www.fairchildsemi.com

FSDx0365RN

FSDM0365RN, FSDL0365RN
Fairchild Power Switch(FPS)

Features

- Internal Avalanche Rugged SenseFET
- Consumes only 0.65W at 240VAC & 0.3W load with Advanced Burst-Mode Operation
- Frequency Scaling for low EMI
- Precision Fixed Operating Frequency
- Internal Start-up Circuit
- Pulse by Pulse Current Limiting
- Over Current Protection
- Over Voltage Protection
- Over Load Protection
- Internal Thermal Shutdown Function
- Auto-Restart Mode
- Under Voltage Lockout
- Low Operating Current (3mA)
- Built-in Soft Start

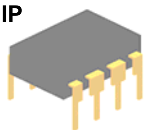
Applications

- SMPS for VCR, SVR, STB, DVD & DVCD
- SMPS for Printer, Facsimile & Scanner
- Adaptor for Camcorder

Description

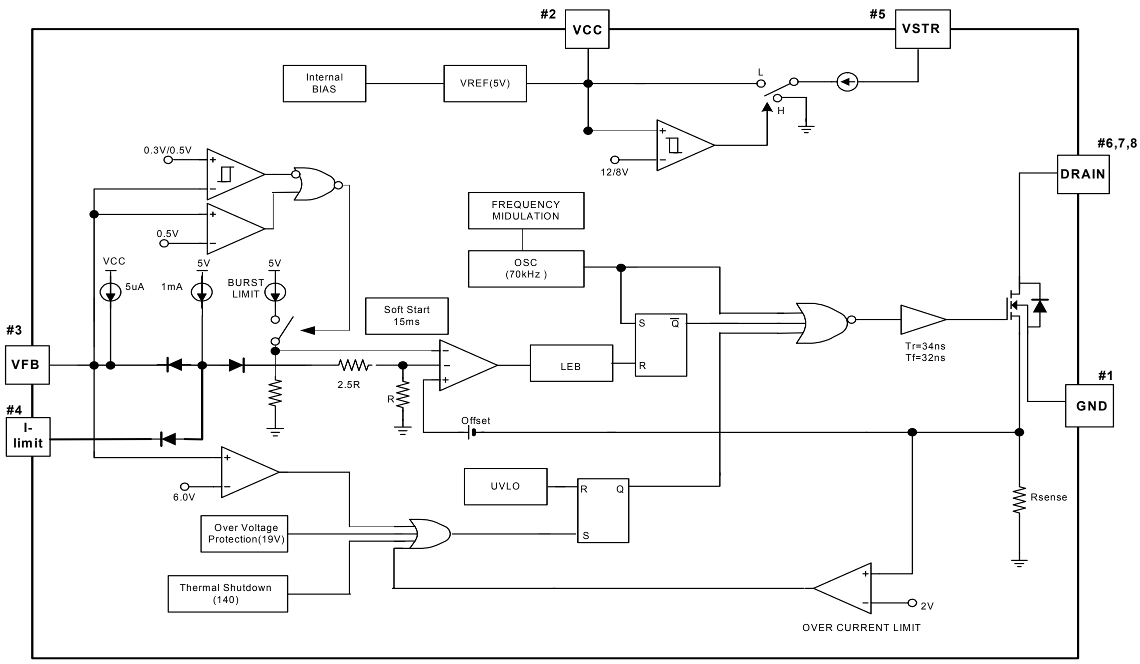
The Fairchild Power Switch(FPS) product family is specially designed for an off-line SMPS with minimal external components. The Fairchild Power Switch(FPS) consists of a high voltage power SenseFET and a current mode PWM IC. Included PWM controller integrates the fixed frequency oscillator, the under voltage lock-out, the leading edge blanking, the optimized gate turn-on/turn-off driver, the thermal shutdown protection, the over voltage protection, and the temperature compensated precision current sources for the loop compensation and the fault protection circuitry. Compared to a discrete MOSFET and a PWM controller or an RCCsolution, a Fairchild Power Switch(FPS) can reduce the total component count, design size and weight and at the same time increase efficiency, productivity, and system reliability. It is well suited for cost effective design of fly-back converters.

8-DIP



1.GND 2.Vcc 3.Vfb 4.Ipk 5.Vstr 6.7.8.Drain

Typical Application



Rev.1.0.0

Absolute Maximum Ratings

(Ta=25°C, unless otherwise specified)

Characteristic	Symbol	Value	Unit
Drain-Gate Voltage (R_{GS}=1MΩ)	V_{DGR}	650	V
Gate-Source (GND) Voltage	V_{GS}	±30	V
Drain Current Pulsed (1)	I_{DM}	12.0	A_{DC}
Single Pulsed Avalanche Energy (2)	E_{AS}	127	mJ
Maximum Supply Voltage	$V_{CC,MAX}$	30	V
Analog Input Voltage Range	V_{FB}	-0.3 to V_{SD}	V
Total Power Dissipation	P_D	1.56	W
	Derating	0.0125	W/°C
Operating Junction Temperature.	T_J	+160	°C
Operating Ambient Temperature.	T_A	-25 to +85	°C
Storage Temperature Range.	T_{STG}	-55 to +150	°C

Note:

