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FAIRCHILD™

January 2016

FJP2160D
ESBC™ Rated NPN Silicon Transistor

Applications

- High Voltage and High Speed Power Switch Application
- Emitter-Switched Bipolar/MOSFET Cascode Application (ESBC™)
- Smart Meter, Smart Breakers, HV Industrial Power Supplies
- Motor Driver and Ignition Driver

ESBC Features (FDC655 MOSFET)

$V_{CS(ON)}$	I_C	Equiv $R_{CS(ON)}$
0.131 V	0.5 A	0.261 Ω(1)

- Low Equivalent On Resistance
- Very Fast Switch: 150 KHz
- Squared RBSOA: Up to 1600 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.

Description

The FJP2160D is a low-cost, high performance power switch designed to provide the best performance when 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 1600 volts and up to 3 amps while providing exceptionally low on-resistance and very low switching losses.

The ESBC™ switch is designed to be easy to drive 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 FJP2160D 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.

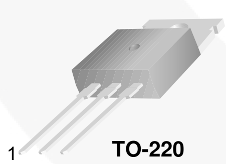


Figure 1. Pin Configuration

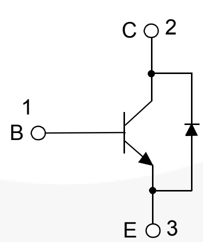


Figure 2. Internal Schematic Diagram

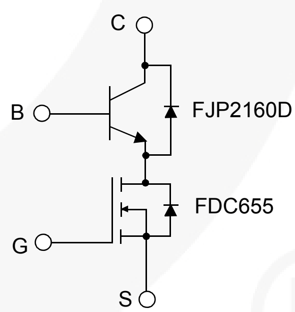


Figure 3. ESBC Configuration(2)

Ordering Information

Part Number	Marking	Package	Packing Method
FJP2160DTU	J2160D	TO-220 3L	Tube

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

Absolute Maximum Ratings[3]

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°C unless otherwise noted.

Symbol	Parameter	Value	Unit
V_{CBO}	Collector-Base Voltage	1600	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°C)	100	W
T_J	Operating and Junction Temperature Range	- 55 to +125	°C
T_{STG}	Storage Temperature Range	- 65 to +150	°C
EAS	Avalanche Energy (T_J = 25°C, 8 mH)	3.5	mJ

Note:

3. Pulse test: pulse width = 20 µs, duty cycle ≤ 10%

Thermal Characteristics

Values are at T_A = 25°C unless otherwise noted.

Symbol	Parameter	Max.	Unit
$R_{\theta jc}$	Thermal Resistance, Junction-to-Case	1.25	°C/W
$R_{\theta ja}$	Thermal Resistance, Junction-to-Ambient	80	°C/W

Electrical Characteristics

Values are at T_A = 25°C unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 0.5 mA, I_E = 0	1600	1689		V
BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 5 mA, I_B = 0	800	870		V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.5 mA, I_C = 0	12.0	14.8		V
I_{CES}	Collector Cut-Off Current	V_{CE} = 1600 V, V_{BE} = 0		0.01	100	µA
I_{CEO}	Collector Cut-Off Current	V_{CE} = 800 V, I_B = 0		0.01	100	µA
I_{EBO}	Emitter Cut-Off Current	V_{EB} = 12 V, I_C = 0		0.05	500	µA
h_{FE}	DC Current Gain	V_{CE} = 3 V, I_C = 0.4 A	20	29	35	
		V_{CE} = 10 V, I_C = 5 mA	20	43		
V_{CE}(sat)	Collector-Emitter Saturation Voltage	I_C = 0.25 A, I_B = 0.05 A		0.16	0.45	V
		I_C = 0.5 A, I_B = 0.167 A		0.12	0.35	
		I_C = 1 A, I_B = 0.33 A		0.25	0.75	
V_{BE}(sat)	Base-Emitter Saturation Voltage	I_C = 500 mA, I_B = 50 mA		0.74	1.20	V
		I_C = 2 A, I_B = 0.4 A		0.85	1.20	
C_{ib}	Input Capacitance	V_{EB} = 10 V, I_C = 0, f = 1 MHz		745	1000	pF
C_{ob}	Output Capacitance	V_{CB} = 200 V, I_E = 0, f = 1 MHz		15		pF
f_T	Current Gain Bandwidth Product	I_C = 0.1 A,V_{CE} = 10 V		5		MHz
V_F	Diode Forward Voltage	I_F = 0.4 A		0.76	1.20	V
		I_F = 1 A		0.83	1.50	

ESBC Configured Electrical Characteristics[4]

