FAIRCHILD SEMICONDUCTOR®

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FSQ0565R, FSQ0765R
Green-Mode Fairchild Power Switch (FPS™) for Quasi-Resonant Operation - Low EMI and High Efficiency

Features

- Optimized for Quasi-Resonant Converter (QRC)
- Low EMI through Variable Frequency Control and AVS (Alternating Valley Switching)
- High-Efficiency through Minimum Voltage Switching
- Narrow Frequency Variation Range over Wide Load and Input Voltage Variation
- Advanced Burst-Mode Operation for Low Standby Power Consumption
- Simple Scheme for Sync Voltage Detection
- Pulse-by-Pulse Current Limit
- Various Protection functions: Overload Protection (OLP), Over-Voltage Protection (OVP), Abnormal Over-Current Protection (AOCP), Internal Thermal Shutdown (TSD) with Hysteresis, Output Short Protection (OSP)
- Under-Voltage Lockout (UVLO) with Hysteresis
- Internal Start-up Circuit
- Internal High-Voltage Sense FET (650V)
- Built-in Soft-Start (17.5ms)

Applications

- Power Supply for LCD TV and Monitor, VCR, SVR, STB, and DVD & DVD Recorder
- Adapter

Related Resourses

Visit: http://www.fairchildsemi.com/apnotes/ for:

- *AN-4134: Design Guidelines for Offline Forward Converters Using Fairchild Power Switch (FPS™)*
- *AN-4137: Design Guidelines for Offline Flyback Converters Using Fairchild Power Switch (FPS™)*
- *AN-4140: Transformer Design Consideration for Offline Flyback Converters Using Fairchild Power Switch (FPS™)*
- *AN-4141: Troubleshooting and Design Tips for Fairchild Power Switch (FPS™) Flyback Applications*
- *AN-4145: Electromagnetic Compatibility for Power Converters*
- *AN-4147: Design Guidelines for RCD Snubber of Flyback*
- *AN-4148: Audible Noise Reduction Techniques for Fairchild Power Switch Fairchild Power Switch(FPS™) Applications*
- *AN-4150: Design Guidelines for Flyback Converters Using FSQ-Series Fairchild Power Switch (FPS™)*

Description

A Quasi-Resonant Converter (QRC) generally shows lower EMI and higher power conversion efficiency than a conventional hard-switched converter with a fixed switching frequency. The FSQ-series is an integrated Pulse-Width Modulation (PWM) controller and SenseFET specifically designed for quasi-resonant operation and Alternating Valley Switching (AVS). The PWM controller includes an integrated fixed-frequency oscillator, Under-Voltage Lockout (UVLO), 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, the FSQ-series can reduce total cost, component count, size, and weight; while simultaneously increasing efficiency, productivity, and system reliability. This device provides a basic platform for cost-effective designs of quasi-resonant switching flyback converters.

Ordering Information

Product Number	PKG.(5)	Operating Temp.	Current Limit	$R_{DS(ON)}$ Max.	Maximum Output Power(1)				Replaces Devices
					$230V_{AC}\pm15\%$(2)		$85\text{-}265V_{AC}$		
					Adapter(3)	Open Frame(4)	Adapter(3)	Open Frame(4)	
FSQ0565R	TO-220F-6L	-40 to +85°C	3.0A	2.2Ω	70W	80W	41W	60W	FSCM0565R FSDM0565RB
FSQ0765R	TO-220F-6L	-40 to +85°C	3.5A	1.6Ω	80W	90W	48W	70W	FSCM0765R FSDM0765RB

Notes:
1. The junction temperature can limit the maximum output power.
2. $230V_{AC}$ or $100/115V_{AC}$ with doubler.
3. Typical continuous power in a non-ventilated enclosed adapter measured at 50°C ambient temperature.
4. Maximum practical continuous power in an open-frame design at 50°C ambient.
5. These parts are RoHS compliant.