1. Repetitive rating: Pulse width limited by maximum junction temperature
2. L = 51mH, starting Tj = 25°C
3. L = 13μH, starting Tj = 25°C

Electrical Characteristics (SenseFET Part)

(Ta = 25°C unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Drain-Source Breakdown Voltage	BV_{DSS}	V_{GS}=0V, I_D=50μA	650	-	-	V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS}=Max. Rating, V_{GS}=0V	-	-	50	μA
		V_{DS}=0.8Max. Rating, V_{GS}=0V, T_C=125°C	-	-	200	μA
Static Drain-Source on Resistance (Note)	$R_{DS(ON)}$	V_{GS}=10V, I_D=0.5A	-	3.6	4.5	Ω
Forward Transconductance (Note)	gfs	V_{DS}=50V, I_D=0.5A	2.0	-	-	S
Input Capacitance	Ciss	V_{GS}=0V, V_{DS}=25V, f=1MHz	-	314.9	-	pF
Output Capacitance	Coss		-	47	-	
Reverse Transfer Capacitance	Crss		-	9	-	
Turn On Delay Time	td(on)	V_{DD}=0.5BV_{DSS}, I_D=1.0A (MOSFET switching time is essentially independent of operating temperature)	-	11.2	-	nS
Rise Time	tr		-	34	-	
Turn Off Delay Time	td(off)		-	28.2	-	
Fall Time	tf		-	32	-	
Total Gate Charge (Gate-Source+Gate-Drain)	Qg	V_{GS}=10V, I_D=1.0A, V_{DS}=0.5BV_{DSS} (MOSFET switching time is essentially independent of operating temperature)	-	-	11.93	nC
Gate-Source Charge	Qgs		-	1.95	-	
Gate-Drain (Miller) Charge	Qgd		-	6.85	-	

Note:

1. Pulse test: Pulse width ≤ 300μS, duty ≤ 2%
2. $S = \frac{1}{R}$

Electrical Characteristics (Control Part) (Continued)

(Ta = 25°C unless otherwise specified)

Characteristic		Symbol	Test condition	Min.	Typ.	Max.	Unit
UVLO SECTION							
Start Threshold Voltage		V_{START}	V_{FB}=GND	11	12	13	V
Stop Threshold Voltage		V_{STOP}	V_{FB}=GND	7	8	9	V
OSCILLATOR SECTION							
Initial Accuracy	Ave	F_{OSC}	**FSDM0365RN**	61	67	73	kHz
	Freq Scaling			-	±2.0	-	kHz
Initial Accuracy	Ave	F_{OSC}	**FSDL0365RN**	45	50	55	kHz
	Freq Scaling			-	±1.5	-	kHz
Frequency Change With Temperature (2)		-	–25°C≤Ta≤+85°C	-	±5	±10	%
Maximum Duty Cycle		Dmax		70	75	80	%
FEEDBACK SECTION							
Feedback Source Current		I_{FB}	Ta=25°C, 0V≤Vfb≤3V	0.7	0.9	1.1	mA
Shutdown Feedback Voltage		V_{SD}	Vfb≥6.5V	5.4	6.0	6.6	V
Shutdown Delay Current		Idelay	Ta=25°C, 5V≤Vfb≤V_{SD}	4	5	6	μA
Start Burst Mode Voltage		V_{BH}	-	-	0.5	-	V
Stop Burst Mode Voltage		V_{BL}	-	-	0.3	-	V
CURRENT LIMIT(SELF-PROTECTION)SECTION							
Peak Current Limit		I_{OVER}	Max. inductor current	1.89	2.15	2.41	A
SOFT START SECTION							
Soft Start Time		tsoft		-	15	20	mS
PROTECTION SECTION							
Over Voltage Protection		V_{OVP}	V_{CC}≥18V	18	19	20	V
Thermal Shutdown Temperature (Tj) (1)		T_{SD}	-	-	140	160	°C
TOTAL STANDBY CURRENT SECTION							
Operating Current		I_{OP}	V_{CC}=20V	-	3	5	mA

Note:
1. These parameters, although guaranteed, are not 100% tested in production
2. These parameters, although guaranteed, are tested in EDS(water test) process

Typical Performance Characteristics(SenseFET part)