Values are at T_A = 25°C unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
f_T	Current Gain Bandwidth Product	I_C = 0.1 A, V_{CE} = 10 V		25		MHz
It_f	Inductive Current Fall Time	V_{GS} = 10 V, R_G = 47 Ω, V_{Clamp} = 500 V, t_p = 3.1 µs, I_C = 0.3 A, I_B = 0.03 A, L_C = 1 mH, SRF = 480 kHz		137		ns
t_s	Inductive Storage Time			350		ns
Vt_f	Inductive Voltage Fall Time			120		ns
Vt_r	Inductive Voltage Rise Time			100		ns
t_c	Inductive Crossover Time			137		ns
It_f	Inductive Current Fall Time	V_{GS} = 10 V, R_G = 47 Ω, V_{Clamp} = 500 V, t_p = 10 µs, I_C = 1 A, I_B = 0.2 A, L_C = 1 mH, SRF = 480 kHz		35		ns
t_s	Inductive Storage Time			980		ns
Vt_f	Inductive Voltage Fall Time			30		ns
Vt_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 A	1600			V
$I_{GS(OS)}$	Gate-Source Leakage Current	V_{GS} = ±20 V		1.0		nA
$V_{CS(ON)}$	Collector-Source On Voltage	V_{GS} = 10 V, I_C = 2 A, I_B = 0.67 A, h_{FE} = 3		2.210		V
		V_{GS} = 10 V, I_C = 1 A, I_B = 0.33 A, h_{FE} = 3		0.321		
		V_{GS} = 10 V, I_C = 0.5 A, I_B = 0.17 A, h_{FE} = 3		0.131		
		V_{GS} = 10 V, I_C = 0.3 A, I_B = 0.06 A, h_{FE} = 5		0.166		
$V_{GS(th)}$	Gate Threshold Voltage	V_{BS} = $V_{GS,}$ I_B = 250 µA		1.9		V
C_{iss}	Input Capacitance (V_{GS} = V_{CB} = 0)	V_{CS} = 25 V, f = 1 MHz		470		pF
$Q_{GS(tot)}$	Gate-Source Charge V_{CB} = 0	V_{GS} = 10 V, I_C = 8 A, V_{CS} = 25 V		9		nC
$r_{DS(ON)}$	Static Drain-Source On Resistance	V_{GS} = 10 V, I_D = 6.3 A		21		mΩ
		V_{GS} = 4.5 V, I_D = 5.5 A		26		
		V_{GS} = 10 V, I_D = 6.3 A, T_J = 125°C		30		

Note:

