t_{D-ON}	Turn-on Delay Time	V_{DS}=300V, I_D=1.1A, R_G=25Ω (1) (2)		7	24	ns
tr	Rise Time			21	52	ns
t_{D-OFF}	Turn-off Delay Time			13	36	ns
tf	Fall Time			27	64	ns
C_{ISS}	Input Capacitance	V_{GS}=0V, V_{DS}=25V, F_S=1MHz		130	170	pF
C_{OSS}	Output Capacitance			19	25	pF
OVER-TEMPERATURE-PROTECTION SECTION						
T_{OTP}	Threshold Temperature for OTP(3)			150		°C

Note:

1. Pulse Test : Pulse width ≦ 300us, Duty cycle ≦ 2%
2. Essentially independent of operating temperature
3. When the Over-temperature protection is activated, the power system will enter latch mode and output is disabled.

Functional Description

The patented topology of FSEZ1016A enables most simplified circuit design especially for battery charger applications. Without secondary feedback circuitry, the CV and CC control can still be achieved accurately. As shown in Figure 4, with the frequency-hopping, PWM operation, EMI problem can be solved by using minimized filter components. FSEZ1016A also provides many protection functions. VDD pin is equipped with over-voltage protection, also with under-voltage lockout. Pulse-by-pulse current limiting and CC control ensure over-current protection at heavy loads. The GATE output is clamped at 15V to protect the external MOSFET from over-voltage damage. Also, the internal over-temperature-protection function shuts down the controller with latch when over heated.

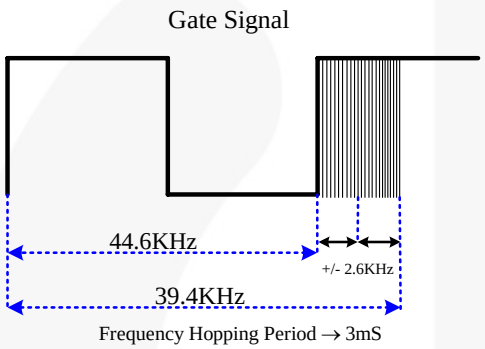


Figure 5. Frequency Hopping

Start-Up Current

The start-up current is only 10uA. Low start-up current allows a start-up resistor with a high resistance and a low-wattage to supply the start-up power for the controller. A 1.5MΩ, 0.25W, start-up resistor and a 10uF/25V V_{DD} hold-up capacitor would be sufficient for an AC-to-DC power adapter with a wide input range ($100V_{AC}$ to $240V_{AC}$)

Operating Current

The operating current has been reduced to 3.5mA. The low operating current results in higher efficiency and reduces the V_{DD} hold-up capacitance requirement. Once FSEZ1016A enter deep-green-mode, the operating current will be reduced to 1.2mA, thus that can assist the power supply to easily meet the power conservation requirement.

Green-Mode Operation

Figure 5 shows the characteristics of the PWM frequency vs. the output voltage of the error amplifier (V_{COMV}). The FSEZ1016A uses the positive, proportional, output load parameter (V_{COMV}) as an indication of the output load for modulating the PWM frequency. In heavy load conditions, the PWM frequency is fixed at 42KHz. Once V_{COMV} is lower than V_N, the PWM frequency starts to linearly decrease from 42KHz to 500Hz. Thus providing further power savings and easily meeting international power conservation requirements.