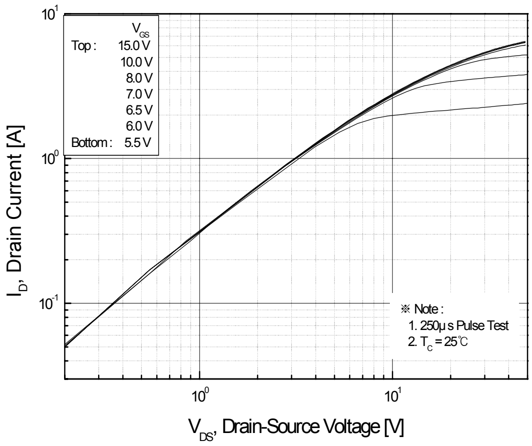


Figure 1. Output Characteristics

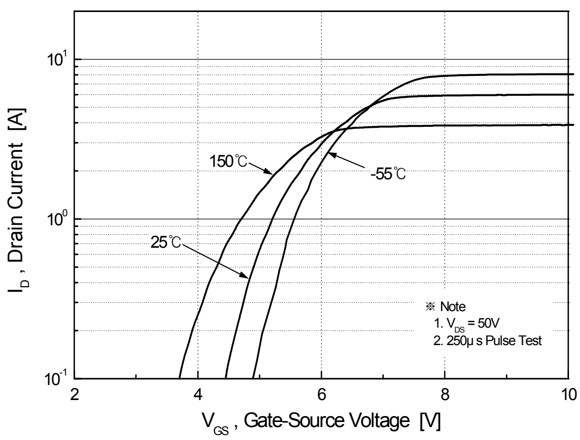


Figure 2. Transfer Characteristics

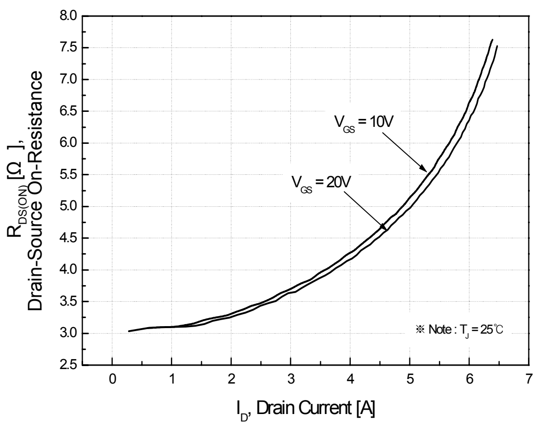


Figure 3. On-Resistance vs. Drain Current

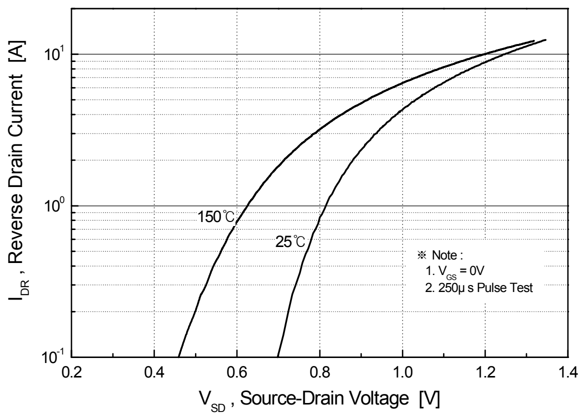


Figure 4. Source-Drain Diode Forward Voltage

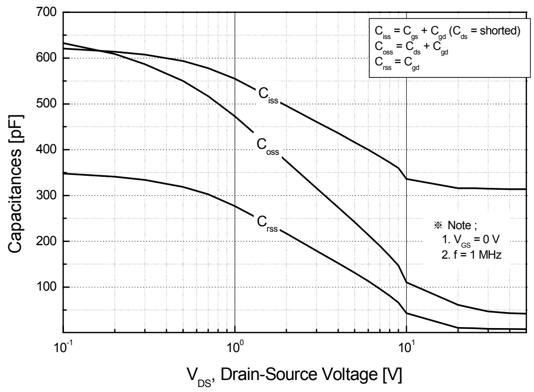


Figure 5. Capacitance vs. Drain-Source Voltage

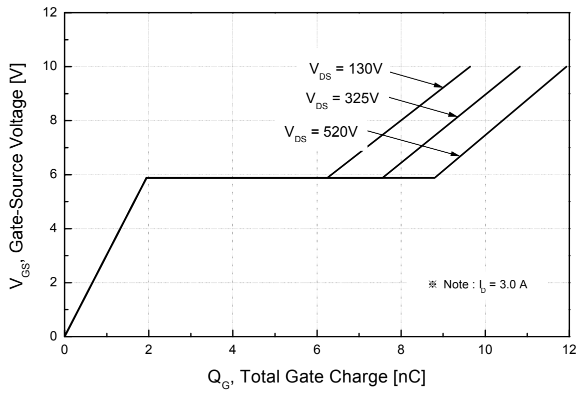


Figure 6. Gate Charge vs. Gate-Source Voltage

Typical Performance Characteristics (Continued)