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

Typical Performance Characteristics

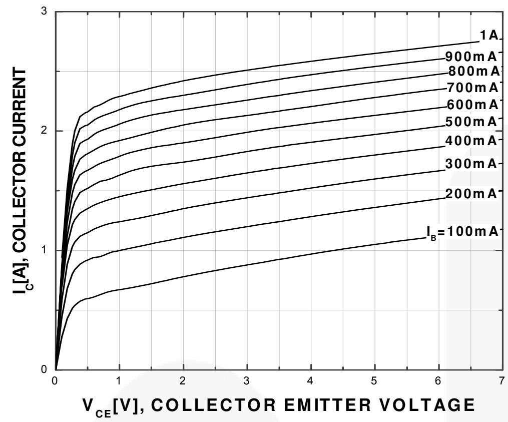


Figure 4. Static Characteristic

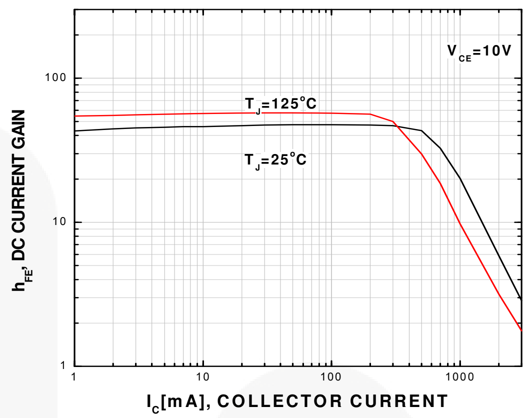


Figure 5. DC Current Gain

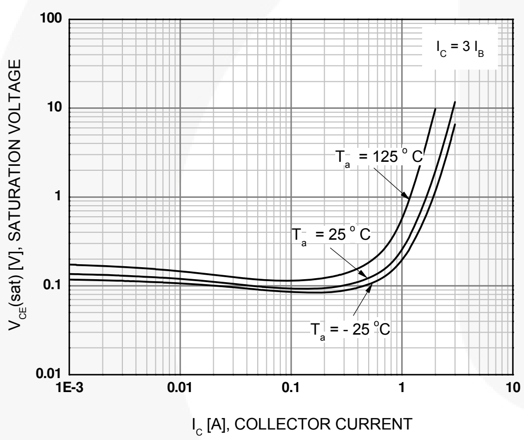


Figure 6. Collector-Emitter Saturation Voltage h_{FE}=3

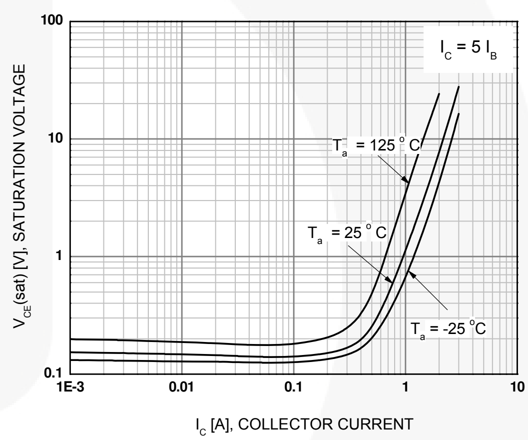


Figure 7. Collector-Emitter Saturation Voltage h_{FE}=5

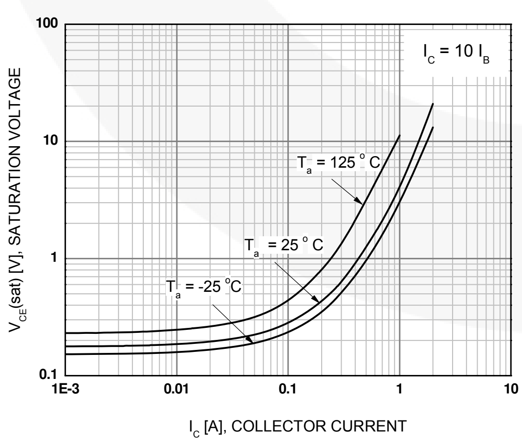


Figure 8. Collector-Emitter Saturation Voltage h_{FE}=10

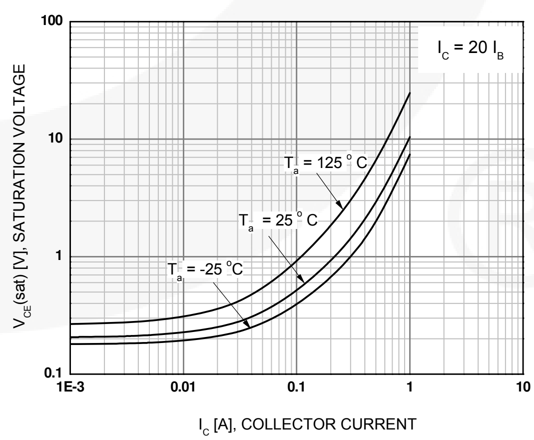


Figure 9. Collector-Emitter Saturation Voltage h_{FE}=20

Typical Performance Characteristics (Continued)

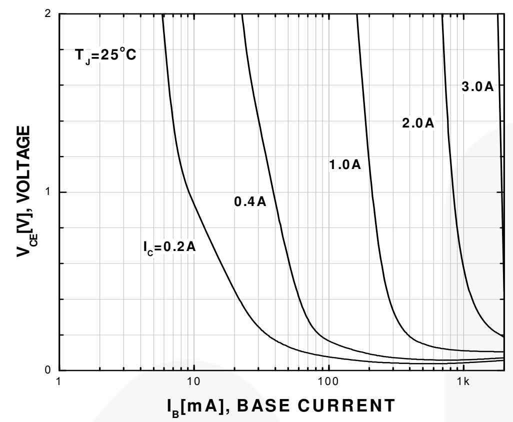


Figure 10. Typical Collector Saturation Voltage

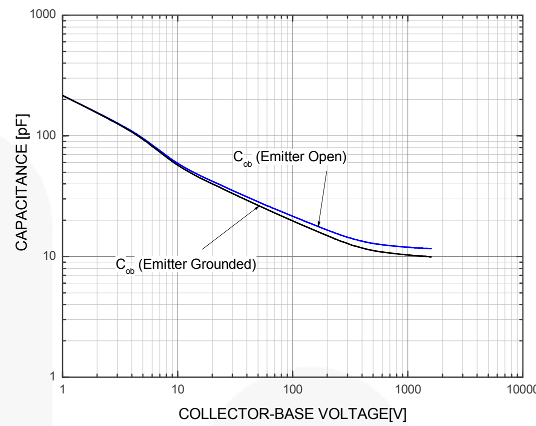


Figure 11. Capacitance

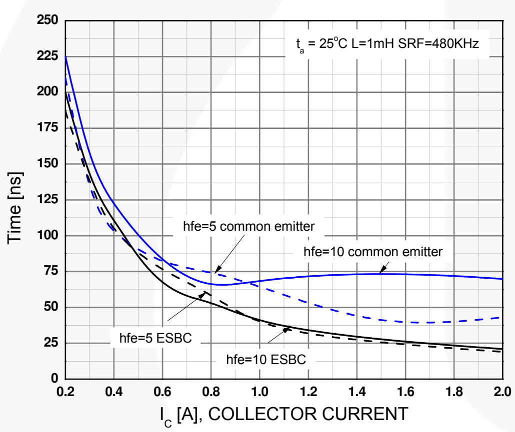


Figure 12. Inductive Load Collector Current Fall-time (t_f)

