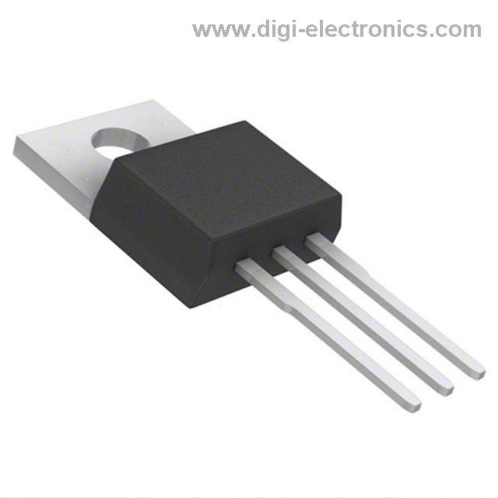
# FJP2160DTU Datasheet




https://www.DiGi-Electronics.com

| | |
|---|---|
| DiGi Electronics Part Number | FJP2160DTU-DG |
| Manufacturer | onsemi |
| Manufacturer Product Number | FJP2160DTU |
| Description | TRANS NPN 800V 2A TO220-3 |
| Detailed Description | Bipolar (BJT) Transistor NPN 800 V 2 A 5MHz 100 W Through Hole TO-220-3 |

Tel: +00 852-30501935

RFQ Email: Info@DiGi-Electronics.com

## Purchase and inquiry

| | |
|---|---|
| Manufacturer Product Number: | Manufacturer: |
| FJP2160DTU | onsemi |
| Series: | Product Status: |
| ESBC™ | Obsolete |
| Transistor Type: | Current - Collector (Ic) (Max): |
| NPN | 2 A |
| Voltage - Collector Emitter Breakdown (Max): | Vce Saturation (Max) @ Ib, Ic: |
| 800 V | 750mV @ 330mA, 1A |
| Current - Collector Cutoff (Max): | DC Current Gain (hFE) (Min) @ Ic, Vce: |
| 100µA | 20 @ 400mA, 3V |
| Power - Max: | Frequency - Transition: |
| 100 W | 5MHz |
| Operating Temperature: | Mounting Type: |
| -55°C ~ 125°C (TJ) | Through Hole |
| Package / Case: | Supplier Device Package: |
| TO-220-3 | TO-220-3 |
| Base Product Number: | |
| FJP216 | |

## Environmental & Export classification

| | |
|---|---|
| RoHS Status: | Moisture Sensitivity Level (MSL): |
| ROHS3 Compliant | 1 (Unlimited) |
| REACH Status: | ECCN: |
| REACH Unaffected | EAR99 |
| HTSUS: | |
| 8541.29.0095 | |

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ON Semiconductor®

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Please note: As part of the Fairchild Semiconductor integration, some of the Fairchild orderable part numbers will need to change in order to meet ON Semiconductor's system requirements. Since the ON Semiconductor product management systems do not have the ability to manage part nomenclature that utilizes an underscore (_), the underscore (_) in the Fairchild part numbers will be changed to a dash (-). This document may contain device numbers with an underscore (_). Please check the ON Semiconductor website to verify the updated device numbers. The most current and up-to-date ordering information can be found at www.onsemi.com. Please email any questions regarding the system integration to Fairchild_questions@onsemi.com.

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.

