ZXMS6004EV1 USER GUIDE

Device features

- Compact high power dissipation package
- Short circuit protection
- Thermal shutdown with auto restart
- Over voltage protection (active clamping)
- Load dump protection (actively protect load)
- Input ESD protection
- 3.3V and 5V logic level input
- Low input current
- 1.3A continuous current rating

Description

The ZXMS6004EV1 board (Figure 1) is intended for the evaluation of the ZXMS6004FF self protected low side MOSFET. The evaluation board enables the user to evaluate the over-temperature, over-current and over-voltage (active clamp) features of the ZXMS6004FF. Furthermore, this evaluation board allows the user to compare the performance of the ZXMS6004FF, which is packaged, in the SOT23 Flat package, against the much larger SOT223 footprint devices (BSP75G)

Ordering Information

Evaluation board order number
ZXMS6004EV1

Device order number
ZXMS6004FFTA

Figure 1 Evaluation board layout

Schematic diagram

The schematic of the evaluation circuit is shown in Figure 2. A nominal 12V DC should be supplied to the board via terminal block P1. 'IN' is the gate signal applied to the protected MOSFET. Zener diode Z1 clamps 'IN' below the maximum voltage rating of the ZXMS6004FF's gate. To drive the protected MOSFET from a microcontroller, an open Drain small signal N-channel MOSFET/Bipolar should be connected to test point 'IN' with its gate driven by the logic level output from the microcontroller.

A load to the board, such as a solenoid or a halogen lamp, is to be inserted between test point 'LOAD+' and 'LOAD-'. Jumpers J1 and J2, are provided to select the load current path. J1 is located above Q2 and must be fitted for evaluating the ZXMS6004FF. Alternatively, fit J2 in its position to evaluate the BSP75G. It is important to note that although the nominal DC current rating of Q1 and Q2 is similar, the devices have different short-circuit current limit. The ZXMS6004FF has a higher current limit, 2.2A typical which makes it more suitable for driving loads requiring higher in-rush current.

The on-board diagnostic circuit can be used to report the occurrence of a over-current or thermal shutdown mode on the protected MOSFET. LEDs D1 and D2 indicate the MOSFET status. D1 turns on when either the ZXMN6004FF or the BSP75G is in current limit or thermal shut-down mode. If a temporarily short circuit is applied by shorting out the load across 'LOAD+' and 'LOAD-', the protected MOSFET will limit the overload current (short circuit current), the limit of which is defined by the 'IN' voltae (for more details, refer to datasheets for the ZXMS6004FF or BSP75G). In current limit mode, the MOSFET Drain voltage increases. This voltage appears across R3 and R4, and turns on Q3 and Q4. As long as the Drain voltage is pulled high, Q3 and Q4 are on.

The short circuit current also flows through sense resistors R2, R10 and R11. The voltage developed across these resistors turns on Q5. Under overload condition, temperature of Q1 or Q2 rises. Upon the junction temperature of the MOSFET reaching its internal thermal trip point, the device will go into thermal shutdown. The thermal trip point temperature is typically 170°C (150°C min) at the device junction. In thermal shutdown, Q1 is off and the Drain current is zero. The Drain voltage is still pulled to the supply rail voltage. However, there is no voltage across the sense resistors and Q5 is off. Thereby D2 switches on only when the MOSFET is in over current limit mode, and switches off when the device goes into thermal shutdown. In the default board configuration, Jumper J3 is not fitted to enable thermal shutdown status reporting. Nevertheless, D2 can be disabled by fitting in J3.

Additional test points 'DRAIN' and 'SOURCE' on the evaluation board to provide access to Drain and Source of the protected MOSFETs.

