



# FJBE2150D ESBC™ Rated NPN Silicon Transistor

## ESBC Features (FDC655 MOSFET)

$V_{CS(ON)}$	$I_C$	Equiv. $R_{CS(ON)}$
0.131 V	0.5 A	$0.261 \Omega^{(1)}$

- Low Equivalent On Resistance
- Very Fast Switch: 150 kHz
- Squared RBSOA: Up to 1500 V
- Avalanche Rated
- Low Driving Capacitance, No Miller Capacitance (Typ. 12 pF Capacitance at 200 V)
- Low Switching Losses
- Reliable HV Switch: No False Triggering due to High dv/dt Transients

## Applications

- High-Voltage and High-Speed Power Switches
- Emitter-Switched Bipolar/MOSFET Cascode (ESBC™)
- Smart Meters, Smart Breakers, HV Industrial Power Supplies
- Motor Drivers and Ignition Drivers

## Description

The FJBE2150D is a low-cost, high-performance power switch designed to be used in an ESBC™ configuration in applications such as: power supplies, motor drivers, smart grid, or ignition switches. The power switch is designed to operate up to 1500 volts and up to 3 amps, while providing exceptionally low on-resistance and very low switching losses.

The ESBC™ switch is designed to be driven using off-the-shelf power supply controllers or drivers. The ESBC™ MOSFET is a low-voltage, low-cost, surface-mount device that combines low-input capacitance and fast switching. The ESBC™ configuration further minimizes the required driving power because it does not have Miller capacitance.

The FJBE2150D provides exceptional reliability and a large operating range due to its square Reverse-Bias-Safe-Operating-Area (RBSOA) and rugged design. The device is avalanche rated and has no parasitic transistors, so is not prone to static dv/dt failures.

The power switch is manufactured using a dedicated high-voltage bipolar process and is packaged in high-voltage HV-D2PAK rated at 2500 V creepage and clearance.

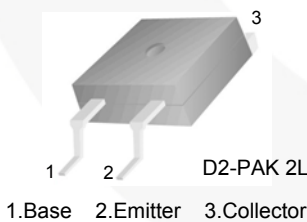


Figure 1. Pin Configuration

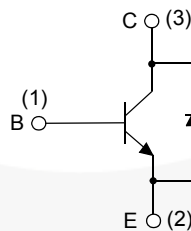


Figure 2. Internal Schematic Diagram

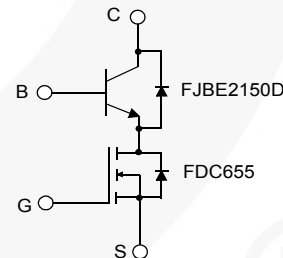


Figure 3. ESBC Configuration<sup>(2)</sup>

## Ordering Information

Part Number	Marking	Package	Packing Method
FJBE2150DTU	J2150D	D2-PAK 2L (TO-263 2L)	Tube

### Notes:

1. Figure of Merit.
2. Other Fairchild MOSFETs can be used in this ESBC application.

## 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. Values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Value	Unit
$V_{CBO}$	Collector-Base Voltage	1500	V
$V_{CEO}$	Collector-Emitter Voltage	800	V
$V_{EBO}$	Emitter-Base Voltage	12	V
$I_C$	Collector Current	2	A
$I_{CP}$	Collector Current (Pulse)	3	A
$I_B$	Base Current	1	A
$I_{BP}$	Base Current (Pulse)	2	A
$P_D$	Power Dissipation ( $T_C = 25^\circ\text{C}$ )	110	W
$T_J$	Operating and Junction Temperature Range	- 55 to +125	$^\circ\text{C}$
$T_{STG}$	Storage Temperature Range	- 65 to +150	$^\circ\text{C}$
EAS	Avalanche Energy ( $T_J = 25^\circ\text{C}$ , 8 mH)	3.5	mJ

## Thermal Characteristics<sup>(3)</sup>

Values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Max.	Unit
$R_{\theta jc}$	Thermal Resistance, Junction to Case	1.13	$^\circ\text{C/W}$
$R_{\theta ja}$	Thermal Resistance, Junction to Ambient	76.42	$^\circ\text{C/W}$

### Note:

- Device mounted on FR-4 PCB, board size = 76.2 mm x 114.3 mm, land pattern 12.70 mm x 9.45 mm, trace size = 10 mil.