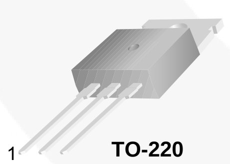



**Figure 1. Pin Configuration**

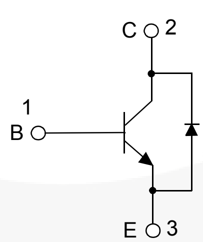



**Figure 2. Internal Schematic Diagram**

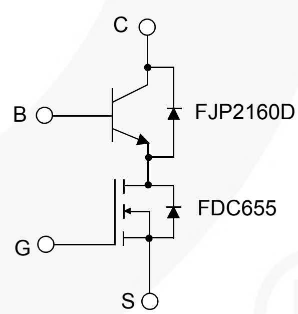



**Figure 3. ESBC Configuration(2)**

## 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

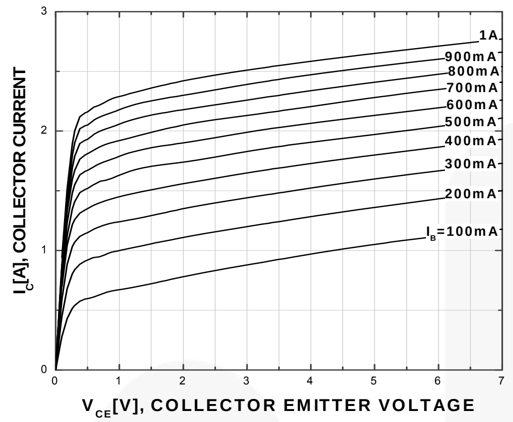



**Figure 4. Static Characteristic**

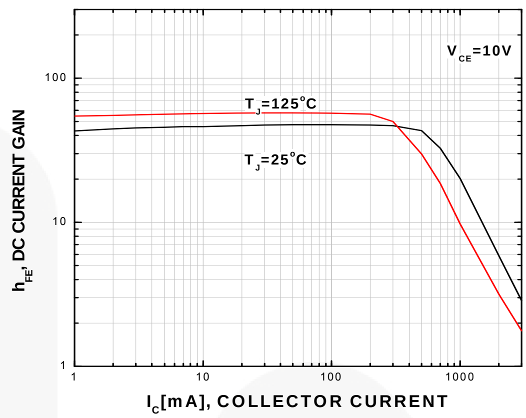



**Figure 5. DC Current Gain**

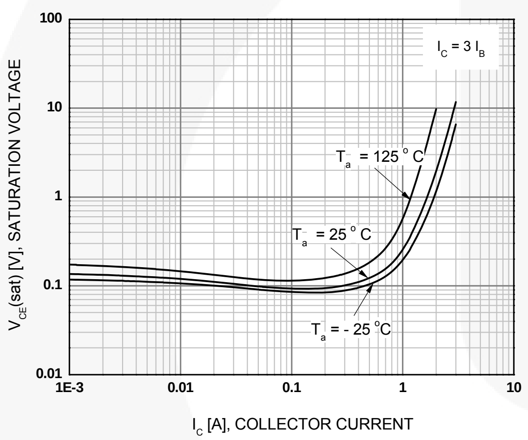



