FAIRCHILD SEMICONDUCTOR®

January 2010

FAN6862
Highly Integrated Green-Mode PWM Controller

Features

- Low Startup Current: 8μA
- Low Operating Current in Green Mode: 3mA
- 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)
- Constant Output Power Limit (Full AC Input Range)
- Internal Latch Circuit for OVP, OTP
- Fixed PWM Frequency (65KHz) with Frequency Hopping
- Feedback Open-Loop Protection with 56ms Delay
- Soft Start Time: 4ms
- 400mA Driving Capability

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, and Motor Drivers

Description

A highly integrated PWM controller, FAN6862 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 FAN6862 is designed for SMPS and integrates a frequency-hopping function that helps reduce EMI emission of a power supply with minimum line filters. The built-in synchronized slope compensation is proprietary sawtooth compensation for constant output power limit over universal AC input range. The gate output is clamped at 18V to protect the external MOSFET from over-voltage damage.

Other protection functions include V_{DD} over-voltage protection and over-temperature protection. For over-temperature protection, an external NTC thermistor can be applied to sense the ambient temperature. When V_{DD} OVP or OTP is activated, an internal latch circuit latches off the controller.

Part Number	OVP	OTP	OLP
FAN6862TY	Latch	Latch	Auto Restart
FAN6862NY	Latch	Latch	Auto Restart

Ordering Information

Part Number	Operating Temperature Range	Eco Status	Package	Packing Method
FAN6862TY	-40 to +105°C	Green	6-Pin SSOT-6	Tape & Reel
FAN6862NY	-40 to +105°C	Green	8-Pin Dual In-Line Package (DIP)	Tube

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

Typical Application

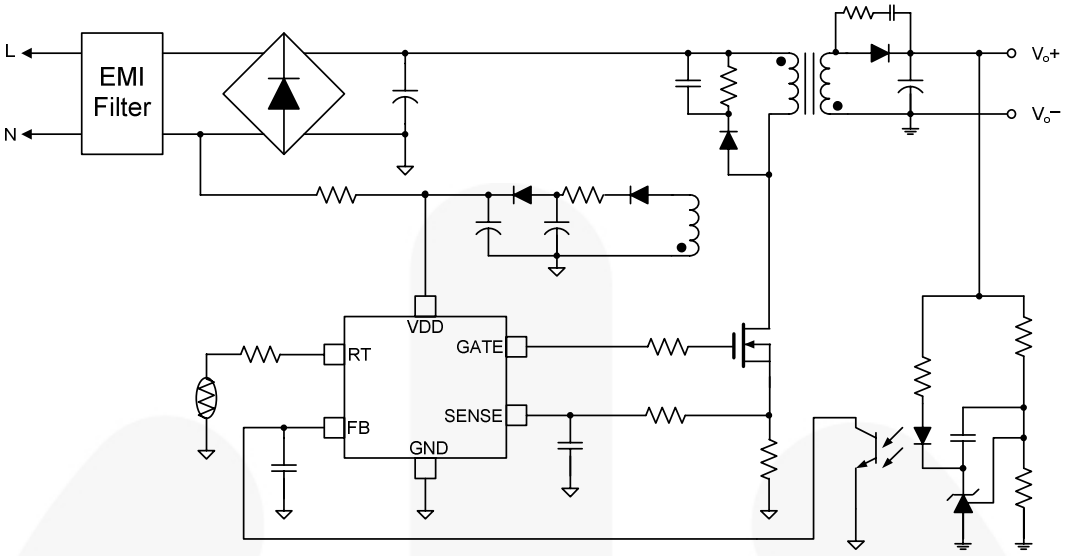


Figure 1. Typical Application

Block Diagram

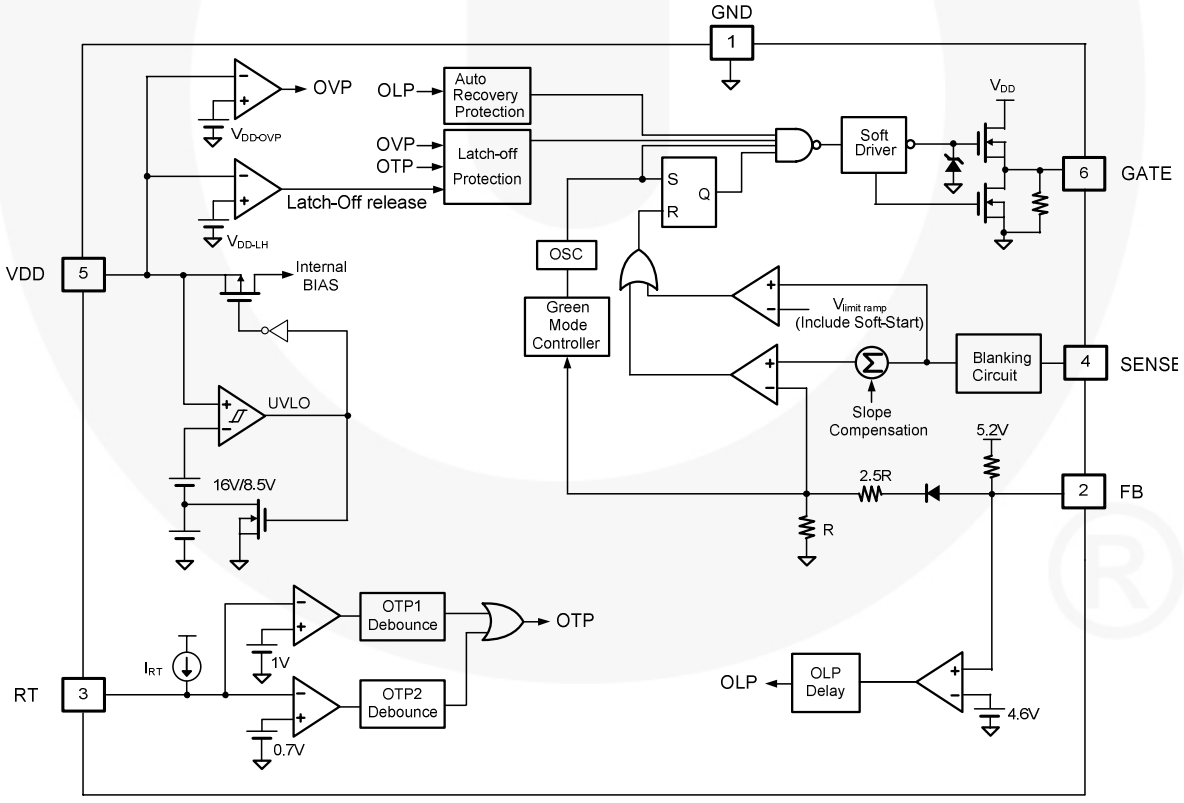
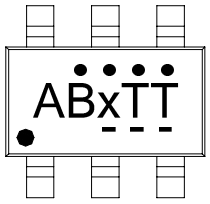
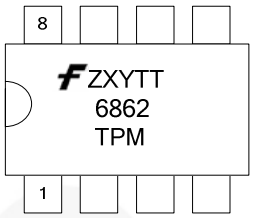


