FS8S0765RC

Fairchild Power Switch(FPS)

Features

- Primary side regulation
- External sync terminal/Soft start
- Burst mode operation to reduce the power loss at the standby mode
- Reference voltage changed by external sync and Vfb
- Wide operating frequency range up to 150KHz
- Pulse by pulse over current limiting
- Low start-up current (Max:80uA)
- Low operating current (Max:15mA)
- Over voltage protection (Auto restart mode)
- Over load protection (Auto restart mode)
- Over current protection (Auto restart mode)
- Internal thermal shutdown (Auto restart mode)
- Under voltage lockout
- Internal high voltage SenseFET

Application

- Monitor SMPS

Description

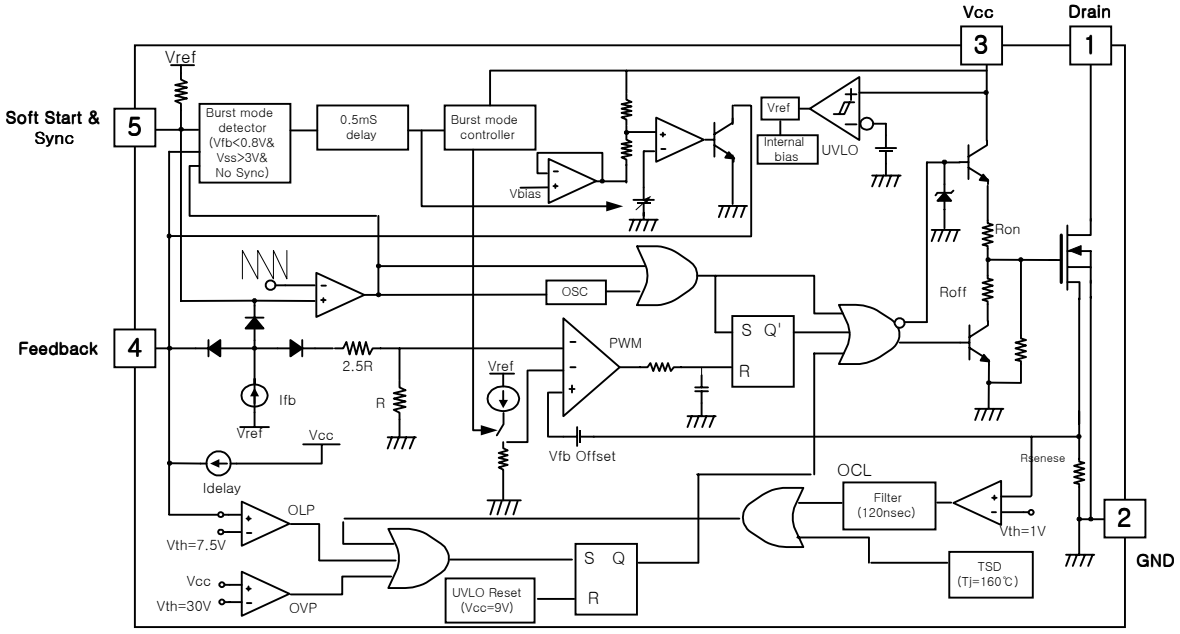
The Fairchild Power Switch(FPS) product family are specially designed for an off-line SMPS with minimal external components. The Fairchild Power Switch(FPS) consists of a high voltage power SenseFET and a current mode PWM IC. Included PWM controller features the integrated oscillator to be synchronized with the external sync, the under voltage lockout, 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 with a discrete MOSFET and a controller or a RCC switching converter solution, the 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 has a basic platform well suited for the cost effective monitor power supply.

TO-220-5L

1

1. Drain 2. GND 3. V_{CC} 4. Feedback 5. Sync

Internal Block Diagram



Rev.1.0.0

Pin Definitions

Pin Number	Pin Name	Pin Function Description
1	Drain	High voltage power SenseFET drain. This pin is designed to drive the transformer directly and is capable of switching a maximum of 650V and 4A.
2	GND	This pin is the control ground and the SenseFET source.
3	Vcc	Vcc is regulated at 22V during the normal mode by the internal Vcc feedback loop. During the off mode Vcc fluctuates between 11V and 12V.
4	Feedback	This pin is connected to the inverting input of the PWM comparator through two diodes and a resistor divider. For stable operation, a capacitor should be placed between this pin and GND.
5	Soft Start & Sync	This pin performs the soft start operation and detects the external sync signal.

Absolute Maximum Ratings

(Ta=25°C, unless otherwise specified)

Parameter	Symbol	Value	Unit
Drain-Source(GND) Voltage (1)	V_{DSS}	650	V
Drain-Gate Voltage (R_{GS}=1MΩ)	V_{DGR}	650	V
Gate-Source (GND) Voltage	V_{GS}	±30	V
Drain Current Pulsed (2)	I_{DM}	28	A_{DC}
Single Pulsed Avalanche Energy (3)	E_{AS}	370	mJ
Single Pulsed Avalanche Current (4)	I_{AS}	17	A
Continuous Drain Current (Tc = 25°C)	I_D	7	A_{DC}
Continuous Drain Current (T_C=100°C)	I_D	4.5	A_{DC}
Supply Voltage	V_{CC}	35	V
Input Voltage Range	V_{FB}	-0.3 to Vcc	V
	V_{S_S}	-0.3 to 10	V
Total Power Dissipation	P_D(Watt H/S)	145	W
	Derating	1.16	W/°C
Operating Junction Temperature	T_j	+150	°C
Operating Ambient Temperature	T_A	-25 to +85	°C
Storage Temperature Range	T_{STG}	-55 to +150	°C

Notes:

1. Tj=25°C to 150°C
2. Repetitive rating: Pulse width limited by maximum junction temperature
3. L=14mH, starting Tj=25°C
4. L=13uH, 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=250μA	650	-	-	V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS}=650V, V_{GS}=0V	-	-	200	μA
		V_{DS}=520V V_{GS}=0V, T_C=125°C	-	-	300	μA
Static Drain Source On Resistance (1)	$R_{DS(ON)}$	V_{GS}=10V, I_D=3.5A	-	1.4	1.6	Ω
Forward Transconductance	gfs	V_{DS}=40V, I_D=3.5A	-	8	-	mho
Input Capacitance	Ciss	V_{GS}=0V, V_{DS}=25V, f = 1MHz	-	1415	-	pF
Output Capacitance	Coss		-	100	-	
Reverse Transfer Capacitance	Crss		-	15	-	
Turn On Delay Time	td(on)	V_{DD}=325V, I_D=6.5A (MOSFET switching time is essentially independent of operating temperature)	-	25	-	nS
Rise Time	tr		-	60	-	
Turn Off Delay Time	td(off)		-	115	-	
Fall Time	tf		-	65	-	
Total Gate Charge (Gate-Source+Gate-Drain)	Qg	V_{GS}=10V, I_D=6.5A, V_{DS}=325V (MOSFET switching time is essentially independent of operating temperature)	-	40	-	nC
Gate-Source Charge	Qgs		-	7	-	
Gate-Drain (Miller) Charge	Qgd		-	12	-	