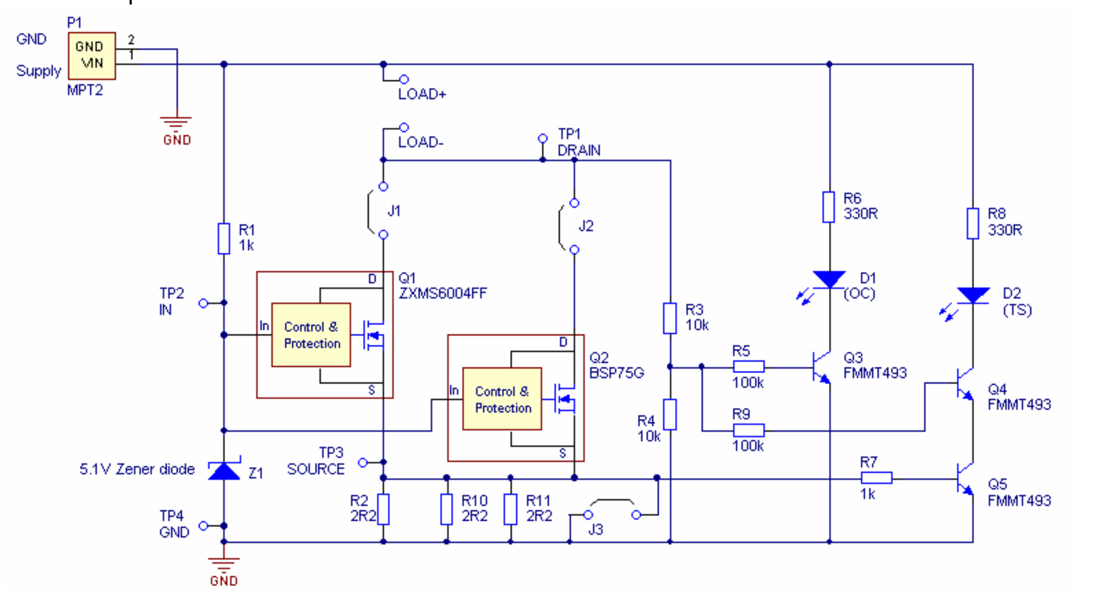


Figure 2: Evaluation board schematic diagram and connection

Table 1: Evaluation board component details (BOM)

Ref.	Value	Package	Part	Manufacturer	Notes
D1,D2	yellow LED	0805	QTLP630C-Y	Kingbright	
J1,J2,J3	2-way pin header				2.54mm pitch
LOAD+, LOAD-	1.3mm loop terminal		Generic		
P1	2-way terminal				2.54mm pitch
Q1		SOT23FF	ZXMS6004FF	Zetex	
Q2		SOT223	BSP75G	Zetex	
Q3,Q4,Q5		SOT23	FMMT493	Zetex	
R1, R7	1kΩ	0805			125mW, 1%
R3,R4	10kΩ	0805	Generic		125mW, 1%
R2,R10,R11	2.2Ω	2512	Generic		2W, 5%
R5,R9	100kΩ	0805	Generic		125mW, 1%
R6,R8	330Ω	0805	Generic		125mW, 1%
TP1,TP2,TP3, TP4	1.3mm loop terminal		Generic		
Z1	5.1V Zener Diode	SOD323	DDZ5V1BS	Diodes Inc.	

Evaluation guideline

Current limit and over temperature shut down test

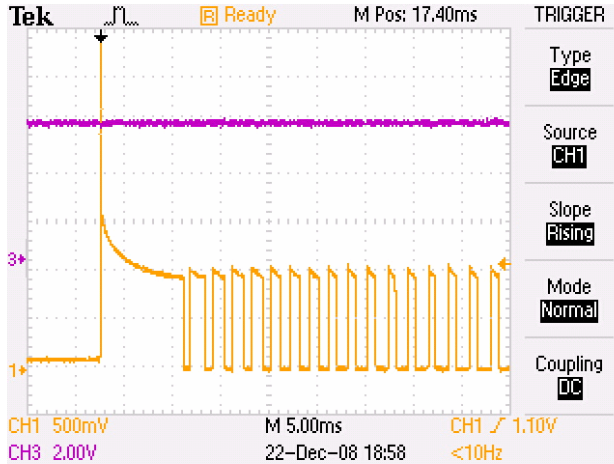
1. Select MOSFET for evaluation. Fit in jumper J1 to select ZXMS6004FF or J2 for BSP75G
2. Connect a 12V DC power supply to P1 with polarity as denoted by VIN and GND respectively
3. Connect a load across the test points 'LOAD+' and 'LOAD-'
4. Switch on the DC power supply. The load should power up
5. Measure the voltage VSENSE between test points 'SOURCE' and 'GND' using an oscilloscope. The current through the MOSFET is equal to VSENSE/0.73
6. Apply a temporary short circuit to the load[†]. Over-current protection is triggered and the MOSFET current is limited. Observe the change to the magnitude of VSENSE. Typical waveform shown in Figure 3, 4 and 5
7. Observe status LEDs D1 and D2 turns on[‡]. Thermal shut down indicator is disable if jumper J3 is fitted and D2 is always off
8. D2 flashing indicates that the MOSFET is in thermal shutdown and auto recycle mode. LED D2 is off when over temperature protection shut down the MOSFET. The delay of D2 flashing from when a short circuit is applied depends on the protected MOSFET temperature. If the MOSFET is already at a high temperature before application of a short circuit, the delay will be shorter
9. Removing short circuit to end test

Notes:
[†]: The protected MOSFET is not intended for use in continuous current limiting mode
[‡]: If thermal shut down indicator is enabled, the flash speed of D2 indicates the frequency at which thermal shutdown and auto re-try cycles occur. Thermal re-try cycles of ZXMS6004FF will toggle D2 at frequency above 400Hz which is perceived as dimming of D2 by human eye.

Figure 3
ZXMS6004FF current limit expanded, showing thermal cycling (CH1: VSENSE; CH3: VGATE)

MOSFET current is equal to VSENSE/0.7.