Figure 2. Block Diagram

Marking Information



ABx:	ABD: FAN6862TY
TT:	Wafer Lot Code
●●●●:	Year Code
_ _ _:	Week Code



F – Fairchild Logo
Z – Plant Code
X – 1-Digit Year Code
Y – 1-Digit Week Code
TT – 2-Digit Die Run Code
T – Package Type (N:DIP)
P – Y: Green Package
M – Manufacture Flow Code

Figure 3. Top Mark

Pin Configuration

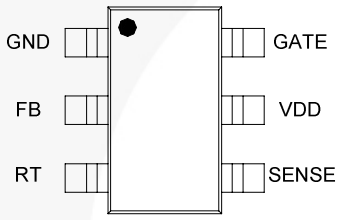


Figure 4. SSOT-6

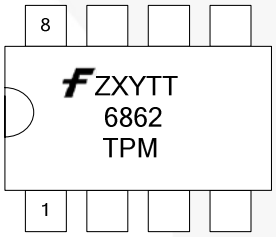


Figure 5. DIP-8

Pin Definitions

Pin # **DIP8**	**Pin # SSOT-6**	**Name**	**Description**
8	1	GND	Ground.
7	2	FB	**Feedback**. The FB pin provides the output voltage regulation signal. It provides feedback to the internal PWM comparator, so that the PWM comparator can control the duty cycle. This pin also provide for OLP: if V_{FB} is larger than the trigger level and delays for a long time, the controller stops and restarts.
6		NC	No Connect Pin
5	3	RT	**Temperature Detection**. An external NTC thermistor is connected from this pin to GND for over-temperature protection. The impedance of the NTC decreases at high temperatures. Once the voltage of the RT pin drops below a threshold, PWM output is disabled.
4	4	SENSE	**Current Sense**. This pin senses the voltage across a resistor. When the voltage reaches the internal threshold, PWM output is disabled. This activates over-current protection. This pin also provides current amplitude information for current-mode control.
3		NC	No Connect Pin
2	5	VDD	Power Supply.
1	6	GATE	**Driver Output**. The totem-pole output driver for driving the power MOSFET.

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		Min.	Max.	Unit
V_{DD}	Supply Voltage			30	V
V_L	Input Voltage to FB, SENSE, RT Pin		-0.3	7.0	V
P_D	Power Dissipation at T_A<50°C	SSOT-6		300	mW
		DIP-8		800	
Θ_{JC}	Thermal Resistance (Junction-to-Case)	SSOT-6		115	°C/W
		DIP-8		67	
T_J	Operating Junction Temperature		-40	+150	°C
T_{STG}	Storage Temperature Range		-55	+150	°C
T_L	Lead Temperature, Wave Soldering, 10 Seconds			+260	°C
ESD	Human Body Model, JESD22-A114			3.00	kV
	Charge Device Model, JESD22-C101			1.25	

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	-40	+105	°C

Electrical Characteristics

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

Symbol	Parameter		Test Condition	Min.	Typ.	Max.	Unit
V_{DD} Section							
V_{DD-OP}	Continuously Operating Voltage					24	V
V_{DD-ON}	Turn-on Threshold Voltage			15	16	17	V
V_{DD-OFF}	Turn-off Voltage			7.5	8.5	9.5	V
V_{DD-LH}	Threshold voltage for Latch-Off release			3	4	5	V
I_{DD-ST}	Startup Current		V_{DD-ON}–0.16V		8	30	µA
I_{DD-OP}	Normal Operating Supply Current		C_L=1nF		3	4	mA
I_{DD-BM}	Green-Mode Operating Supply Current		GATE open, V_{FB}=V_{FB-G}			2.5	mA
V_{DD-OVP}	V_{DD} Over-Voltage Protection			24	25	26	V
$t_{D-VDDOVP}$	V_{DD} OVP Debounce Time				30	50	µs
I_{DD-LH}	Latch-Off Holding Current		V_{DD}=5V		40	65	µA
Feedback Input Section							
A_V	Input-Voltage to Current-Sense Attenuation			1/4.0	1/3.5	1/3.0	V/V
Z_{FB}	Input Impedance				5.5		kΩ
$V_{FB-OPEN}$	FB Pin Open Voltage			5.0	5.2	5.4	V
V_{FB-OLP}	Threshold Voltage for Open-Loop Protection			4.3	4.6	4.9	V
t_{D-OLP}	Open-Loop Protection Delay Time			53	56	60	ms
Current Sense Section							
t_{PD}	Delay to Output				100	250	ns
t_{LEB}	Leading-Edge Blanking Time			270	360		ns
V_{STHFL}	Flat Threshold Voltage for Current Limit		Duty>51%		0.5		V
V_{STHVA}	Valley Threshold Voltage for Current Limit		Duty=0%		0.44		V
V_{SLOPE}	Slope Compensation		Duty=DCY_{MAX}		0.273		V
$t_{SOFT-START}$	Period During Startup time				4		ms
Oscillator Section							
f_{OSC}	Normal PWM Frequency	Center Frequency	V_{FB}>V_{FB-N}	62	65	68	kHz
		Hopping Range	V_{FB}≥V_{FB-N}		±4.2		
		Hopping Range	V_{FB}=V_{FB-G}		±2.9		
t_{hop-1}	Hopping Period 1		V_{FB}≥V_{FB-N}		4.4		ms
t_{hop-3}	Hopping Period 3		V_{FB}=V_{FB-G}		11.5		ms
f_{OSC-G}	Green Mode Minimum Frequency				22.5		kHz
V_{FB-N}	FB Threshold Voltage For Frequency Reduction				2.2		V
V_{FB-G}	FB Voltage at f_{OSC-G}				2.1		V
V_{FB-ZDC}	FB Threshold Voltage for Zero Duty				1.7		V
f_{DV}	Frequency Variation vs. V_{DD} Deviation		V_{DD}=11.5V to 20V	0	0.02	2.00	%
f_{DT}	Frequency Variation vs. Temperature Deviation		T_A= -40 to +105°C			2	%

Continued on the following page…

Electrical Characteristics (Continued)