**Electrical Characteristics<sup>(4)</sup>**Values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$BV_{CBO}$	Collector-Base Breakdown Voltage	$I_C = 0.5\text{ mA}, I_E = 0$	1500	1689		V
$BV_{CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 5\text{ mA}, I_B = 0$	800	870		V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 0.5\text{ mA}, I_C = 0$	12.0	14.8		V
$I_{CES}$	Collector Cut-off Current	$V_{CE} = 1500\text{ V}, V_{BE} = 0$		0.01	100	$\mu\text{A}$
$I_{CEO}$	Collector Cut-off Current	$V_{CE} = 800\text{ V}, I_B = 0$		0.01	100	$\mu\text{A}$
$I_{EBO}$	Emitter Cut-off Current	$V_{EB} = 12\text{ V}, I_C = 0$		0.05	500	$\mu\text{A}$
$h_{FE}$	DC Current Gain	$V_{CE} = 3\text{ V}, I_C = 0.4\text{ A}$	20	29	35	
		$V_{CE} = 10\text{ V}, I_C = 5\text{ mA}$	20	43		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = 0.25\text{ A}, I_B = 0.05\text{ A}$		0.16		V
		$I_C = 0.5\text{ A}, I_B = 0.167\text{ A}$		0.12		
		$I_C = 1\text{ A}, I_B = 0.33\text{ A}$		0.25		
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	$I_C = 500\text{ mA}, I_B = 50\text{ mA}$		0.74	1.20	V
		$I_C = 2\text{ A}, I_B = 0.4\text{ A}$		0.85	1.20	
$C_{IB}$	Input Capacitance	$V_{EB} = 10\text{ V}, I_C = 0, f = 1\text{ MHz}$		745	1000	pF
$C_{OB}$	Output Capacitance	$V_{CB} = 200\text{ V}, I_E = 0, f = 1\text{ MHz}$		15		pF
$f_T$	Current Gain Bandwidth Product	$I_C = 0.1\text{ A}, V_{CE} = 10\text{ V}$		5		MHz
$V_F$	Diode Forward Voltage	$I_F = 0.4\text{ A}$		0.76	1.20	V
		$I_F = 1\text{ A}$		0.83	1.50	

**Note:**4. Pulse test: pulse width = 20  $\mu\text{s}$ , duty cycles  $\leq 10\%$ .

## ESBC Configured Electrical Characteristics<sup>(5)</sup>

Values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$f_T$	Current Gain Bandwidth Product	$I_C = 0.1\text{ A}, V_{CE} = 10\text{ V}$		25		MHz
$t_{f_i}$	Inductive Current Fall Time	$V_{GS} = 10\text{ V}, R_G = 47\ \Omega,$ $V_{Clamp} = 500\text{ V},$ $t_p = 3.1\ \mu\text{s}, I_C = 0.3\text{ A},$ $I_B = 0.03\text{ A}, L_C = 1\text{ mH},$ $SRF = 480\text{ kHz}$		137		ns
$t_s$	Inductive Storage Time			350		ns
$V_{t_f}$	Inductive Voltage Fall Time			120		ns
$V_{t_r}$	Inductive Voltage Rise Time			100		ns
$t_c$	Inductive Crossover Time			137		ns
$t_{f_i}$	Inductive Current Fall Time		$V_{GS} = 10\text{ V}, R_G = 47\ \Omega,$ $V_{Clamp} = 500\text{ V},$ $t_p = 10\ \mu\text{s}, I_C = 1\text{ A},$ $I_B = 0.2\text{ A}, L_C = 1\text{ mH},$ $SRF = 480\text{ kHz}$		35	
$t_s$	Inductive Storage Time			980		ns
$V_{t_f}$	Inductive Voltage Fall Time			30		ns
$V_{t_r}$	Inductive Voltage Rise Time			195		ns
$t_c$	Inductive Crossover Time			210		ns
$V_{CSW}$	Maximum Collector Source Voltage at Turn-off without Snubber	$h_{FE} = 5, I_C = 2\text{ A}$		1500		
$I_{GS(OS)}$	Gate-Source Leakage Current	$V_{GS} = \pm 20\text{ V}$		1.0		nA
$V_{CS(ON)}$	Collector-Source On Voltage	$V_{GS} = 10\text{ V}, I_C = 2\text{ A}, I_B = 0.67\text{ A},$ $h_{FE} = 3$		2.210		V
		$V_{GS} = 10\text{ V}, I_C = 1\text{ A}, I_B = 0.33\text{ A},$ $h_{FE} = 3$		0.321		
		$V_{GS} = 10\text{ V}, I_C = 0.5\text{ A}, I_B = 0.17\text{ A},$ $h_{FE} = 3$		0.131		
		$V_{GS} = 10\text{ V}, I_C = 0.3\text{ A}, I_B = 0.06\text{ A},$ $h_{FE} = 5$		0.166		
$V_{GS(th)}$	Gate Threshold Voltage	$V_{BS} = V_{GS}, I_B = 250\ \mu\text{A}$		1.9		V
$C_{iss}$	Input Capacitance ( $V_{GS} = V_{CB} = 0$ )	$V_{CS} = 25\text{ V}, f = 1\text{ MHz}$		470		pF
$Q_{GS(tot)}$	Gate-Source Charge $V_{CB} = 0$	$V_{GS} = 10\text{ V}, I_C = 8\text{ A}, V_{CS} = 25\text{ V}$		9		nC
$r_{DS(ON)}$	Static Drain-Source On Resistance	$V_{GS} = 10\text{ V}, I_D = 6.3\text{ A}$		21		m $\Omega$
		$V_{GS} = 4.5\text{ V}, I_D = 5.5\text{ A}$		26		
		$V_{GS} = 10\text{ V}, I_D = 6.3\text{ A}, T_J = 125^\circ\text{C}$		30		

