

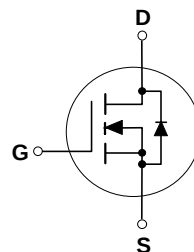
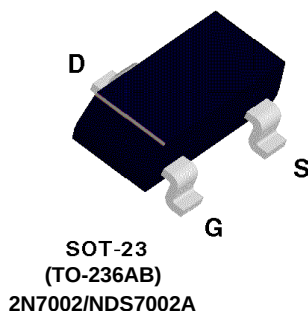
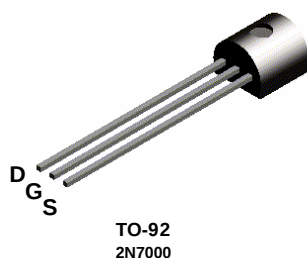
## 2N7000 / 2N7002 / NDS7002A N-Channel Enhancement Mode Field Effect Transistor

### General Description

These N-Channel enhancement mode field effect transistors are produced using Fairchild's proprietary, high cell density, DMOS technology. These products have been designed to minimize on-state resistance while provide rugged, reliable, and fast switching performance. They can be used in most applications requiring up to 400mA DC and can deliver pulsed currents up to 2A. These products are particularly suited for low voltage, low current applications such as small servo motor control, power MOSFET gate drivers, and other switching applications.

### Features

- High density cell design for low  $R_{DS(ON)}$ .
- Voltage controlled small signal switch.
- Rugged and reliable.
- High saturation current capability.



### Absolute Maximum Ratings $T_A = 25^\circ\text{C}$ unless otherwise noted

| Symbol                            | Parameter                                                                       | 2N7000     | 2N7002 | NDS7002A | Units |
|-----------------------------------|---------------------------------------------------------------------------------|------------|--------|----------|-------|
| V <sub>DSS</sub>                  | Drain-Source Voltage                                                            | 60         |        |          | V     |
| V <sub>DGR</sub>                  | Drain-Gate Voltage (R <sub>GS</sub> ≤ 1 MΩ)                                     | 60         |        |          | V     |
| V <sub>GSS</sub>                  | Gate-Source Voltage - Continuous                                                | ±20        |        |          | V     |
|                                   | - Non Repetitive (tp < 50μs)                                                    | ±40        |        |          |       |
| I <sub>D</sub>                    | Maximum Drain Current - Continuous                                              | 200        | 115    | 280      | mA    |
|                                   | - Pulsed                                                                        | 500        | 800    | 1500     |       |
| P <sub>D</sub>                    | Maximum Power Dissipation                                                       | 400        | 200    | 300      | mW    |
|                                   | Derated above 25°C                                                              | 3.2        | 1.6    | 2.4      | mW/°C |
| T <sub>J</sub> , T <sub>STG</sub> | Operating and Storage Temperature Range                                         | -55 to 150 |        |          | °C    |
| T <sub>L</sub>                    | Maximum Lead Temperature for Soldering Purposes, 1/16" from Case for 10 Seconds | 300        |        |          | °C    |

### THERMAL CHARACTERISTICS

|                 |                                         |       |     |     |                    |
|-----------------|-----------------------------------------|-------|-----|-----|--------------------|
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient | 312.5 | 625 | 417 | $^\circ\text{C/W}$ |
|-----------------|-----------------------------------------|-------|-----|-----|--------------------|