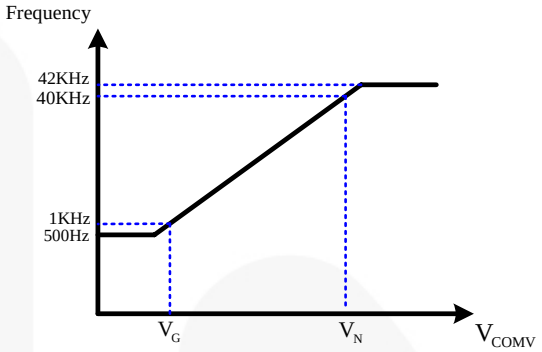


Figure 6. Green-Mode operation Frequency vs V_{COMV}

Constant Voltage(CV) and Constant Current(CC) Operation

An innovative technique of the FSEZ1016A can accurately achieve CV/CC characteristic output without secondary side voltage or current feedback circuitry. There has a feedback signal for CV/CC operation that is from the reflected voltage across the primary auxiliary winding, this voltage signal is proportional to secondary winding, so it provides controller the feedback signal from secondary side and achieve constant voltage output property. In constant current output operation, this voltage signal will be detected and examined by the precise constant current regulation controller, then determined the on-time of the MOSFET to control input power and provide constant current output property. With feedback voltage Vcs across current sense resistor, the controller can obtain input power of power supply. Therefore, the region of constant current output operation can be adjusted by current sense resistor.

Temperature Compensation

The FSEZ1016A has a built in temperature compensation, in order to get better constant voltage regulation at different ambient temperature. This internal compensation current is a positive temperature coefficient (PTC) current that can compensate the forward-voltage drop of the secondary diode of varying with temperature. This variation caused output voltage rising at high temperature.

Leading-Edge Blanking

Each time the power MOSFET is switched on, a turn-on spike will inevitable occur at the sense-resistor. To avoid premature termination of the switching pulse, a leading-edge blanking time is built in. Conventional RC filtering can therefore be omitted. During this blanking period, the current-limit comparator is disabled and it cannot switch off gate driver.

Under Voltage Lockout (UVLO)

The turn-on and turn-off thresholds of the FSEZ1016A are fixed internally at 16V/5V. During start-up, the hold-up capacitor must be charged to 16V through the start-up resistor, so that the FSEZ1016A will be enabled. The hold-up capacitor will continue to supply V_{DD} until power can be delivered from the auxiliary winding of the main transformer. V_{DD} must not drop below 5V during this start-up process. This UVLO hysteresis window ensures that hold-up capacitor will be adequate to supply V_{DD} during start-up.

VDD Over-Voltage Protection

VDD over-voltage protection has been built in to prevent damage due to over voltage conditions. When the voltage VDD exceeds 28V due to abnormal conditions, PWM pulses will be disabled until the VDD voltage drops below the UVLO and then start-up again. Over-voltage conditions are usually caused by open feedback loops.

Over Temperature Protection (OTP)

The FSEZ1016A has a built-in temperature sensing circuit to shut down PWM output once the junction temperature exceeds 150°C. While PWM output is shut down, the V_{DD} voltage will gradually drop to the UVLO voltage. Some of the FSEZ1016A's internal circuits will be shut down, and V_{DD} will gradually start increasing again. When V_{DD} reaches 16V, all the internal circuits including the temperature sensing circuit will start operating normally. If the junction temperature is still higher than 150°C, the PWM controller will be shut down immediately. This situation will continue until the temperature drop below 120°C.

Gate Output

The FSEZ1016A BiCMOS output stage is a fast totem pole gate driver. Cross conduction has been avoided to minimize heat dissipation, increase efficiency, and enhance reliability. The output driver is clamped by an internal 15V Zener diode in order to protect power MOSFET transistors against undesired over-voltage gate signals.

Built-in Slope Compensation

The sensed voltage across the current sense resistor is used for current mode control and pulse-by-pulse current limiting. Built-in slope compensation will improve stability and prevent sub-harmonic oscillations due to peak-current mode control. The FSEZ1016A has a synchronized, positively-sloped ramp built-in at each switching cycle.

Noise Immunity

Noise from the current sense or the control signal can cause significant pulse width jitter, particularly in continuous-conduction mode. While slope compensation helps alleviate these problems, further precautions should still be taken. Good placement and layout practices should be followed. Avoiding long PCB traces and component leads, locating compensation and filter components near the FSEZ1016A, and increasing the power MOS gate resistance is advised.