Note:

(1) Pulse test : Pulse width ≤ 300μS, duty 2%

Electrical Characteristics (Continued)

(Ta=25°C unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
UVLO SECTION						
Start Threshold Voltage	V_{START}	V_{FB}=GND	14	15	16	V
Stop Threshold Voltage	V_{STOP}	V_{FB}=GND	8	9	10	V
OSCILLATOR SECTION						
Initial Frequency	F_{OSC}	-	18	20	22	kHz
Voltage Stability	F_{STABLE}	12V ≤ Vcc ≤ 23V	0	1	3	%
Temperature Stability (1)	ΔF_{OSC}	-25°C ≤ Ta ≤ 85°C	0	±5	±10	%
Maximum Duty Cycle	D_{MAX}	-	92	95	98	%
Minimum Duty Cycle	D_{MIN}	-	-	-	0	%
FEEDBACK SECTION						
Feedback Source Current	I_{FBSO}	V_{FB}=GND	0.7	0.9	1.1	mA
Feedback Sink Current	I_{FBSI}	V_{FB}=4V,V_{CC}=19V	2.4	3.0	3.6	mA
Shutdown Feedback Voltage	V_{SD}	Vfb ≥ 6.9V	6.9	7.5	8.1	V
Shutdown Delay Current	Idelay	V_{FB}=5V	1.6	2.0	2.4	µA
PROTECTION SECTION						
Over Voltage Protection	V_{OVP}	Vcc ≥ 27V	27	30	33	V
Over Current Latch Voltage (2)	V_{OCL}	-	0.95	1.0	1.05	V
Thermal Shutdown Temp.(1)	T_{SD}	-	140	160	-	°C
SYNC & SOFTSTART SECTION						
Softstart Vortage	V_{SS}	Vfb=2	4.7	5.0	5.3	V
Softstart Current	I_{SS}	Vss=0V	0.8	1.0	1.2	mA
Sync High Threshold Voltage	V_{SH}	Vcc=16V,Vfb=5V	6.7	7.2	7.9	V
Sync Low Threshold Voltage	V_{SL}	Vcc=16V,Vfb=5V	5.4	5.8	6.2	V

Note:

1. These parameters, although guaranteed at the design, are not tested in mass production.
2. These parameters, although guaranteed, are tested in EDS(wafer test) process.

Electrical Characteristics(Continued)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Vcc REGULATION SECTION(NORMAL MODE)						
Normal Mode Regulation Voltage	V_{CCNO}	Vfb=4V, Fsync=25kHz Ifb=900uA	21.56	22.0	22.44	V
Transconductance	GM	Vfb=4V, Fsync=25kHz	-	2.0	-	mA/V
Vcc Regulation Temperature Stability	ΔVcc	Vfb=4V, Fsync=25kHz	-	2.0	-	%
BURST MODESECTION(DPMS MODE)						
Burst Mode High Threshold Voltage	V_{BUH}	Vfb=0V	11.6	12	12.4	V
Burst Mode Low Threshold Voltage	V_{BUL}	Vfb=0V	10.6	11	11.4	V
Burst Mode Enable FB Voltage	V_{BUFB}	Vcc=10.5V	0.7	0.8	0.9	V
Burst Mode Enable S_S Voltage	V_{BUSS}	Vcc=10.5V,Vfb=0V	2.5	3.0	3.5	V
Burst Mode Enable Delay Time	T_{BUDT}	Vcc=10.5V,Vfb=0V	-	0.5	-	ms
Burst Mode Frequency	F_{BU}	Vcc=10.5V,Vfb=0V	32	40	48	kHz
CURRENT LIMIT(SELF-PROTECTION)SECTION						
Peak Current Limit(1)	I_{OVER}	-	3.52	4.0	4.48	A
Burst Mode Peak Current Limit	I_{BU_PK}	-	0.45	0.6	0.75	A
TOTAL DEVICE SECTION						
Start Up Current	I_{START}	V_{CC}=Vstart-0.1V	-	40	80	uA
Operating Supply Current (2)	I_{OP}	Vfb=GND, V_{CC}=16V	-	9	15	mA
	$I_{OP(MIN)}$	Vfb=GND, V_{CC}=12V				
	$I_{OP(MAX)}$	Vfb=GND, V_{CC}=27V				

Note:

1. These parameters indicate inductor current.
2. These parameters are the current flowing in the control IC.

Typical Performance Characteristics

(These characteristic graphs are normalized at Ta= 25°C)

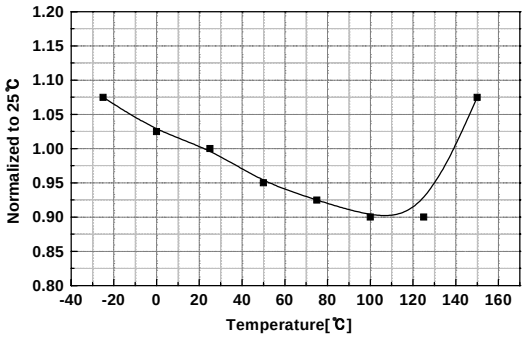


Figure 1. Start Up Current vs. Temp.

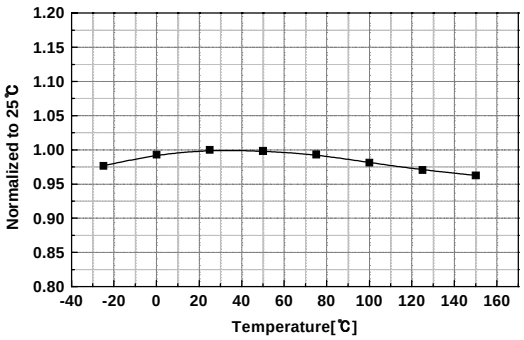


Figure 2. Operating Supply Current vs. Temp.

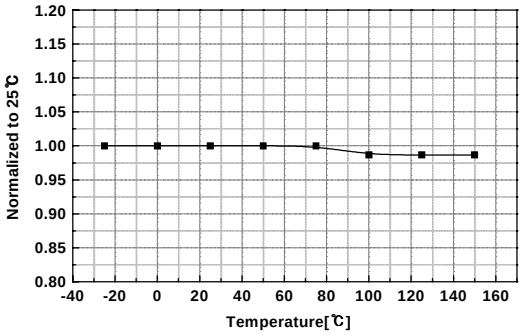


Figure 3. Start Threshold Voltage vs. Temp.

