



Is Now Part of



**ON Semiconductor®**

To learn more about ON Semiconductor, please visit our website at  
[www.onsemi.com](http://www.onsemi.com)

Please note: As part of the Fairchild Semiconductor integration, some of the Fairchild orderable part numbers will need to change in order to meet ON Semiconductor's system requirements. Since the ON Semiconductor product management systems do not have the ability to manage part nomenclature that utilizes an underscore (\_), the underscore (\_) in the Fairchild part numbers will be changed to a dash (-). This document may contain device numbers with an underscore (\_). Please check the ON Semiconductor website to verify the updated device numbers. The most current and up-to-date ordering information can be found at [www.onsemi.com](http://www.onsemi.com). Please email any questions regarding the system integration to [Fairchild\\_questions@onsemi.com](mailto:Fairchild_questions@onsemi.com).

ON Semiconductor and the ON Semiconductor logo are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.



June 2006

# FSCM0465R

## Green Mode Fairchild Power Switch (FPS™)

### Features

- Internal Avalanche Rugged SenseFET
- Low Start-up Current (max. 40µA)
- Low Power Consumption; under 1W at 240VAC and 0.4W Load
- Precise Fixed Operating Frequency (66kHz)
- Frequency Modulation for Low EMI
- Pulse-by-Pulse Current Limiting (Adjustable)
- Over-Voltage Protection (OVP)
- Overload Protection (OLP)
- Thermal Shutdown Function (TSD)
- Auto-Restart Mode
- Under-Voltage Lock Out (UVLO) with Hysteresis
- Built-in Soft-Start (15ms)

### Applications

- SMPS for VCR, SVR, STB, DVD, and DVCD
- Adaptor
- SMPS for LCD Monitor

### Related Application Notes

- **AN-4137:** Design Guidelines for Off-line Flyback Converters Using Fairchild Power Switch (FPS)
- **AN-4140:** Transformer Design Consideration for Off-line Flyback Converters using Fairchild Power Switch
- **AN-4141:** Troubleshooting and Design Tips for Fairchild Power Switch Flyback Applications
- **AN-4148:** Audible Noise Reduction Techniques for FPS Applications

### Description

The FSCM0465R is an integrated Pulse-Width Modulator (PWM) and SenseFET specifically designed for high-performance offline Switch Mode Power Supplies (SMPS) with minimal external components. This device is an integrated high-voltage power-switching regulator that combines an avalanche rugged SenseFET with a current mode PWM control block. The PWM controller includes an integrated fixed-frequency oscillator, under-voltage lockout, leading edge blanking (LEB), optimized gate driver, internal soft-start, temperature-compensated precise current sources for a loop compensation, and self-protection circuitry. Compared with a discrete MOSFET and PWM controller solution, it can reduce total cost, component count, size, and weight while simultaneously increasing efficiency, productivity, and system reliability. This device is a basic platform well suited for cost-effective designs of flyback converters.

### Ordering Information

Product Number	Package	Pb-Free	Marking Code	BV <sub>DSS</sub>	R <sub>DS(ON)</sub> Max.	Packing Method
FSCM0465RJ	D2-PAK-6L	Yes	CM0465R	650V	2.6 Ω	Tube
FSCM0465RJX	D2-PAK-6L	Yes				Tape & Reel
FSCM0465RIWDTU <sup>(1)</sup>	I2-PAK-6L	Yes				Tube
FSCM0465RGWDTU <sup>(1)</sup>	TO-220-6L	Yes				Tube

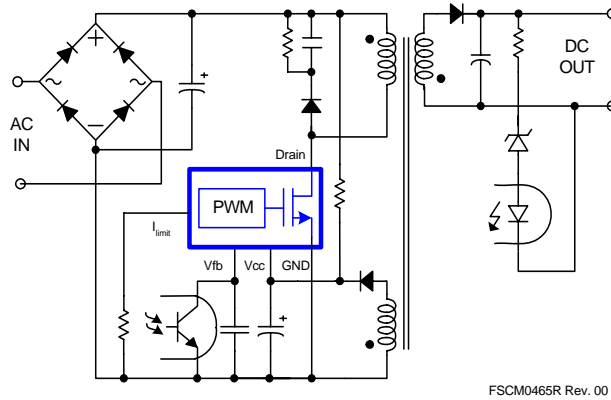
#### Note:

1. WDTU: Forming Type

FPS™ is a trademark of Fairchild Semiconductor Corporation.

FSCM0465R Green Mode Fairchild Power Switch (FPS™)

**Typical Circuit**



FSCM0465R Rev. 00

**Figure 1. Typical Flyback Application**

**Output Power Table**

Product	230VAC $\pm 15\%$ <sup>(3)</sup>		85–265VAC	
	Adapter <sup>(1)</sup>	Open Frame <sup>(2)</sup>	Adapter <sup>(1)</sup>	Open Frame <sup>(2)</sup>
FSCM0465RJ	40W	55W	30W	40W
FSCM0565RJ	50W	65W	40W	50W
FSCM0765RJ	65W	70W	50W	60W
FSCM0465RI	60W	70W	40W	50W
FSCM0465RG	60W	70W	40W	50W
FSCM0565RG	70W	85W	60W	70W
FSCM0765RG	85W	95W	70W	85W

**Notes:**

1. Typical continuous power in a non-ventilated enclosed adapter measured at 50°C ambient
2. Maximum practical continuous power in an open-frame design at 50°C ambient
3. 230 VAC or 100/115 VAC with doubler