**Figure 6. Collector-Emitter Saturation Voltage $h_{FE}$=3**

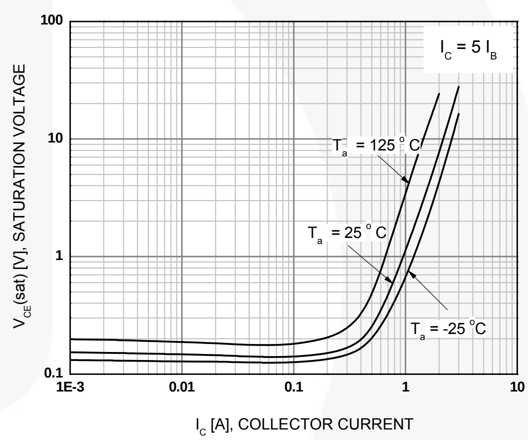



**Figure 7. Collector-Emitter Saturation Voltage $h_{FE}$=5**

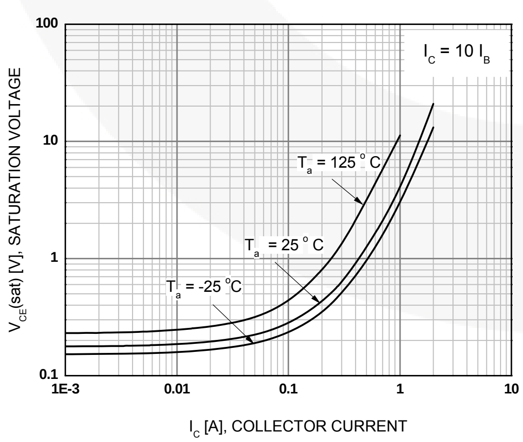



**Figure 8. Collector-Emitter Saturation Voltage $h_{FE}$=10**

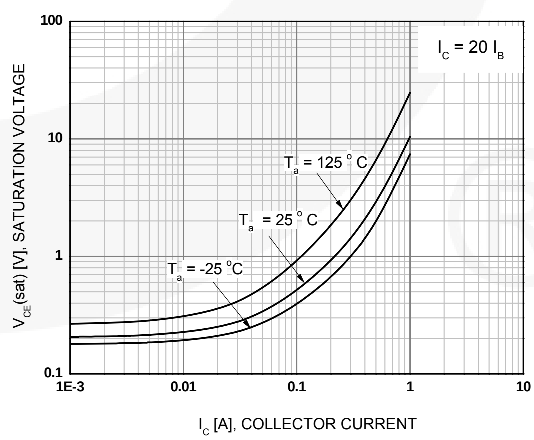



**Figure 9. Collector-Emitter Saturation Voltage $h_{FE}$=20**

## Typical Performance Characteristics (Continued)

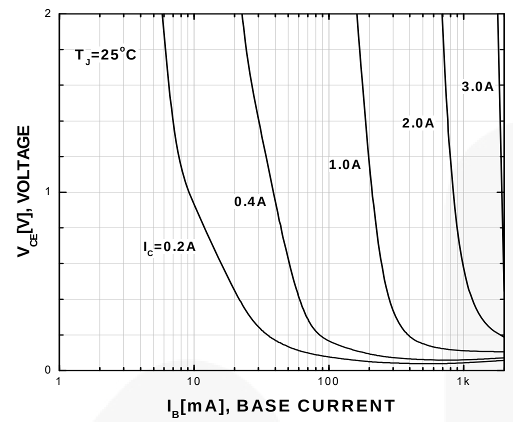