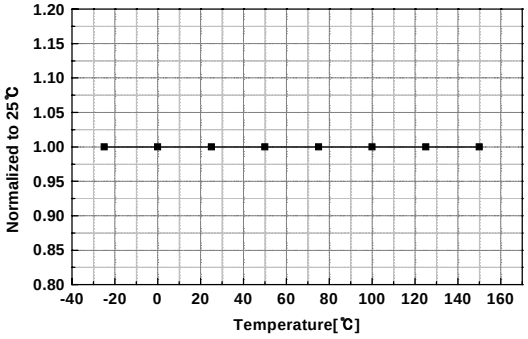


Figure 4. Stop Threshold Voltage vs. Temp.

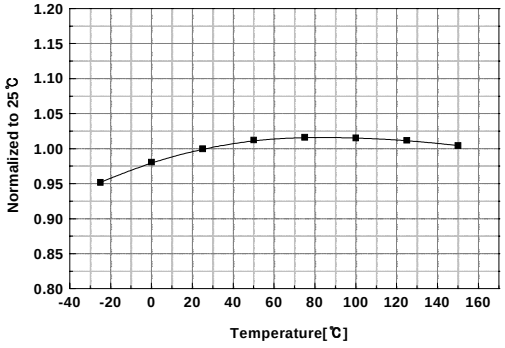


Figure 5. Initial Freqency vs. Temp.

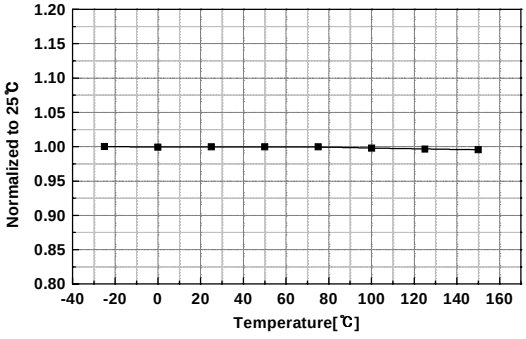


Figure 6. Maximum Duty Cycle vs. Temp.

Typical Performance Characteristics(Continued)

(These characteristic graphs are normalized at Ta= 25°C)

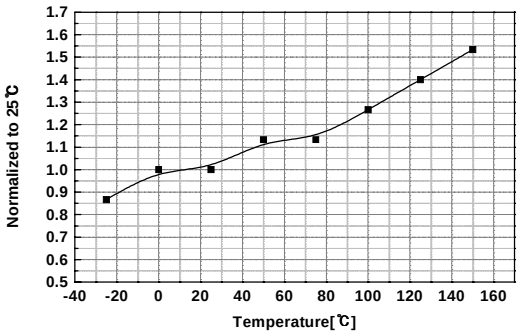


Figure 7. Feedback Offset Voltage vs. Temp.

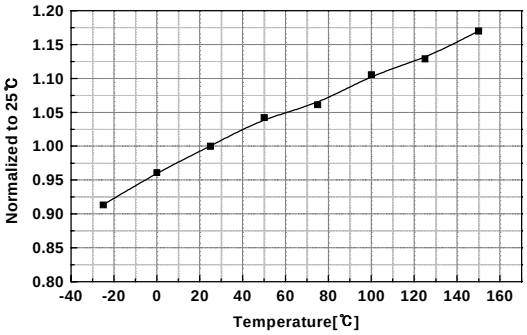


Figure 8. Feedback Sink Current vs. Temp.

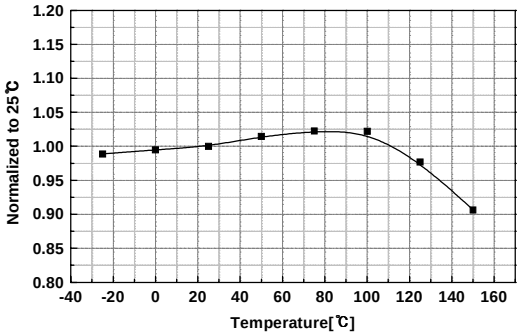


Figure 9. Shutdown Delay Current vs. Temp.

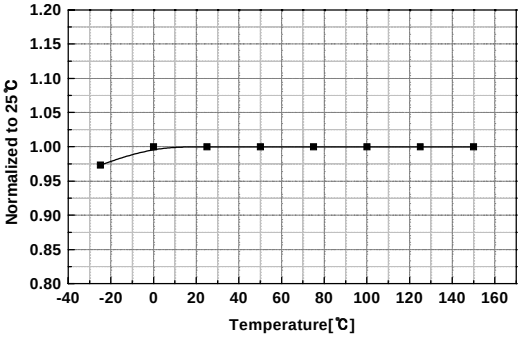


Figure 10. Shutdown Feedback Voltage vs. Temp.

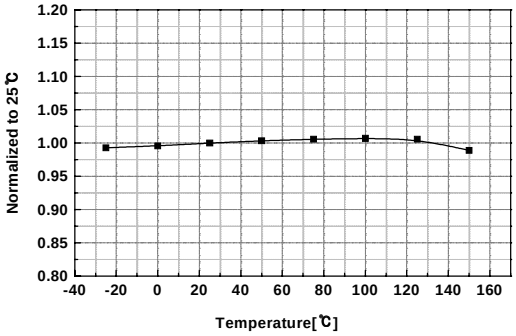


Figure 11. Soft Start Voltage vs. Temp.

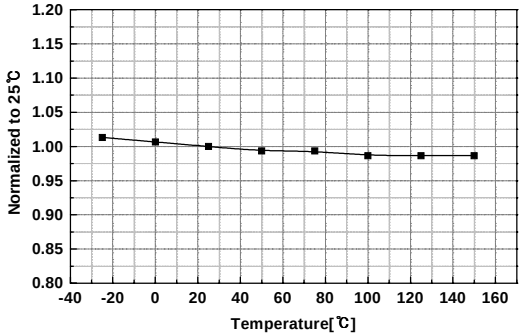


Figure 12. Over Voltage Protection vs. Temp.