### Note:

5. Used typical FDC655 MOSFET values in table. Values can vary if other Fairchild MOSFETs are used.

## Typical Performance Characteristics

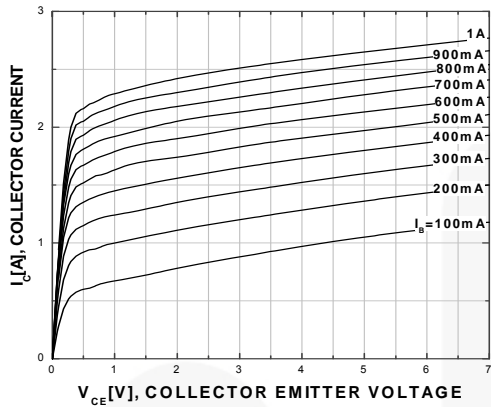


Figure 4. Static Characteristic

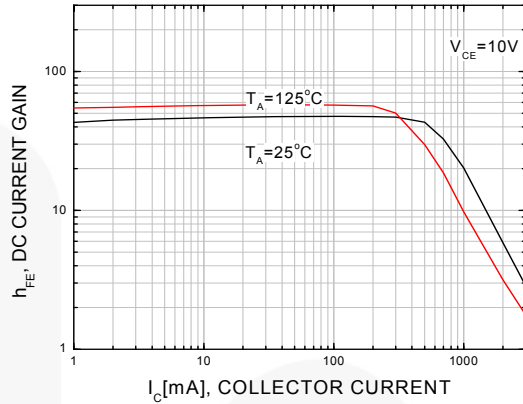


Figure 5. DC Current Gain

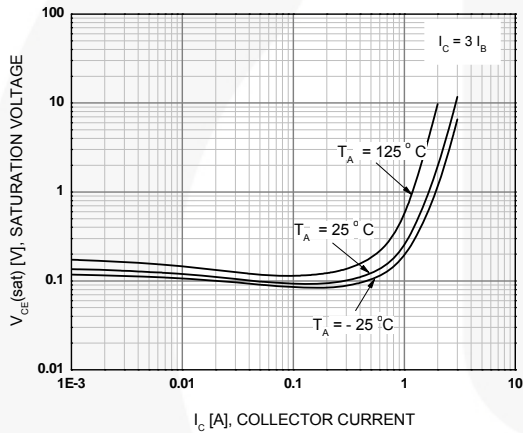


Figure 6. Collector-Emitter Saturation Voltage  
 $h_{FE} = 3$

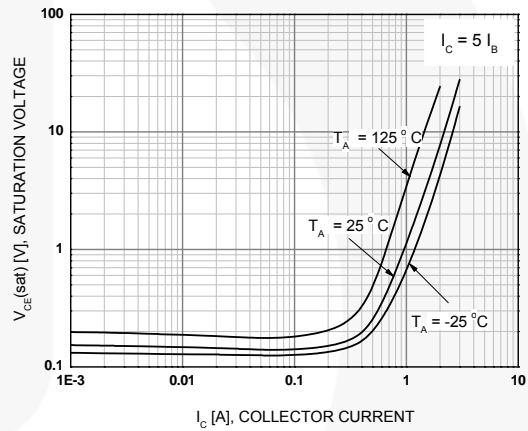


Figure 7. Collector-Emitter Saturation Voltage  
 $h_{FE} = 5$

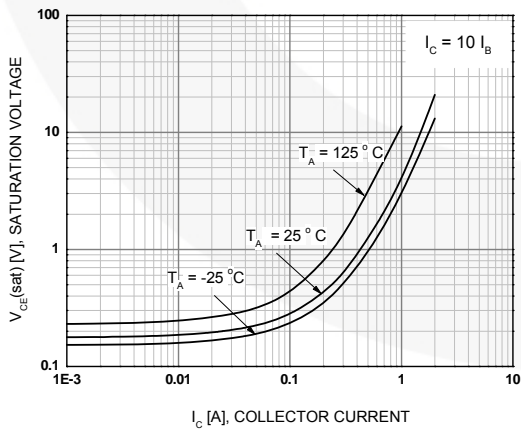


Figure 8. Collector-Emitter Saturation Voltage  
 $h_{FE} = 10$

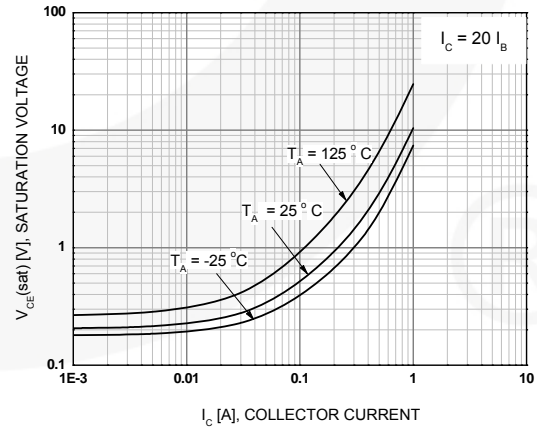


Figure 9. Collector-Emitter Saturation Voltage  