**Figure 10. Typical Collector Saturation Voltage**

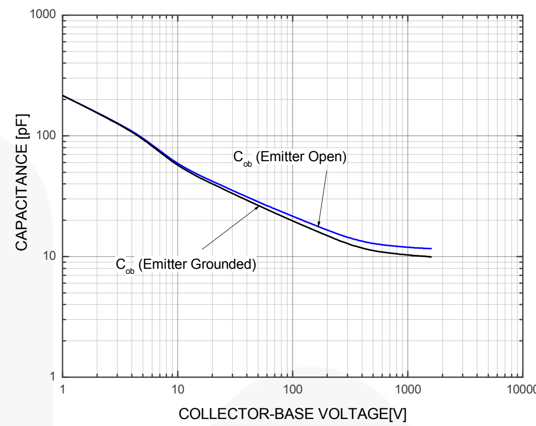



**Figure 11. Capacitance**

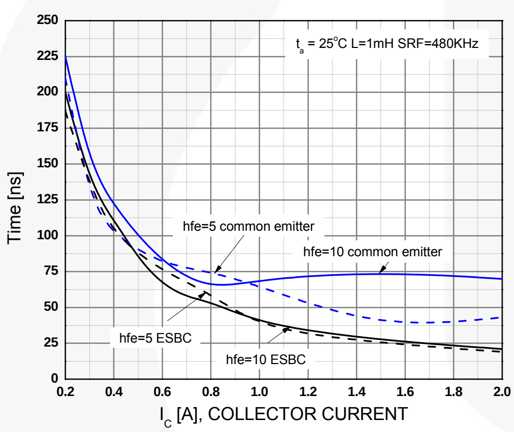



**Figure 12. Inductive Load Collector Current Fall-time ($t_f$)**

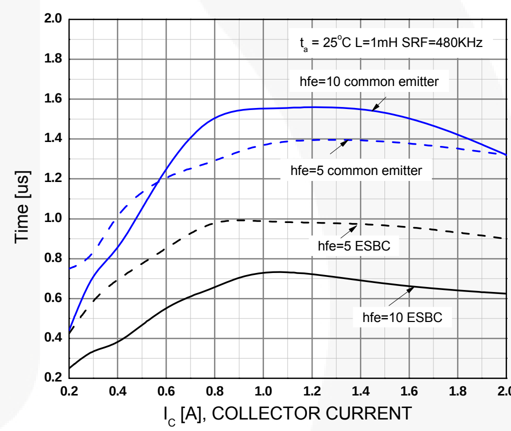



**Figure 13. Inductive Load Collector Current Storage time ($t_{stg}$)**

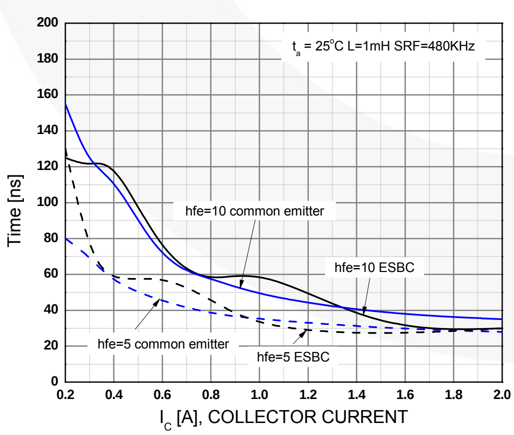



**Figure 14. Inductive Load Collector Voltage Fall-time ($t_f$)**

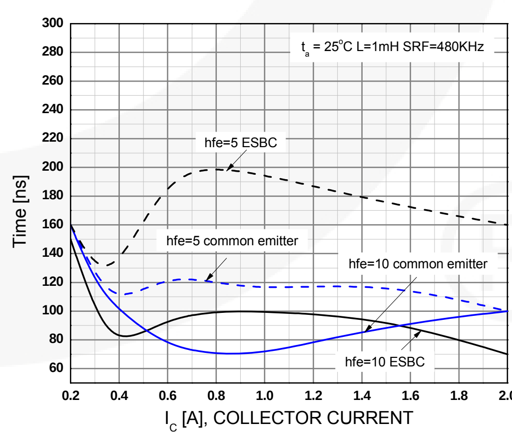