Application Diagram

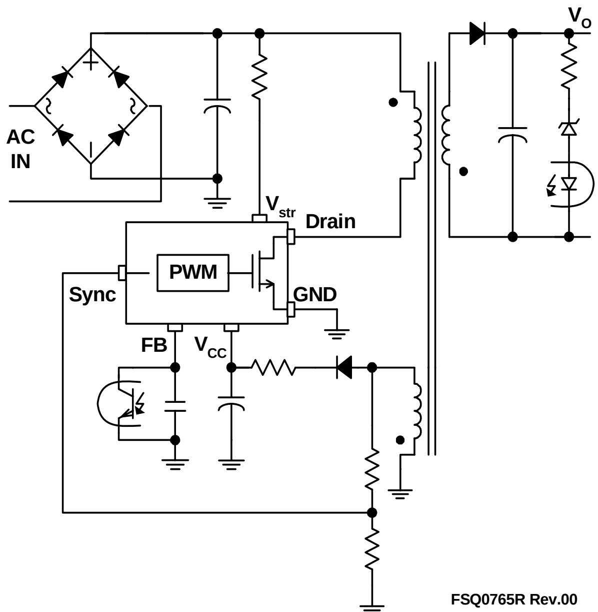

Figure 1. Typical Flyback Application

Internal Block Diagram

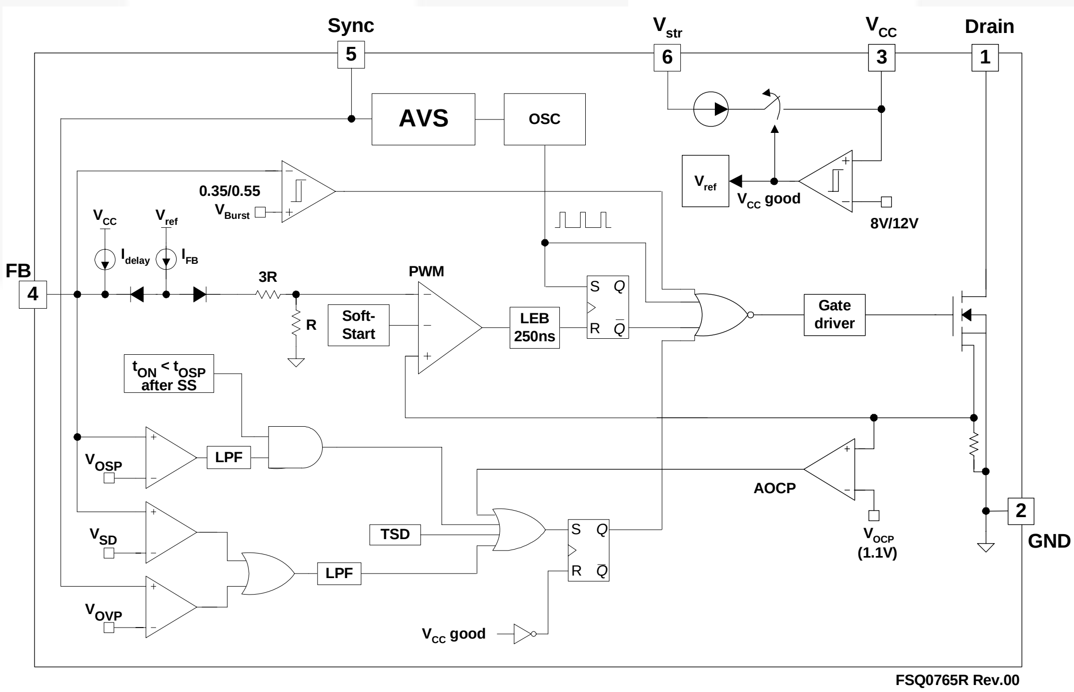

Figure 2. Internal Block Diagram

Pin Configuration

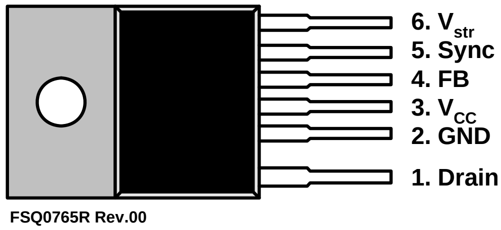

Figure 3. Pin Configuration (Top View)

Pin Definitions

Pin #	Name	Description
1	Drain	**SenseFET drain.** High-voltage power SenseFET drain connection.
2	GND	**Ground.** This pin is the control ground and the SenseFET source.
3	V_{CC}	**Power Supply.** This pin is the positive supply input. This pin provides internal operating current for both start-up and steady-state operation.
4	FB	**Feedback.** 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 6V, the overload protection triggers, which shuts down the FPS.
5	Sync	**Sync.** This pin is internally connected to the sync-detect comparator for quasi-resonant switching. In normal quasi-resonant operation, the threshold of the sync comparator is 1.2V/1.0V.
6	V_{str}	**Start-up.** This pin is connected directly, or through a resistor, to the high-voltage DC link. At start-up, the internal high-voltage current source supplies internal bias and charges the external capacitor connected to the V_{CC} pin. Once V_{CC} reaches 12V, the internal current source is disabled. It is not recommended to connect V_{str} and Drain together.

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. T_A = 25°C, unless otherwise specified.

Symbol	Parameter			Min.	Max.	Unit
V_{str}	V_{str} Pin Voltage			500		V
V_{DS}	Drain Pin Voltage			650		V
V_{CC}	Supply Voltage				20	V
V_{FB}	Feedback Voltage Range			-0.3	13	V
V_{Sync}	Sync Pin Voltage			-0.3	13	V
I_{DM}	Drain Current Pulsed	FSQ0565R			11	A
		FSQ0765R			14.4	A
I_D	Continuous Drain Current(6)	FSQ0565R	T_C = 25°C		2.8	A
			T_C = 100°C		1.7	
		FSQ0765R	T_C = 25°C		3.6	A
			T_C = 100°C		2.28	
E_{AS}	Single Pulsed Avalanche Energy(7)	FSQ0565R			190	mJ
		FSQ0765R			570	mJ
P_D	Total Power Dissipation(Tc=25°C)				45	W
T_J	Operating Junction Temperature			-40	Internally limited	°C
T_A	Operating Ambient Temperature			-40	+85	°C
T_{STG}	Storage Temperature			-55	+150	°C
ESD	Electrostatic Discharge Capability, Human Body Model			2.0		kV
	Electrostatic Discharge Capability, Charged Device Model			2.0		kV

Notes:
6. Repetitive rating: Pulse width limited by maximum junction temperature.
7. L=14mH, starting T_J=25°C.