 $h_{FE} = 20$

## Typical Performance Characteristics (Continued)

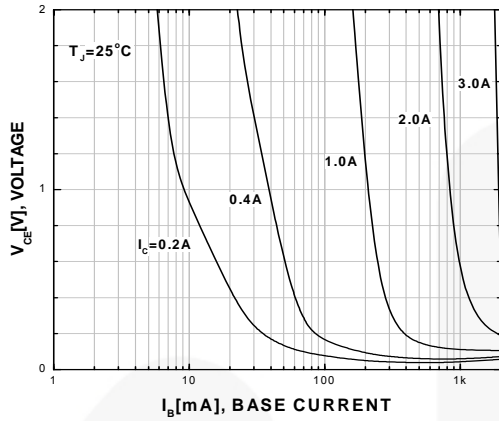


Figure 10. Typical Collector Saturation Voltage

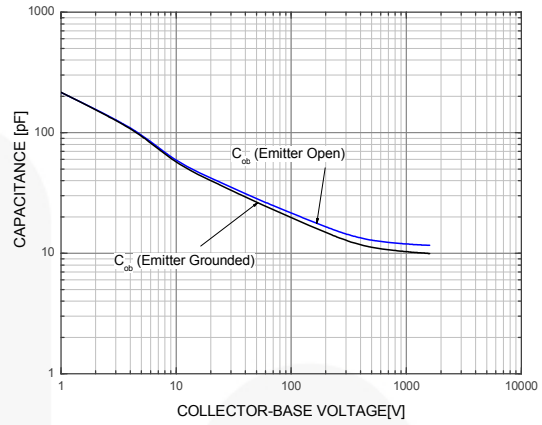


Figure 11. Capacitance

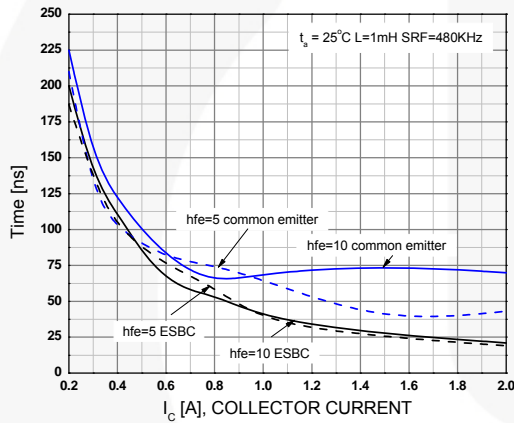


Figure 12. Inductive Load Collector Current Fall-Time ( $t_f$ )

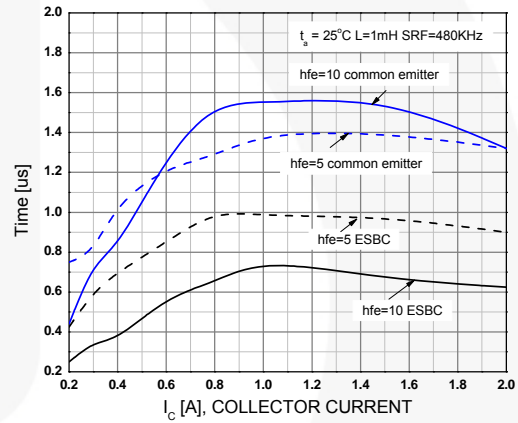


Figure 13. Inductive Load Collector Current Storage Time ( $t_{stg}$ )

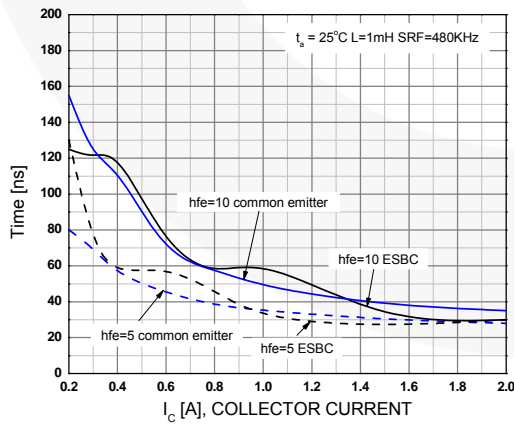


Figure 14. Inductive Load Collector Voltage Fall-Time ( $t_f$ )

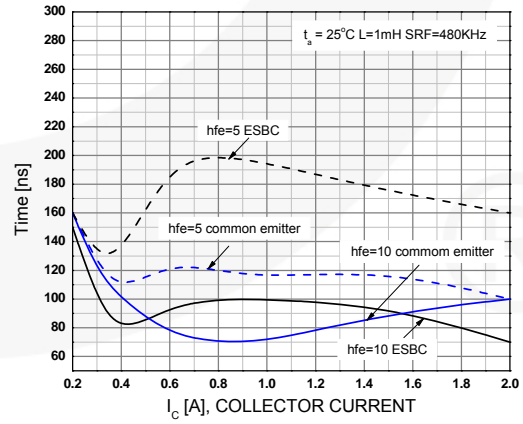
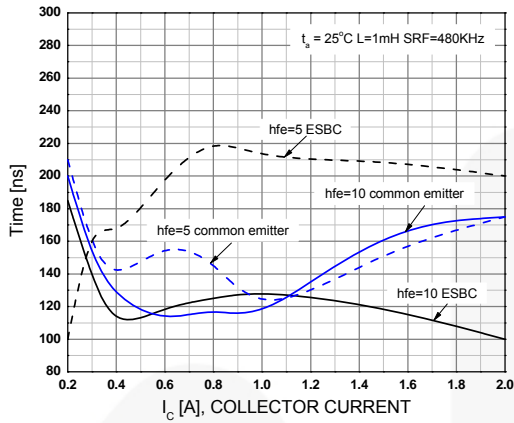
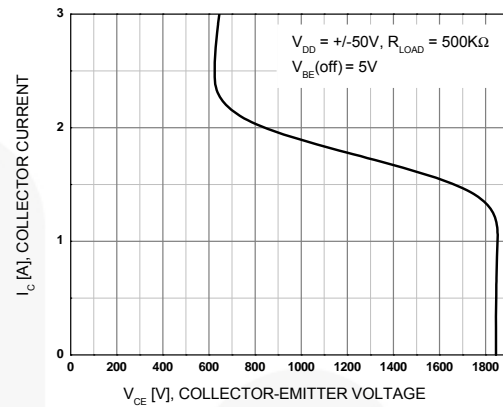