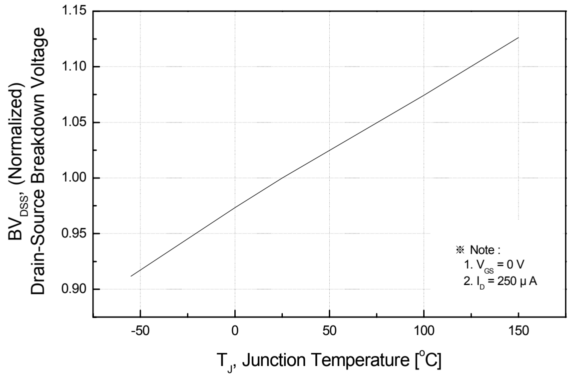


Figure 7. Breakdown Voltage vs. Temperature

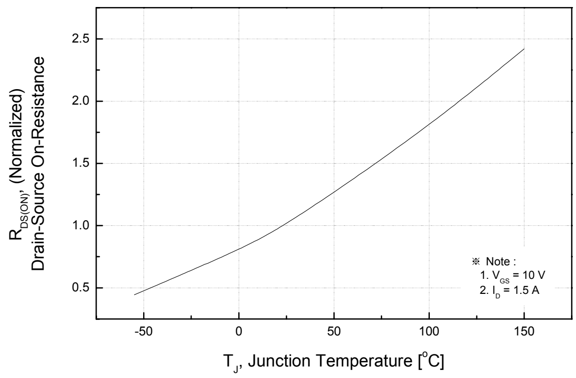


Figure 8. On-Resistance vs. Temperature

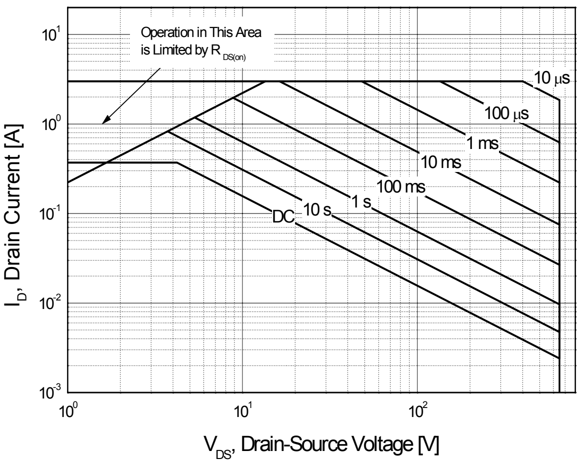


Figure 9. Max. Safe Operating Area

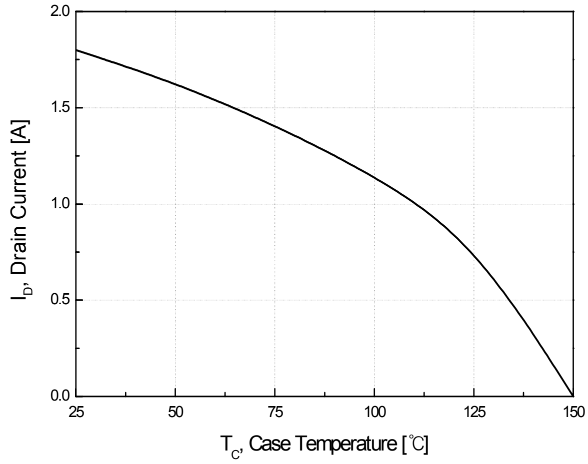


Figure 10. Max. Drain Current vs. Case Temperature

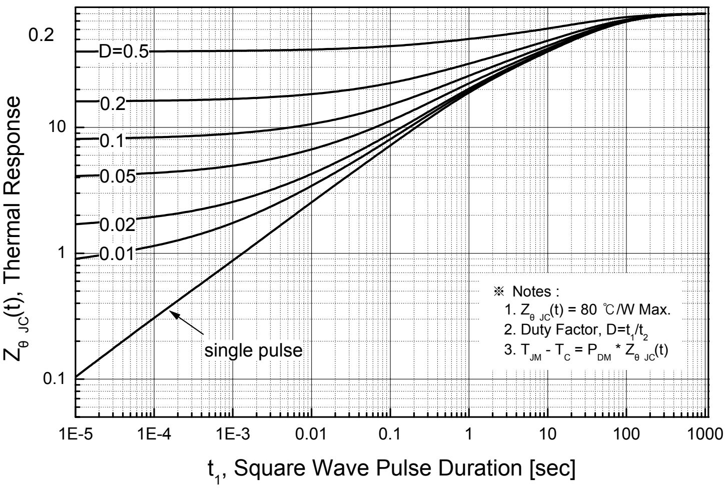


Figure 11. Thermal Response

Functional Description

1. **Startup** : This pin used to be IC's supply pin at the conventional device using start-up resistor. By using J-FET(HV reg) start-up it can remove start-up resistor. An internal high voltage J-FET can provide 1mA current source to Vcc capacitor. To start FPS devices, the Vcc must exceed the start-up threshold, 12V. Below this value the device is inactive and consumes less than 5mA from this pin, 3mA typically. This current source continuously operate more during the soft-start time, 15mS, which is sometimes not enough to get the bias from the transformer of Vcc.

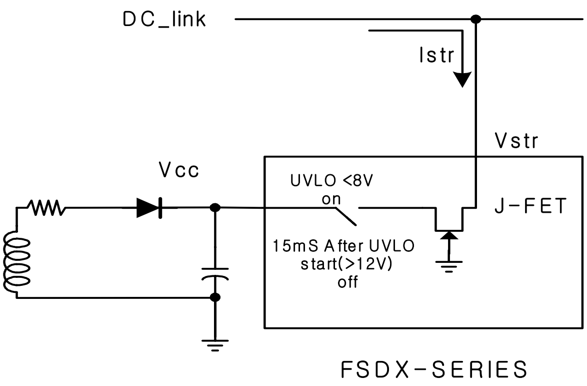


Figure 1. Internal startup circuit

2. Feedback Control : FPS employs current mode control as shown in figure 2. Usually opto-coupler along with KA431 are used to implement feedback network. Comparing the feedback voltage with the sensing voltage of drain current makes it possible to control the switching duty. When the voltage of the reference pin of KA431 exceeds the internal reference voltage of 2.5V, the opto-coupler diode, pulling down the feedback voltage, increases current. It probably happens when the input voltage is increased or the output load is decreased. The feedback voltage(Vfb) has as same level as the comparator voltage(Vcom) because the diodes are biased internally through the main current source(1mA).