Thermal Impedance

T_A = 25°C unless otherwise specified.

Symbol	Parameter	Package	Value	Unit
θ_{JA}	Junction-to-Ambient Thermal Resistance(8)	TO-220F-6L	50	°C/W
θ_{JC}	Junction-to-Case Thermal Resistance(9)		2.8	°C/W

Notes:
8. Free standing with no heat-sink under natural convection.
9. Infinite cooling condition - refer to the SEMI G30-88.

Electrical Characteristics

T_A = 25°C unless otherwise specified.

Symbol	Parameter		Condition	Min.	Typ.	Max.	Unit
SENSEFET SECTION							
BV_{DSS}	Drain Source Breakdown Voltage		V_{CC} = 0V, I_D = 100µA	650			V
I_{DSS}	Zero-Gate-Voltage Drain Current		V_{DS} = 560V			300	µA
$R_{DS(ON)}$	Drain-Source On-State Resistance	FSQ0565R	T_J = 25°C, I_D = 0.5A		1.76	2.20	Ω
		FSQ0765R	T_J = 25°C, I_D = 0.5A		1.3	1.6	
C_{OSS}	Output Capacitance	FSQ0565R	V_{GS} = 0V, V_{DS} = 25V, f = 1MHz		78		pF
		FSQ0765R			125		
$t_{d(on)}$	Turn-On Delay Time	FSQ0565R	V_{DD} = 350V, I_D = 25mA		22		ns
		FSQ0765R			22		
t_r	Rise Time	FSQ0565R	V_{DD} = 350V, I_D = 25mA		52		ns
		FSQ0765R			70		
$t_{d(off)}$	Turn-Off Delay Time	FSQ0565R	V_{DD} = 350V, I_D = 25mA		95		ns
		FSQ0765R			105		
t_f	Fall Time	FSQ0565R	V_{DD} = 350V, I_D = 25mA		50		ns
		FSQ0765R			65		
CONTROL SECTION							
$t_{ON.MAX}$	Maximum On Time		T_J = 25°C	8.8	10.0	11.2	µs
t_B	Blanking Time		T_J = 25°C, V_{sync} = 5V	13.5	15.0	16.5	µs
t_W	Detection Time Window		T_J = 25°C, V_{sync} = 0V		6.0		µs
f_S	Initial Switching Frequency			59.6	66.7	75.8	kHz
Δf_S	Switching Frequency Variation(11)		-25°C < T_J < 85°C		±5	±10	%
t_{AVS}	AVS Triggering Threshold(9)	On Time	at V_{IN} = 240V_{DC}, Lm = 360µH (AVS triggered when V_{AVS}>spec & t_{AVS}<spec.)		4.0		µs
V_{AVS}		Feedback Voltage			1.2		V
t_{SW}	Switching Time Variance by AVS(11)		Sync = 500kHz sine input V_{FB} = 1.2V, t_{ON} = 4.0µs	13.5		20.5	µs
I_{FB}	Feedback Source Current		V_{FB} = 0V	700	900	1100	µA
D_{MIN}	Minimum Duty Cycle		V_{FB} = 0V			0	%
V_{START}	UVLO Threshold Voltage			11	12	13	V
V_{STOP}			After turn-on	7	8	9	V
$t_{S/S}$	Internal Soft-Start Time		With free-running frequency		17.5		ms
BURST-MODE SECTION							
V_{BURH}	Burst-Mode Voltages		T_J = 25°C, t_{PD} = 200ns(10)	0.45	0.55	0.65	V
V_{BURL}				0.25	0.35	0.45	V
Hysteresis					200		mV

Continued on the following page...

Electrical Characteristics (Continued)

T_A = 25°C unless otherwise specified.