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

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
PWM Output Section						
DCY_{MAX}	Maximum Duty Cycle			70		%
V_{OL}	Output Voltage Low	V_{DD}=15V, I_O=50mA			1.5	V
V_{OH}	Output Voltage High	V_{DD}=8V, I_O=50mA	6			V
t_R	Rising Time	C_L=1nF		150	200	ns
t_F	Falling Time	C_L=1nF		35		ns
V_{CLAMP}	Gate Output Clamping Voltage	V_{DD}=20V	15.0	16.5	18.0	V
Over-Temperature Protection (OTP) Section						
I_{RT}	Output Current of RT Pin			100		µA
V_{OTP}	Threshold Voltage for Over-Temperature Protection	T_A=25°C	0.95	1.00	1.05	V
t_{DOTP}	Over-Temperature Debounce Time	V_{FB}=V_{FB-N}		17		ms
		V_{FB}=V_{FB-G}		51		
V_{OTP2}	2nd Threshold Voltage for Over-Temperature Protection	T_A=25°C	0.60	0.70	0.75	V
t_{DOTP2}	2nd Over-Temperature Debounce Time			100		µs

Typical Performance Characteristics

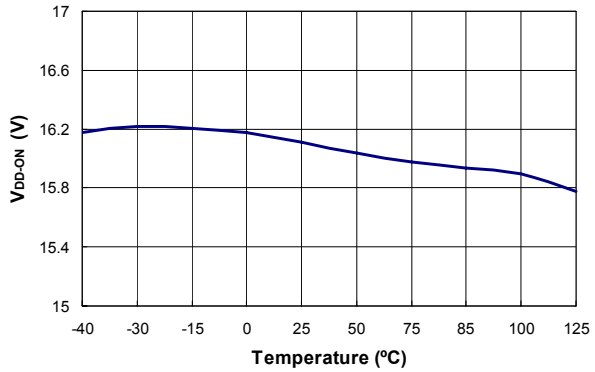


Figure 6. Turn-on Threshold Voltage (V_{DD-ON}) vs. Temperature

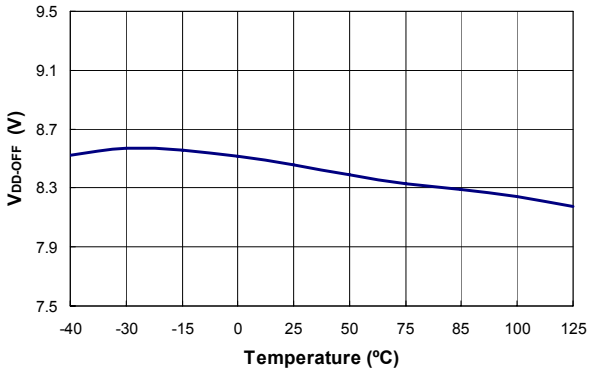


Figure 7. Turn-off Threshold Voltage (V_{DD-OFF}) vs. Temperature

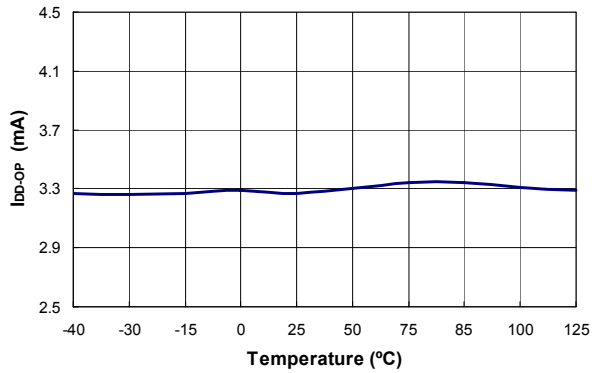


Figure 8. Operating Current (I_{DD-OP}) vs. Temperature

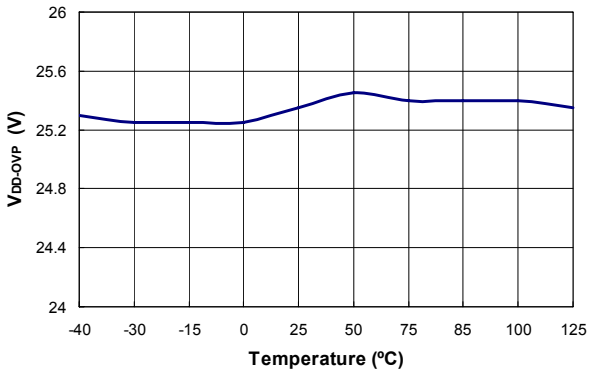


Figure 9. V_{DD} Over-Voltage Protection (V_{DD-OVP}) vs. Temperature

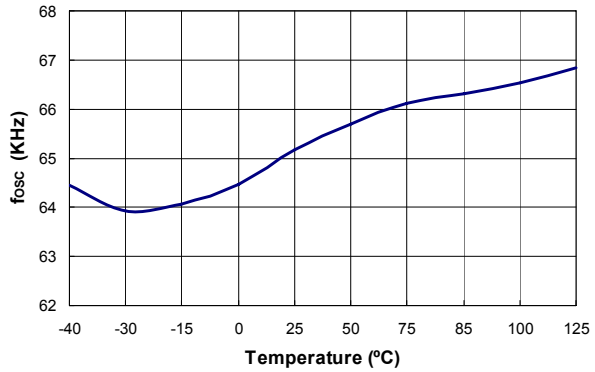


Figure 10. Center Frequency (f_{OSC}) vs. Temperature

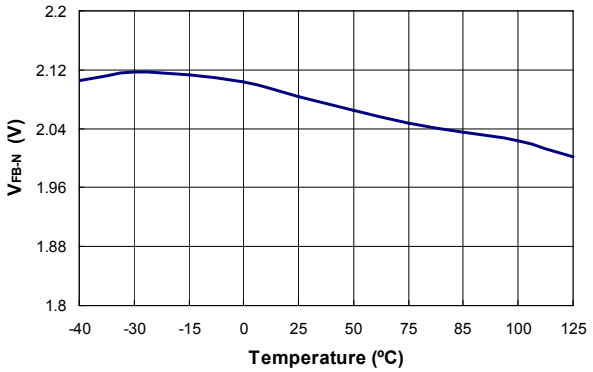


Figure 11. FB Threshold Voltage for Frequency Reduction (V_{FB-N}) vs. Temperature

Typical Performance Characteristics (Continued)