Typical Performance Characteristics(Continued)

(These characteristic graphs are normalized at Ta= 25°C)

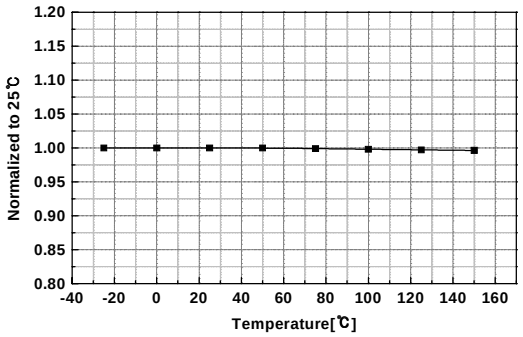


Figure 13. Normal Mode Regulation Voltage vs. Temp.

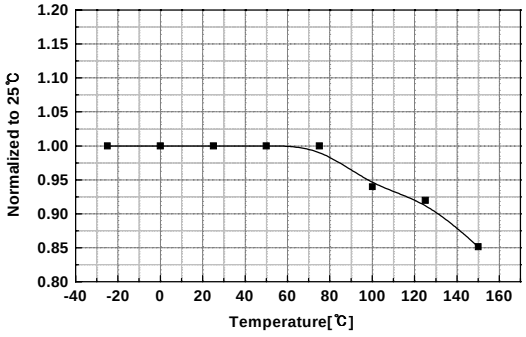


Figure 14. Transconductance vs. Temp.

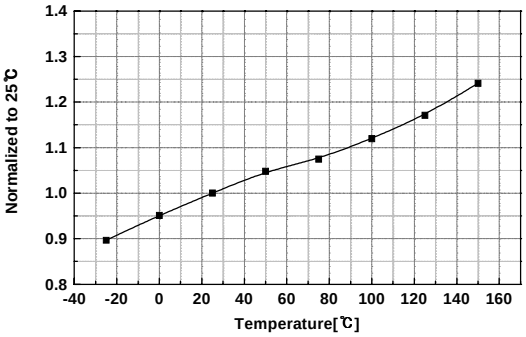


Figure 15. Feedback Sink Current vs. Temp.

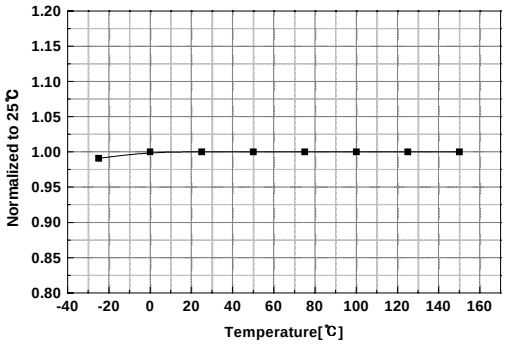


Figure 16. Burst Mode Low Threshold Voltage vs. Temp.

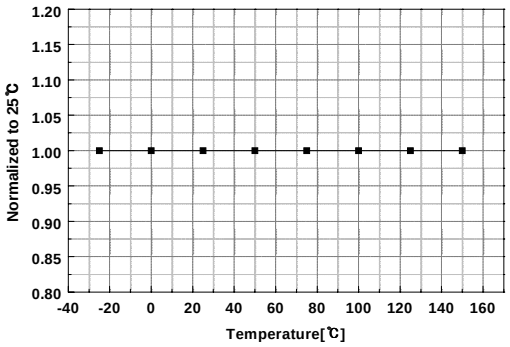


Figure 17. Burst Mode High Threshold Voltage vs. Temp.

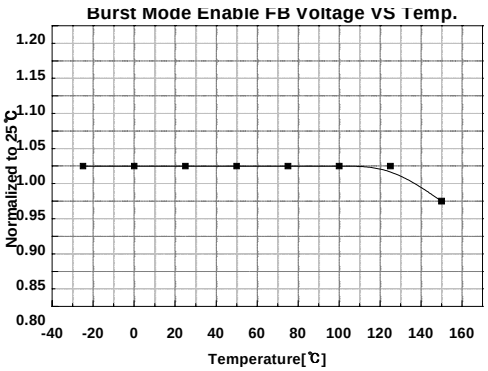


Figure 18. Burst Mode Enable Voltage vs. Temp.

Typical Performance Characteristics(Continued)

(These characteristic graphs are normalized at Ta= 25°C)

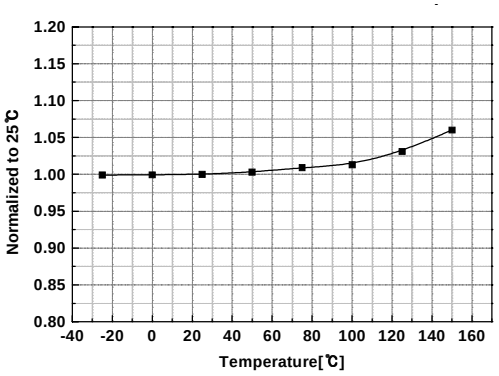


Figure 19. Burst Mode Peak Current vs. Temp.

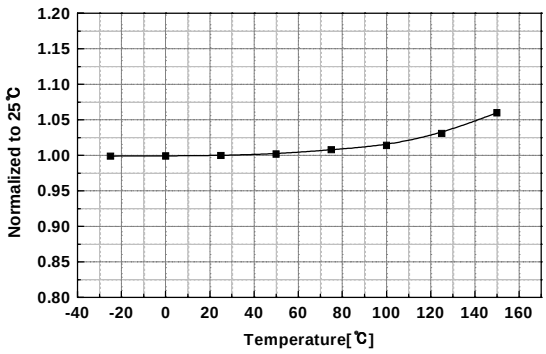


Figure 20. Peak Current vs. Temp.

Function Information

1. Start up circuit : To guarantee stable operation of the control IC, the FS8S0765RC has the UVLO circuit with 6V hysteresis. The Vcc start up voltage is 15V and the stop voltage is 9V. When the Vcc reaches 15V, the control IC operates. Once the control IC start operating, it continues to operate until the Vcc is below the stop voltage, 9V.

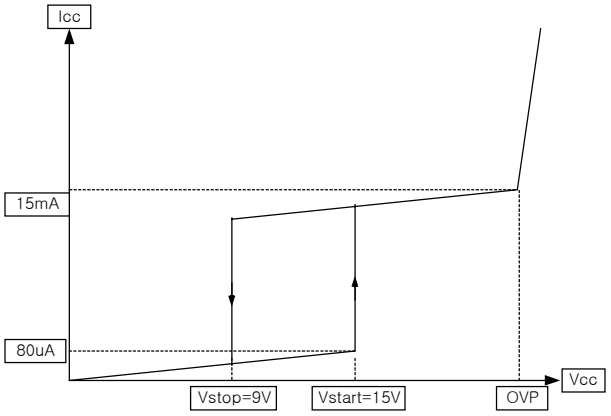


Figure 1. Strat up with hysteresis

2. The primary side regulation : To control the transformer output, the FPS compares the feedback voltage with the current sensing voltage. To generate the feedback voltage, the existing FPS uses the photo coupler and TL431, etc in the secondary side regulation SMPS. But in the SMPS using the FS8S0765RC, these components do not need. The regulation circuit to control the feedback voltage is built in the control IC as shown figure 2. During the normal operation, the Vcc voltage is regulated to 22V by the Vcc reference voltage, V1. And at burst mode, the Vcc voltage fluctuates between 11V to 12V by the reference voltage, V2.