### Internal Block Diagram

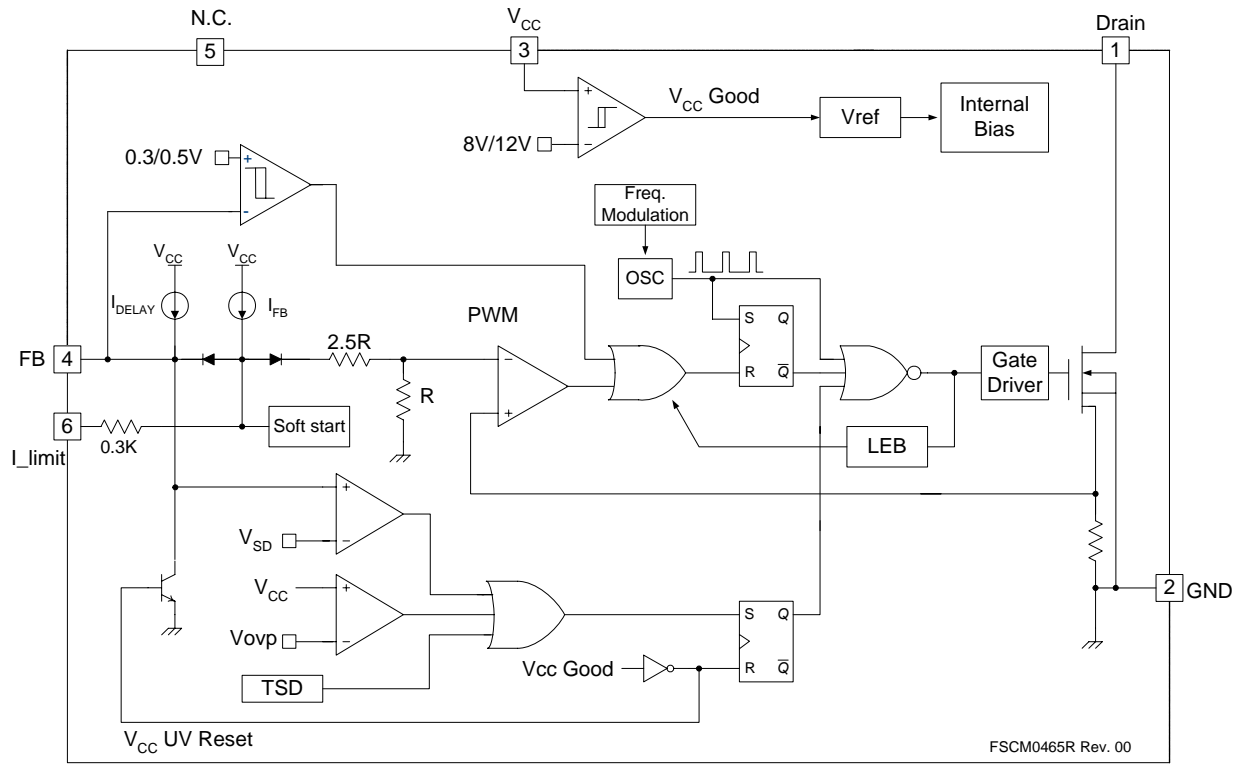


Figure 2. Functional Block Diagram of FSCM0465R

## Pin Configuration

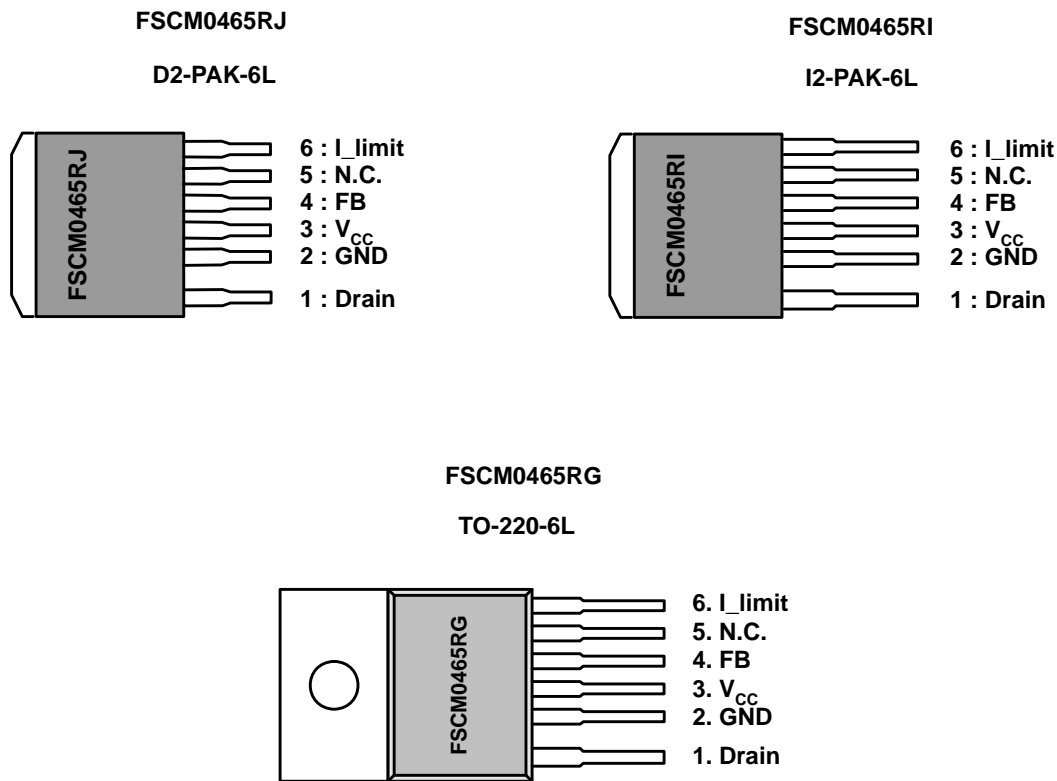


Figure 3. Pin Configuration (Top View)

## Pin Definitions

Pin Number	Pin Name	Pin Function Description
1	Drain	<b>SenseFET Drain.</b> This pin is the high-voltage power SenseFET drain. It is designed to drive the transformer directly.
2	GND	<b>Ground.</b> This pin is the control ground and the SenseFET source.
3	V <sub>CC</sub>	<b>Power Supply.</b> This pin is the positive supply voltage input. During startup, the power is supplied through the startup resistor from DC link. When V <sub>CC</sub> reaches 12V, the power is supplied from the auxiliary transformer winding.
4	Feedback (FB)	<b>Feedback.</b> This pin is internally connected to the inverting input of the PWM comparator. The collector of an opto-coupler is typically tied to this pin. For stable operation, a capacitor should be placed between this pin and GND. If the voltage of this pin reaches 6.0V, the overload protection is activated, resulting in shutdown of the FPS.
5	N.C.	This pin is not connected.
6	I_limit	<b>Current Limit.</b> This pin is for the pulse-by-pulse current limit level programming. By using a resistor to GND on this pin, the current limit level can be changed. If this pin is left floating, the typical current limit is 2.0A.

## Absolute Maximum Ratings

The “Absolute Maximum Ratings” are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the Electrical Characteristics tables are not guaranteed at the absolute maximum ratings.

$T_A = 25^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Value	Unit	
$BV_{DSS}$	Drain-Source Breakdown Voltage <sup>(1)</sup>	650	V	
$V_{DGR}$	Drain-Gate Voltage ( $R_{GS}=1M\Omega$ )	650	V	
$V_{GS}$	Gate-Source (GND) Voltage	$\pm 30$	V	
$I_{DM}$	Drain Current Pulsed <sup>(2)</sup>	16	$A_{DC}$	
$I_D$	Continuous Drain Current (TO-220-6L, I2-PAK-6L)	$T_C = 25^\circ\text{C}$	4.0	$A_{DC}$
		$T_C = 100^\circ\text{C}$	2.5	$A_{DC}$
	Continuous Drain Current (D2-PAK-6L)	$T_C = 25^\circ\text{C}$	2.3	$A_{DC}$
		$T_C = 100^\circ\text{C}$	1.4	$A_{DC}$
$V_{CC}$	Supply Voltage	20	V	
$V_{FB}$	Feedback Voltage Range	-0.3 to $V_{CC}$	V	
$P_D$	Total Power Dissipation (TO-220-6L)	140	W	
Derating		-1.1	W/ $^\circ\text{C}$	
$P_D$	Total Power Dissipation (I2-PAK-6L)	75	W	
Derating		-1.5	W/ $^\circ\text{C}$	
$P_D$	Total Power Dissipation (D2-PAK-6L)	80	W	
Derating		-0.64	W/ $^\circ\text{C}$	
$T_J$	Operating Junction Temperature	Internally limited	$^\circ\text{C}$	
$T_A$	Operating Ambient Temperature	-25 to +85	$^\circ\text{C}$	
$T_{STG}$	Storage Temperature	-55 to +150	$^\circ\text{C}$	
	ESD Capability, HBM Model (All pins except Vfb)	2.0 (GND-Vfb = 1.5kV) ( $V_{CC}$ -Vfb = 1.0kV)	kV	
	ESD Capability, Machine Model (All pins except Vfb)	300 (GND-Vfb = 250V) ( $V_{CC}$ -Vfb = 100V)	V	

### Notes:

- $T_j = 25^\circ\text{C}$  to  $150^\circ\text{C}$
- Repetitive rating: Pulse-width limited by maximum junction temperature
- $T_C$ : Case back surface temperature with infinite heat sink