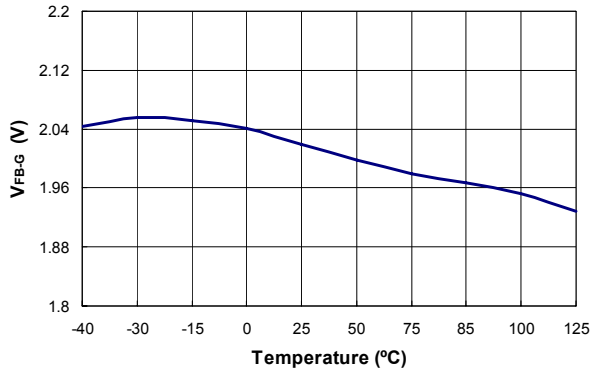


Figure 12. FB Voltage at f_{OSC-G} (V_{FB-G}) vs. Temperature

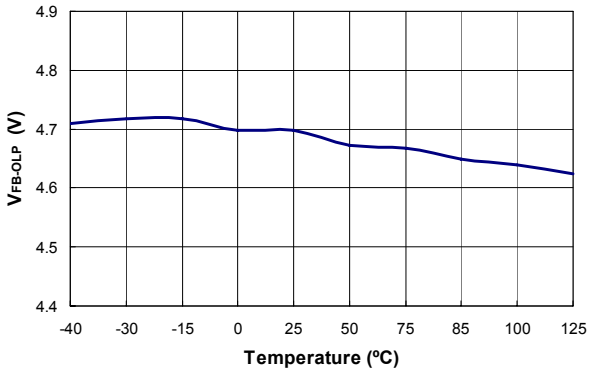


Figure 13. Threshold Voltage for Open-Loop Protection (V_{FB-OLP}) vs. Temperature

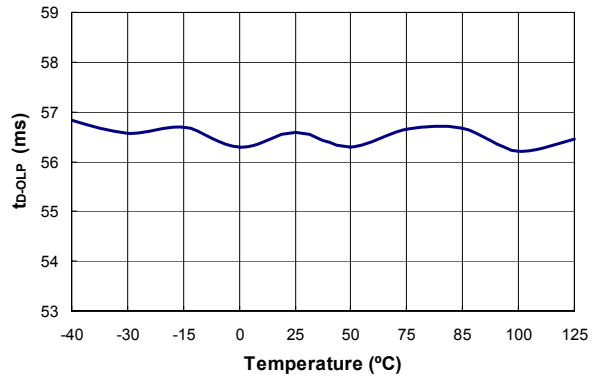


Figure 14. Open-Loop Protection Delay Time (t_{D-OLP}) vs. Temperature

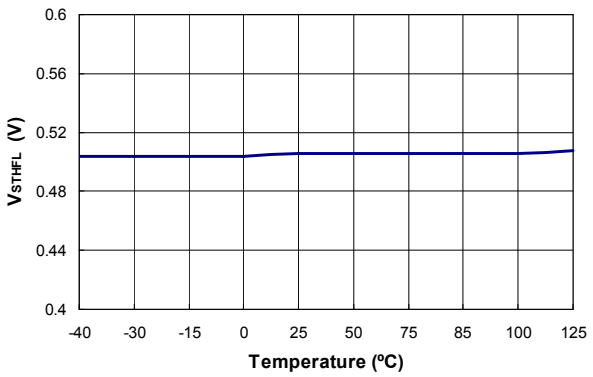


Figure 15. Flat Threshold Voltage for Current Limit (V_{STHFL}) vs. Temperature

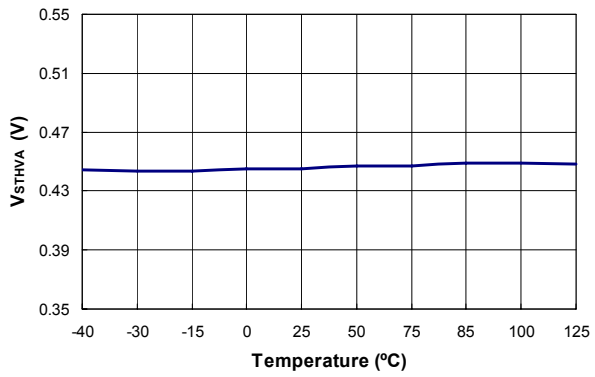


Figure 16. Valley Threshold Voltage for Current Limit (V_{STHVA}) vs. Temperature

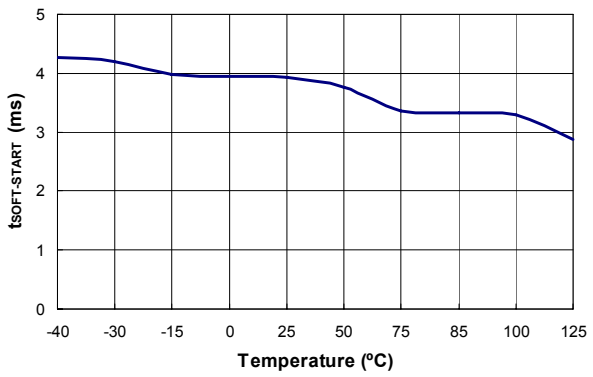


Figure 17. Period during Startup ($t_{SOFT-START}$) vs. Temperature

Typical Performance Characteristics (Continued)

