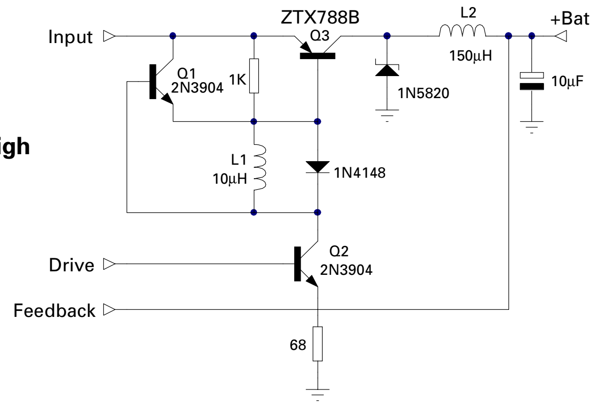
High Speed Turn-off Circuit for PNP Pass Transistors

Cost-Effective replacement of P-Channel MOSFETs

Figure 1
Active Turn-off Circuit for High Current, Low $V_{ce(sat)}$ PNP.



The turn-off circuit shown in Figure 1 can be used with an efficient PNP transistor as a cost effective alternative to P-Channel MOSFETs in step-down (Buck) converters.

It is well appreciated that optimised Bipolar transistor technologies can display lower on-state loss than similar sized (or indeed much larger) MOSFETs, thereby leading to lower cost switch options. [This is essentially due to the pattern of current flow within the structure, and allows relatively small die geometries to display current capabilities far in excess of like packaged MOSFET options.]

However at high switching frequencies, the turn-off times of the Bipolar device, and particularly the storage time portion of the turn-off transition, can lead to significant switching power losses, limiting the product's operation at frequencies much above 70kHz. The MOSFET (being a majority carrier device) does not exhibit storage time effects, and so simpler passive turn-off networks can be employed at low-medium switching frequencies (~100kHz) providing turn-on and turn-off times in tens of nano-seconds. (Note : Though for optimum performance, and especially at higher switching frequencies, attention must be given to the control of gate charge, and the gate drive circuitry must be capable of sourcing/sinking high charge/discharge currents.)

The addition of a few inexpensive components to effect this turn-off circuit allows low loss operation to 150kHz and beyond. Comparison of turn-off times with passive turn-off circuitry, and with this modification show a dramatic improvement. Storage time particularly being reduced from typically 500ns (see Note 1 below) to several nano-seconds, and the entire turn-off event being measured at 50ns.

When a cost analysis is performed, it will be evident that this option has much in it's favour - a cost saving of x2 to x4 being possible.

The ZTX788B is one member of the ZTX788B - 796A Super-β PNP family, which are also available in the SOT223 surface mount package.

Note 1: Measured on a simple PWM IC controlled, 12 to 5V,100kHz converter, biased for 1A output, and the PNP operated with a forced gain of 50.

PARAMETER	SYMBOL	VALUE		UNIT	
Collector-Base Voltage	V_{CBO}	-15		V	
Collector-Emitter Voltage	V_{CEO}	-15		V	
Emitter-Base Voltage	V_{EBO}	-5		V	
Peak Pulse Current	I_{CM}	-8		A	
Continuous Collector Current	I_C	-3		A	
Practical Power Dissipation*	P_{totp}	1.5		W	
Power Dissipation at T_{amb}=25°C derate above 25°C	P_{tot}	1 5.7		W mW/°C	
Operating and Storage Temperature Range	tj:tstg	-55 to +200		°C	
		MIN.	MAX.		CONDITIONS.
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$		-0.15 -0.25 -0.45	V V V	I_C=-0.5A, I_B=-2.5mA* I_C=-1A, I_B=-5mA* I_C=-2A, I_B=-10mA*
Static Forward Current Transfer Ratio	h_{FE}	500 400 300 150	1500		I_C=-10mA, V_{CE}=-2V* I_C=-1A, V_{CE}=-2V* I_C=-2A, V_{CE}=-2V* I_C=-6A, V_{CE}=-2V*

Table 1
Maximum Ratings and Sample Parametric Data for ZTX788B Transistor - (For full details please refer to the datasheet).

ZETEX