Symbol	Parameter		Condition	Min.	Typ.	Max.	Unit
PROTECTION SECTION							
I_{LIMIT}	Peak Current Limit	FSQ0565R	T_J = 25°C, di/dt = 370mA/µs	2.64	3.00	3.36	A
		FSQ0765R	T_J = 25°C, di/dt = 460mA/µs	3.08	3.50	3.92	
V_{SD}	Shutdown Feedback Voltage		V_{CC} = 15V	5.5	6.0	6.5	V
I_{DELAY}	Shutdown Delay Current		V_{FB} = 5V	4	5	6	µA
t_{LEB}	Leading-Edge Blanking Time(11)				250		ns
t_{OSP}	Output Short Protection(9)	Threshold Time	T_J = 25°C OSP triggered when t_{ON}<t_{OSP} , V_{FB}>V_{OSP} & lasts longer than t_{OSP_FB}		1.2	1.4	µs
V_{OSP}		Threshold Feedback Voltage		1.8	2.0		V
t_{OSP_FB}		Feedback Blanking Time		2	2.5	3.0	µs
T_{SD}	Thermal Shutdown(9)	Shutdown Temperature		125	140	155	°C
Hys		Hysteresis			60		
SYNC SECTION							
V_{SH1}	Sync Threshold Voltage 1		V_{CC} = 15V, V_{FB} = 2V	1.0	1.2	1.4	V
V_{SL1}				0.8	1.0	1.2	
t_{sync}	Sync Delay Time(11)(12)				230		ns
V_{SH2}	Sync Threshold Voltage 2		V_{CC} = 15V, V_{FB} = 2V	4.3	4.7	5.1	V
V_{SL2}				4.0	4.4	4.8	
V_{CLAMP}	Low Clamp Voltage		I_{SYNC_MAX} = 800µA I_{SYNC_MIN} = 50µA	0.0	0.4	0.8	V
V_{OVP}	Over-Voltage Protection	Threshold Voltage	V_{CC} = 15V, V_{FB} = 2V	7.4	8	9.6	V
t_{OVP}		Blanking Time(11)		1.0	1.7	2.4	µs
TOTAL DEVICE SECTION							
I_{OP}	Operating Supply Current (Control Part Only)		V_{CC} = 13V	1	3	5	mA
I_{START}	Start Current		V_{CC} = 10V (before V_{CC} reaches V_{START})	350	450	550	µA
I_{CH}	Start-up Charging Current		V_{CC} = 0V, V_{STR} = mininmum 50V	0.65	0.85	1.00	mA
V_{STR}	Minimum V_{STR} Supply Voltage				26		V

Notes:

10. Propagation delay in the control IC.
11. Guaranteed by design, but not tested in production.
12. Includes gate turn-on time.

Comparison Between FSDM0x65RNB and FSQ-Series

Function	FSDM0x65RE	FSQ-Series	FSQ-Series Advantages
Operation Method	Constant Frequency PWM	Quasi-Resonant Operation	■ Improved efficiency by valley switching ■ Reduced EMI noise ■ Reduced components to detect valley point
EMI Reduction	Frequency Modulation	Reduce EMI Noise	■ Valley Switching ■ Inherent Frequency Modulation ■ Alternate Valley Switching
Hybrid Control		CCM or AVS Based on Load and Input Condition	■ Improves efficiency by introducing hybrid control
Burst-Mode Operation	Burst-Mode Operation	Advanced Burst-Mode Operation	■ Improved standby power by AVS in burst-mode
Strong Protections	OLP, OVP	OLP, OVP, AOCP, OSP	■ Improved reliability through precise AOCP ■ Improved reliability through precise OSP
TSD	145°C without Hysteresis	140°C with 60°C Hysteresis	■ Stable and reliable TSD operation ■ Converter temperature range

Typical Performance Characteristics

These characteristic graphs are normalized at T_A= 25°C.