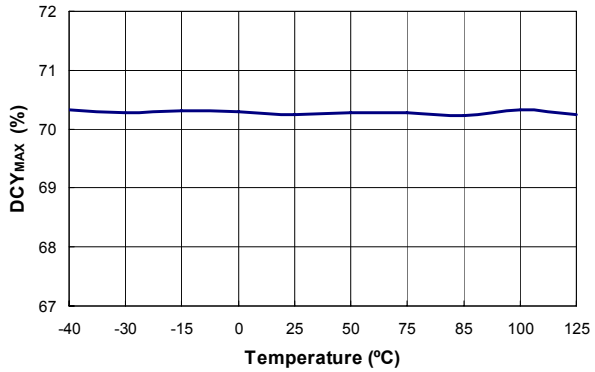


Figure 18. Maximum Duty Cycle (DCY_{MAX}) vs. Temperature

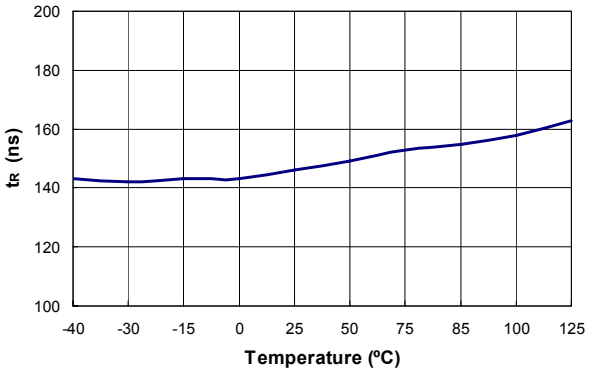


Figure 19. Rising Time (t_R) vs. Temperature

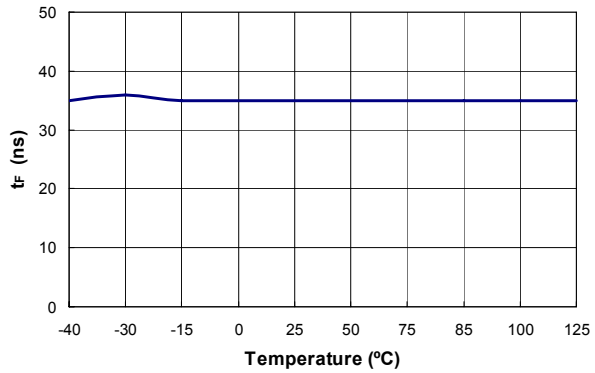


Figure 20. Falling Time (t_F) vs. Temperature

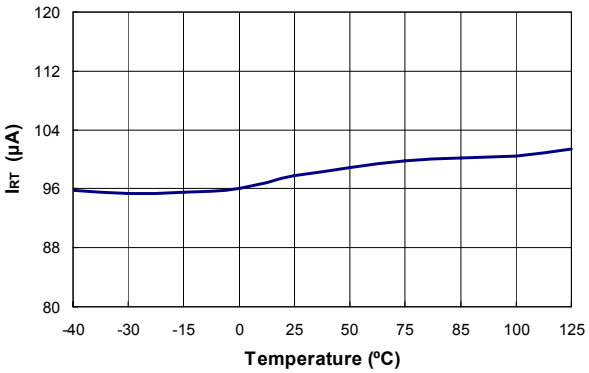


Figure 21. Output Current of RT Pin (I_{RT}) vs. Temperature

Operation Description

Startup Operation

Figure 22 shows a typical startup circuit and transformer auxiliary winding for a FAN6862 application. Before FAN6862 begins switching operation, it consumes only startup current (typically 8μA) and the current supplied through the startup resistor charges the V_{DD} capacitor (C_{DD}). When V_{DD} reaches turn-on voltage of 16V (V_{DD-ON}), FAN6862 begins switching and the current consumed increases to 3mA. Then, the power required is supplied from the transformer auxiliary winding. The large hysteresis of V_{DD} (8.5V) provides more holdup time, which allows using a small capacitor for V_{DD}. The startup resistor is typically connected to AC line for a fast reset of latch protection.

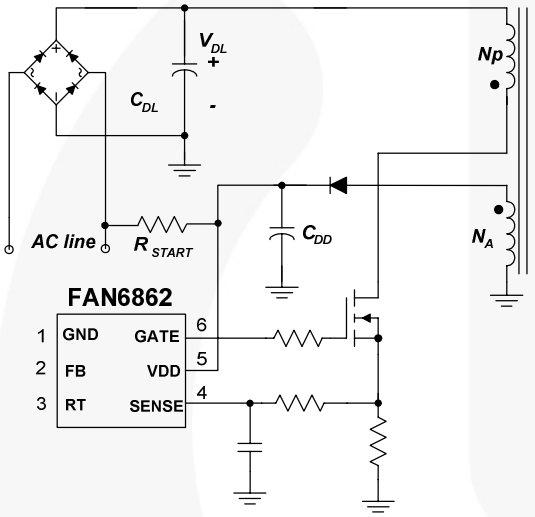


Figure 22. Startup Circuit

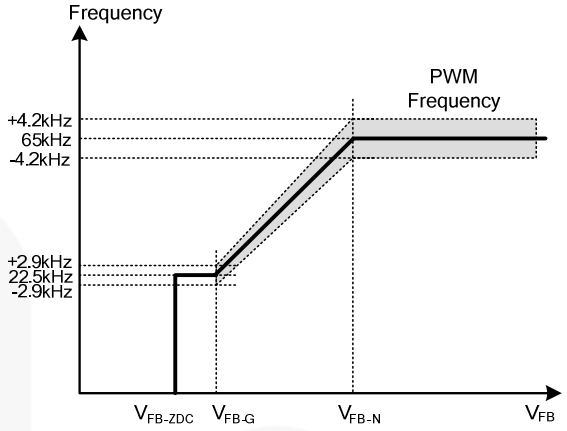


Figure 23. PWM Frequency

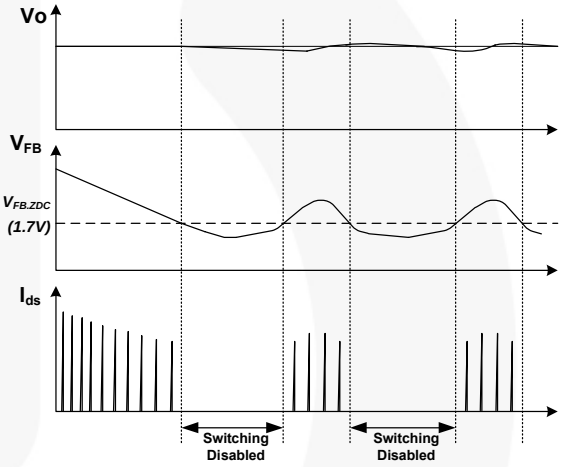


Figure 24. Burst Mode Operation

Green-Mode Operation

The FAN6862 uses feedback voltage (V_{FB}) as an indicator of the output load and modulates the PWM frequency, as shown in Figure 23, such that the switching frequency decreases as load decreases. In heavy load conditions, the switching frequency is 65KHz. Once V_{FB} decreases below V_{FB-N} (2.2V), the PWM frequency starts to linearly decrease from 65KHz to 22.5kHz to reduce the switching losses. As V_{FB} decreases below V_{FB-G} (2.1V), the switching frequency is fixed at 22.5kHz and FAN6862 enters “deep” green mode, where the operating current decreases to 2.5mA (maximum), further reducing the standby power consumption. As V_{FB} decreases below V_{FB-ZDC} (1.7V), FAN6862 enters burst-mode operation. When V_{FB} drops below V_{FB-ZDC}, FAN6862 stops switching and the output voltage starts to drop, which causes the feedback voltage to rise. Once V_{FB} rises above V_{FB-ZDC}, switching resumes. Burst mode alternately enables and disables switching, thereby reducing switching loss in standby mode, as shown in Figure 24.

Frequency Hopping

EMI reduction is accomplished by frequency hopping, which spreads the energy over a wider frequency range than the bandwidth measured by the EMI test equipment. An internal frequency hopping circuit changes the switching frequency between 60.8kHz and 69.2kHz with a period of 4.4ms, as shown in Figure 25.

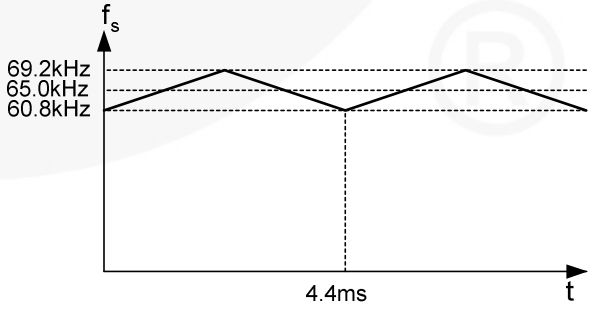


Figure 25. Frequency Hopping

Protections

Self-protective functions include V_{DD} Over-Voltage Protection (OVP), Open-Loop / Overload Protection (OLP), Over-Current Protection (OCP), Short-Circuit Protection, and Over-Temperature Protection (OTP). OLP, OCP, and SCP are auto-restart mode protections; while OVP and OTP are latch-mode protections.