**Figure 15. Inductive Load Collector Voltage Rise-time ($t_r$)**

## Typical Performance Characteristics (Continued)

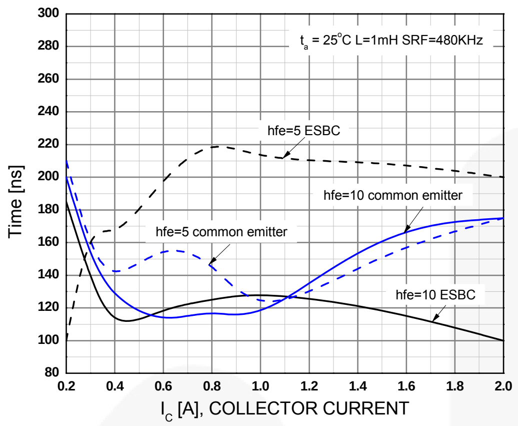



**Figure 16. Inductive Load Collector Current/Voltage Crossover ($t_C$)**

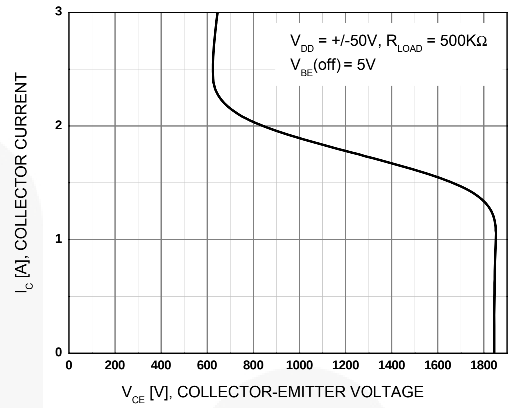



**Figure 17. BJT Reverse Bias Safe Operating Area**

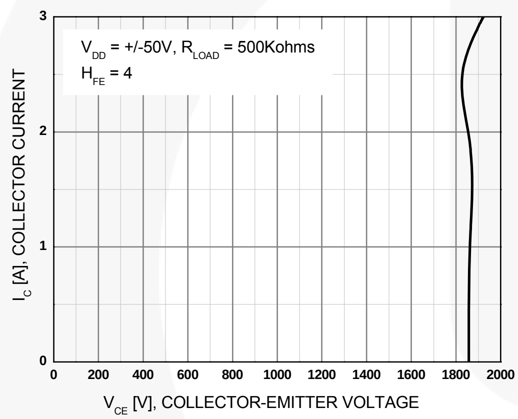



**Figure 18. ESBC RBSOA**

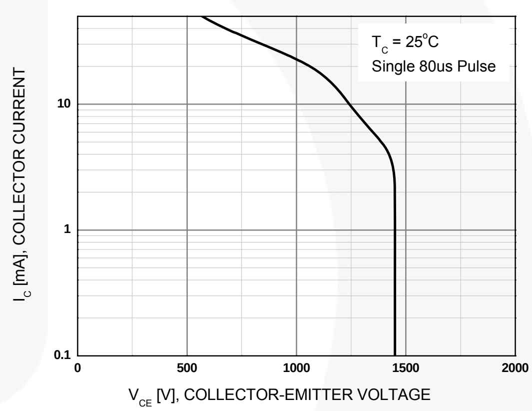



**Figure 19. Crossover Forward Bias Safe Operating Area**

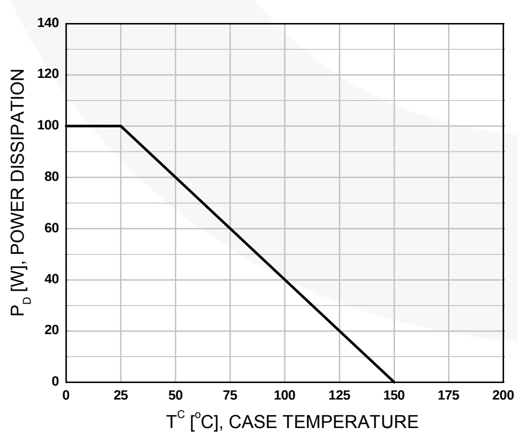