# **Electrical Characteristics** $T_A = 25^{\circ}\text{C}$ unless otherwise noted

| Symbol                      | Parameter                         | Conditions                                                  | Type               | Min | Typ  | Max  | Units |
|-----------------------------|-----------------------------------|-------------------------------------------------------------|--------------------|-----|------|------|-------|
| OFF CHARACTERISTICS         |                                   |                                                             |                    |     |      |      |       |
| BV <sub>DSS</sub>           | Drain-Source Breakdown Voltage    | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 10 μA               | All                | 60  |      |      | V     |
| I <sub>DSS</sub>            | Zero Gate Voltage Drain Current   | V <sub>DS</sub> = 48 V, V <sub>GS</sub> = 0 V               | 2N7000             |     |      | 1    | μA    |
|                             |                                   | T <sub>J</sub> =125°C                                       |                    |     | 1    | mA   |       |
|                             |                                   | V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V               | 2N7002             |     |      | 1    | μA    |
|                             |                                   | T <sub>J</sub> =125°C                                       | NDS7002A           |     |      | 0.5  | mA    |
| I <sub>GSSF</sub>           | Gate - Body Leakage, Forward      | V <sub>GS</sub> = 15 V, V <sub>DS</sub> = 0 V               | 2N7000             |     |      | 10   | nA    |
|                             |                                   | V <sub>GS</sub> = 20 V, V <sub>DS</sub> = 0 V               | 2N7002<br>NDS7002A |     |      | 100  | nA    |
| I <sub>GSSR</sub>           | Gate - Body Leakage, Reverse      | V <sub>GS</sub> = -15 V, V <sub>DS</sub> = 0 V              | 2N7000             |     |      | -10  | nA    |
|                             |                                   | V <sub>GS</sub> = -20 V, V <sub>DS</sub> = 0 V              | 2N7002<br>NDS7002A |     |      | -100 | nA    |
| ON CHARACTERISTICS (Note 1) |                                   |                                                             |                    |     |      |      |       |
| V <sub>GS(th)</sub>         | Gate Threshold Voltage            | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1 mA   | 2N7000             | 0.8 | 2.1  | 3    | V     |
|                             |                                   | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA | 2N7002<br>NDS7002A | 1   | 2.1  | 2.5  |       |
| R <sub>DS(on)</sub>         | Static Drain-Source On-Resistance | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 500 mA             | 2N7000             |     | 1.2  | 5    | Ω     |
|                             |                                   | T <sub>J</sub> =125°C                                       |                    |     | 1.9  | 9    |       |
|                             |                                   | V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 75 mA             |                    |     | 1.8  | 5.3  |       |
|                             |                                   | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 500 mA             | 2N7002             |     | 1.2  | 7.5  |       |
|                             |                                   | T <sub>J</sub> =100°C                                       |                    |     | 1.7  | 13.5 |       |
|                             |                                   | V <sub>GS</sub> = 5.0 V, I <sub>D</sub> = 50 mA             |                    |     | 1.7  | 7.5  |       |
|                             |                                   | T <sub>J</sub> =100C                                        |                    | 2.4 | 13.5 |      |       |
|                             |                                   | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 500 mA             | NDS7002A           |     | 1.2  | 2    |       |
|                             |                                   | T <sub>J</sub> =125°C                                       |                    |     | 2    | 3.5  |       |
|                             |                                   | V <sub>GS</sub> = 5.0 V, I <sub>D</sub> = 50 mA             |                    |     | 1.7  | 3    |       |
| T <sub>J</sub> =125°C       |                                   | 2.8                                                         | 5                  |     |      |      |       |
| V <sub>DS(on)</sub>         | Drain-Source On-Voltage           | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 500 mA             | 2N7000             |     | 0.6  | 2.5  | V     |
|                             |                                   | V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 75 mA             |                    |     | 0.14 | 0.4  |       |
|                             |                                   | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 500mA              | 2N7002             |     | 0.6  | 3.75 |       |
|                             |                                   | V <sub>GS</sub> = 5.0 V, I <sub>D</sub> = 50 mA             |                    |     | 0.09 | 1.5  |       |
|                             |                                   | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 500mA              | NDS7002A           |     | 0.6  | 1    |       |
|                             |                                   | V <sub>GS</sub> = 5.0 V, I <sub>D</sub> = 50 mA             |                    |     | 0.09 | 0.15 |       |