3. Leading edge blanking (LEB) : When MOSFET turns on, usually there exists high current spike in the MOSFET current caused by primary-side capacitance and secondary-side rectifier reverse recovery. In order to prevent premature termination of the switching pulse due to the current spike, the FPS employs leading edge blanking (LEB). The leading edge blanking circuit can't work the PWM comparator for a short time after the MOSFET is turned on.

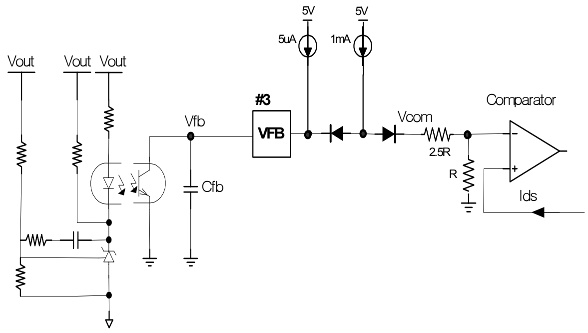


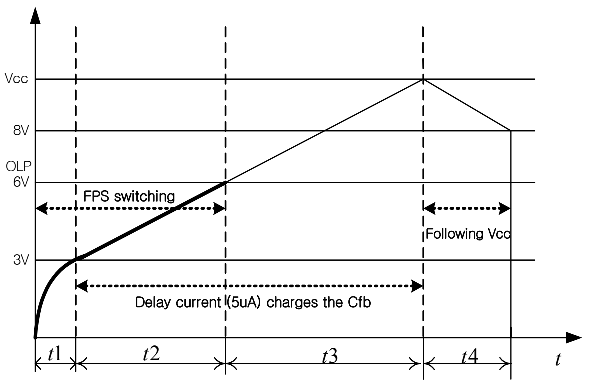
Figure 2. Pulse width modulation (PWM) circuit

4. Protection Circuit : The FPS has several protective functions such as over load protection (OLP), over voltage protection(OVP), over current protection(OCP), under voltage lock out(UVLO) and thermal shutdown (TSD). Because these protection circuits are fully integrated inside IC without external components, the reliability can be improved without increasing cost. when it is confronted by these fault conditions, the FPS gets into auto-restart operation which makes switch off and on periodically by the Vcc. When Vcc reaches UVLO stop voltage, 8V, the protection is reset and the internal high voltage current source charges Vcc capacitor with 1mA. When Vcc reaches the UVLO start voltage,12V, the FPS resumes its normal operation. In this manner, the auto-restart alternately enables and disables the switching of the power MOSFET until the fault condition is eliminated as shown in figure 3.

TBD

Figure 3. Auto restart operation after protection

4.1 Over Load Protection (OLP) : Overload means that the load current exceeds a pre-set level due to an abnormal situation. In this situation, protection circuit should be activated in order to protect the SMPS. However, even when the SMPS is in the normal operation, the over load protection circuit can be activated during the load transition. In order to avoid this undesired operation, the over load protection circuit is designed to be activated after a specified time to determine whether it is a transient situation or an overload situation. Because of the pulse-by-pulse current limit capability, the maximum peak current through the SMPS is limited, and therefore the maximum input power is restricted with a given input voltage. If the output consumes beyond this maximum power, the output voltage (Vo) decreases below the set voltage. This reduces the current through the opto-coupler diode, which also reduces opto-coupler transistor current increasing feedback voltage (Vfb). If Vfb exceeds 3V, D1 is blocked and the 5uA current source starts to charge Cfb slowly compared to when the 250uA current source charges Cfb. In this condition, Vfb continues increasing until it reaches 4V, and the switching operation is terminated at that time as shown in figure 4. The delay time for shutdown is the time required to charge Cfb from 3V to 4V with 5uA.



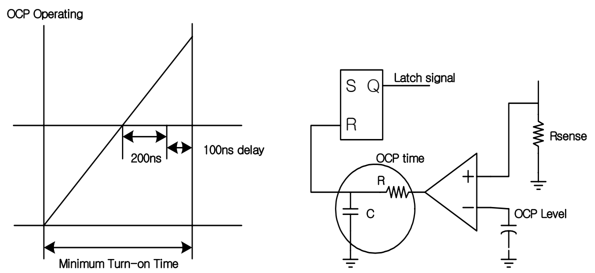
$$t1 = -\frac{1}{RC_{fb}} ln\left(1 - \frac{V(t1)}{R}\right); V(t1) = 3V, R = 2.8K\Omega, C_{fb} = C_{fb\_fig.2}$$

$$t2 = C_{fb}\frac{(V(t1+t2) - V(t1))}{I_{delay}}; I_{delay} = 5uA, V(t1+t2) - V(t1) = 3V$$

Figure 4. Over load protection

4.2 Thermal Shutdown (TSD) : The SenseFET and the control IC are built in one package. This makes it easy for the control IC to detect the heat generation from the SenseFET. When the temperature exceeds approximately 150°C, the thermal shutdown is activated. And after hysteresis 50°C he FPS resumes its normal operation.