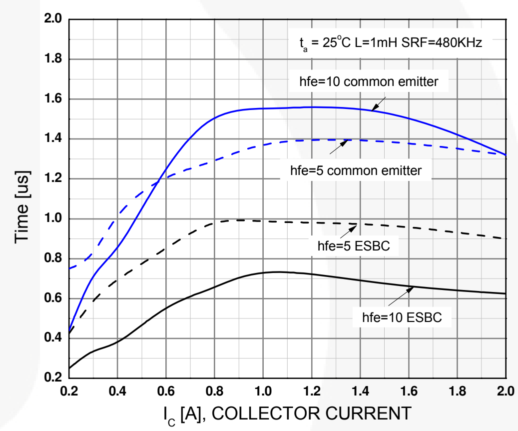


Figure 13. Inductive Load Collector Current Storage time (t_{stg})

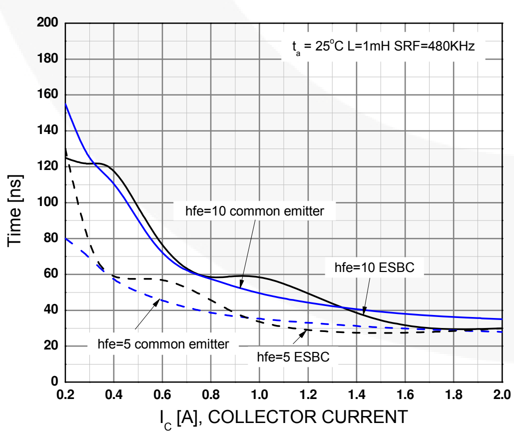


Figure 14. Inductive Load Collector Voltage Fall-time (t_f)

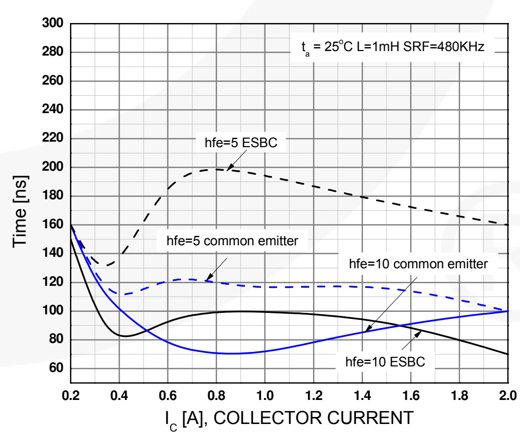


Figure 15. Inductive Load Collector Voltage Rise-time (t_r)

Typical Performance Characteristics (Continued)

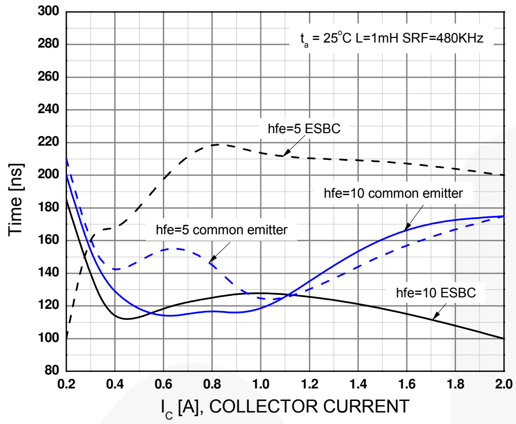


Figure 16. Inductive Load Collector Current/Voltage Crossover (t_C)