**Figure 20. Power Derating**

## Test Circuits

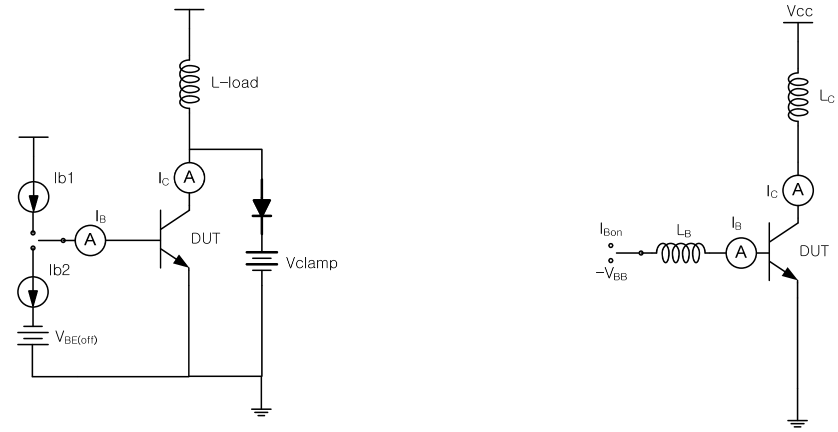



**Figure 21. Test Circuit For Inductive Load and Reverse Bias Safe Operating**

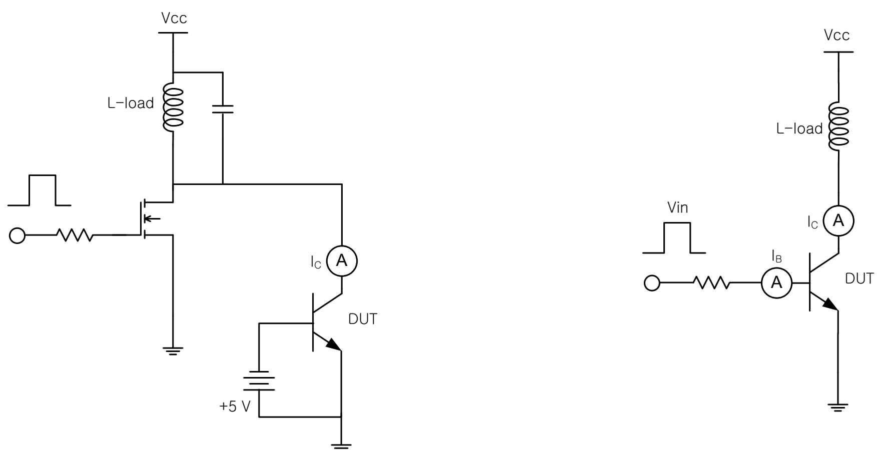



**Figure 22. Energy Rating Test Circuit**

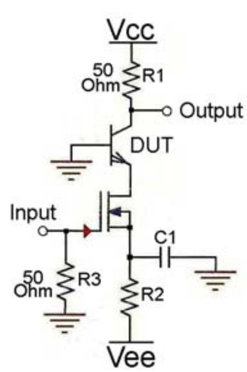



**Figure 23. Ft Measurement**

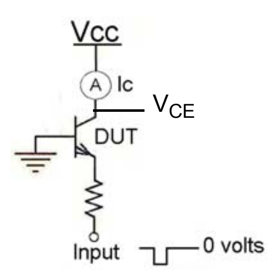



**Figure 24. FBSOA**

## Test Circuits (Continued)

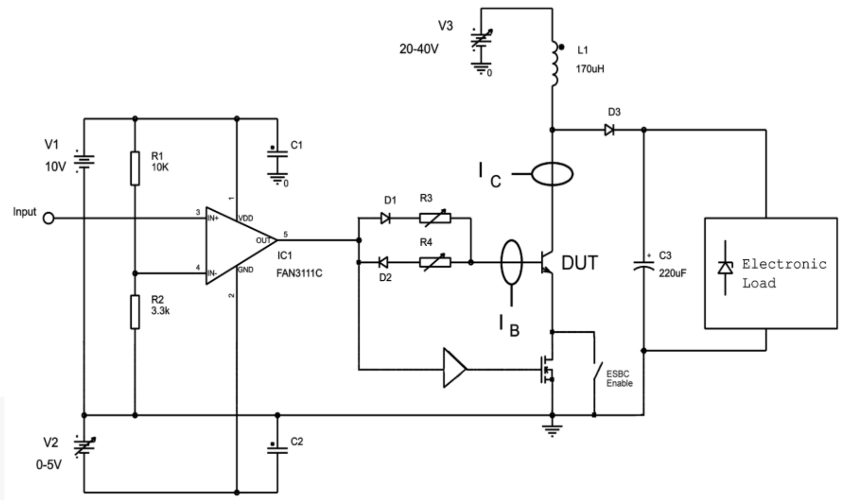