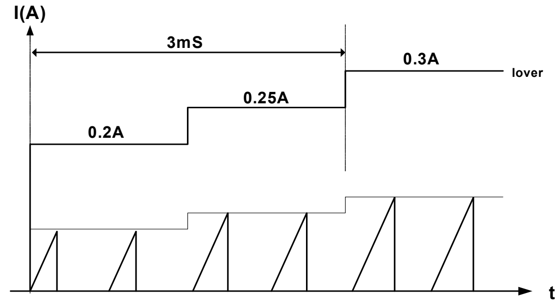
4.3 Over Current Protection (OCP) :

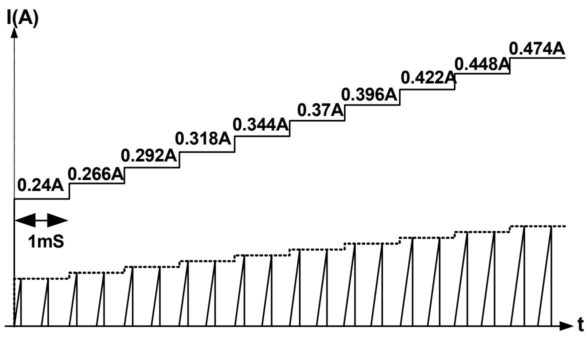


Fiqure 5. OCP Function & Block

Even though the FPS has OLP (Over Load Protection) and pulse by pulse current limiting feature, these are not enough to protect FPS when a secondary side diode short or load short occurs. Therefore, FPS has internal OCP (Over Current Protection) circuit as shown in figure 5. When the gate turn-on signal is applied to the power MOSFET, the OCP block is enabled and monitors the current through the sensing resistor for 1us. The voltage across the resistor is compared with the preset OCP level. If the sensing resistor voltage is greater than the OCP level for longer than 200ns within the allowed comparison time of 1us, the reset signal is applied to the latch, resulting in the shutdown of SMPS. Here, the additional delay of 100ns after the 200ns delay is the time required for the operation of the protection circuit.

4.4 Soft Start : FPS has an internal soft start circuit that increases the feedback voltage together with the MOSFET current slowly when it starts up. The soft start time is 3msec in FPS.





5. Burst operation : In order to minimize the power dissipation in the standby mode, FPS has burst operations.

TBD

Figure 5. Circuit for burst operation

The FPS enters into the burst mode for itself when the feedback voltage decreases as the load decreases. When the feedback voltage decreases below 0.5V, the FPS stops the switching operation. Then, the output voltage drops below the set voltage, which increases the feedback voltage. When the feedback voltage goes higher than 0.6V, the FPS resumes the switching operation and the feedback voltage decreases. When the feedback voltage drops to 0.5V again, the FPS ceases the switching operation. In this manner, the burst operation alternately enables and disables the switching of the power MOSFET to reduce the switching loss in the standby mode.

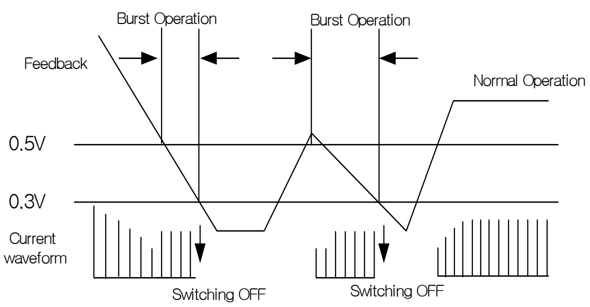
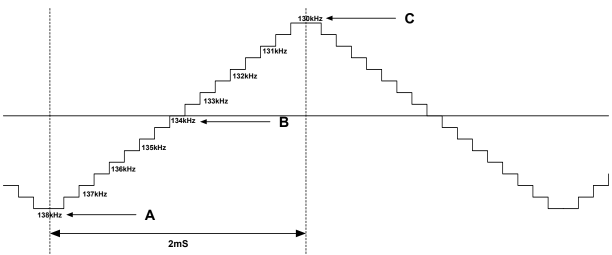
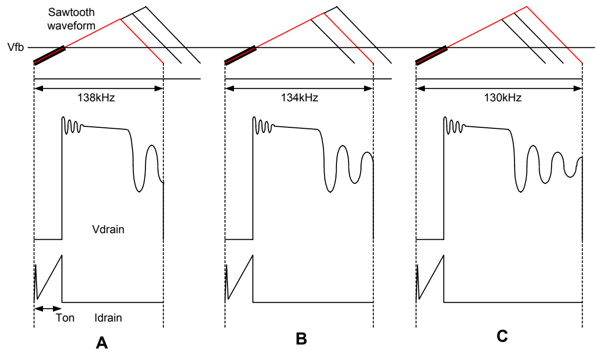