The frequency of thermal re-try cycle depends on the overload current level, device temperature, package thermal resistance, ambient temperature, thermal trip point's hysteresis and PCB heat-sinking



(CH1: 500mV/div; CH3: 2V/div)

Figure 4
BSP75G current limit expanded, showing thermal recycling (CH1: VSENSE; CH3: VGATE)

BSP75G has a lower current limit value than ZXMS2004FF for the same VIN value

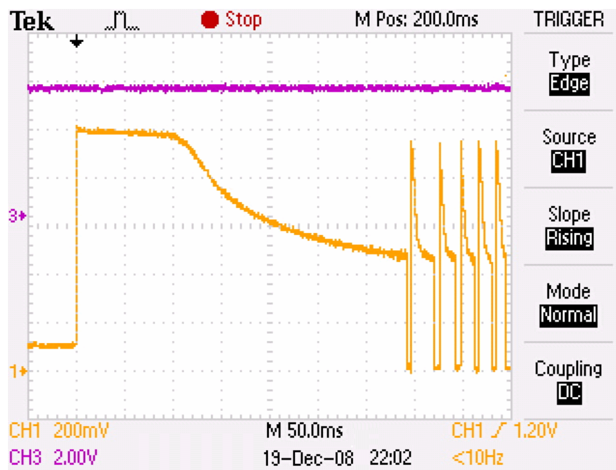
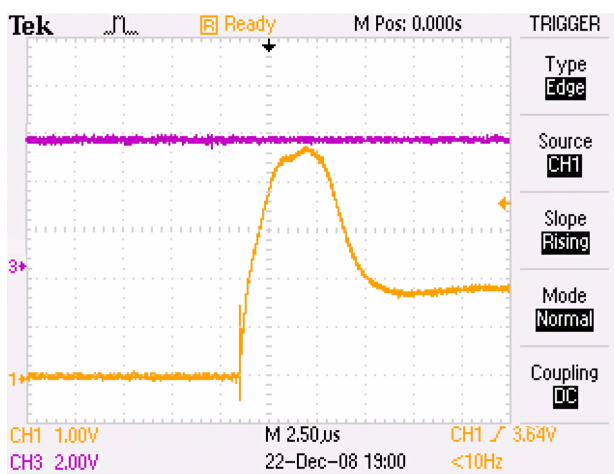


Figure 5
ZXMS6004FF current limit (CH1: VSENSE; CH3: VGATE)

The current-limit protection is designed to be de-activated at low V_{DS} to minimize on state power dissipation. Thereby, a higher current pulse is allowed to flow through the MOSFET initially when a short circuit is applied before the current limit kicks in



Inductive load active clamping test

1. Connect an inductive load across the test pins 'LOAD+' and 'LOAD-'
2. Connect the Drain of a small-signal N-channel MOSFET or the Collector of a BJT to test point 'IN'. The Source or Emitter of the small-signal transistor connected to 'GND'. Drive the Gate/Base of that transistor with a low frequency square wave from a signal generator. The

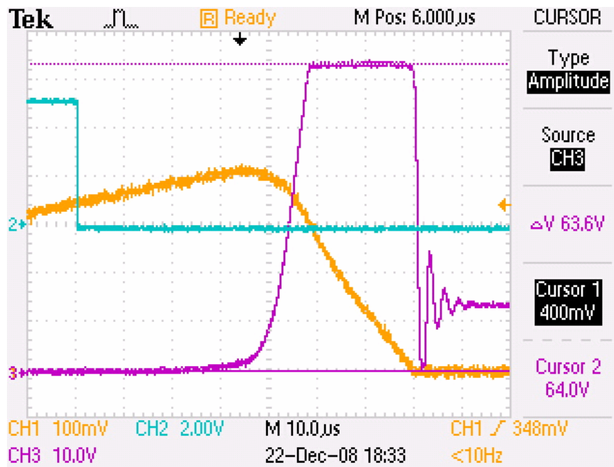
square wave pulses switches the transistor on and off, and subsequently turns off the protected MOSFET when 'IN' test point is pulled low to ground

3. Switch on the DC power supply
4. Connect scope probes to test points 'DRAIN' and 'SOURCE' to observe voltages at Drain and Source of the protected MOSFET. The current through the MOSFET is equal to VSENSE divided by 0.73. The scope probes are grounded at 'GND'
5. The Drain voltage of the protected MOSFET will be momentarily higher than supply rail due to the inductive-'kick' when switching off an inductive load. If this inductive 'kick' tries to raise Drain-Source voltage of Q1/Q2 above 67V, the Drain-Source voltage will be clamped to typically 67V. Example test waveform shown in Fig. 6

Figure 6
ZXMS6004FF driving a 3mH inductive load, supply voltage VIN = 12V
(CH1: VSENSE; CH2: VGATE; CH3: VDRAIN)

Figure shows 67V active clamping of Drain voltage at MOSFET turn off. Turn off delay time around 40µs

The active clamp voltage is lower than the avalanche voltage; the device dissipates less instantaneous power in the active clamp mode than in avalanche mode, affording the device a greater energy handling capability



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