## Electrical Characteristics

$T_A = 25^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
<b>SenseFET SECTION</b>						
$I_{DSS}$	Zero Gate Voltage Current	$V_{DS} = \text{Max, Rating } V_{GS} = 0\text{V}$	-	-	250	$\mu\text{A}$
$R_{DS(ON)}$	Static Drain Source on Resistance <sup>(1)</sup>	$V_{GS} = 10\text{V, } I_D = 2.3\text{A}$	-	2.2	2.6	$\Omega$
$C_{OSS}$	Output Capacitance	$V_{GS} = 0\text{V, } V_{DS} = 25\text{V, } f = 1\text{MHz}$	-	60	-	pF
$t_{d(on)}$	Turn-on Delay Time	$V_{DD} = 325\text{V, } I_D = 3.2\text{A}^{(4)}$	-	23	-	ns
$t_r$	Rise Time		-	20	-	
$t_{d(off)}$	Turn-off Delay Time		-	65	-	
$t_f$	Fall Time		-	27	-	
<b>CONTROL SECTION</b>						
$f_{OSC}$	Switching Frequency	$V_{CC} = 14\text{V, } V_{FB} = 5\text{V}$	60	66	72	kHz
$\Delta f_{MOD}$	Switching Frequency Modulation Range		-	$\pm 3$	-	kHz
$t_{MOD}$	Switching Frequency Modulation Cycle		-	4	-	ms
$f_{STABLE}$	Switching Frequency Stability	$10\text{V} \leq V_{CC} \leq 17\text{V}$	0	1	3	%
$\Delta f_{OSC}$	Switching Frequency Variation <sup>(2)</sup>	$-25^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$	-	$\pm 5$	$\pm 10$	%
$D_{MAX}$	Maximum Duty Cycle		75	80	85	%
$D_{MIN}$	Minimum Duty Cycle		-	-	0	%
$V_{START}$	UVLO Threshold Voltage	$V_{FB} = \text{GND}$	11	12	13	V
$V_{STOP}$			7	8	9	V
$I_{FB}$	Feedback Source Current	$V_{FB} = \text{GND}$	0.7	0.9	1.1	mA
$t_{S/S}$	Internal Soft-Start Time		10	15	20	ms
<b>BURST MODE SECTION</b>						
$V_{BURH}$	Burst Mode Voltages	$V_{CC} = 14\text{V}$	0.4	0.5	0.6	V
$V_{BURL}$		$V_{CC} = 14\text{V}$	0.24	0.3	0.36	V
<b>PROTECTION SECTION</b>						
$I_{LIMIT}$	Peak Current Limit <sup>(3)</sup>	$V_{CC} = 14\text{V, } V_{FB} = 5\text{V}$	2.2	2.5	2.8	A
$V_{OVP}$	Over-Voltage Protection		18	19	20	V
$T_{SD}$	Thermal Shutdown Temperature <sup>(2)</sup>		130	145	160	$^\circ\text{C}$
$I_{DELAY}$	Shutdown Delay Current	$V_{FB} = 4\text{V}$	3.5	5.3	7	$\mu\text{A}$
$V_{SD}$	Shutdown Feedback Voltage	$V_{FB} \geq 5.5\text{V}$	5.5	6	6.5	V
<b>TOTAL DEVICE SECTION</b>						
$I_{start}$	Startup Current		-	20	40	$\mu\text{A}$
$I_{OP(MIN)}$	Operating Supply Current	$V_{CC} = 10\text{V, } V_{FB} = 0\text{V}$	-	2.5	5	mA
$I_{OP(MAX)}$		$V_{CC} = 20\text{V, } V_{FB} = 0\text{V}$				

### Notes:

1. Pulse Test: Pulse width  $\leq 300\mu\text{S}$ , duty  $\leq 2\%$
2. These parameters, although guaranteed at the design, are not tested in mass production.
3. These parameters indicate the inductor current. Where packages are I2PAK or D2PAK, this should be decreased to 2.0A by external resistor.
4. MOSFET switching time is essentially independent of operating temperature.

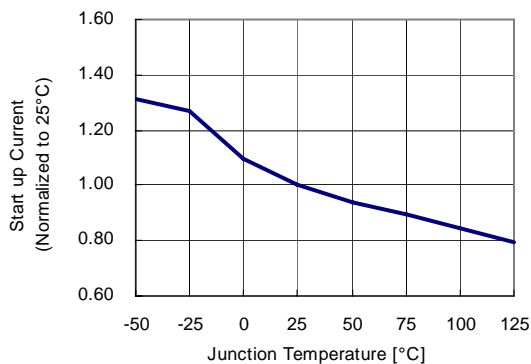
## Comparison Between FSDM0465RB and FSCM0465R

Function	FSDM0465RB	FSCM0465R
Frequency Modulation	N/A	Available - Frequency modulation range ( $\Delta f_{MOD}$ ) = $\pm 3$ kHz - Frequency modulation cycle ( $t_{MOD}$ ) = 4ms
Pulse-by-pulse Current Limit	Internally fixed (2.0A max.)	Programmable using external resistor (2.8A max.)
Internal Startup Circuit	Available	N/A (Requires a startup resistor) Startup current: 40 $\mu$ A (max.)
Packages	TO-220F-6L	TO-220-6L I2-PAK-6L D2-PAK-6L

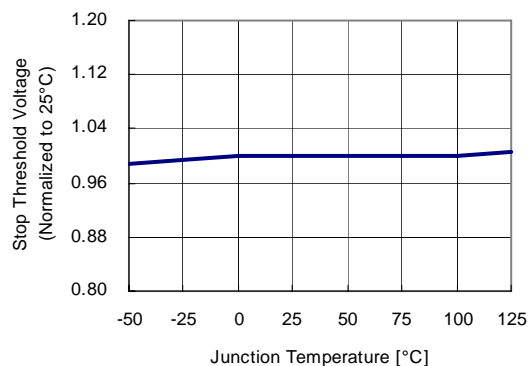


## Typical Performance Characteristics

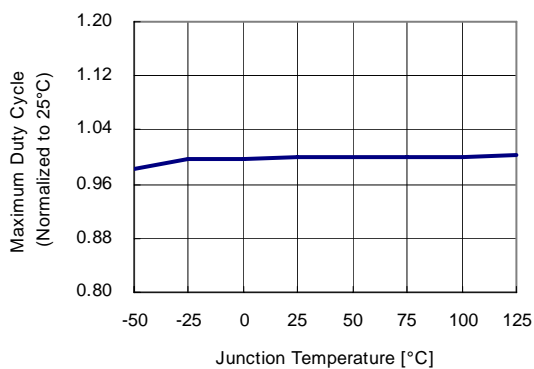
These characteristic graphs are normalized at  $T_A = 25^\circ\text{C}$ .



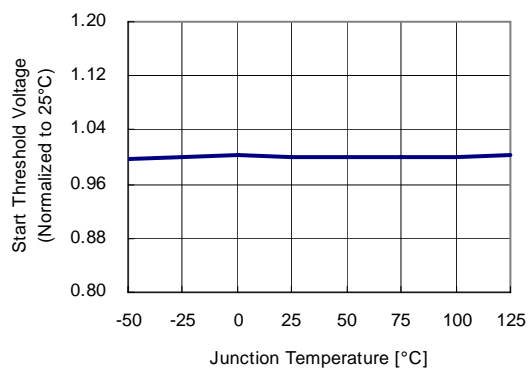
**Figure 4. Startup Current vs. Temp.**



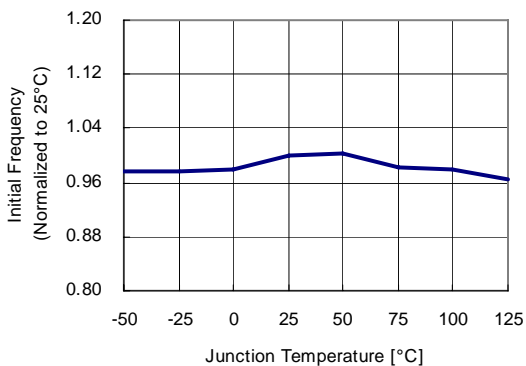
**Figure 5. Stop Threshold voltage vs. Temp.**



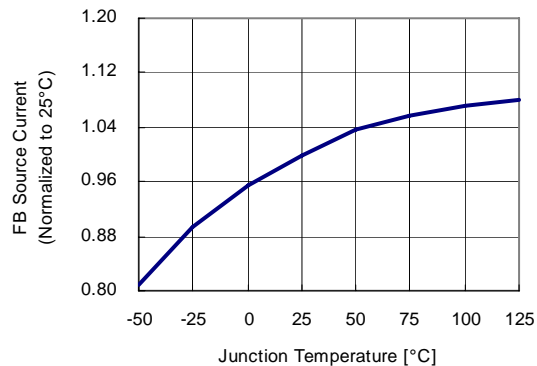
**Figure 6. Maximum Duty Cycle vs. Temp.**



**Figure 7. Start Threshold Voltage vs. Temp.**



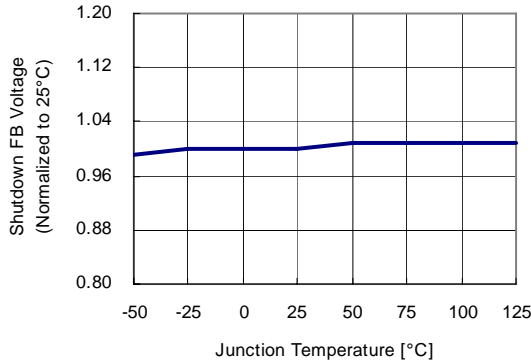
**Figure 8. Initial Frequency vs. Temp.**



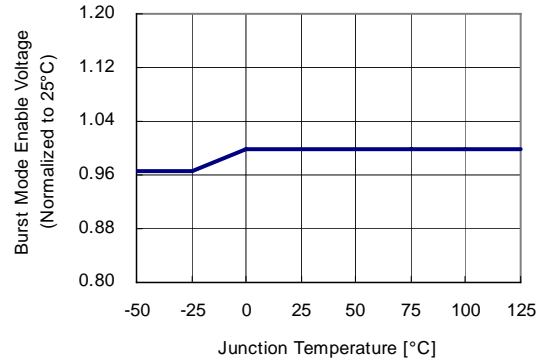
**Figure 9. Feedback Source Current vs. Temp.**

## Typical Performance Characteristics (Continued)

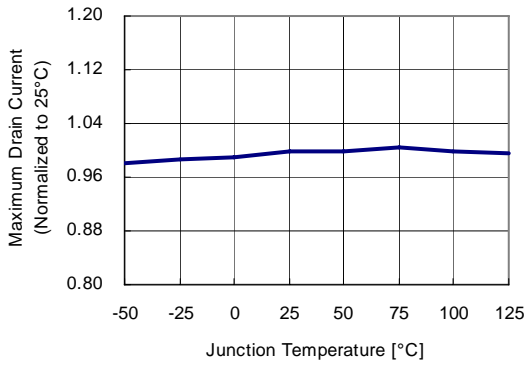
These characteristic graphs are normalized at  $T_A = 25^\circ\text{C}$ .