Figure 6. Waveforms of burst operation

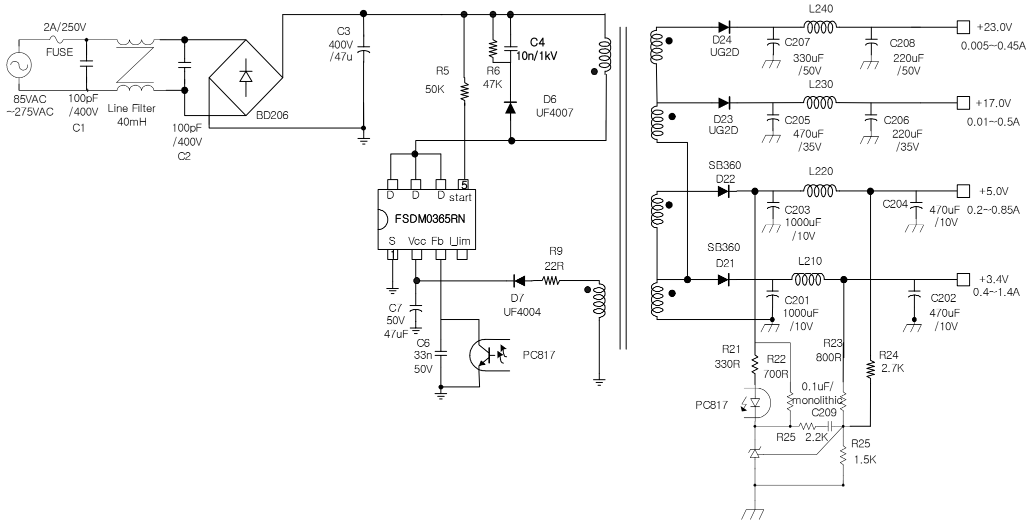
6. Frequency Modulation





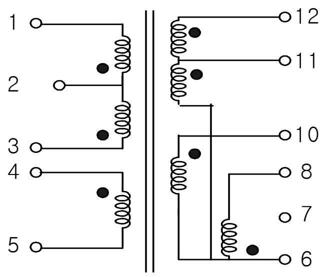
Typical application circuit

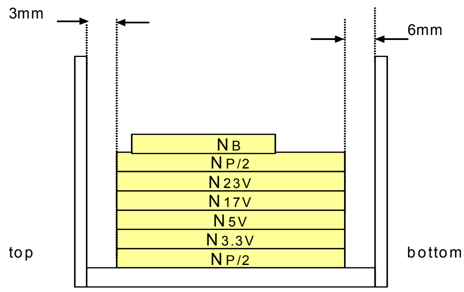
1. Set Top Box Example Circuit



1. **TRANSFORMER SPECIFICATION**

- **SCHEMATIC DIAGRAM (TRANSFORMER)**





2. **WINDING SPECIFICATION**

NO.	PIN(S → F)	WIRE	TURNS	WINDING METHOD
NP/2	3 → 2	0.25 Φ × 1	22	SOLENOID WINDING
N3.3V	6 → 8	0.3 Φ × 8	2	STACK WINDING
N5V	10 → 6	0.3 Φ × 2	1	STACK WINDING
N16V	11 → 6	0.3 Φ × 4	7	SOLENOID WINDING
N23V	12 → 11	0.3 Φ × 2	3	SOLENOID WINDING
NP/2	2 → 1	0.25 Φ × 1	22	SOLENOID WINDING
NB	4 → 5	0.25 Φ × 1	10	CENTER WINDING

3. **ELECTRIC CHARACTERISTIC**

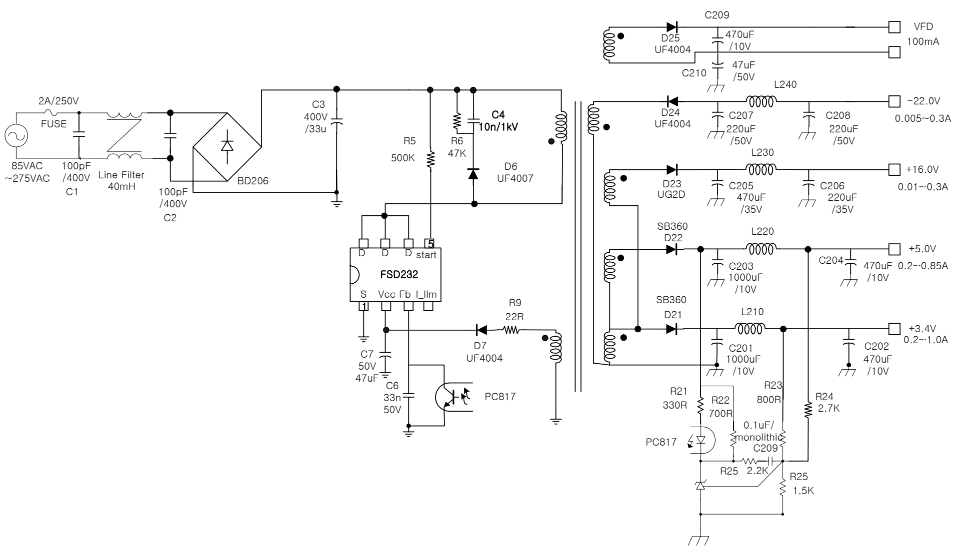
CLOSURE	PIN	SPEC.	REMARKS
INDUCTANCE	1 - 3	800uH ± 10%	1KHz, 1V
LEAKAGE L	1 - 3	15uH MAX.	2nd ALL SHORT