Auto-Restart Mode Protection: Once a fault condition is detected, switching is terminated and the MOSFET remains off. This causes V_{DD} to fall because no more power is delivered from auxiliary winding. When V_{DD} falls to V_{DD-OFF} (8.5V), the protection is reset and the operating current reduces to startup current, which causes V_{DD} to rise. FAN6862 resumes normal operation when V_{DD} reaches V_{DD-ON} (16V). In this manner, the auto-restart can alternately enable and disable the switching of the MOSFET until the fault condition is eliminated (*see Figure 26*).

Latch-Mode Protection: Once this protection is triggered, switching is terminated and the MOSFET remains off. The latch is reset only when V_{DD} is discharged below 4V by unplugging AC power line.

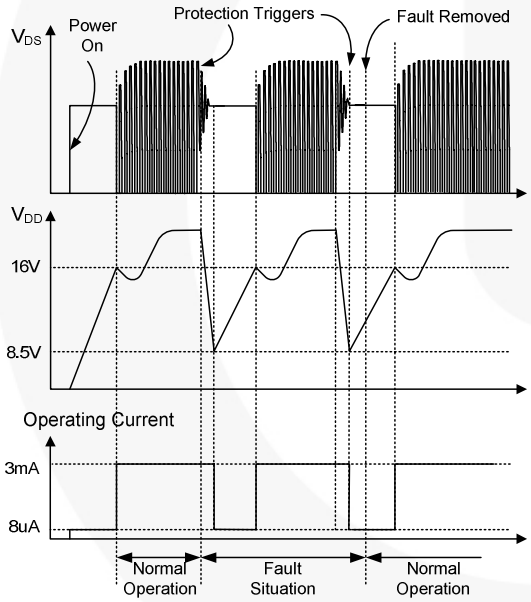


Figure 26. Auto Restart Operation

Over-Current Protection (OCP)
FAN6862 has over-current protection thresholds. It is for pulse-by-pulse current limit, which turns off MOSFET for the remainder of the switching cycle when the sensing voltage of MOSFET drain current reaches the threshold. The other threshold is for the over-current protection, which shuts down the MOSFET gate when the sensing voltage of MOSFET drain current is above the threshold longer than the shutdown delay (56ms).

Open-Loop / Over-Load Protection (OLP)
When the upper branch of the voltage divider for the shunt regulator (KA431 shown) is broken, as shown in Figure 27, no current flows through the opto-coupler transistor, which pulls up the feedback voltage to 5.2V.

When the feedback voltage is above 4.6V longer than 56ms, OLP is triggered. This protection is also triggered when the SMPS output drops below the nominal value longer than 56ms due to the overload condition.

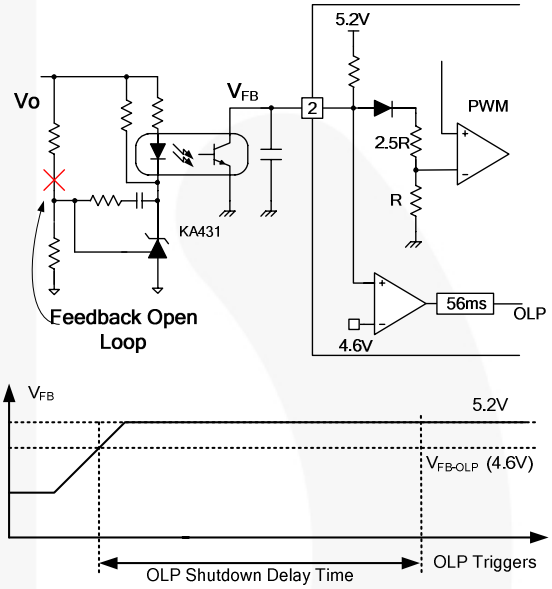


Figure 27. OLP Operation

V_{DD} Over-Voltage Protection (OVP)
V_{DD} over-voltage protection prevents IC damage caused by over voltage on the V_{DD} pin. The OVP is triggered when V_{DD} reaches 25V. A debounce time (typically 30μs) prevents false triggering by switching noise.

Over-Temperature Protection (OTP)
The OTP circuit is composed of current source and voltage comparators. Typically, an NTC thermistor is connected between the RT and GND pins. Once the voltage of this pin drops below a threshold of 1.0V, PWM output is disabled after t_{DOTP} debounce time. If this pin drops below 0.7V, it triggers the latch-off protection immediately after t_{DOTP2} debounce time.

Constant Output Power Limit

FAN6862 has saw-limiter for pulse-by-pulse current limit, which guarantees almost constant power limit over different line voltages of universal input range.

The conventional pulse-by-pulse current limiting scheme has a constant threshold for current limit comparator, which results in a higher power limit for high line voltage. FAN6862 has a sawtooth current limit threshold that increases progressively within a switching cycle, which provides lower current limit for high line and makes the actual power limit level almost constant over different line voltages of universal input range, as shown in Figure 28.

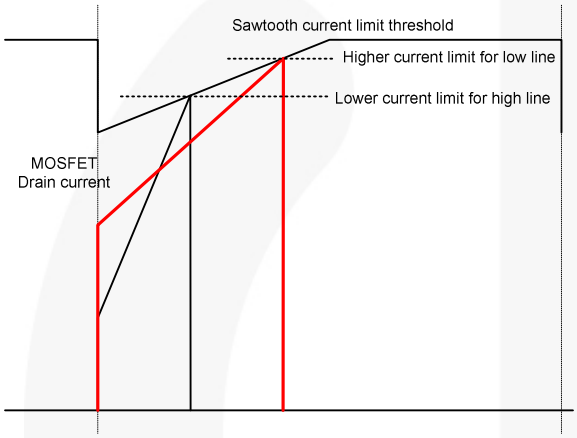


Figure 28. Sawtooth Current Limiter

Leading-Edge Blanking (LEB)

Each time the power MOSFET is switched on, a turn-on spike occurs across the sense-resistor caused by primary-side capacitance and secondary-side rectifier reverse recovery. To avoid premature termination of the switching pulse, a leading-edge blanking time is built in. During this blanking period (360ns), the PWM comparator is disabled and cannot switch off the gate driver. Thus, RC filter with a small RC time constant is enough for current sensing.