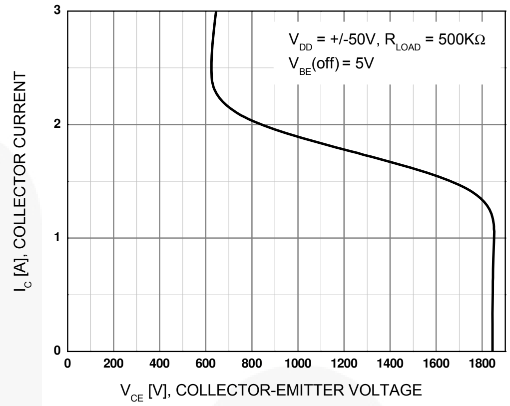


Figure 17. BJT Reverse Bias Safe Operating Area

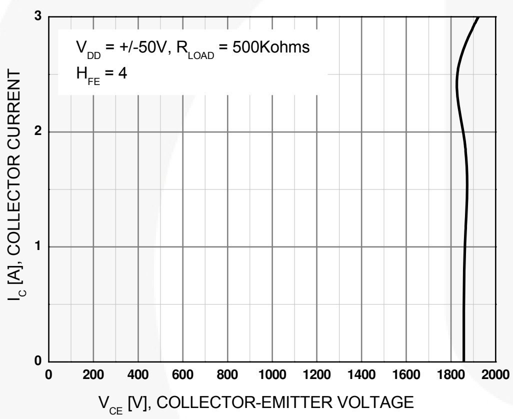


Figure 18. ESBC RBSOA

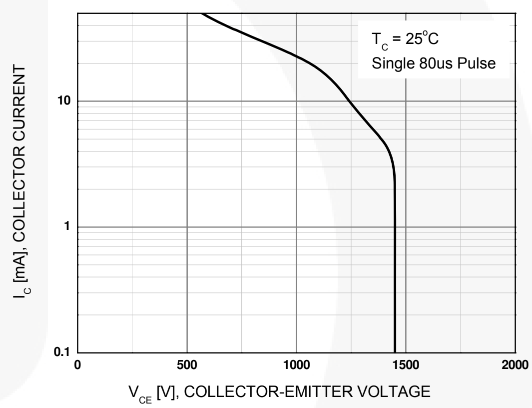


Figure 19. Crossover Forward Bias Safe Operating Area

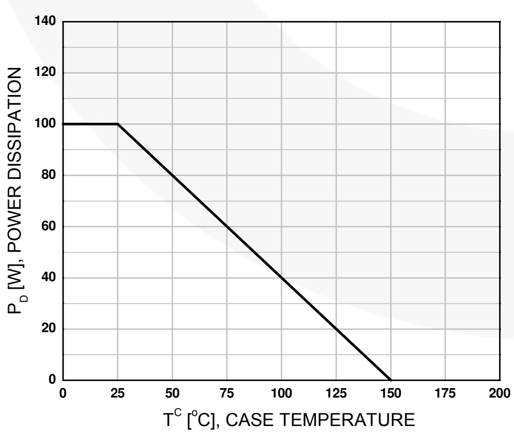


Figure 20. Power Derating

Test Circuits

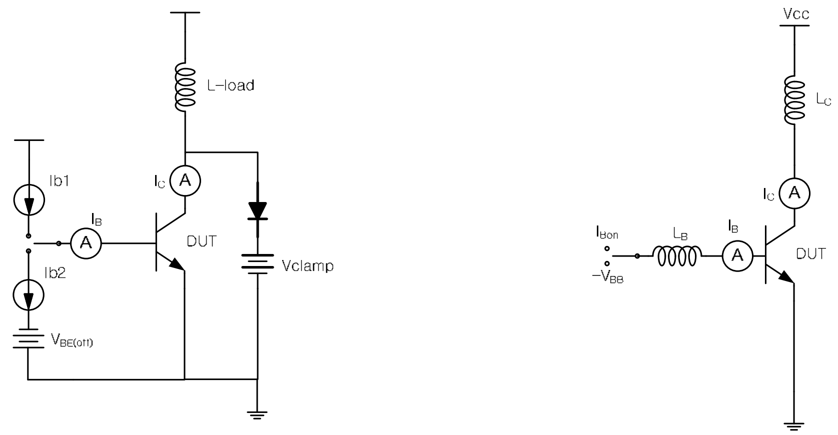


Figure 21. Test Circuit For Inductive Load and Reverse Bias Safe Operating

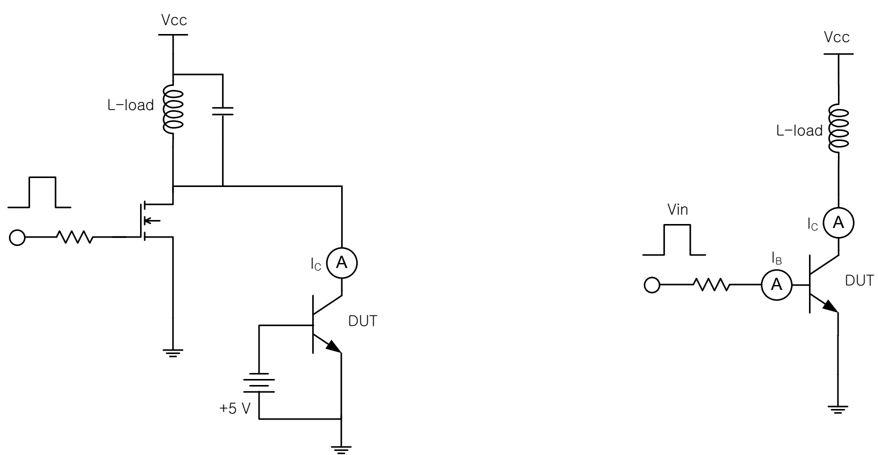


Figure 22. Energy Rating Test Circuit

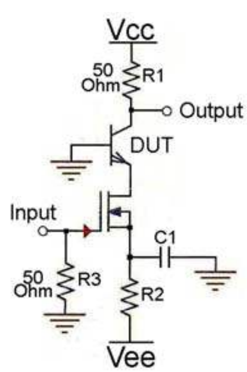


Figure 23. Ft Measurement

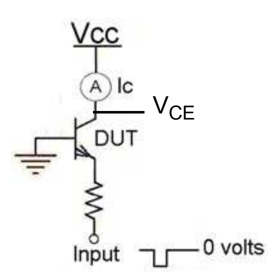


Figure 24. FBSOA

Test Circuits (Continued)