Applications Information

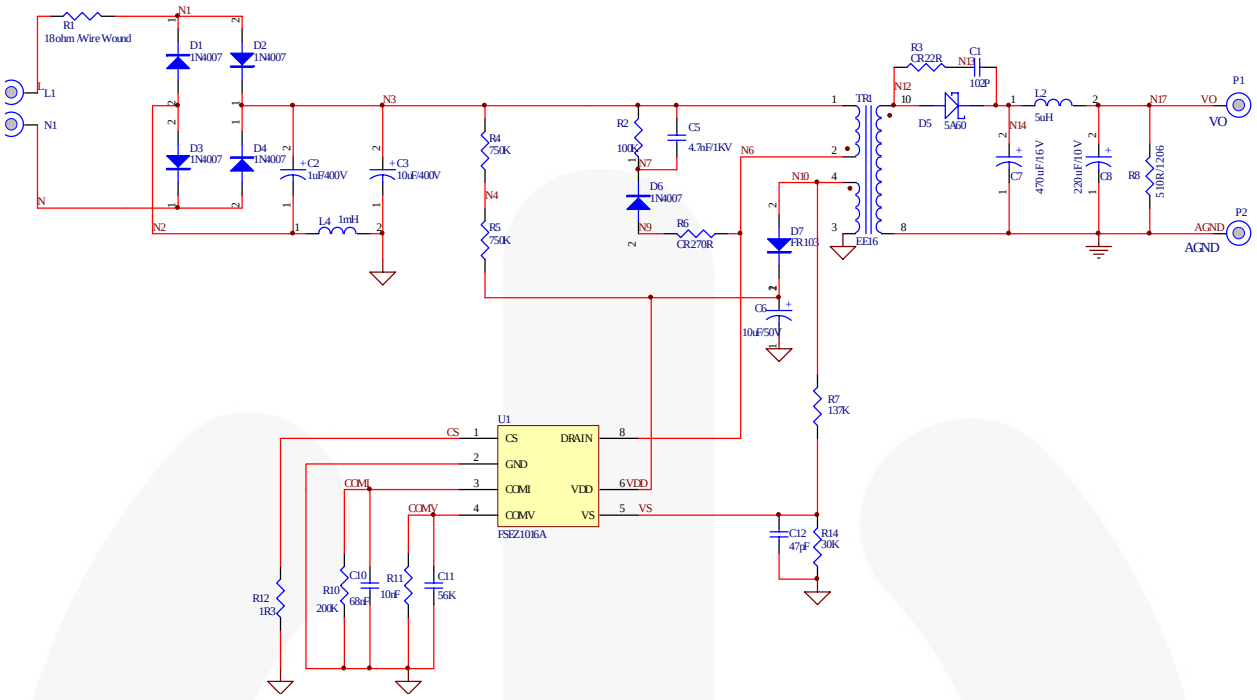


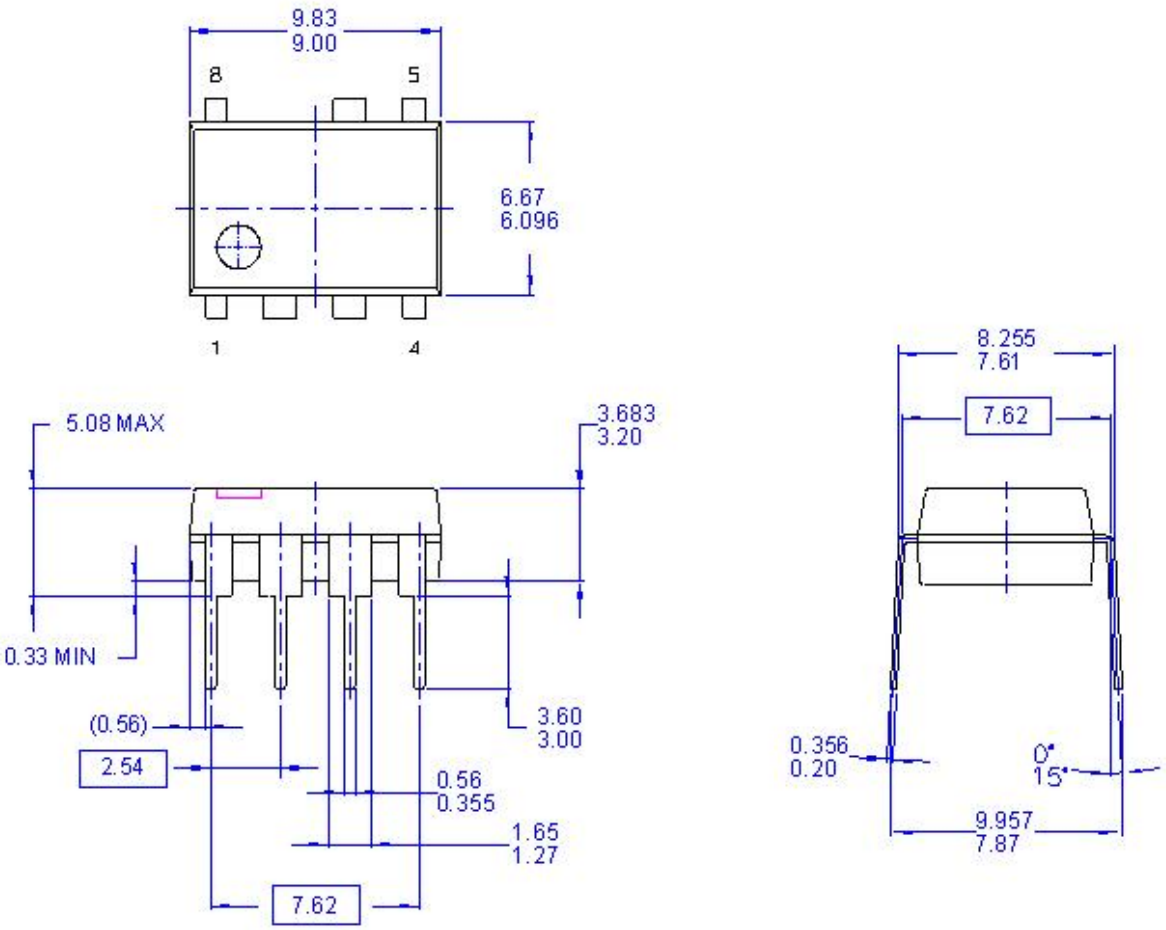
Figure 7. 5W (5V/1A) Application Circuit

BOM

Designator	Part Type	Designator	Part Type
D1, D2, D3, D4, D6	1N4007	R2	R 100 KΩ
D5	SB560	R3	R 22 Ω
D7	FR103	R4, R5	R 750 KΩ
C1	1nF	R6	R 270 Ω
C2	EC 1μF/400V	R7	R 137 KΩ
C3	EC 10μF/400V	R8	R 510 Ω
C5	4.7nF/1KV	R10	R 200 KΩ
C6	EC 10μF/50V	R11	R 56KΩ
C7	EC 470μF/16V	R12	R 1.3 Ω
C8	EC 220μF/10	R14	R 30 Ω
C10	68nF	L2	5uH
C11	10nF	L4	1mH
C12	47pF	T1	EE16 (1.5mH)
R1	R 18 Ω	U1	IC FSEZ1016A

Physical Dimensions

7PINS-DIP(N)



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7PINS-SOP(M)