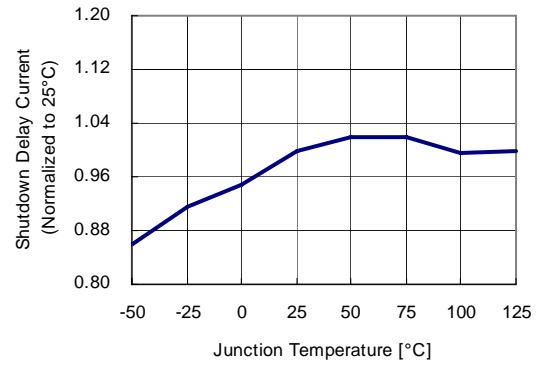
**Figure 10. Shutdown Feedback voltage vs. Temp.**



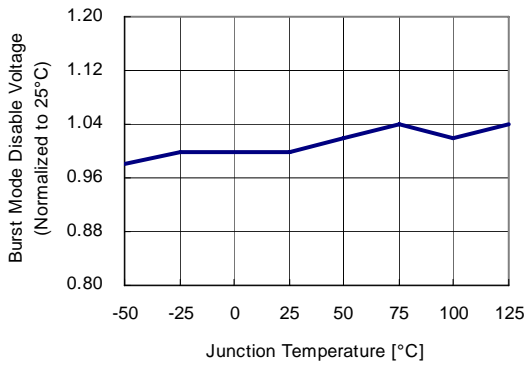
**Figure 11. Burst Mode Enable Voltage vs. Temp.**



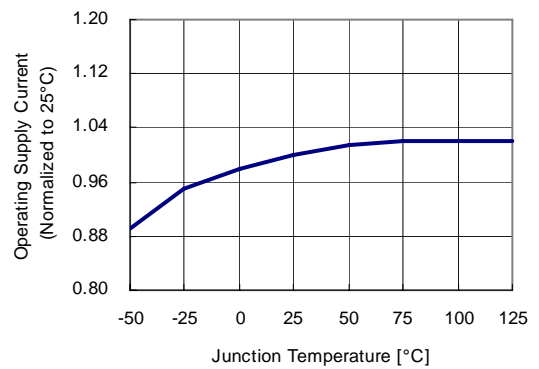
**Figure 12. Maximum Drain Current vs. Temp.**



**Figure 13. Shutdown Delay Current vs. Temp.**



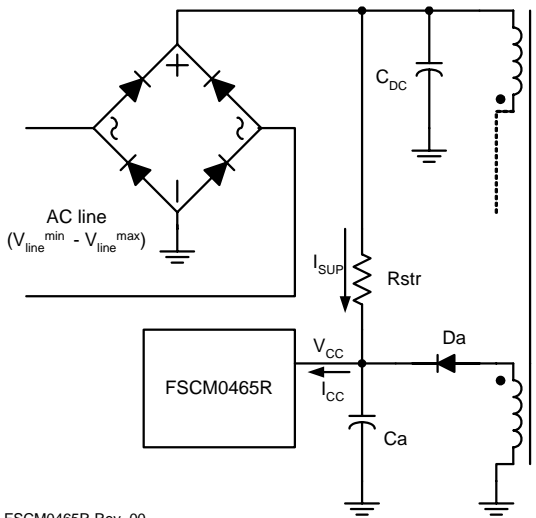
**Figure 14. Burst Mode Disable Voltage vs. Temp.**



**Figure 15. Operating Supply Current vs. Temp.**

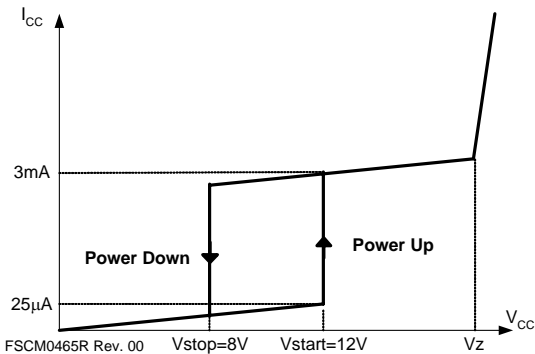
## Functional Description

**1. Startup:** Figure 16 shows the typical startup circuit and transformer auxiliary winding for the FSCM0465R application. Before the FSCM0465R begins switching, it consumes only startup current (typically 20μA) and the current supplied from the DC link supply current consumed by the FPS ( $I_{CC}$ ) and charges the external capacitor ( $C_a$ ) connected to the  $V_{CC}$  pin. When  $V_{CC}$  reaches start voltage of 12V ( $V_{START}$ ), the FSCM0465R begins switching and the current consumed by the FSCM0465R increases to 2.5mA. Then the FSCM0465R continues its normal switching operation and the power required for this device is supplied from the transformer auxiliary winding, unless  $V_{CC}$  drops below the stop voltage of 8V ( $V_{STOP}$ ). To guarantee the stable operation of the control IC,  $V_{CC}$  has under-voltage lockout (UVLO) with 4V hysteresis. Figure 17 shows the relationship between the current consumed by the FPS ( $I_{CC}$ ) and the supply voltage ( $V_{CC}$ ).



FSCM0465R Rev. 00

Figure 16. Startup Circuit



FSCM0465R Rev. 00

Figure 17. Relation Between Operating Supply Current and  $V_{CC}$  Voltage

The minimum current supplied through the startup resistor is given by:

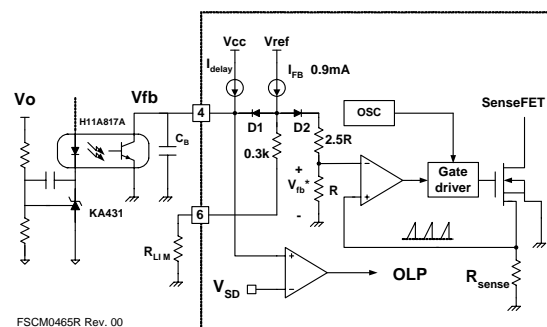
$$I_{sup}^{min} = (\sqrt{2} \cdot V_{line}^{min} - V_{start}) \cdot \frac{1}{R_{str}} \quad (1)$$

where  $V_{line}^{min}$  is the minimum input voltage,  $V_{start}$  is the start voltage (12V) and  $R_{str}$  is the startup resistor. The startup resistor should be chosen so that  $I_{sup}^{min}$  is larger than the maximum startup current (40μA). If not,  $V_{CC}$  can not be charged to the start voltage and FPS fails to start.

**2. Feedback Control:** The FSCM0465R employs current mode control, as shown in Figure 18. An optocoupler (such as the H11A817A) and a shunt regulator (such as the KA431) are typically used to implement the feedback network. Comparing the feedback voltage with the voltage across the  $R_{sense}$  resistor makes it possible to control the switching duty cycle. When the reference pin voltage of the KA431 exceeds the internal reference voltage of 2.5V, the H11A817A LED current increases, pulling down the feedback voltage and reducing the duty cycle. This event typically happens when the input voltage is increased or the output load is decreased.