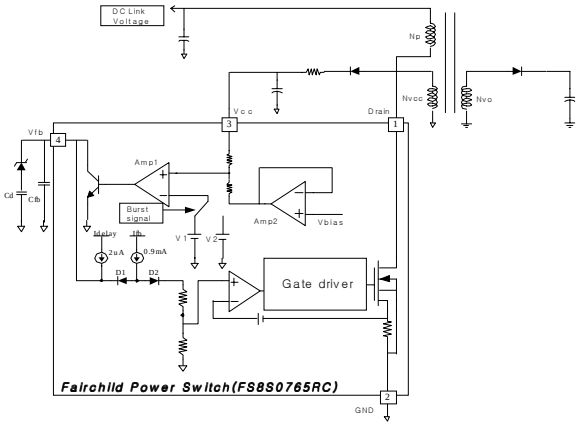


Figure 2. Circuit for the primary side regulation

3. Protection function : The FS8S0765RC has 3 self protective functions(OCP, OLP and TSD). Because it does not require the additional external components, the reliability can be achieved without cost increase. These protection functions operate in auto restart mode. The protection is reset when the Vcc voltage goes below 9V. The control IC operates again when the Vcc voltage is recharged to 15V.

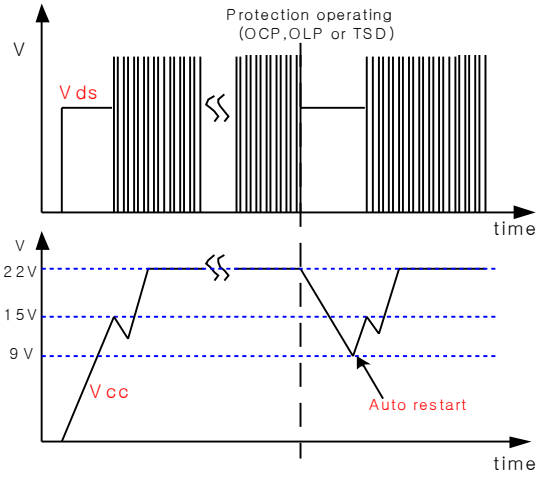


Figure 3. Auto restart operation after protection

3.1 Over Current Protection(OCP) : Although the cycle by cycle over current limit tries to limit the peak current to a predetermined level, it can not work during the leading edge blanking. When the secondary rectifying diodes or the transformer pins are shorted, a steep current with extremely high di/dt can flow during the leading edge blanking. The OCP block is added to ensure the reliability. It turns off the SenseFET within 300ns after the abnormal over current condition is sensed.

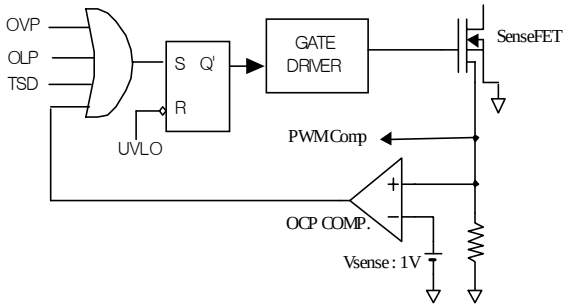


Figure 4. OCP block

3.2 Over Load Protection(OLP) : During the over load condition, the ouput of the internal error amp(Amp1) shown in the figure 2 is zero. The feedback voltage, Vfb is charged up by the internal current source of 2uA. When Vfb touches 7.5V, the OLP block is activated as shown in figure 5.

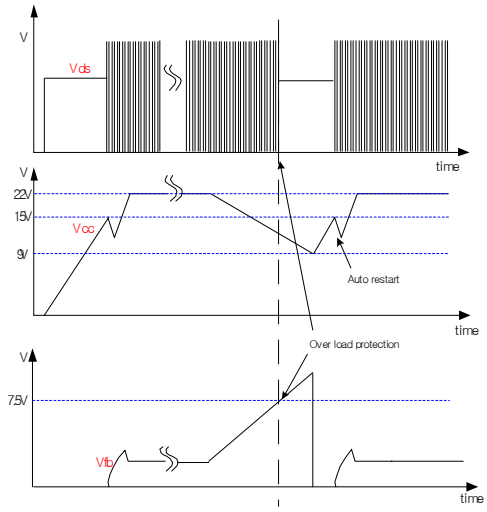


Figure 5. The waveforms at the OLP and auto restart

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 160°C, the thermal shutdown operates.

4. Soft Start : During the initial start up, the sink current of the internal error amp(Amp1) shown in the figure 2 remains zero. During this period, the soft start capacitor, Css is charged by the 0.9mA current source and the 50K resistor from 5V voltage source and the feedback capacitor, Cfb is charged by the 0.9mA current source and the 2uA current, as shown in the figure 6. By choosing much bigger Css than Cfb, the feedback voltage, Vfb is increased slowly forcing the SenseFET current to increase slowly. After Vfb reaches its steady state value, only the current through the 50K resistor charges the Css exponentially. If the value of Css is too large so the rising speed of Vfb is higher than that of the soft start voltag, Vss, there is possibility that Vfb touches 7.5V, the over load detection level during the soft start period. In order to avoid this phenomenon, it is recommended that the value of Css should not exceed 100 times of Cfb.