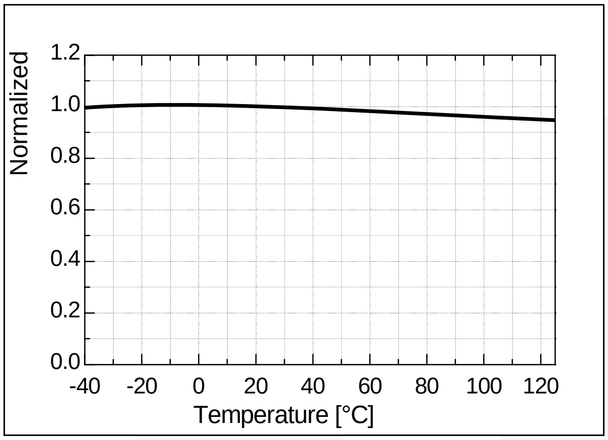

Figure 4. Operating Supply Current (I_{OP}) vs. T_A

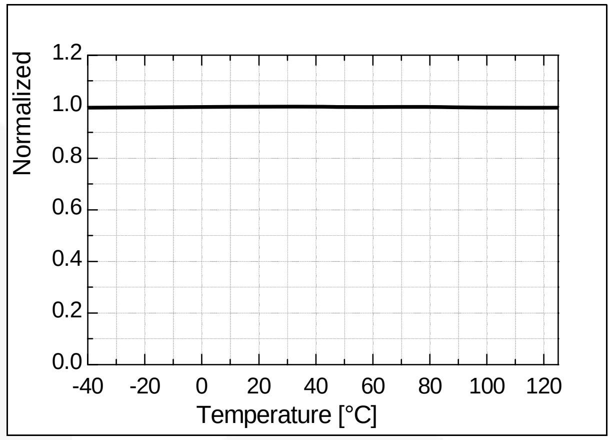

Figure 5. UVLO Start Threshold Voltage (V_{START}) vs. T_A

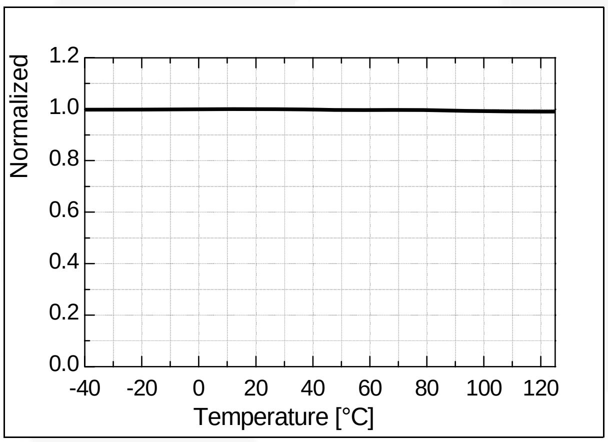

Figure 6. UVLO Stop Threshold Voltage (V_{STOP}) vs. T_A

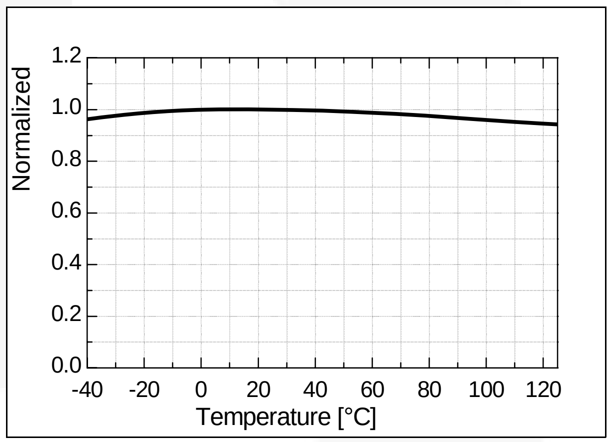

Figure 7. Start-up Charging Current (I_{CH}) vs. T_A

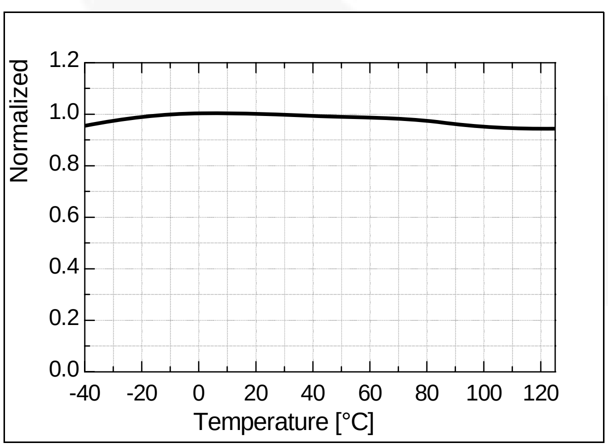

Figure 8. Initial Switching Frequency (f_S) vs. T_A

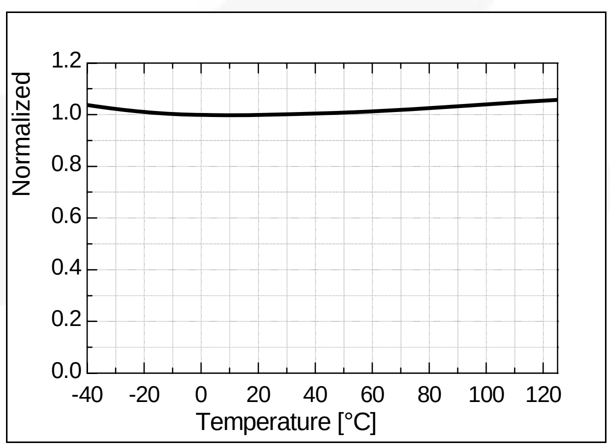

Figure 9. Maximum On Time ($t_{ON.MAX}$) vs. T_A

Typical Performance Characteristics (Continued)

These characteristic graphs are normalized at T_A= 25°C.