# Electrical Characteristics $T_A = 25^\circ\text{C}$ unless otherwise noted

| Symbol                                                 | Parameter                                             | Conditions                                                                                                                     | Type               | Min | Typ  | Max | Units |
|--------------------------------------------------------|-------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------|-----|------|-----|-------|
| ON CHARACTERISTICS Continued (Note 1)                  |                                                       |                                                                                                                                |                    |     |      |     |       |
| I <sub>D(ON)</sub>                                     | On-State Drain Current                                | V <sub>GS</sub> = 4.5 V, V <sub>DS</sub> = 10 V                                                                                | 2N7000             | 75  | 600  |     | mA    |
|                                                        |                                                       | V <sub>GS</sub> = 10 V, V <sub>DS</sub> ≥ 2 V <sub>DS(on)</sub>                                                                | 2N7002             | 500 | 2700 |     |       |
|                                                        |                                                       | V <sub>GS</sub> = 10 V, V <sub>DS</sub> ≥ 2 V <sub>DS(on)</sub>                                                                | NDS7002A           | 500 | 2700 |     |       |
| g <sub>FS</sub>                                        | Forward Transconductance                              | V <sub>DS</sub> = 10 V, I <sub>D</sub> = 200 mA                                                                                | 2N7000             | 100 | 320  |     | mS    |
|                                                        |                                                       | V <sub>DS</sub> ≥ 2 V <sub>DS(on)</sub> , I <sub>D</sub> = 200 mA                                                              | 2N7002             | 80  | 320  |     |       |
|                                                        |                                                       | V <sub>DS</sub> ≥ 2 V <sub>DS(on)</sub> , I <sub>D</sub> = 200 mA                                                              | NDS7002A           | 80  | 320  |     |       |
| DYNAMIC CHARACTERISTICS                                |                                                       |                                                                                                                                |                    |     |      |     |       |
| C <sub>iss</sub>                                       | Input Capacitance                                     | V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V,<br>f = 1.0 MHz                                                                  | All                |     | 20   | 50  | pF    |
| C <sub>oss</sub>                                       | Output Capacitance                                    |                                                                                                                                | All                |     | 11   | 25  | pF    |
| C <sub>rss</sub>                                       | Reverse Transfer Capacitance                          |                                                                                                                                | All                |     | 4    | 5   | pF    |
| t <sub>on</sub>                                        | Turn-On Time                                          | V <sub>DD</sub> = 15 V, R <sub>L</sub> = 25 Ω,<br>I <sub>D</sub> = 500 mA, V <sub>GS</sub> = 10 V,<br>R <sub>GEN</sub> = 25    | 2N7000             |     |      | 10  | ns    |
|                                                        |                                                       | V <sub>DD</sub> = 30 V, R <sub>L</sub> = 150 Ω,<br>I <sub>D</sub> = 200 mA, V <sub>GS</sub> = 10 V,<br>R <sub>GEN</sub> = 25 Ω | 2N7002<br>NDS7002A |     |      | 20  |       |
| t <sub>off</sub>                                       | Turn-Off Time                                         | V <sub>DD</sub> = 15 V, R <sub>L</sub> = 25 Ω,<br>I <sub>D</sub> = 500 mA, V <sub>GS</sub> = 10 V,<br>R <sub>GEN</sub> = 25    | 2N7000             |     |      | 10  | ns    |
|                                                        |                                                       | V <sub>DD</sub> = 30 V, R <sub>L</sub> = 150 Ω,<br>I <sub>D</sub> = 200 mA, V <sub>GS</sub> = 10 V,<br>R <sub>GEN</sub> = 25 Ω | 2N7002<br>NDS7002A |     |      | 20  |       |
| DRAIN-SOURCE DIODE CHARACTERISTICS AND MAXIMUM RATINGS |                                                       |                                                                                                                                |                    |     |      |     |       |
| I <sub>S</sub>                                         | Maximum Continuous Drain-Source Diode Forward Current |                                                                                                                                | 2N7002             |     |      | 115 | mA    |
|                                                        |                                                       |                                                                                                                                | NDS7002A           |     |      | 280 |       |
| I <sub>SM</sub>                                        | Maximum Pulsed Drain-Source Diode Forward Current     |                                                                                                                                | 2N7002             |     |      | 0.8 | A     |
|                                                        |                                                       |                                                                                                                                | NDS7002A           |     |      | 1.5 |       |
| V <sub>SD</sub>                                        | Drain-Source Diode Forward Voltage                    | V <sub>GS</sub> = 0 V, I <sub>S</sub> = 115 mA (Note 1)                                                                        | 2N7002             |     | 0.88 | 1.5 | V     |
|                                                        |                                                       | V <sub>GS</sub> = 0 V, I <sub>S</sub> = 400 mA (Note 1)                                                                        | NDS7002A           |     | 0.88 | 1.2 |       |

Note:

1. Pulse Test: Pulse Width  $\leq 300\mu\text{s}$ , Duty Cycle  $\leq 2.0\%$ .

## Typical Electrical Characteristics

2N7000 / 2N7002 / NDS7002A

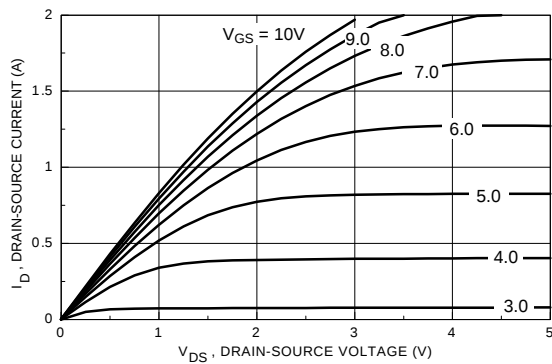


Figure 1. On-Region Characteristics

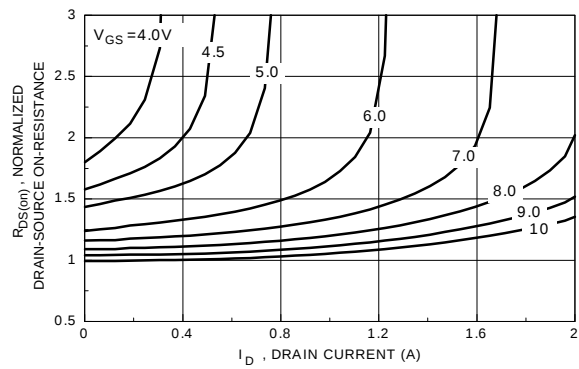


Figure 2. On-Resistance Variation with Gate Voltage and Drain Current

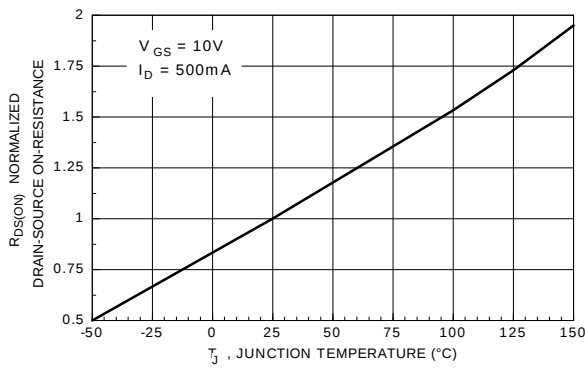


Figure 3. On-Resistance Variation with Temperature

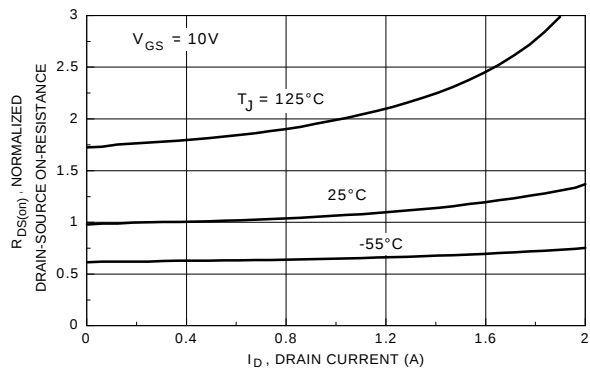


Figure 4. On-Resistance Variation with Drain Current and Temperature

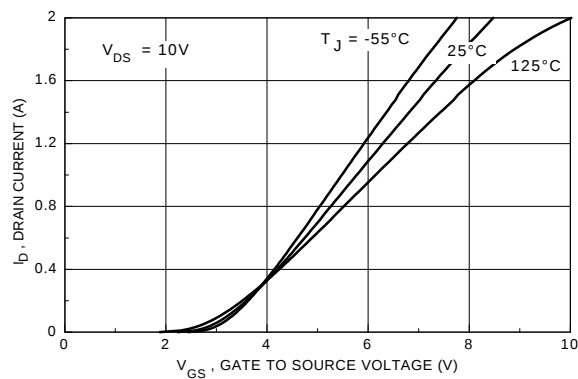


Figure 5. Transfer Characteristics