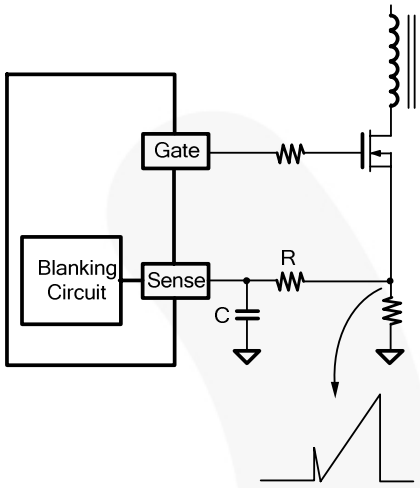


Figure 29. Current Sense R-C Filter

Soft-Start

The FAN6862 has an internal soft-start circuit that increases pulse-by-pulse current-limit comparator inverting input voltage slowly after it starts. The typical soft-start time is 4ms. The pulsewidth to the power MOSFET is progressively increased to establish the correct working conditions for transformers, rectifier diodes, and capacitors. The voltage on the output capacitors is progressively increased with the intention of smoothly establishing the required output voltage. It also helps prevent transformer saturation and reduces the stress on the secondary diode during startup.

Applications Information

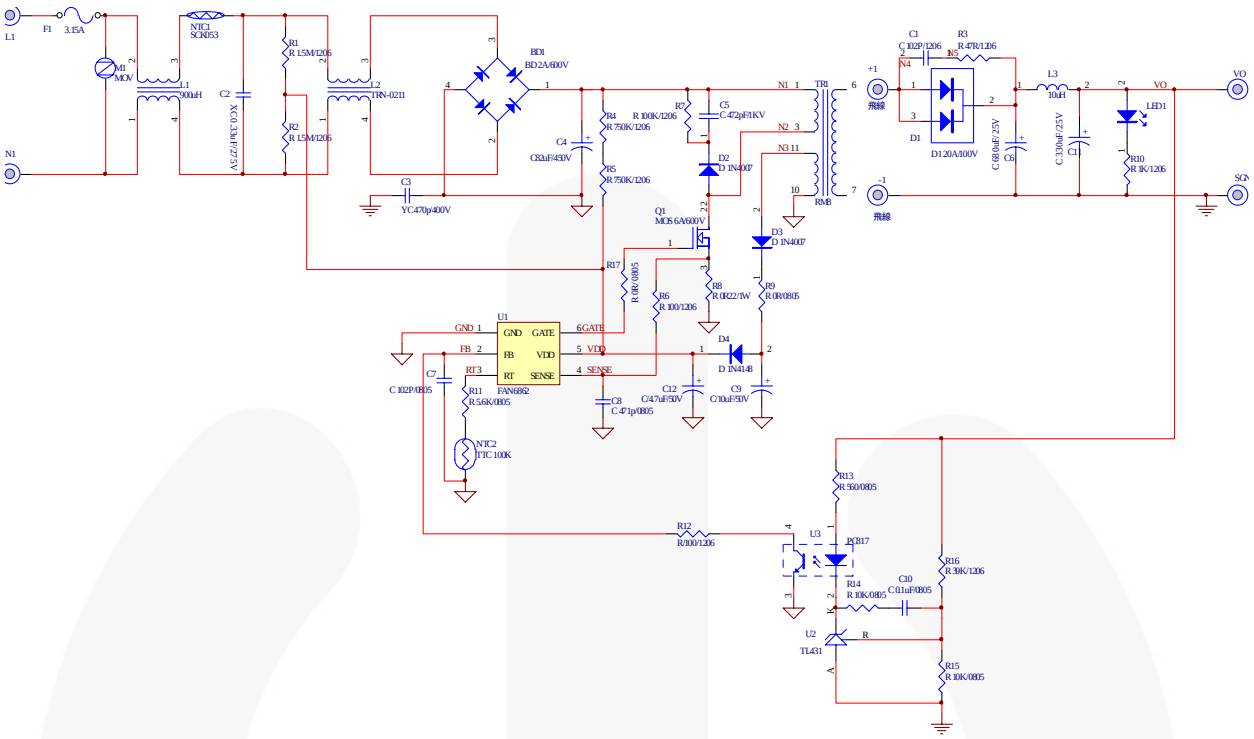


Figure 30. 36W (12V/3A) Application Circuit

BOM

Designator	Part Type	Designator	Part Type
BD1	2KBP06M 2A/600V	C8	CC 470pF/50V
D1	Y2010DN 20A/100V	C9	EC 10μF/50V
D2, D3	1N4007	C10	CC 0.1μF/50V
D4	1N4148	C12	EC 4.7μF/50V
F1	Fuse 3.15A/250V	R1, R2	R 1.5MΩ (option)
NTC1	NTC Thermistor SCK053	R3	R 47Ω
NTC2	NTC Thermistor TTC 100KΩ	R4, R5	R 750KΩ (option)
L1	900μH	R6, R12	R 100Ω
L2	10mH	R7	R 100KΩ
L3	10μH	R8	R 0.22Ω / 1W
TR1	RM-8 400μH	R9	R 0Ω
M1	VZ 9G	R10	R 1KΩ
LED1	LED	R11	R 5.6KΩ
C1	CC 1nF	R13	R 560Ω
C2	XC 0.33μF/275V	R14, R15	R 10KΩ
C3	YC 470pF/400V	R16	R 39KΩ
C4	EC 82μF/400V	U1	IC FAN6862
C5	CC 4.7nF/1KV	U2	TL431
C6, C11	EC 680μF/25V	U3	PC-817
C7	CC 1nF	Q1	MOSFET 6A/600V