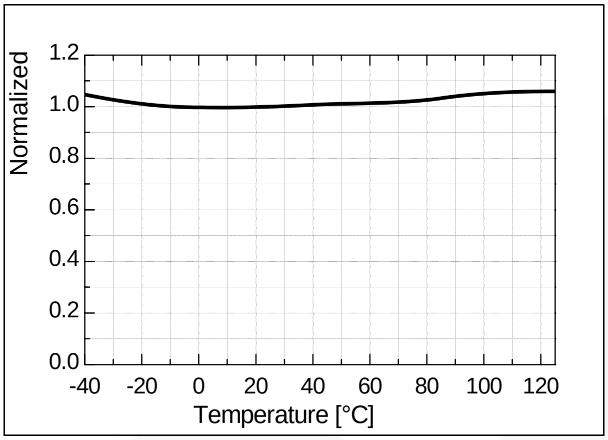

Figure 10. Blanking Time (t_B) vs. T_A

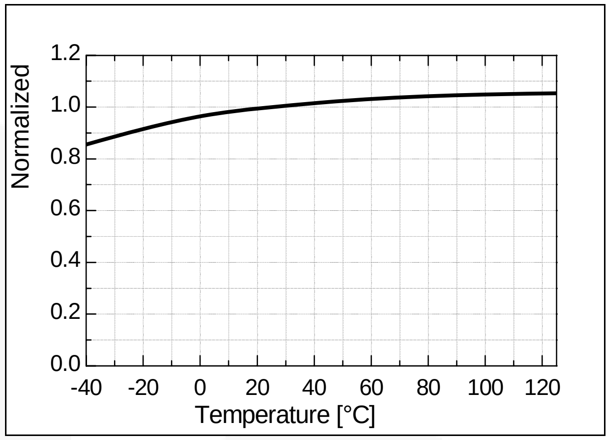

Figure 11. Feedback Source Current (I_{FB}) vs. T_A

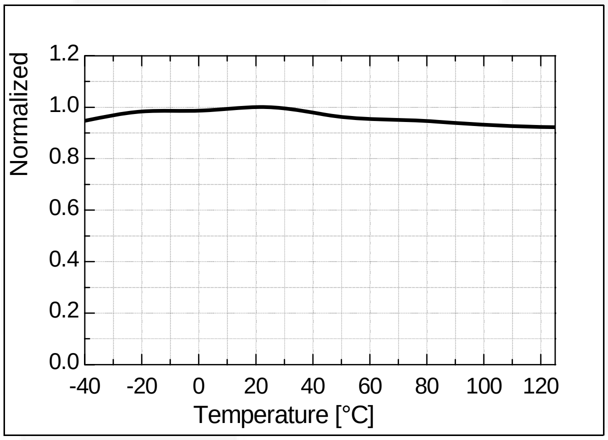

Figure 12. Shutdown Delay Current (I_{DELAY}) vs. T_A

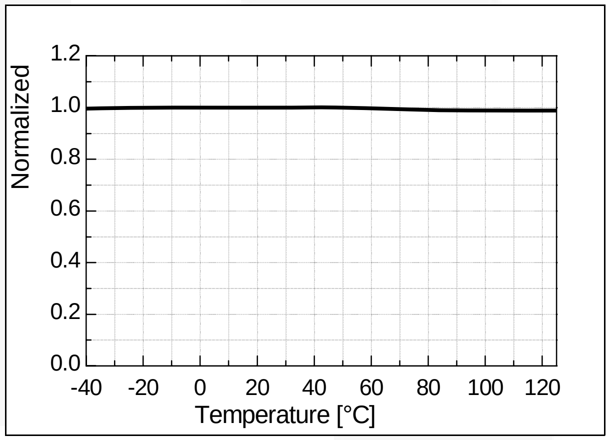

Figure 13. Burst-Mode High Threshold Voltage (V_{burh}) vs. T_A

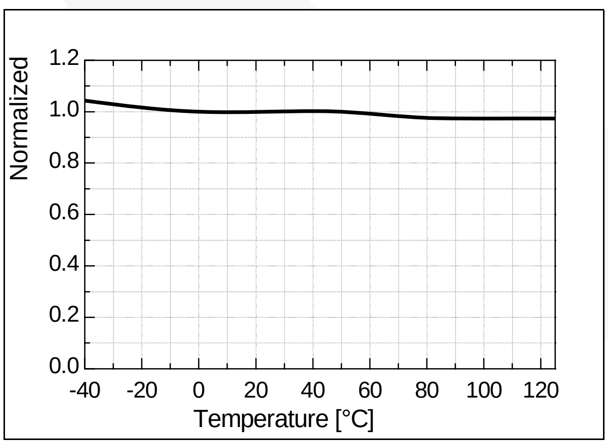

Figure 14. Burst-Mode Low Threshold Voltage (V_{burl}) vs. T_A

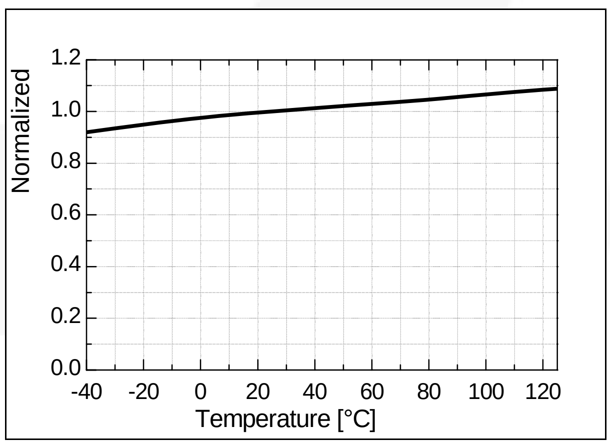

Figure 15. Peak Current Limit (I_{LIM}) vs. T_A

Typical Performance Characteristics (Continued)

These characteristic graphs are normalized at T_A= 25°C.