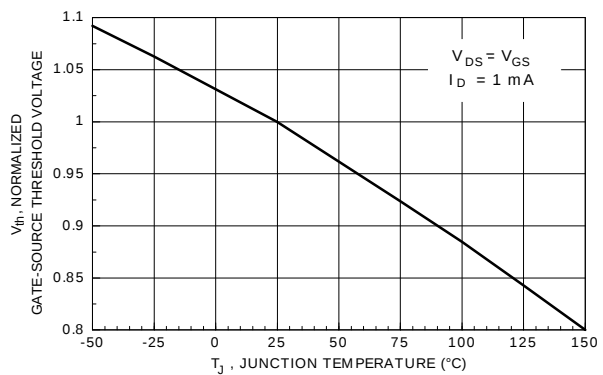


Figure 6. Gate Threshold Variation with Temperature

## Typical Electrical Characteristics (continued)

2N7000 / 2N7002 / NDS7002A

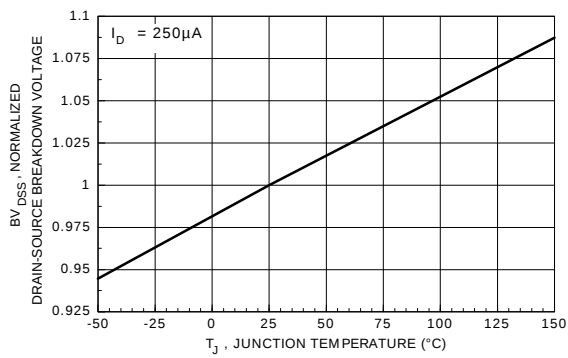


Figure 7. Breakdown Voltage Variation with Temperature

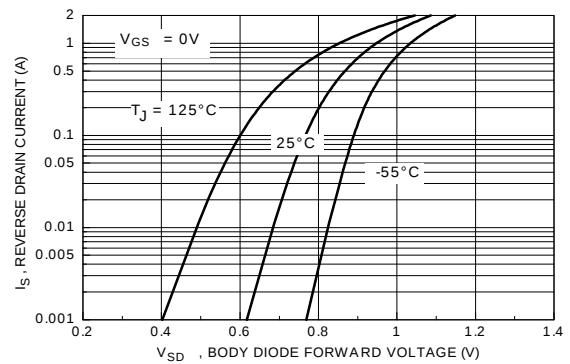


Figure 8. Body Diode Forward Voltage Variation with Temperature

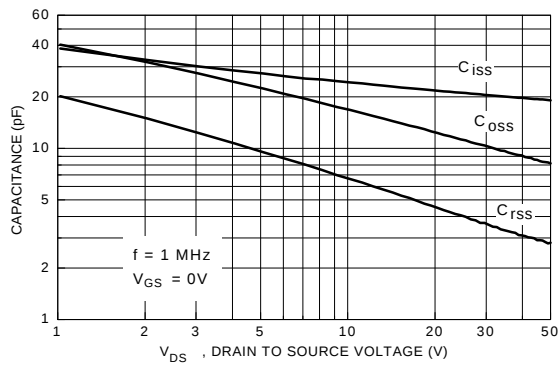


Figure 9. Capacitance Characteristics

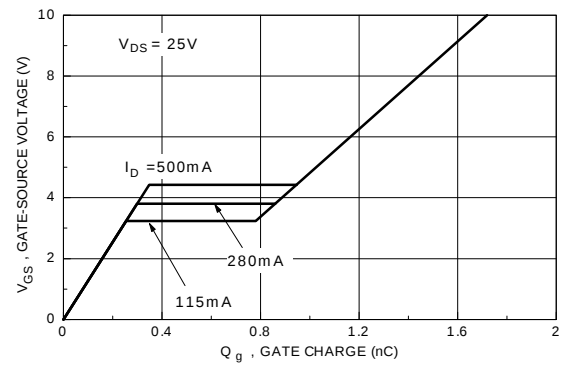


Figure 10. Gate Charge Characteristics

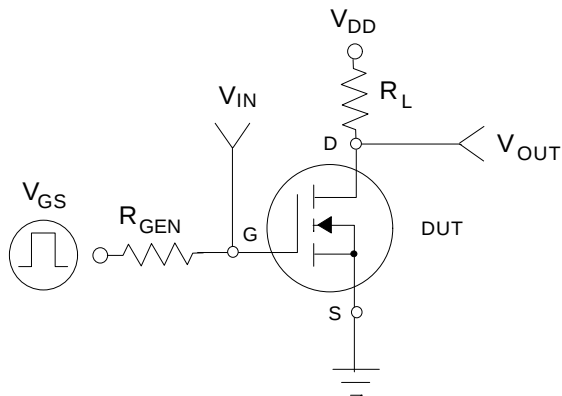


Figure 11.