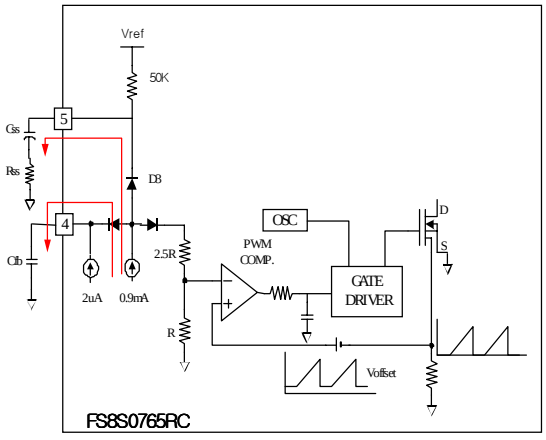


Figure 6. The circuit for the soft start

5. Synchronization : It is well known that the synchronization method is the best way to eliminate the screen noise of the CRT monitor. The switching frequency of the FS8S0765RC can vary from 20 KHz to 150 KHz by an external sync signal. The internal sync comparator detects the sync signal and determines the SenseFET turn-on time. During the high pulse of the sync comparator output voltage, the SenseFET remains an off state. The SenseFET is turned on at the negative edge of the sync comparator output voltage. The reference voltage of the sync comparator is an inverted sawtooth with the base frequency of 20kHz and with the varying range between 5.8V and 7.2V, as shown in the figure 7 and figure 8. The inverted sawtooth reference gets rid of the excessive switching noise at the very first synchronized turn-on. The external sync signal is recommended to have an amplitude of minimum, 4.2V.

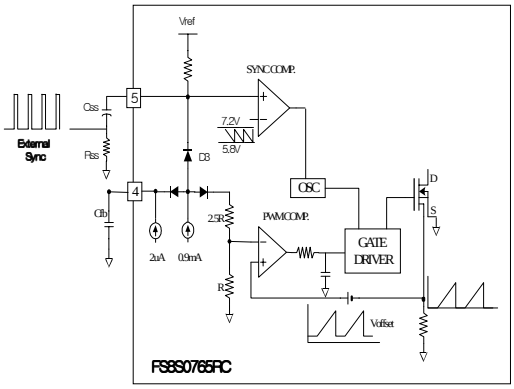


Figure 7. The circuit for the synchronization with external sync

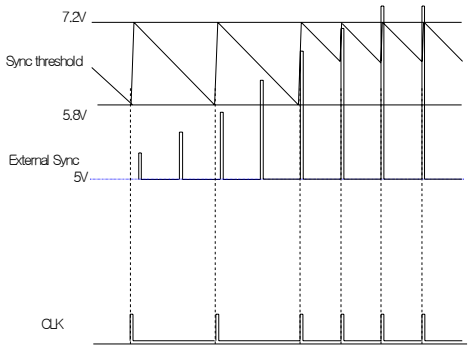


Figure 8. The waveforms at the synchronization.

6. Sync detector and burst operation : At the power saving mode(off mode), the FS8S0765RC reduces the output voltages to almost half of the normal value and enters into the burst mode in order to make the power dissipation minimize. The FS8S0765RC enters the power saving mode when the voltage on pin #5(Vss) is higher than 3V, there is no sync

signal, and the voltage on pin #4(Vfb) is lower than 0.8V.

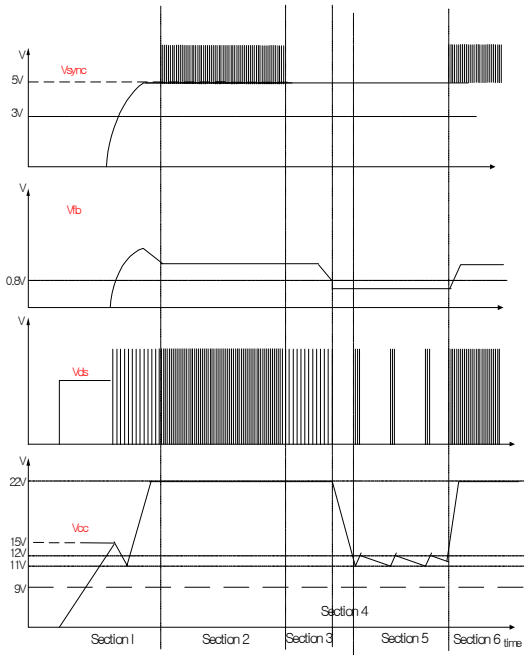
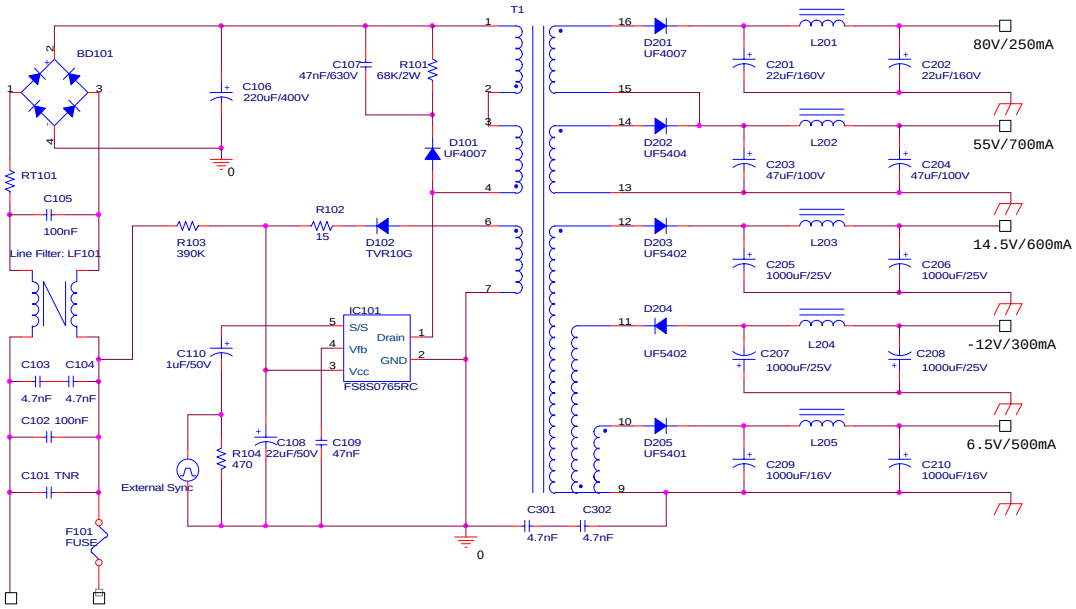