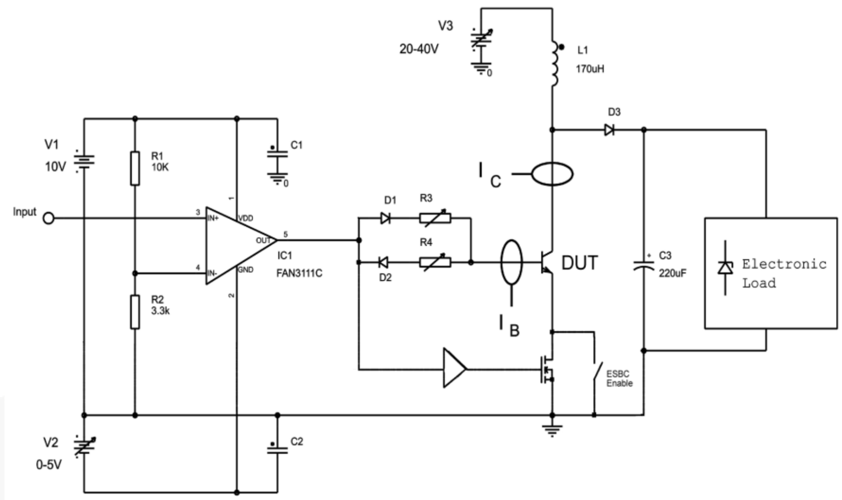


Figure 25. Simplified Saturated Switch Driver Circuit

Functional Test Waveforms

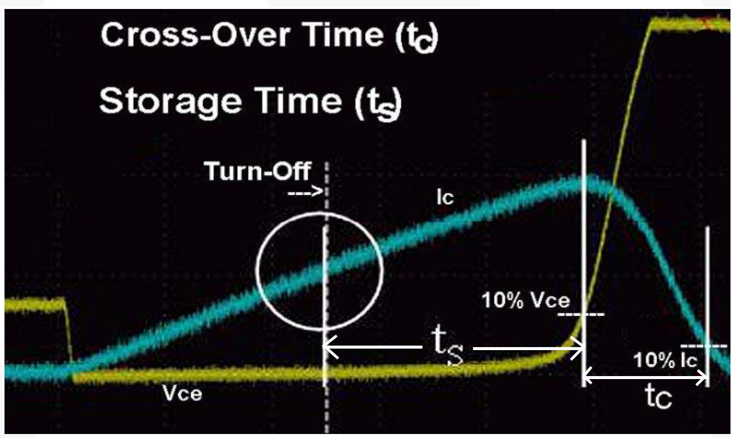


Figure 26. Crossover Time Measurement

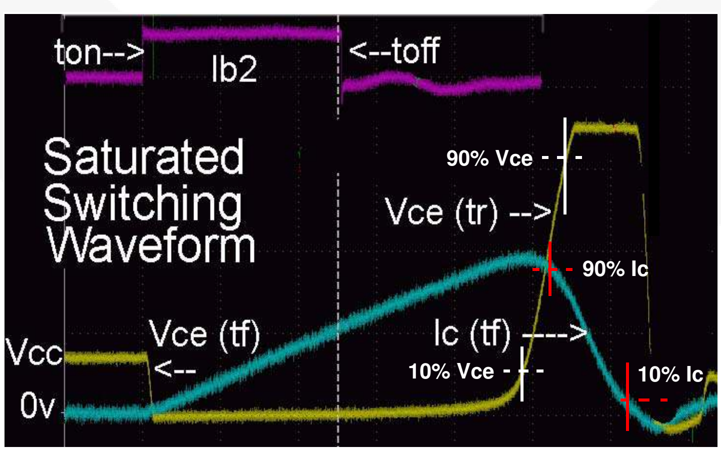


Figure 27. Saturated Switching Waveform

Functional Test Waveforms (Continued)