Figure 15. Inductive Load Collector Voltage Rise-Time ( $t_r$ )

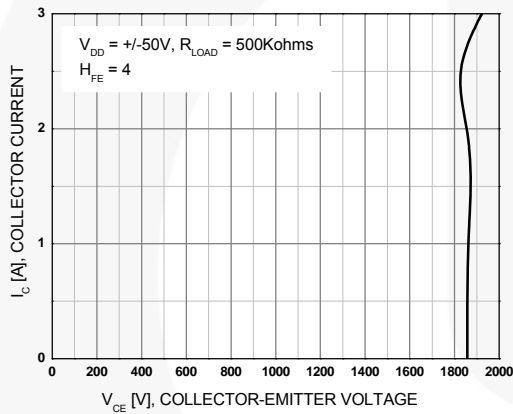
**Typical Performance Characteristics (Continued)**



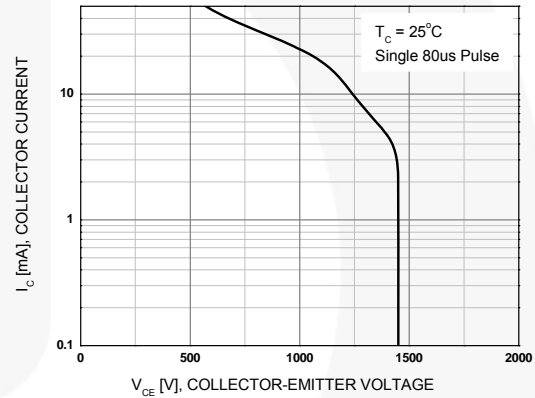
**Figure 16. Inductive Load Collector Current / Voltage Crossover ( $t_c$ )**



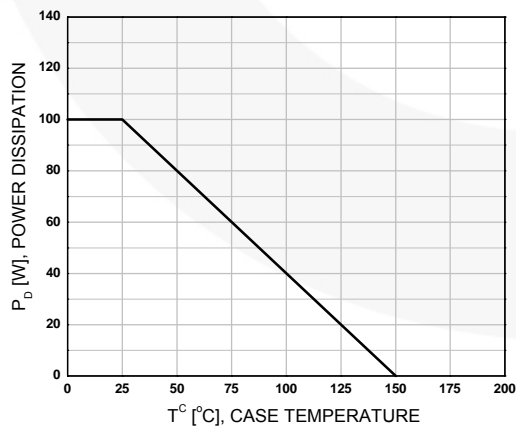
**Figure 17. BJT Reverse Bias Safe Operating Area**



**Figure 18. ESBC RBSOA**

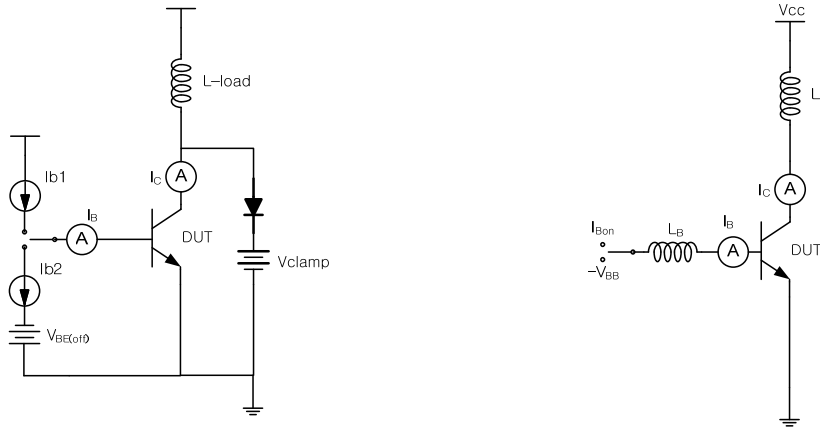


**Figure 19. Crossover Forward Bias Safe Operating Area (FBSOA)**

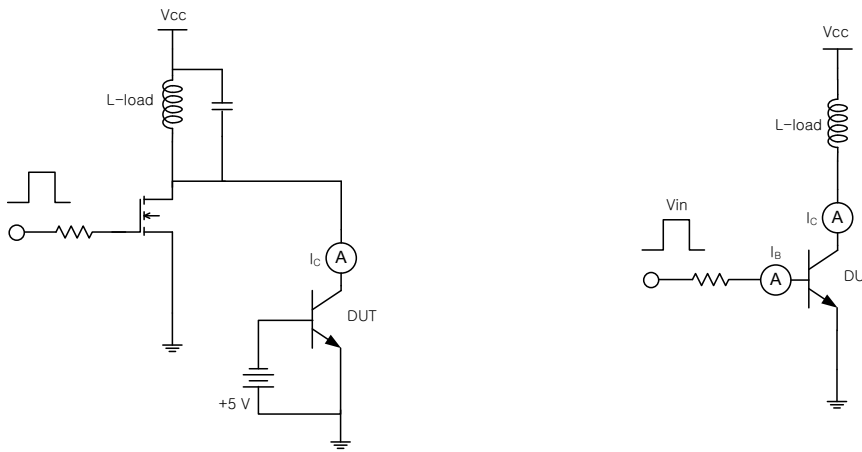


**Figure 20. Power Derating**

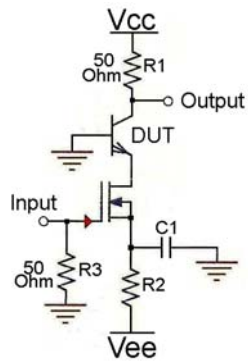
**Test Circuits**



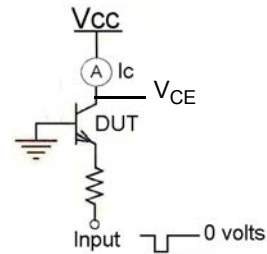
**Figure 21. Test Circuit for Inductive Load and Reverse Bias Safe Operating**