**2.1 Pulse-by-pulse Current Limit:** Because current mode control is employed, the peak current through the SenseFET is determined by the inverting input of the PWM comparator ( $V_{fb}^*$ ) as shown in Figure 18. When the current through the opto-transistor is zero and the current limit pin (#5) is left floating, the feedback current source ( $I_{FB}$ ) of 0.9mA flows only through the internal resistor ( $R+2.5R=2.8k$ ). In this case, the cathode voltage of diode D2 and the peak drain current have maximum values of 2.5V and 2.5A, respectively. The pulse-by-pulse current limit can be adjusted using a resistor to GND on the current limit pin (#5). The current limit level using an external resistor ( $R_{LIM}$ ) is given by:

$$I_{LIM} = \frac{R_{LIM} \cdot 2.5A}{2.8K\Omega + R_{LIM}} \quad (2)$$



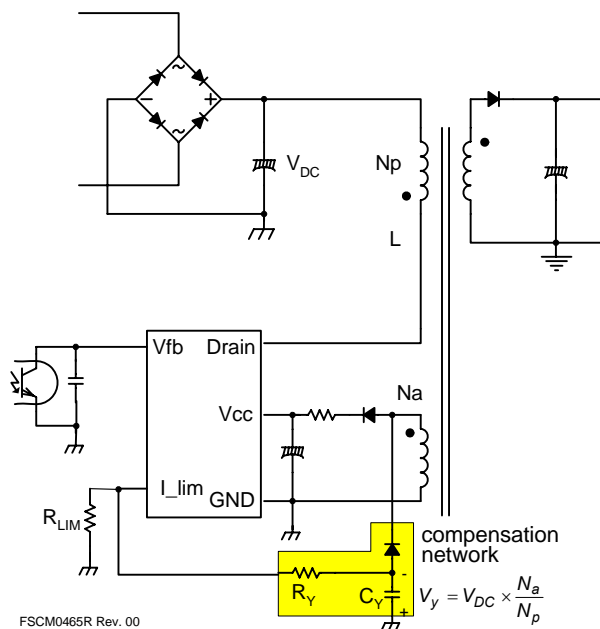
FSCM0465R Rev. 00

Figure 18. Pulse Width Modulation (PWM) Circuit

**2.2 Constant Power Limit Circuit:** Due to the circuit delay of FPS, the pulse-by-pulse limit current increases a little bit when the input voltage increases. This means unwanted excessive power is delivered to the secondary side. To compensate, the auxiliary power compensation network in Figure 19 can be used.  $R_{LIM}$  can adjust pulse-by-pulse current by absorbing internal current source ( $I_{FB}$ : typical value is 0.9mA), depending on the ratio between resistors. With the suggested compensation circuit, additional current from  $I_{FB}$  is absorbed more proportionally to the input voltage ( $V_{DC}$ ) and achieves constant power in wide input range. Choose  $R_{LIM}$  for proper current to the application, then check the pulse-by-pulse current difference between minimum and maximum input voltage. To eliminate the difference (to gain constant power),  $R_y$  can be calculated by:

$$R_y \cong \frac{I_{lim\_spec} \times V_{dc} \times \frac{N_a}{N_p}}{I_{fb} \times \Delta I_{lim\_comp}} \quad (3)$$

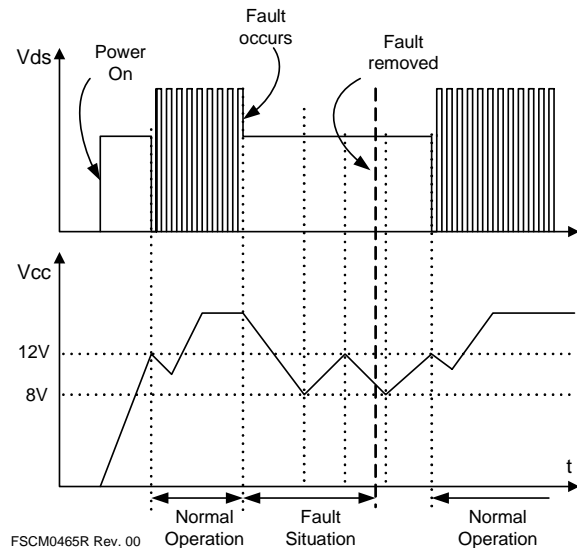
where,  $I_{lim\_spec}$  is the limit current stated on the specification;  $N_a$  and  $N_p$  are the number of turns for  $V_{CC}$  and primary side, respectively;  $I_{fb}$  is the internal current source at feedback pin with a typical value of 0.9mA; and  $\Delta I_{lim\_comp}$  is the current difference which must be eliminated. In case of capacitor in the circuit 1 $\mu$ F, 100V is good choice for all applications.



**Figure 19. Constant power limit circuit**

**2.3 Leading Edge Blanking (LEB):** At the instant the internal SenseFET is turned on, a high-current spike through the SenseFET usually occurs, caused by primary-side capacitance and secondary-side rectifier reverse recovery. Excessive voltage across the Rsense resistor can lead to incorrect feedback operation in the current mode PWM control. To counter this effect, the FSCM0465R employs a leading edge blanking (LEB) circuit. This circuit inhibits the PWM comparator for a short time after the SenseFET is turned on.

**3. Protection Circuit:** The FSCM0465R has several self-protective functions, such as overload protection (OLP), over-voltage protection (OVP) and thermal shutdown (TSD). Because these protection circuits are fully integrated into the IC without external components, the reliability is improved without increasing cost. Once the fault condition occurs, switching is terminated and the SenseFET remains off. This causes  $V_{CC}$  to fall. When  $V_{CC}$  reaches the UVLO stop voltage of 8V, the current consumed by the FSCM0465R decreases to the startup current (typically 20 $\mu$ A) and the current supplied from the DC link charges the external capacitor ( $C_a$ ) connected to the  $V_{CC}$  pin. When  $V_{CC}$  reaches the start voltage of 12V, the FSCM0465R resumes normal operation. In this manner, the auto-restart can alternately enable and disable the switching of the power SenseFET until the fault condition is eliminated (see Figure 20).



**Figure 20. Auto Restart Operation**

**3.1 Overload Protection (OLP):** Overload is defined as the load current exceeding a preset level due to an unexpected event. In this situation, the protection circuit should be activated to protect the SMPS. However, even when the SMPS is in the normal operation, the overload protection circuit can be activated during the load

transition. To avoid this undesired operation, the overload 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 SenseFET is limited and the maximum input power is restricted with a given input voltage. If the output consumes beyond this maximum power, the output voltage ( $V_O$ ) decreases below the set voltage. This reduces the current through the optocoupler LED, which also reduces the optocoupler transistor current, increasing the feedback voltage ( $V_{fb}$ ). If  $V_{fb}$  exceeds 2.5V, D1 is blocked and the 5.3 $\mu$ A current source ( $I_{delay}$ ) starts to charge  $C_B$  slowly up to  $V_{CC}$ . In this condition,  $V_{fb}$  continues increasing until it reaches 6V, when the switching operation is terminated as shown in Figure 21. The delay time for shutdown is the time required to charge  $C_B$  from 2.5V to 6.0V with 5.3 $\mu$ A ( $I_{delay}$ ). A 10 ~ 50ms delay time is typical for most applications.

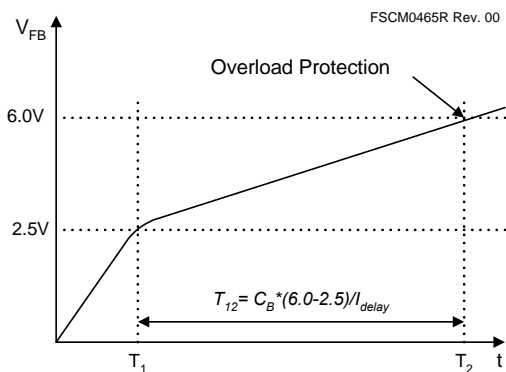


Figure 21. Overload Protection

**3.2 Over-Voltage Protection (OVP):** If the secondary-side feedback circuit were to malfunction or a solder defect causes an opening in the feedback path, the current through the optocoupler transistor becomes almost zero. In this case,  $V_{fb}$  climbs up in a similar manner to the overload situation, forcing the preset maximum current to be supplied to the SMPS until the overload protection is activated. Because more energy than required is provided to the output, the output voltage may exceed the rated voltage before the overload protection is activated, resulting in the breakdown of the devices in the secondary side. To prevent this situation, an over-voltage protection (OVP) circuit is employed. In general,  $V_{CC}$  is proportional to the output voltage and the FSCM0465R uses  $V_{CC}$  instead of directly monitoring the output voltage. If  $V_{CC}$  exceeds 19V, an OVP circuit is activated, resulting in the termination of the switching operation. To avoid undesired activation of OVP during normal operation,  $V_{CC}$  should be designed to be below 19V.