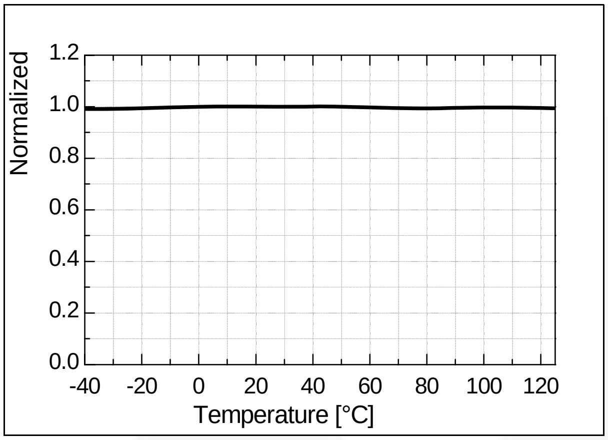

Figure 16. Sync High Threshold Voltage 1 (V_{SH1}) vs. T_A

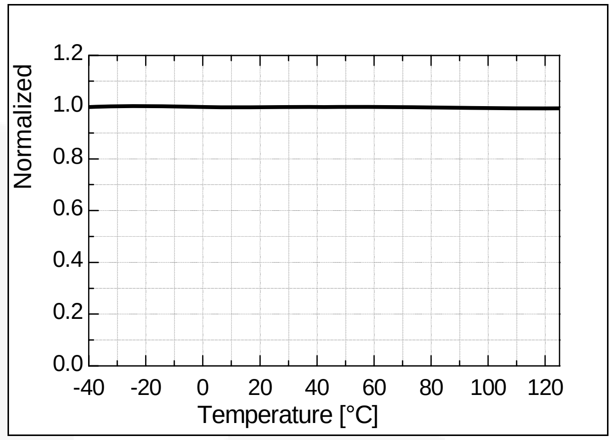

Figure 17. Sync Low Threshold Voltage 1 (V_{SL1}) vs. T_A

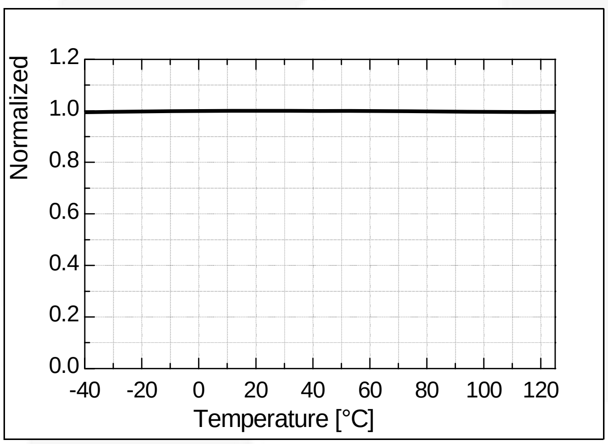

Figure 18. Shutdown Feedback Voltage (V_{SD}) vs. T_A

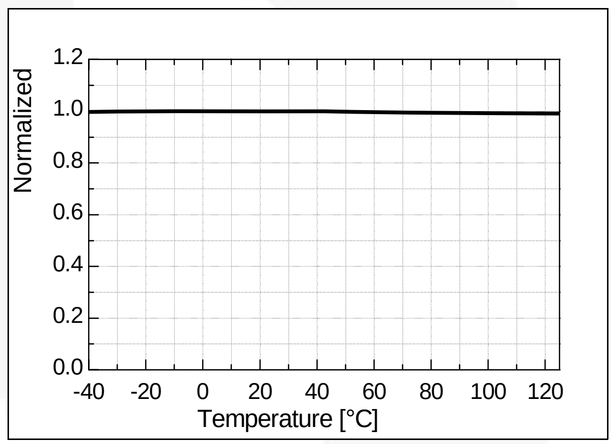