**Figure 22. Energy Rating Test Circuit**



**Figure 23.  $f_T$  Measurement**



**Figure 24. FBSOA**



Test Circuits (Continued)

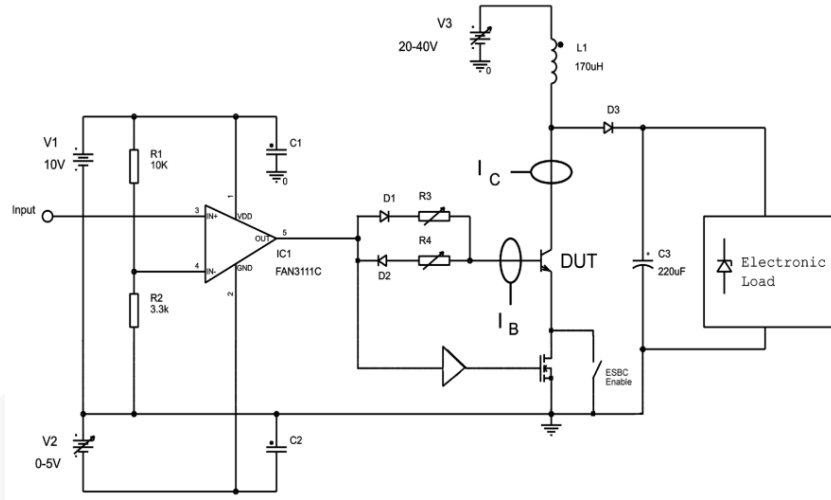


Figure 25. Simplified Saturated Switch Driver Circuit

Functional Test Waveforms

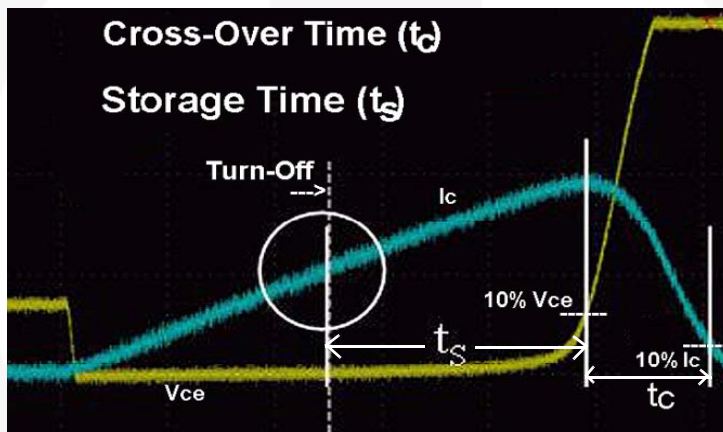


Figure 26. Crossover Time Measurement

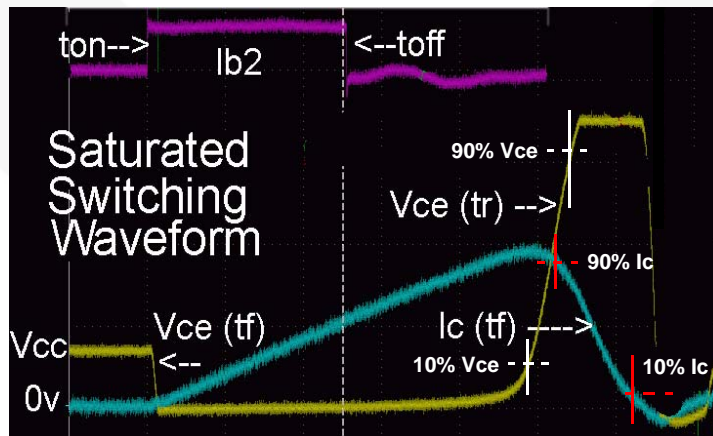
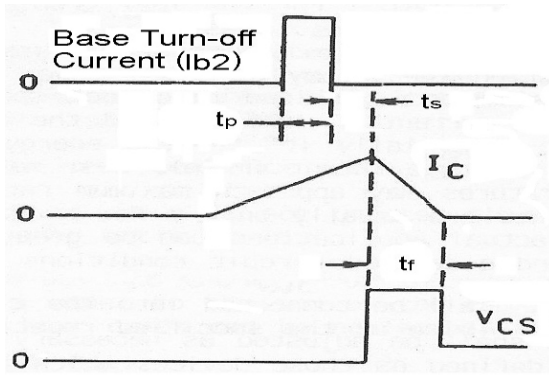
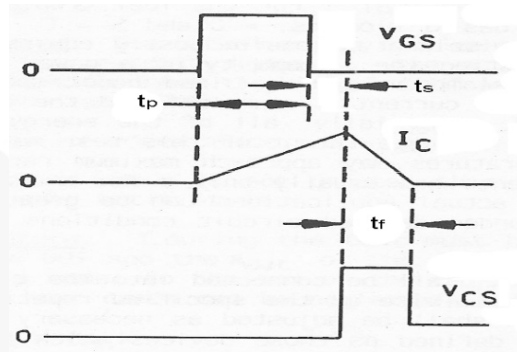