**3.3 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 145°C, the thermal protection is triggered, resulting in shutdown of the FPS.

**4. Frequency Modulation:** EMI reduction can be accomplished by modulating the switching frequency of a switched power supply. Frequency modulation can reduce EMI by spreading the energy over a wider frequency range than the bandwidth measured by the EMI test equipment. The amount of EMI reduction is directly related to the depth of the reference frequency. As can be seen in Figure 22, the frequency changes from 63KHz to 69KHz in 4ms.

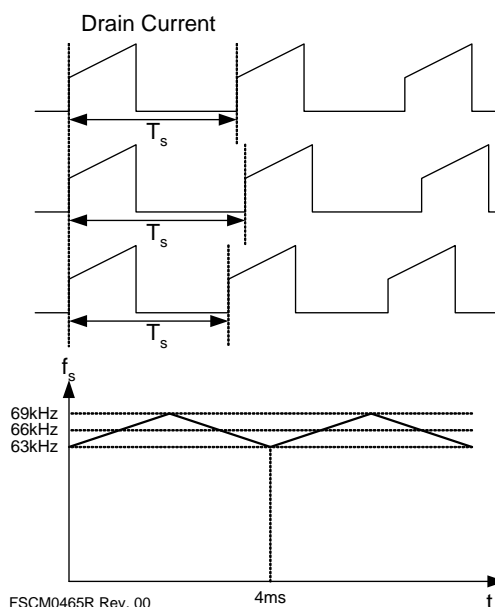
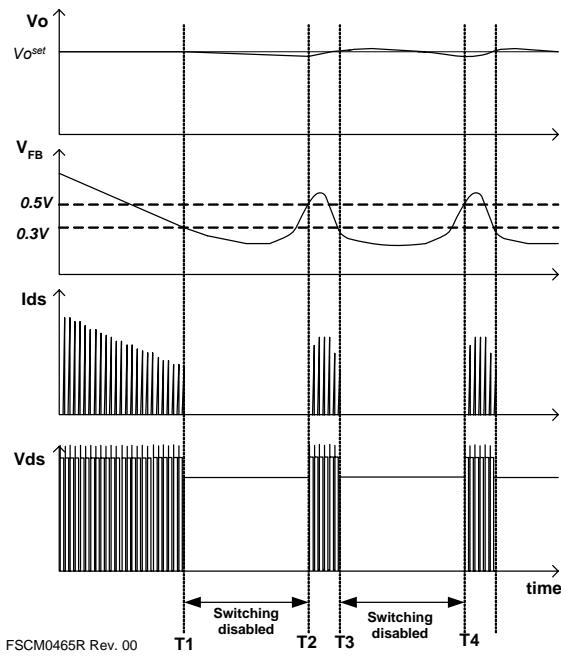


Figure 22. Frequency Modulation

**5. Soft-Start:** The FSCM0465R has an internal soft-start circuit that increases PWM comparator inverting input voltage, together with the SenseFET current, slowly after it starts up. The typical soft-start time is 15ms. The pulse width to the power switching device 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. Preventing transformer saturation and reducing stress on the secondary diode during startup is also helpful.

**6. Burst Operation:** To minimize power dissipation in standby mode, the FSCM0465R enters into burst-mode operation at light load condition. As the load decreases, the feedback voltage decreases. As shown in Figure 23, the device automatically enters burst mode when the feedback voltage drops below  $V_{BURL}$  (300mV). At this point, switching stops and the output voltages start to drop at a rate dependent on standby current load. This causes the feedback voltage to rise. Once it passes  $V_{BURH}$  (500mV), switching resumes. The feedback voltage then falls and the process repeats. Burst mode operation alternately enables and disables switching of the power SenseFET, thereby reducing switching loss in standby mode.



**Figure 23. Waveforms of Burst Operation**

## Typical Application Circuit

Application	Output Power	Input Voltage	Output Voltage (Max. Current)
LCD Monitor	40W	Universal Input (85-265Vac)	5V (2.0A) 12V (2.5A)

### Features

- High efficiency (>81% at 85Vac input)
- Low standby mode power consumption (<1W at 240Vac input and 0.4W load)
- Low component count
- Enhanced system reliability through various protection functions
- Low EMI through frequency modulation
- Internal soft-start (15ms)

### Key Design Notes

- Resistors R107 and R108 are employed to prevent startup at low input voltage
- The delay time for overload protection is designed to be about 50ms with C106 of 100nF. If a faster triggering of OLP is required, C106 can be reduced to 22nF.

### 1. Schematic

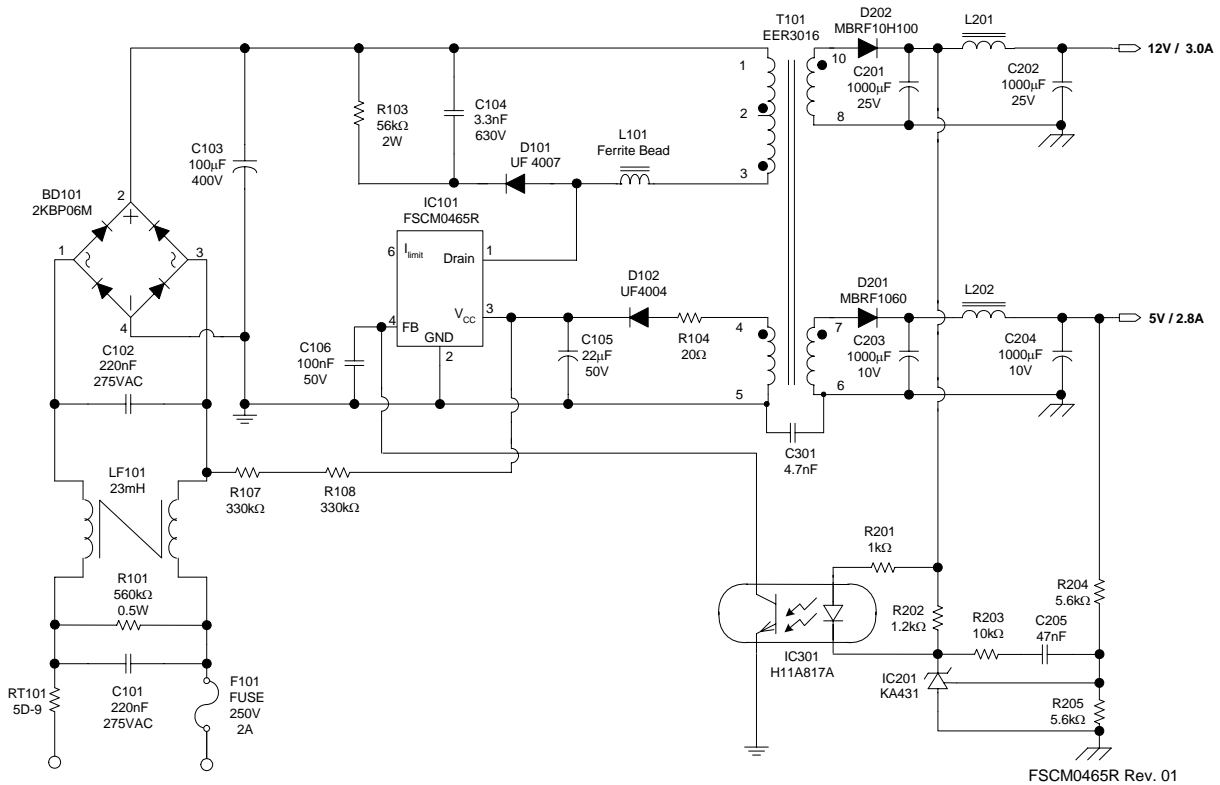


Figure 24. Demo Circuit

## 2. Transformer

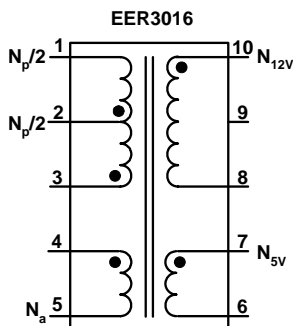


Figure 25. Transformer Schematic Diagram

## 3. Winding Specification

No	Pin (s→f)	Wire	Turns	Winding Method
Na	4 → 5	0.2 $\phi$ × 1	8	Center Winding
Insulation: Polyester Tape t = 0.050mm, 2 Layers				
Np/2	2 → 1	0.4 $\phi$ × 1	18	Solenoid Winding
Insulation: Polyester Tape t = 0.050mm, 2 Layers				
N <sub>12V</sub>	10 → 8	0.3 $\phi$ × 3	7	Center Winding
Insulation: Polyester Tape t = 0.050mm, 2 Layers				
N <sub>5V</sub>	7 → 6	0.3 $\phi$ × 3	3	Center Winding
Insulation: Polyester Tape t = 0.050mm, 2 Layers				
Np/2	3 → 2	0.4 $\phi$ × 1	18	Solenoid Winding
Outer Insulation: Polyester Tape t = 0.050mm, 2 Layers				