Figure 19. Over-Voltage Protection (V_{OV}) vs. T_A

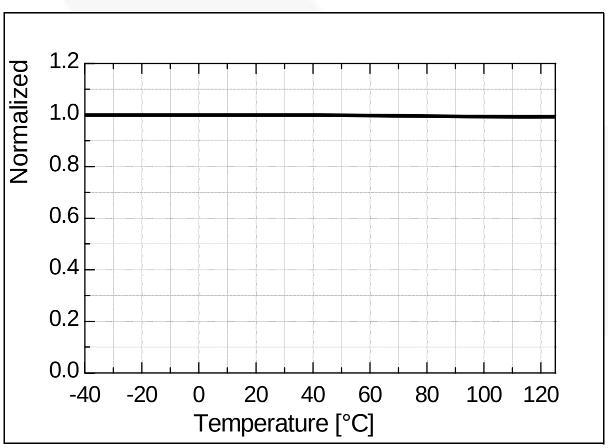

Figure 20. Sync High Threshold Voltage 2 (V_{SH2}) vs. T_A

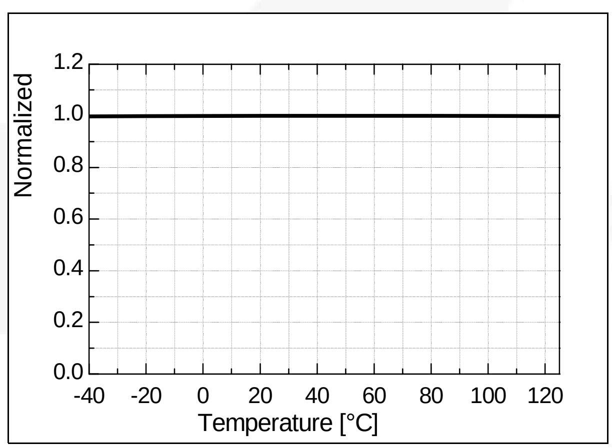

Figure 21. Sync Low Threshold Voltage 2 (V_{SL2}) vs. T_A

Package Dimensions

TO-220F-6L (Forming)

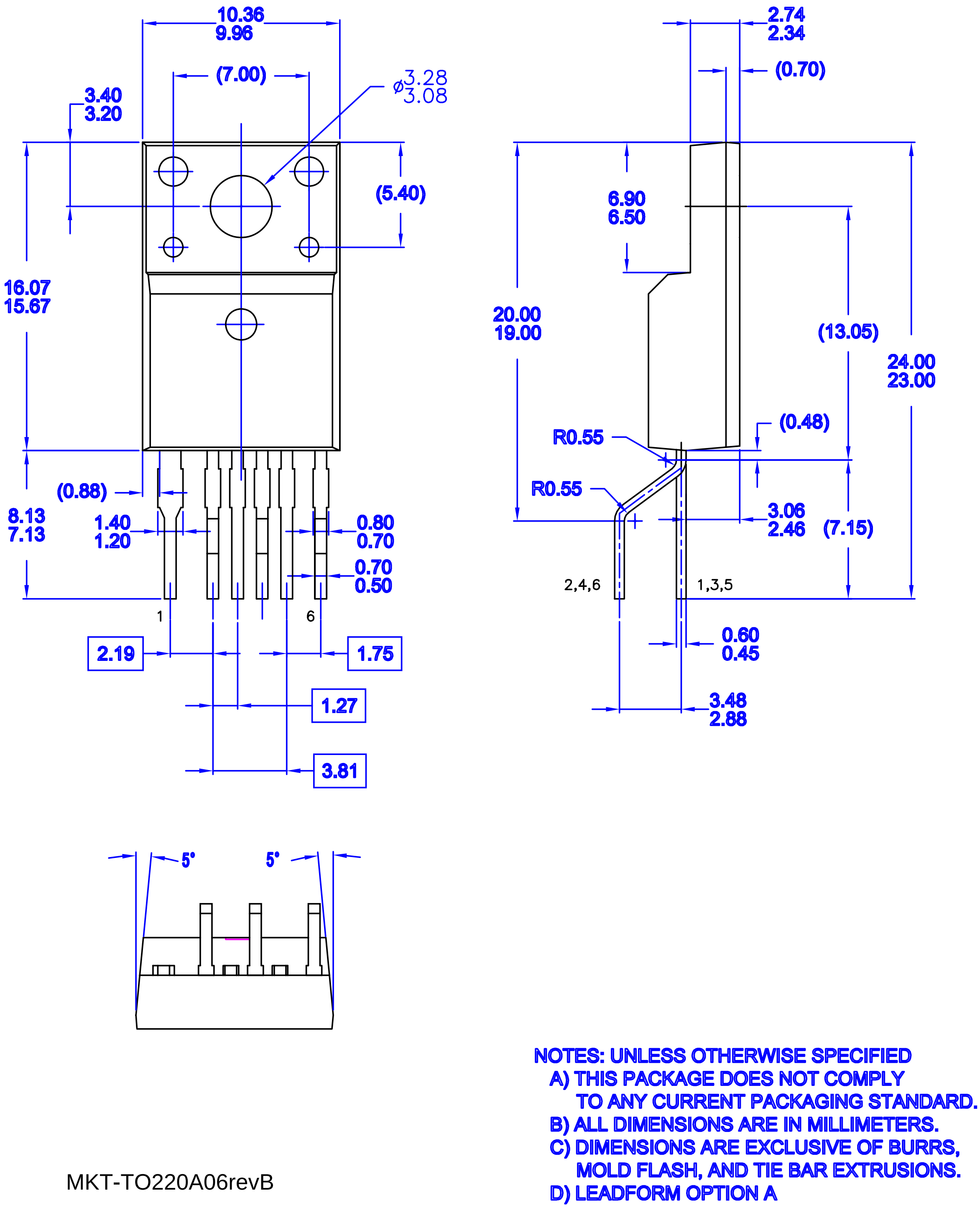

Figure 40. 6-Lead, TO-220 Package