Figure 27. Saturated Switching Waveform

**Functional Test Waveforms (Continued)**



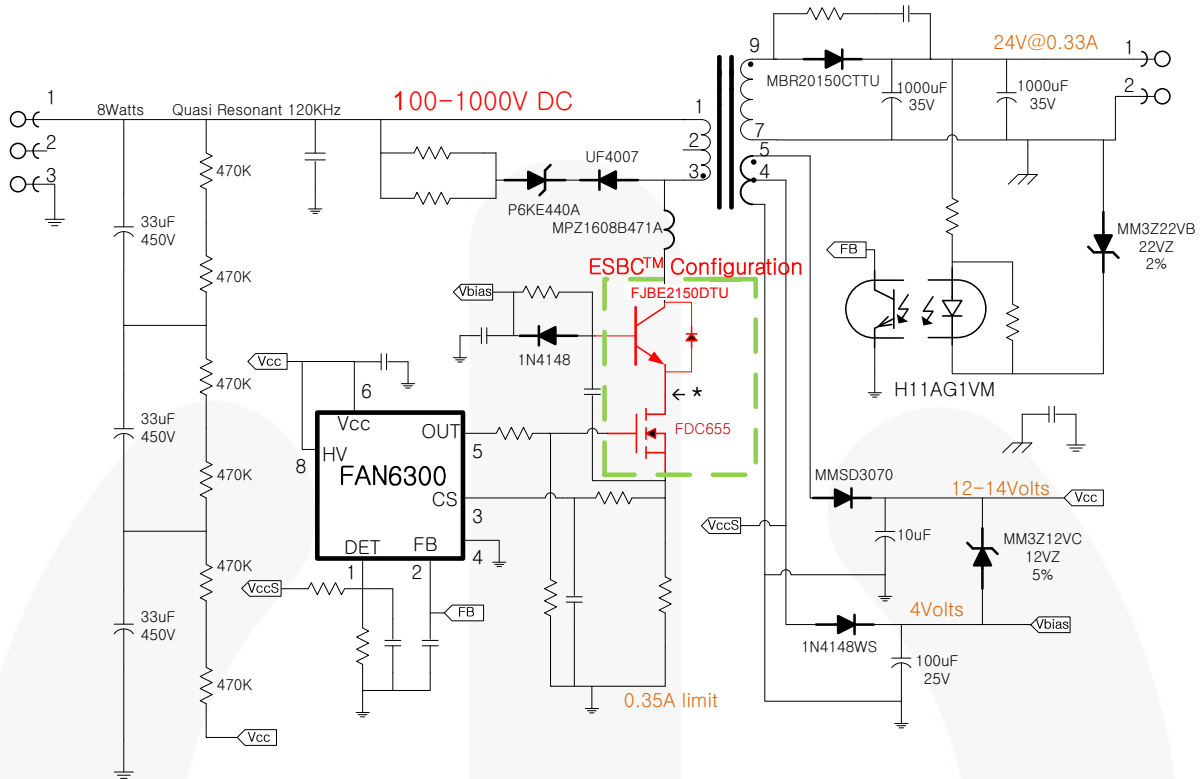
**Figure 28. Storage Time - Common Emitter Base Turn-off ( $I_{b2}$ ) to  $I_C$  Fall-Time**