Figure 9. The operation of the FS8S0765RC at the normal mode and the off mode

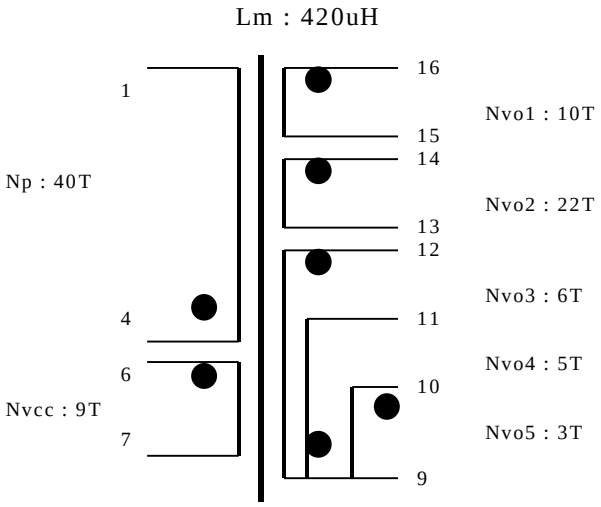
During the power saving mode, the Vcc which was regulated at 22V during the normal mode, fluctuates between 11V and 12V. When the Vcc touches 11V, the FS8S0765RC starts to switch and when the Vcc reaches 12V, it stops switching. During the switching periods, the FS8S0765RC has the switching frequency of 40 KHz and the constant peak MOSFET current of 0.6A. Figure 9 shows operating waveforms. The soft start during the initial start-up is shown in the section 1. During this period, there is no external sync signal and the switching frequency is 20KHz. The section 2 represents the normal mode operation. The switching frequency is synchronized with the external sync signal. In the section 3, the external sync signal is removed, but the load exists and thus the Vfb is higher than 0.8V. In this period the FS8S0765RC does the normal switching operation with the switching frequency of 20KHz. The section 4 and 5 show the burst mode operation. At the end of the section 3, the load is also eliminated and at the beginning of the section 4, the Vfb drops down below 0.8V and the FS8S0765RC stops switching. During the section 4, the Vcc goes down to 11V. When the external sync signal appears at the pin 5, the FS8S0765RC recovers its normal operation.

Typical application circuit

1. 80W Universal Input Power Supply For CRT Monitor



2. Transformer Schematic Diagram



3.Winding Specification

No	Pin (s→f)	Wire	Turns	Winding Method
Np1	4 → 1	$0.3^{\phi} \times 1$	40	Solenoid Winding
Insulation: Polyester Tape t = 0.050mm, 2Layers				
Nvo1	16 → 15	$0.3^{\phi} \times 1$	10	Center Winding
Insulation: Polyester Tape t = 0.050mm, 2Layers				
Nvcc	6 → 7	$0.2^{\phi} \times 1$	9	Solenoid Winding
Insulation: Polyester Tape t = 0.050mm, 2Layers				
Nvo2	14 → 13	$0.3^{\phi} \times 3$	22	Center Winding
Insulation: Polyester Tape t = 0.050mm, 2Layers				
Np2	4 → 1	$0.3^{\phi} \times 1$	40	Solenoid Winding
Insulation: Polyester Tape t = 0.050mm, 2Layers				
Nvo3	12 → 9	$0.3^{\phi} \times 2$	6	Solenoid Winding
Insulation: Polyester Tape t = 0.050mm, 2Layers				
Nvo4	9 → 11	$0.3^{\phi} \times 1$	5	Solenoid Winding
Insulation: Polyester Tape t = 0.050mm, 2Layers				
Nvo3	10 → 9	$0.3^{\phi} \times 2$	3	Solenoid Winding
Outer Insulation: Polyester Tape t = 0.050mm, 2Layers				

4.Electrical Charateristics

	Pin	Specification	Remarks
Inductance	1 - 4	420uH ± 10%	300kHz, 1V
Leakage Inductance	1 - 4	5uH Max	2^{nd} all short

5. Core & Bobbin

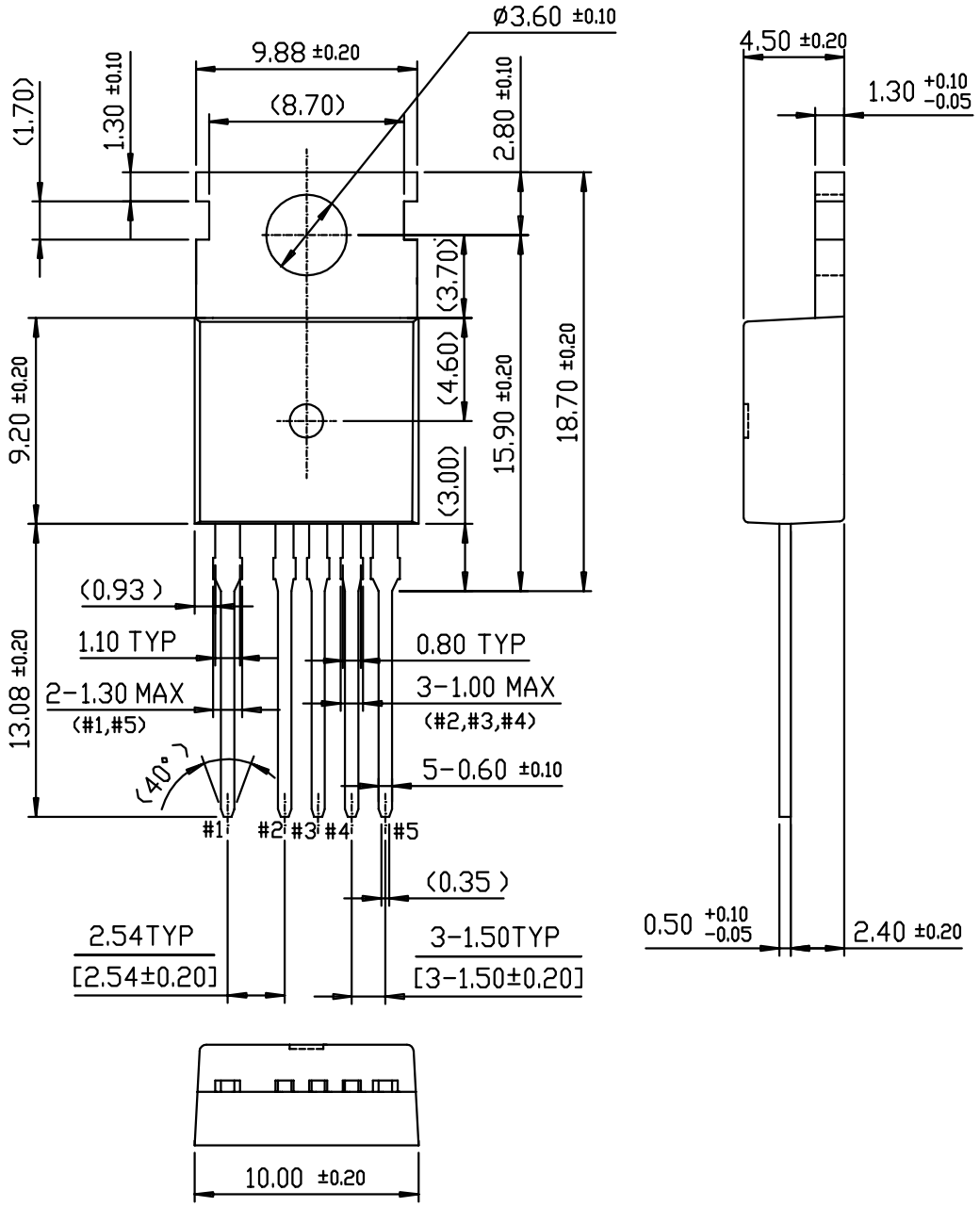
Core : EER 3540
Bobbin : EER3540
Ae(mm2) : 107