## 4. Electrical Characteristics

	Pin	Specification	Remarks
Inductance	1 - 3	520 $\mu$ H $\pm$ 10%	100kHz, 1V
Leakage Inductance	1 - 3	10 $\mu$ H Max	2 <sup>nd</sup> all Short

## 5. Core & Bobbin

- Core: EER 3016
- Bobbin: EER3016
- Ae(mm<sup>2</sup>): 96



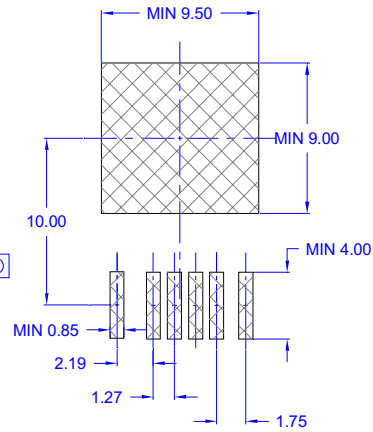
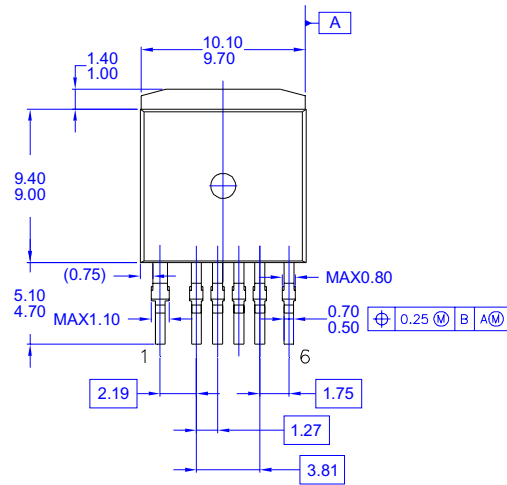
## 6. Demo Circuit Part List

Part	Value	Note	Part	Value	Note
<b>Fuse</b>			C301	4.7nF	Polyester Film Cap.
F101	2A/250V				
<b>NTC</b>			<b>Inductor</b>		
RT101	5D-9		L201	5μH	Wire 1.2mm
<b>Resistor</b>			L202	5μH	Wire 1.2mm
R101	560kΩ	0.5W			
R103	56kΩ	2W			
R104	20Ω	1/4W	<b>Diode</b>		
R107	330kΩ	1/4W	D101	UF4007	
R108	330kΩ	1/4W	D102	UF4004	
R201	1kΩ	1/4W	D201	MBRF1060	
R202	1.2kΩ	1/4W	D202	MBRF10H100	
R203	10kΩ	1/4W			
R204	5.6kΩ	1/4W			
R205	5.6kΩ	1/4W	<b>Bridge Diode</b>		
			BD101	2KBP06M 3N257	Bridge Diode
<b>Capacitor</b>					
C101	220nF/275VAC	Box Capacitor	<b>Line Filter</b>		
C102	220nF/275VAC	Box Capacitor	LF101	23mH	Wire 0.4mm
C103	100μF/400V	Electrolytic Capacitor	<b>IC</b>		
C104	3.3nF/630V	Ceramic Capacitor	IC101	FSCM0465R	FPS™ (2.5A, 650V)
C105	22μF/50V	Electrolytic Capacitor	IC201	KA431(TL431)	Voltage Reference
C106	100nF/50V	Ceramic Capacitor	IC301	H11A817A	Opto-coupler
C201	1000μF/25V	Electrolytic Capacitor			
C202	1000μF/25V	Electrolytic Capacitor			
C203	1000μF/10V	Electrolytic Capacitor			
C204	1000μF/10V	Electrolytic Capacitor			
C205	47nF/50V	Ceramic Capacitor			

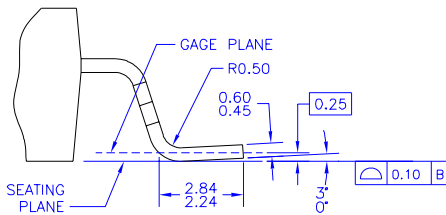
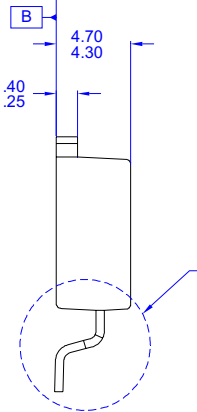
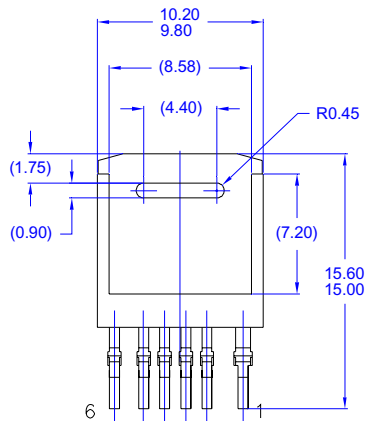
## Package Dimensions

### D2-PAK-6L

Dimensions are in millimeters unless otherwise specified.



LAND PATTERN RECOMMENDATION



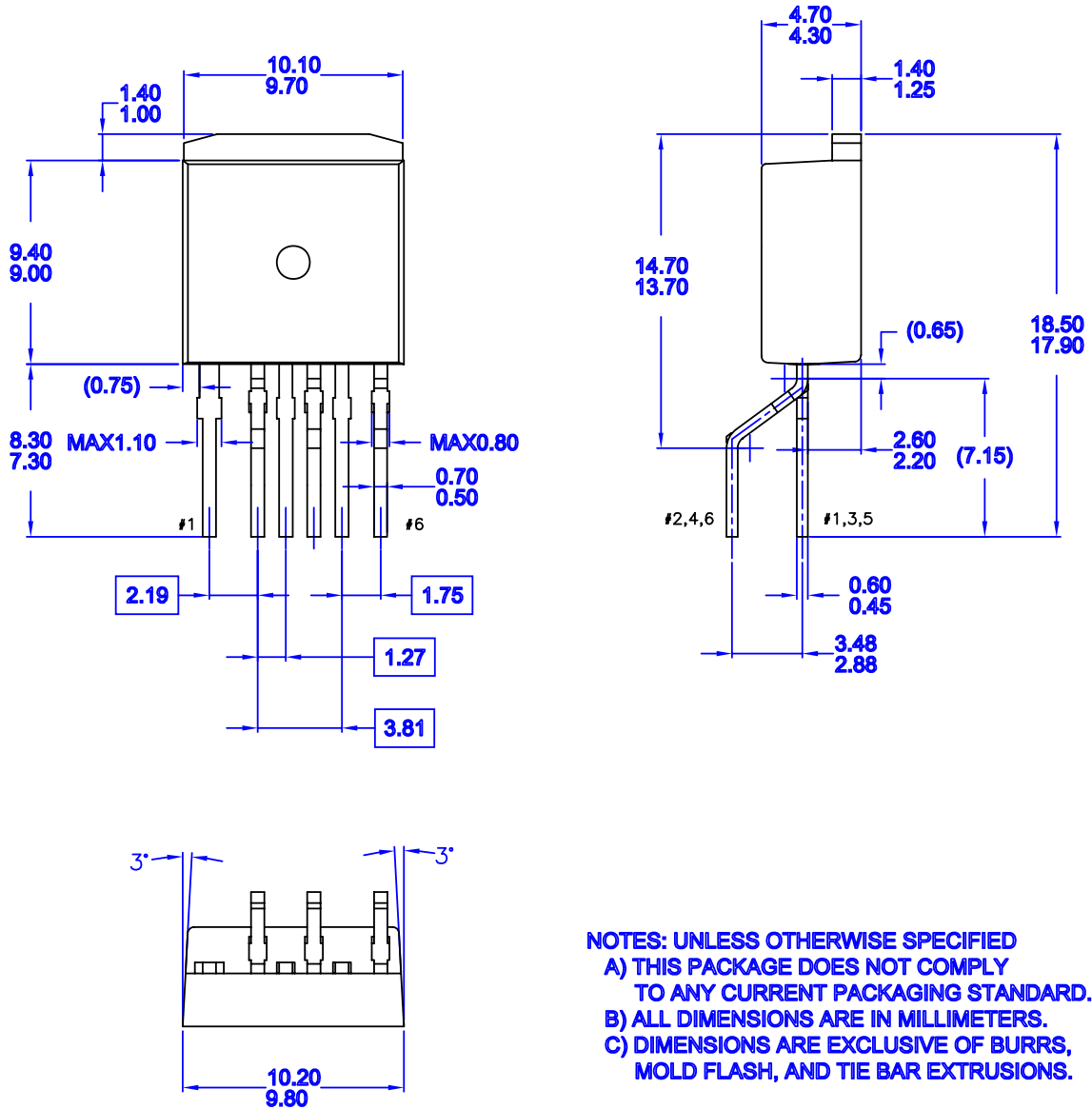
DETAIL A, ROTATED 90°  
 SCALE: 2X  
 MKT-TO263A6