**Figure 29. Storage Time - ESBC FET Gate (off) to  $I_C$  Fall-Time**



## Very Wide Input Voltage Range Supply



\* Make short as possible

Figure 30. 8 W; Secondary-Side Regulation: 3 Capacitor Input; Quasi Resonant

## Driving ESBC Switches

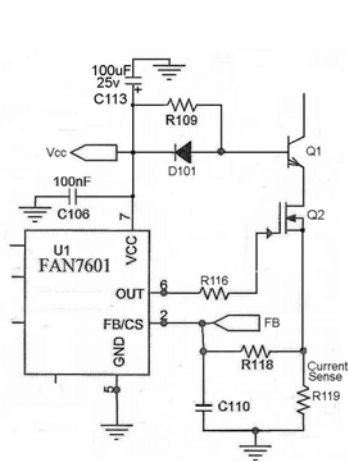


Figure 31.  $V_{CC}$  Derived

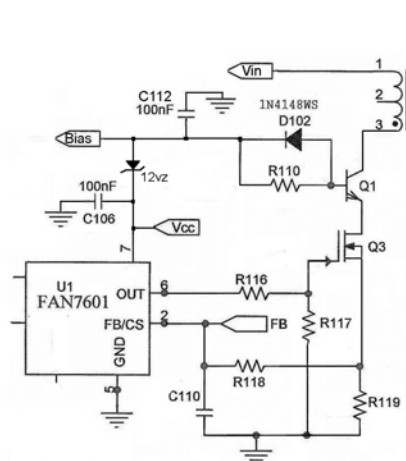


Figure 32.  $V_{bias}$  Supply Derived

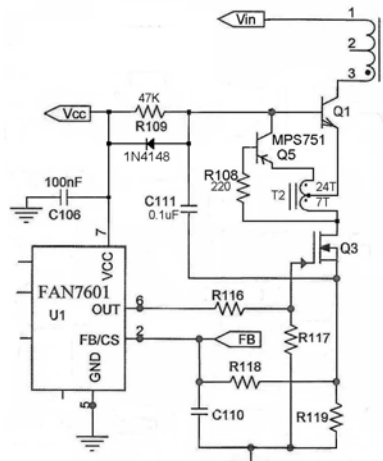
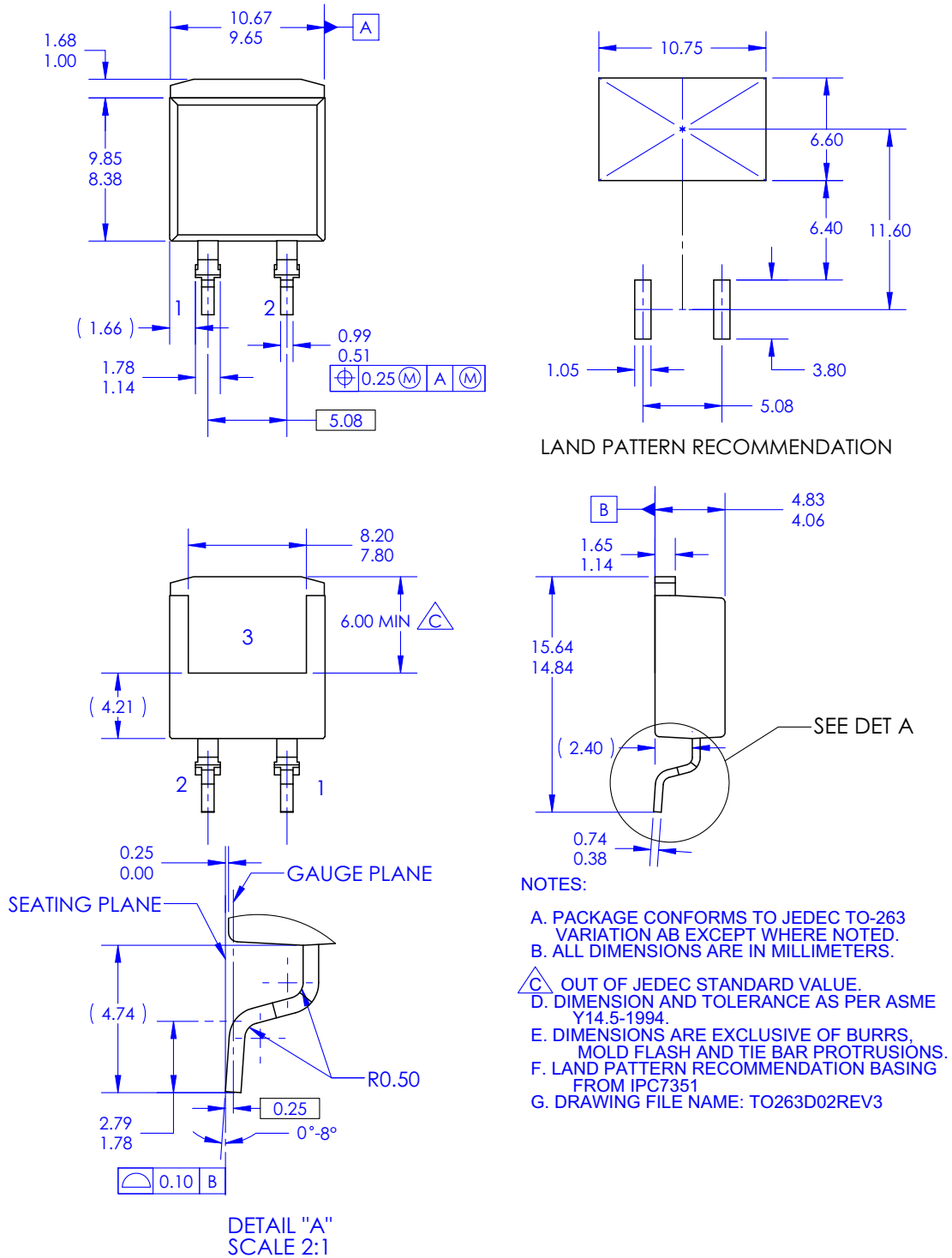


Figure 33. Proportional Drive

### Physical Dimensions



**Figure 34. 2 LEAD, TO-263, JEDEC TO263 VARIATION AB, D2PAK**



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- FastvCore™
- FETBench™
- FPS™
- F-PFS™
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- GreenBridge™
- Green FPS™
- Green FPS™ e-Series™
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- OPTOLOGIC®
- OPTOPLANAR®
- ®
- Power Supply WebDesigner™
- PowerTrench®
- PowerXS™
- Programmable Active Droop™
- QFET®
- QS™
- Quiet Series™
- RapidConfigure™
- ™
- Saving our world, 1mW/W/kW at a time™
- SignalWise™
- SmartMax™
- SMART START™
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- SPM®
- STEALTH™
- SuperFET®
- SuperSOT™-3
- SuperSOT™-6
- SuperSOT™-8
- SupreMOS®
- SyncFET™
- Sync-Lock™
- ®
- TinyBoost®
- TinyBuck®
- TinyCalc™
- TinyLogic®
- TINYOPTO™
- TinyPower™
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- TranSiC™
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- TRUECURRENT®\*
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- ™
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**Definition of Terms**

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

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