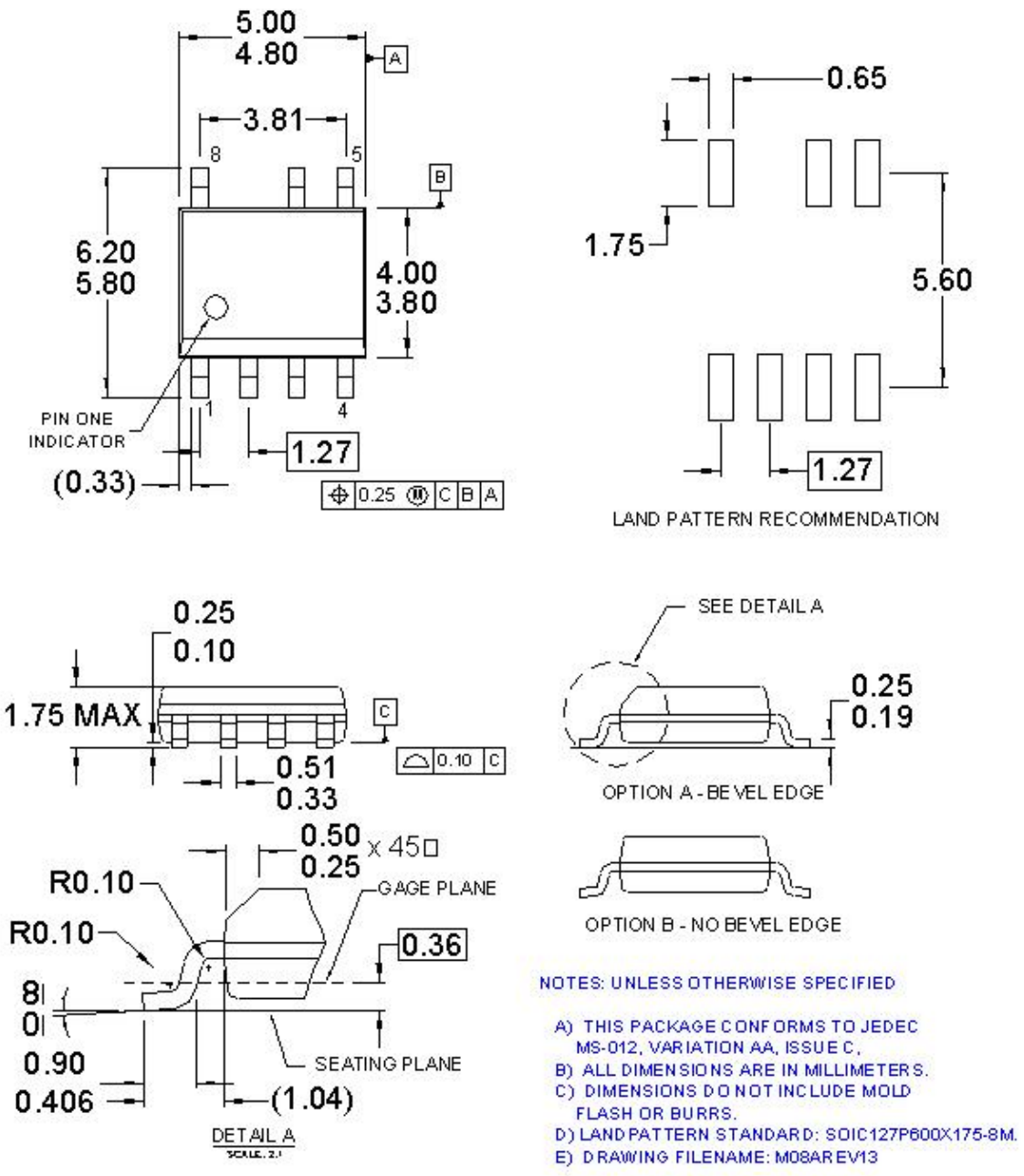

Figure 9. Official FSC Drawings only - ALWAYS include DWG number & revision

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ANTI-COUNTERFEITING POLICY

Fairchild Semiconductor Corporation's Anti-Counterfeiting Policy. Fairchild's Anti-Counterfeiting Policy is also stated on our external website, www.fairchildsemi.com, under Sales Support.

Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild's quality standards for handling and storage and provide access to Fairchild's full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

Rev. I35