Physical Dimensions

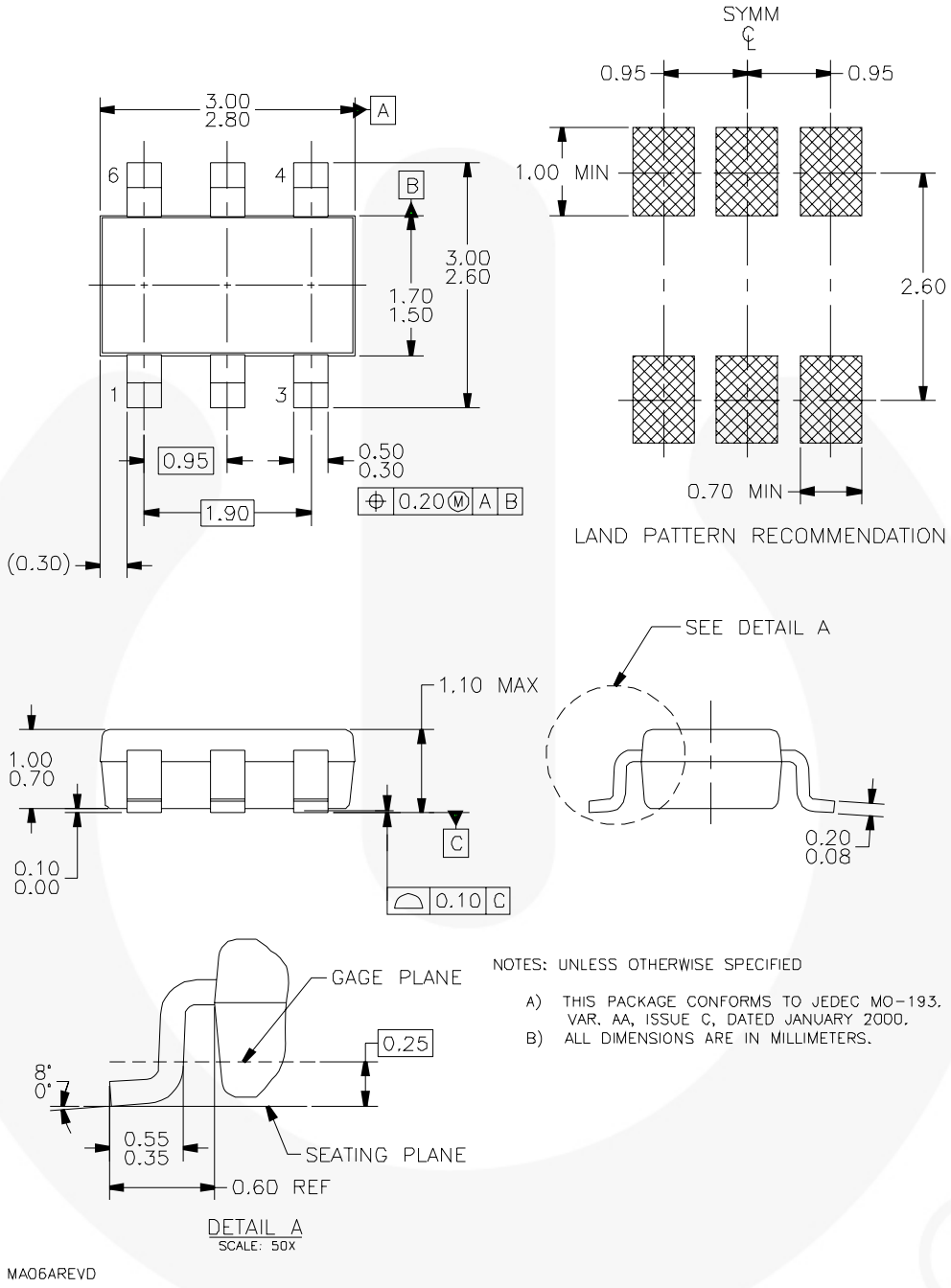


Figure 31. 6-Pin, SUPERSOT6 “SSOT-6”, JEDEC MO-193, 1.6mm Wide Package

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Physical Dimensions

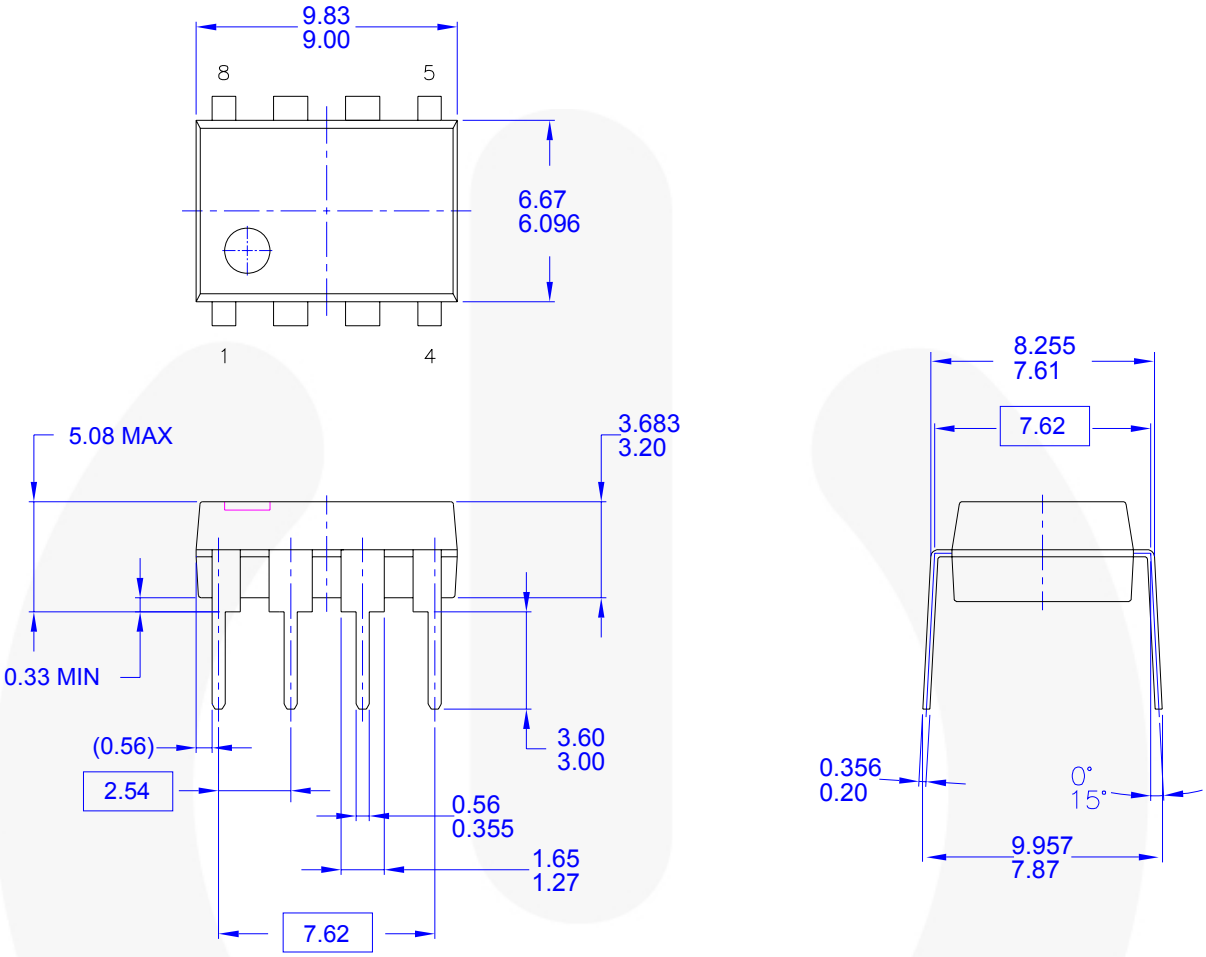

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Figure 32. 8-Pin Dual In-Line Package (DIP)

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