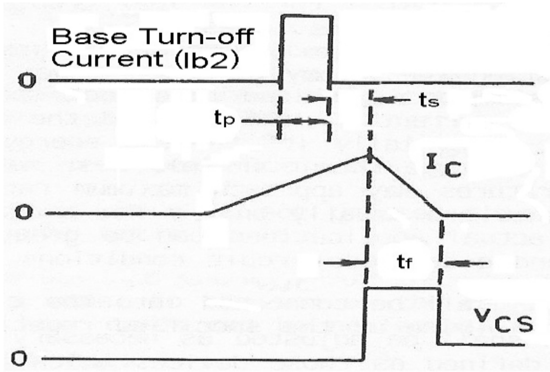


Figure 28. Storage Time - Common Emitter Base turn off (Ib2) to Ic Fall-time

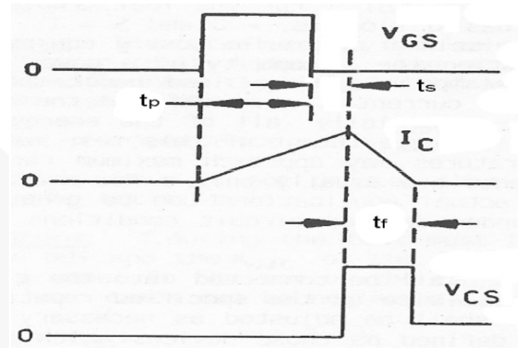
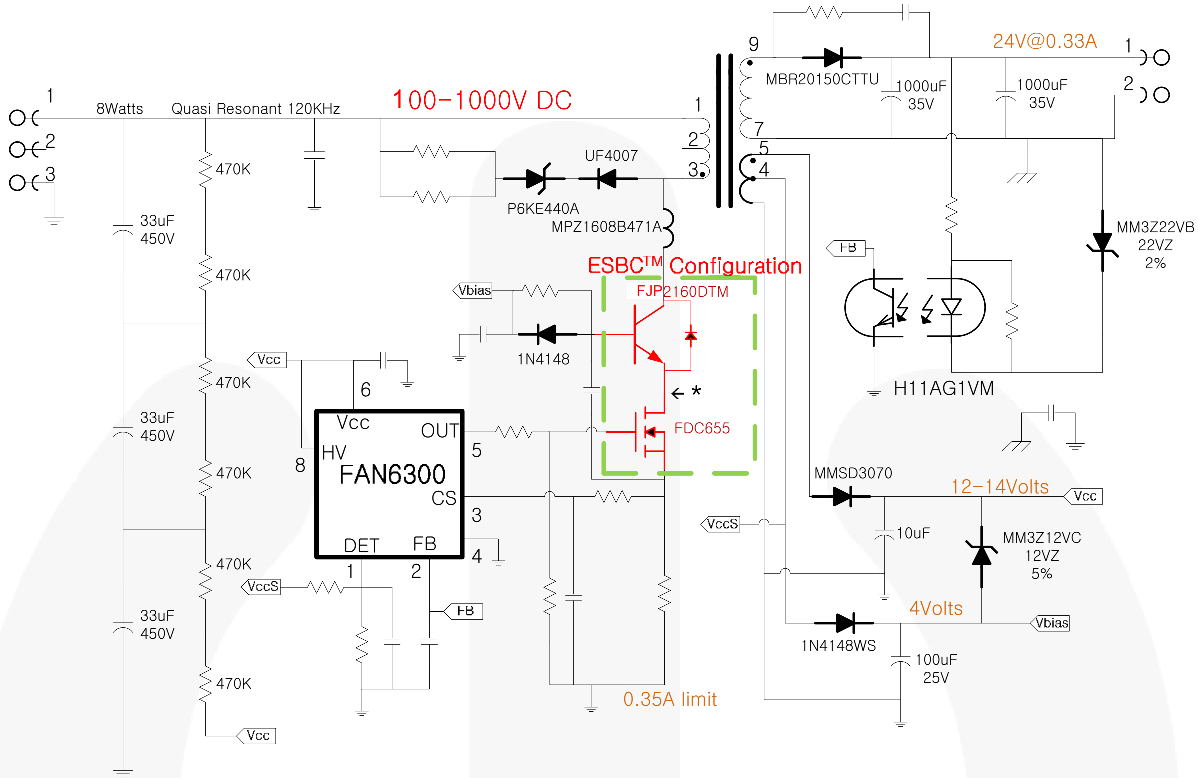