**Figure 25. Simplified Saturated Switch Driver Circuit**

## Functional Test Waveforms

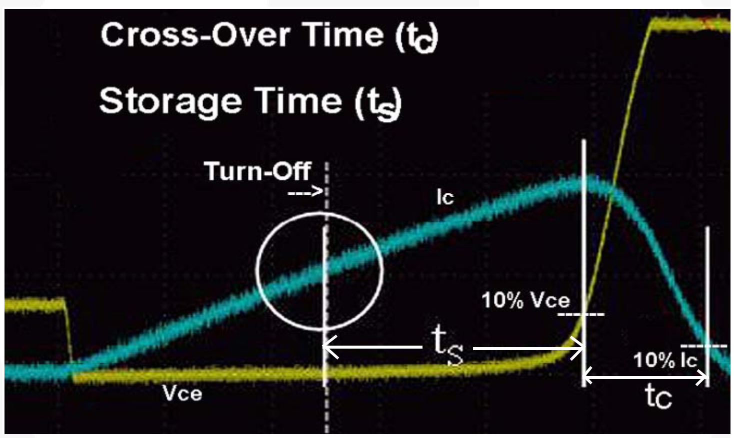



**Figure 26. Crossover Time Measurement**

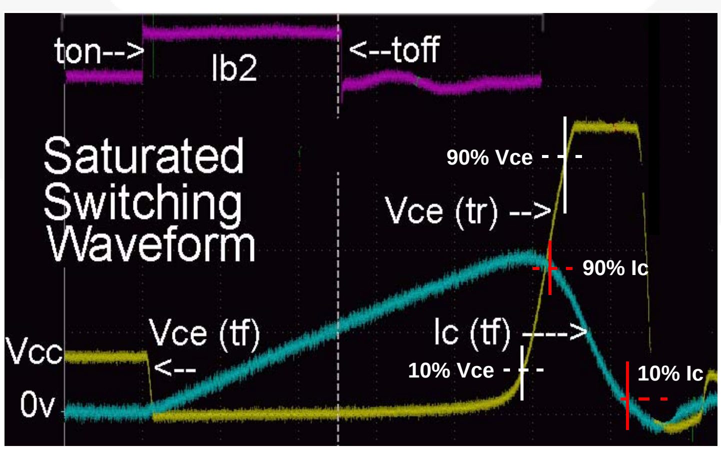



**Figure 27. Saturated Switching Waveform**

## Functional Test Waveforms (Continued)

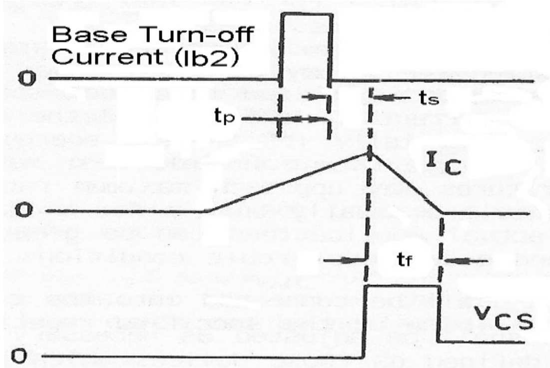



**Figure 28. Storage Time - Common Emitter Base turn off (Ib2) to Ic Fall-time**

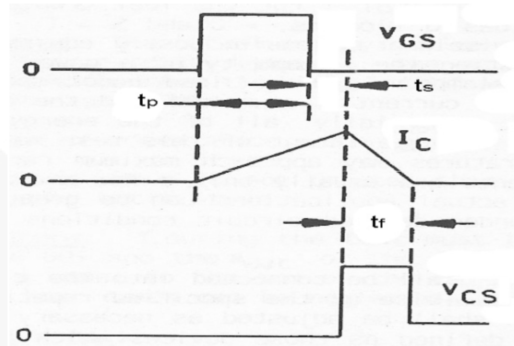
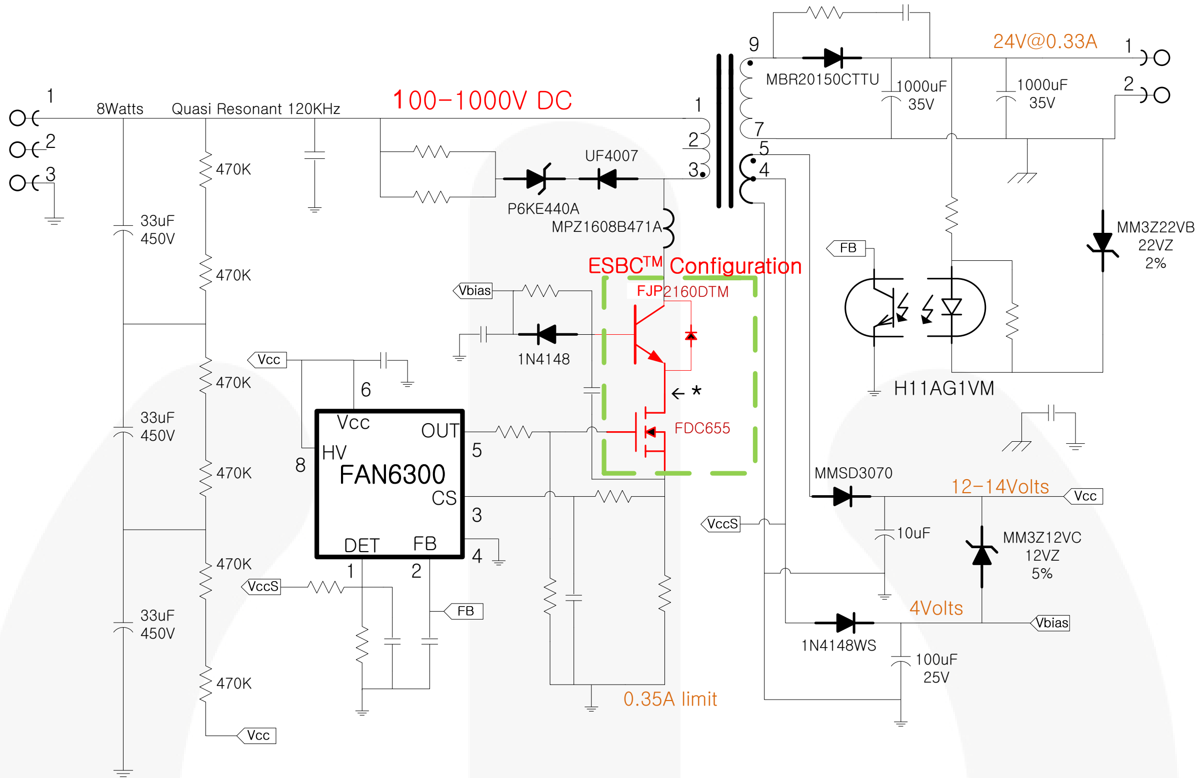