6.Demo Circuit Part List

Part	Value	Note	Part	Value	Note
Fuse			C201	22nF/160V	Electorlytic Capacitor
F101	3A/250V		C202	22nF/160V	Electorlytic Capacitor
NTC			C203	47nF/100V	Electorlytic Capacitor
RT101	10D-9		C204	47nF/100V	Electorlytic Capacitor
Resistor			C205	1000nF/25V	Electorlytic Capacitor
R101	68K	2W	C206	1000nF/25V	Electorlytic Capacitor
R102	15	1/4W	C207	1000nF/25V	Electorlytic Capacitor
R103	390K	1W	C208	1000nF/25V	Electorlytic Capacitor
R104	470	1/4W	C209	1000nF/25V	Electorlytic Capacitor
			C210	1000nF/25V	Electorlytic Capacitor
			C301	4.7nF	AC Filter Capacitor
			C302	4.7nF	AC Filter Capacitor
Inductor					
L201 ~ L205	13uH				
			Diode		
			D101	UF4007	
Capacitor			D102	TVR10G	
C101	471D10	TNR	D201	UF4007	
C102	100nF	Box Capacitor	D202	UF5404	
C103	4.7nF	AC Filter Capacitor	D203	UF5402	
C104	4.7nF	AC Filter Capacitor	D204	UF5402	
C105	100nF	Box Capacitor	D205	UF5401	
C106	220nF/400V	Electorlytic Capacitor			
C107	47nF/630V	Caramic Capacitor	BD101	KBL406	Bridge Diode
C108	22nF/50V	Caramic Capacitor	**Line Filter**		
C109	47nF	Caramic Capacitor	LF101	24mH	
C110	1nF/50V	Electorlytic Capacitor	**IC**		
			IC101	FS8S0765RC	(7A, 650V)

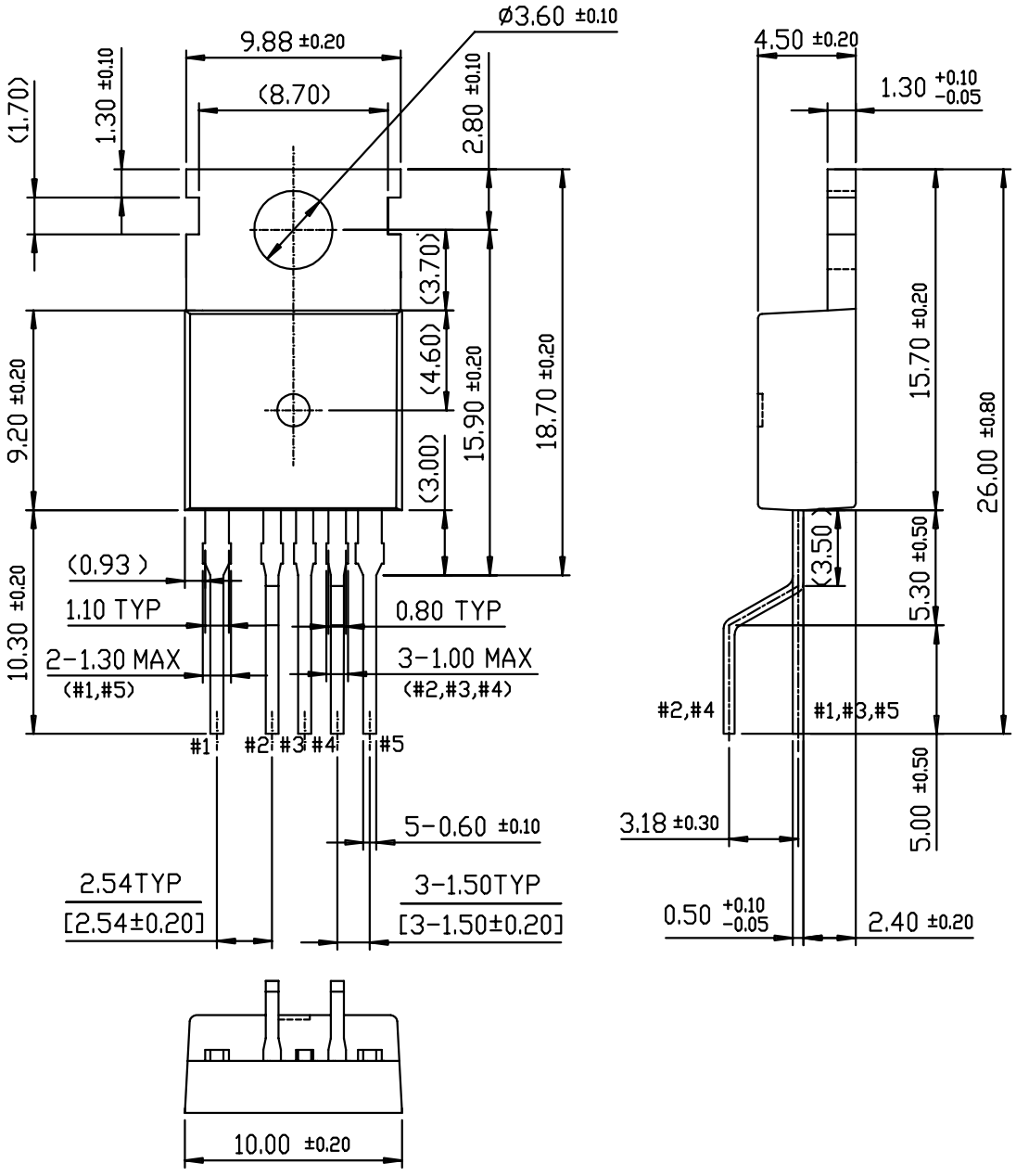
Package Dimensions

TO-220-5L



Package Dimensions (Continued)

TO-220-5L(Forming)



Ordering Information

Product Number	Package	Marking Code	BVdss	Rds(on)Max.
FS8S0765RCTU	TO-220-5L	8S0765RC	650V	1.6
FS8S0765RCYDTU	TO-220-5L(Forming)			

TU : Non Forming Type
YDTU : Forming Type