4. BOBBIN & CORE.

CORE: EER2828
BOBBIN: EER2828

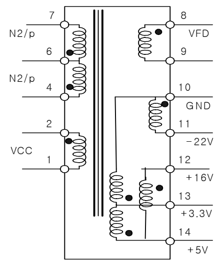
Typical application circuit

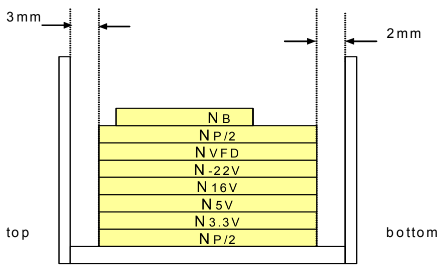
2. DVD Player



1. Transformer Details

1.1. Schematic & Construction





1.2. Winding Details

NO.	PIN(S → F)	WIRE	TURNS	WINDING METHOD
NP/2	4 → 6	0.25 Φ × 1	22	SOLENOID WINDING
N3.3V	13 → 10	0.3 Φ × 7	2	STACK WINDING
N5V	14 → 13	0.3 Φ × 3	1	STACK WINDING
N16V	12 → 14	0.3 Φ × 2	6	SOLENOID WINDING
N-22V	10 → 11	0.3 Φ × 1	12	SOLENOID WINDING
NVFD	8 → 9	0.3 Φ × 1	2	SOLENOID WINDING
NP/2	6 → 7	0.25 Φ × 1	22	SOLENOID WINDING
NB	2 → 1	0.25 Φ × 1	8	CENTER WINDING

1.3. Electrical Characteristics

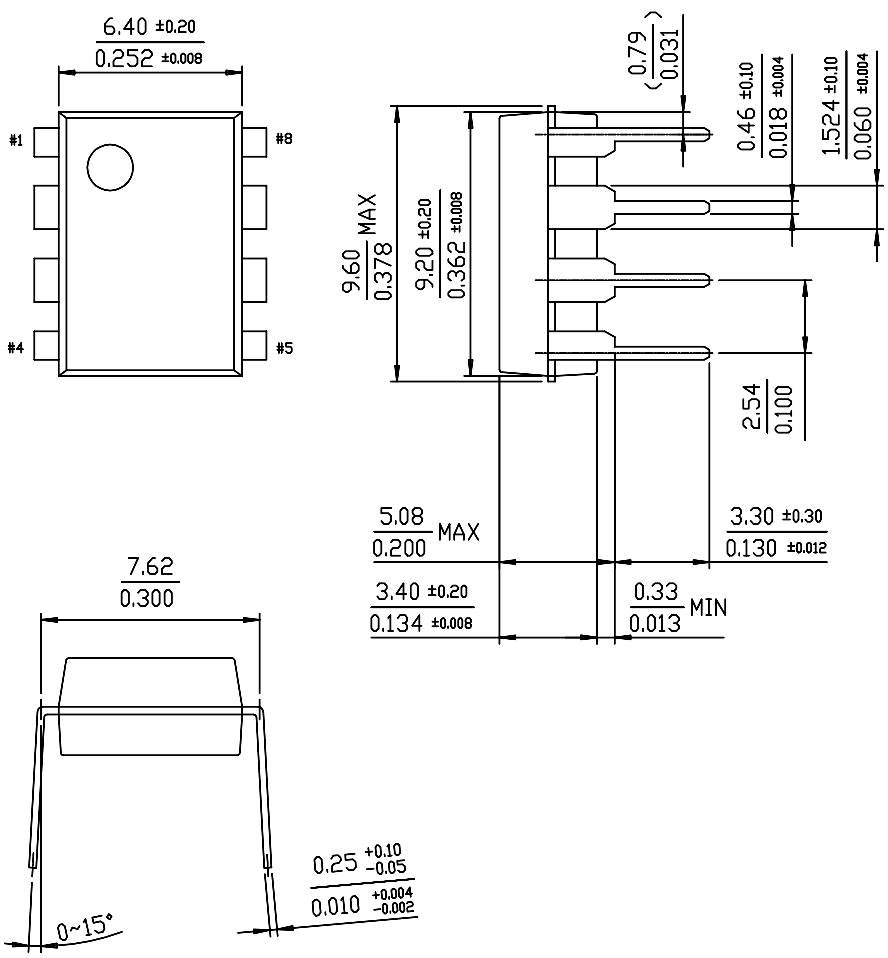
CLOSURE	PIN	SPEC.	REMARKS
INDUCTANCE	1 - 3	820uH ± 10%	1KHz, 1V
LEAKAGE L	1 - 3	15uH MAX.	2nd ALL SHORT

1.4. Core and Bobbin

CORE: EER2820
BOBBIN: EER2820

Package Dimensions

8-DIP



Ordering Information

Product Number	Package	Marking Code	BV_{DSS}	F_{OSC}	$R_{DS(on)}$
FSDM0365RN	8-DIP	DM0365R	650V	67kHz	3.6Ω
FSDL0365RN	8-DIP	DL0365R	650V	50kHz	3.6Ω

DISCLAIMER

LIFE SUPPORT POLICY

8/28/03 0.0m 001
Stock#DSxxxxxxxx