Figure 29. Storage Time - ESBC FET Gate (off) to Ic Fall-time

Very Wide Input Voltage Range Supply

- 8watt; SecReg: 3 cap input; Quasi Resonant



* Make short as possible

Figure 30. Very Wide Input Voltage Range Supply

Driving ESBC Switches

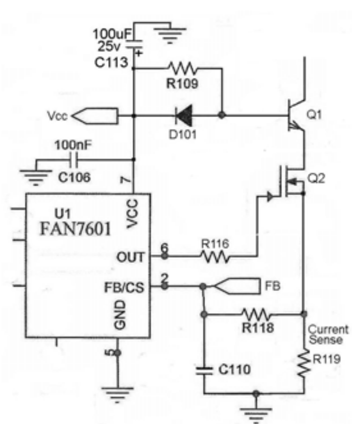


Figure 31. Vcc Derived

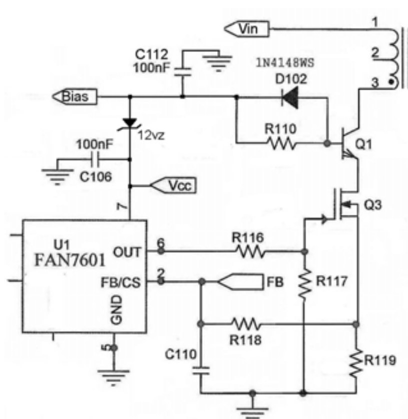


Figure 32. Vbias Supply Derived

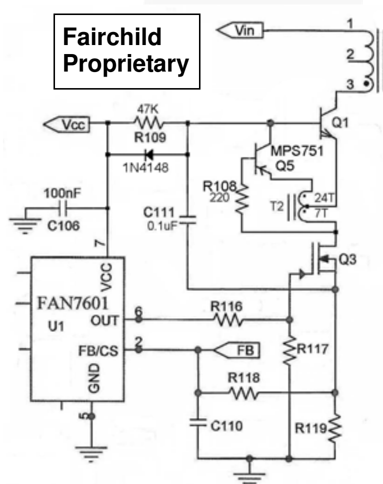
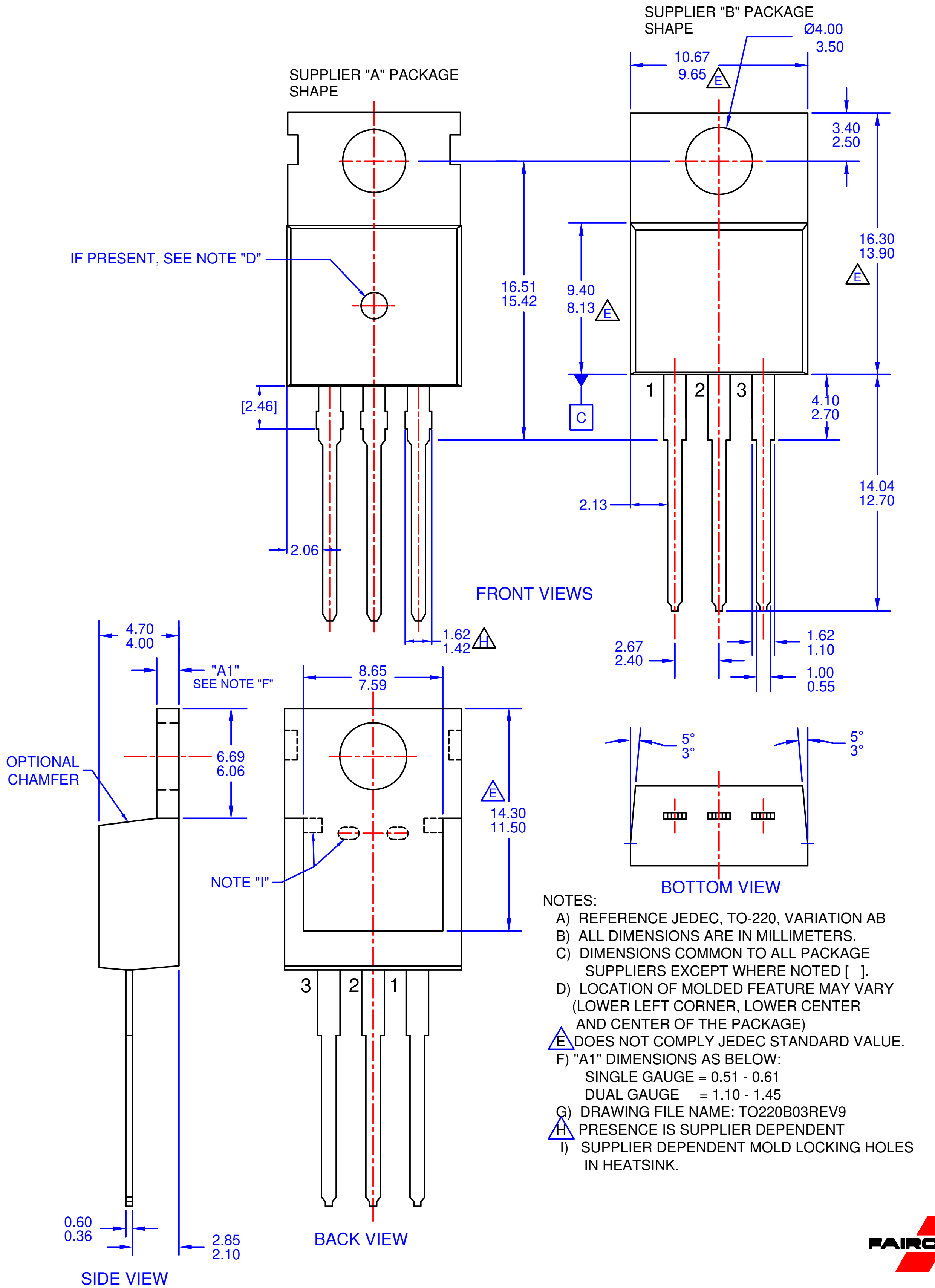


Figure 33. Proportional Drive



NOTES:

A) REFERENCE JEDEC, TO-220, VARIATION AB
B) ALL DIMENSIONS ARE IN MILLIMETERS.
C) DIMENSIONS COMMON TO ALL PACKAGE SUPPLIERS EXCEPT WHERE NOTED [ ].
D) LOCATION OF MOLDED FEATURE MAY VARY (LOWER LEFT CORNER, LOWER CENTER AND CENTER OF THE PACKAGE)
E) DOES NOT COMPLY JEDEC STANDARD VALUE.
F) "A1" DIMENSIONS AS BELOW:
   SINGLE GAUGE = 0.51 - 0.61
   DUAL GAUGE = 1.10 - 1.45
G) DRAWING FILE NAME: TO220B03REV9
H) PRESENCE IS SUPPLIER DEPENDENT
I) SUPPLIER DEPENDENT MOLD LOCKING HOLES IN HEATSINK.

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