- NOTES: UNLESS OTHERWISE SPECIFIED  
 A) THIS PACKAGE DOES NOT COMPLY TO ANY CURRENT PACKAGING STANDARD.  
 B) ALL DIMENSIONS ARE IN MILLIMETERS.  
 C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.  
 D) DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994

## Package Dimensions (Continued)

### I2-PAK-6L (Forming)

Dimensions are in millimeters unless otherwise specified.



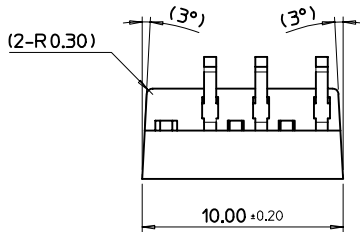
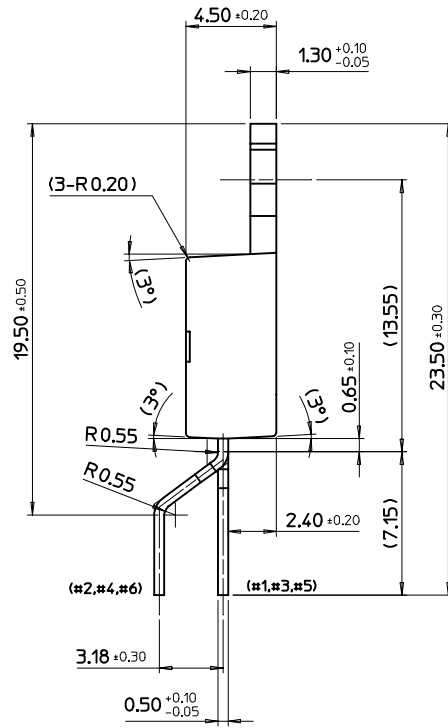
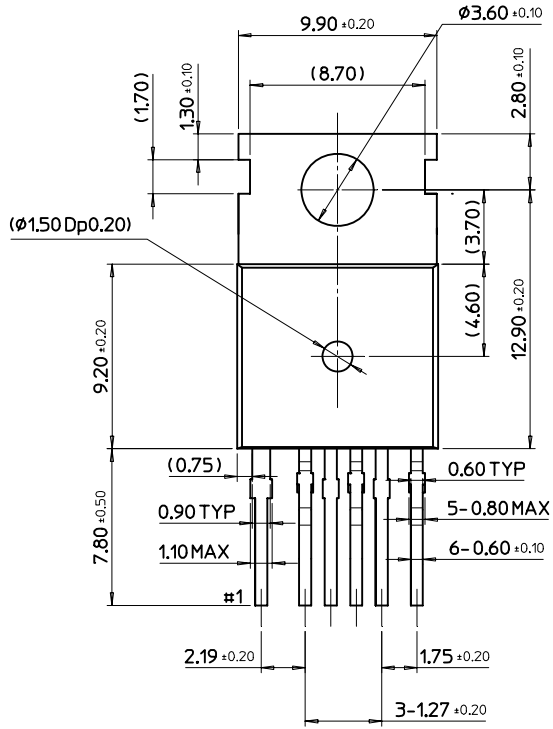
MKT-TO262A6

**NOTES: UNLESS OTHERWISE SPECIFIED**  
**A) THIS PACKAGE DOES NOT COMPLY TO ANY CURRENT PACKAGING STANDARD.**  
**B) ALL DIMENSIONS ARE IN MILLIMETERS.**  
**C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.**

**Package Dimensions** (Continued)

**TO-220-6L (Forming)**

Dimensions are in millimeters unless otherwise specified.



**NOTE**

1. THESE DIMENSIONS DO NOT INCLUDE MOLD PROTRUSION.
2. ( ) IS REFERENCE
3. ( ) IS ASS'Y OUT QUALITY

DRW-PKG-0054-000 REV.00

## TRADEMARKS

The following are registered and unregistered trademarks Fairchild Semiconductor owns or is authorized to use and is not intended to be an exhaustive list of all such trademarks.

ACEx™	FAST®	ISOPLANAR™	PowerEdge™	SuperFET™
ActiveArray™	FASTr™	LittleFET™	PowerSaver™	SuperSOT™-3
Bottomless™	FPST™	MICROCOUPLER™	PowerTrench®	SuperSOT™-6
Build it Now™	FRFET™	MicroFET™	QFET®	SuperSOT™-8
CoolFET™	GlobalOptoisolator™	MicroPak™	QS™	SyncFET™
CROSSVOLT™	GTO™	MICROWIRE™	QT Optoelectronics™	TCM™
DOME™	HiSeC™	MSX™	Quiet Series™	TinyLogic®
EcoSPARK™	I <sup>2</sup> C™	MSXPro™	RapidConfigure™	TINYOPTO™
E <sup>2</sup> C MOS™	i-Lo™	OCX™	RapidConnect™	TruTranslation™
EnSigna™	ImpliedDisconnect™	OCXPro™	µSerDes™	UHC™
FACT™	IntelliMAX™	OPTOLOGIC®	ScalarPump™	UniFET™
FACT Quiet Series™		OPTOPLANAR™	SILENT SWITCHER®	UltraFET®
Across the board. Around the world.™		PACMAN™	SMART START™	VCX™
The Power Franchise®		POP™	SPM™	Wire™
Programmable Active Droop™		Power247™	Stealth™	

## DISCLAIMER

FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION, OR DESIGN. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS. THESE SPECIFICATIONS DO NOT EXPAND THE TERMS OF FAIRCHILD'S WORLDWIDE TERMS AND CONDITIONS, SPECIFICALLY THE WARRANTY THEREIN, WHICH COVERS THESE PRODUCTS.

## LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF FAIRCHILD SEMICONDUCTOR CORPORATION.

As used herein:

- Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, or (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in significant injury to the user.
- A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and 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	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

Rev. 119

ON Semiconductor and  are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## PUBLICATION ORDERING INFORMATION

### LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor  
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA  
**Phone:** 303-675-2175 or 800-344-3860 Toll Free USA/Canada  
**Fax:** 303-675-2176 or 800-344-3867 Toll Free USA/Canada  
**Email:** [orderlit@onsemi.com](mailto:orderlit@onsemi.com)

**N. American Technical Support:** 800-282-9855 Toll Free  
USA/Canada  
**Europe, Middle East and Africa Technical Support:**  
Phone: 421 33 790 2910  
**Japan Customer Focus Center**  
Phone: 81-3-5817-1050

**ON Semiconductor Website:** [www.onsemi.com](http://www.onsemi.com)  
**Order Literature:** <http://www.onsemi.com/orderlit>  
For additional information, please contact your local  
Sales Representative