**Figure 29. Storage Time - ESBC FET Gate (off) to Ic Fall-time**

## 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

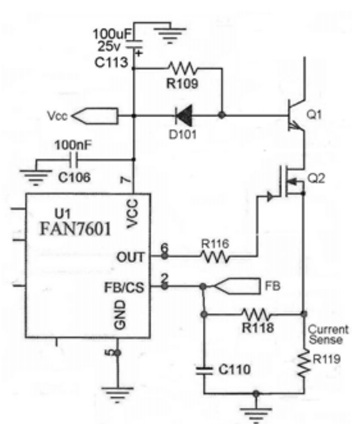



**Figure 31. Vcc Derived**

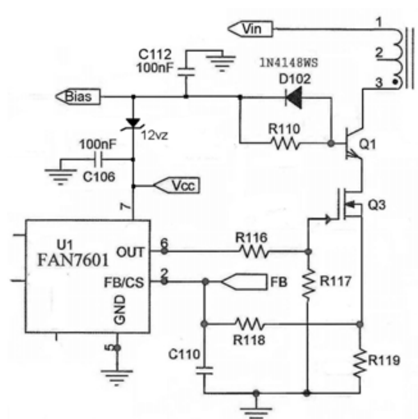



**Figure 32. Vbias Supply Derived**

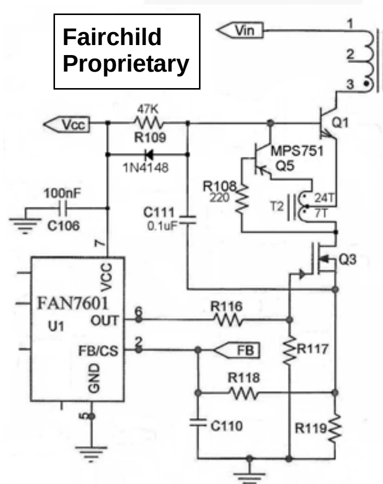
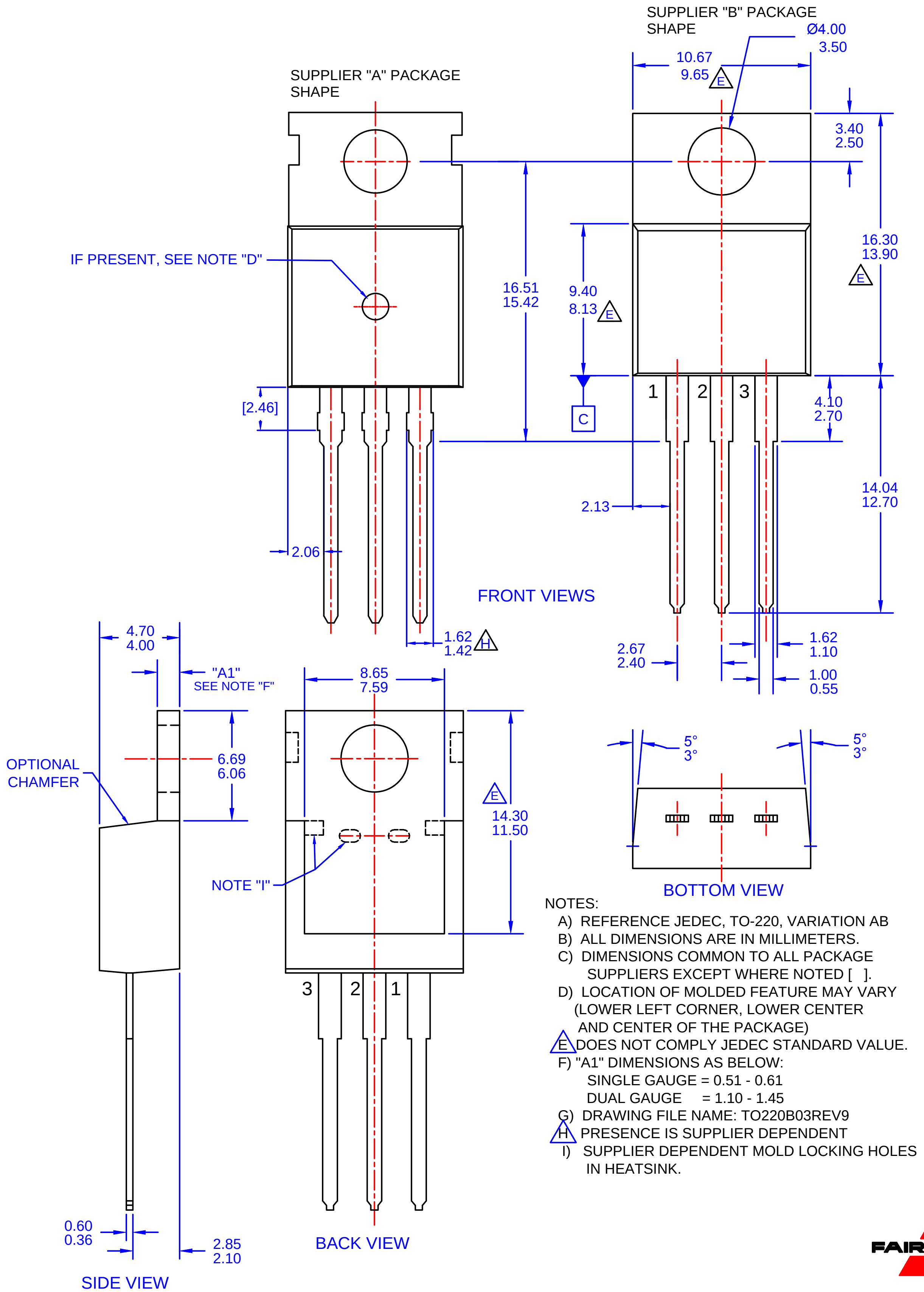



**Figure 33. Proportional Drive**




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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