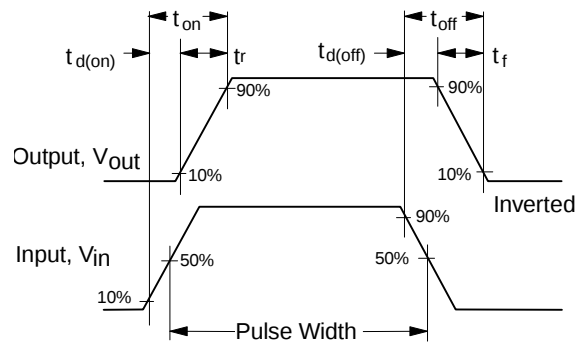
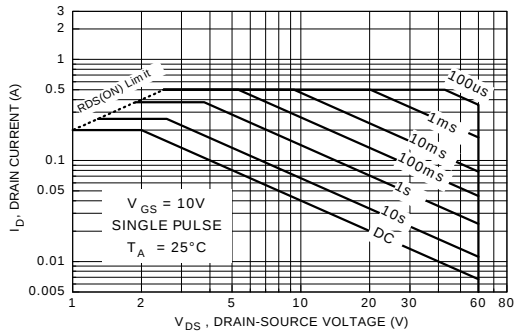
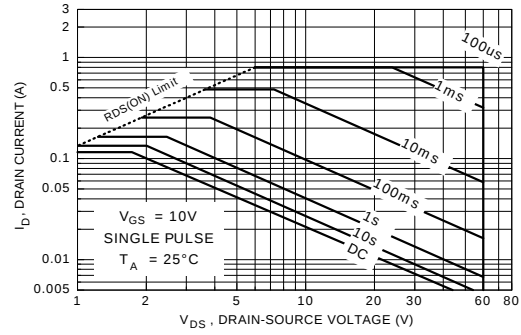


Figure 12. Switching Waveforms

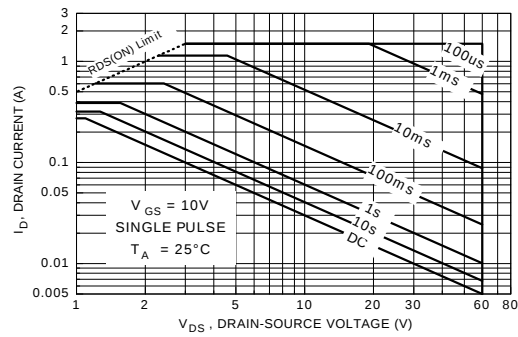
## Typical Electrical Characteristics (continued)



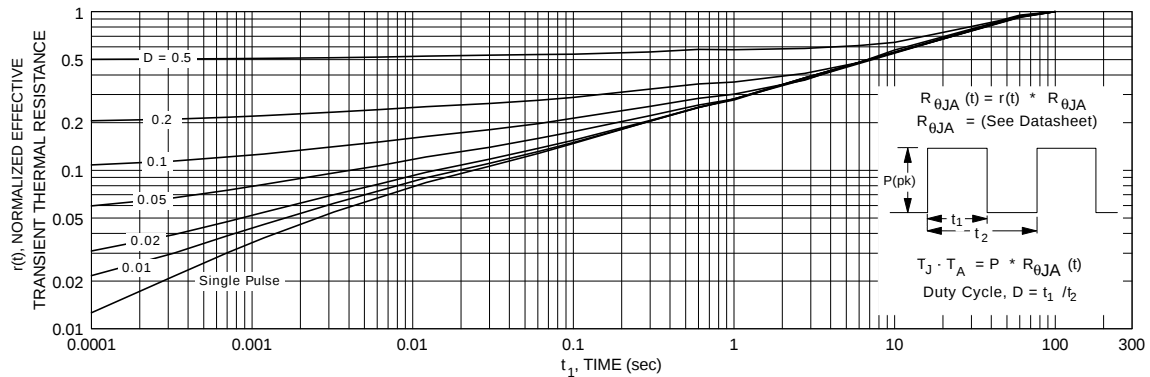
**Figure 13. 2N7000 Maximum Safe Operating Area**



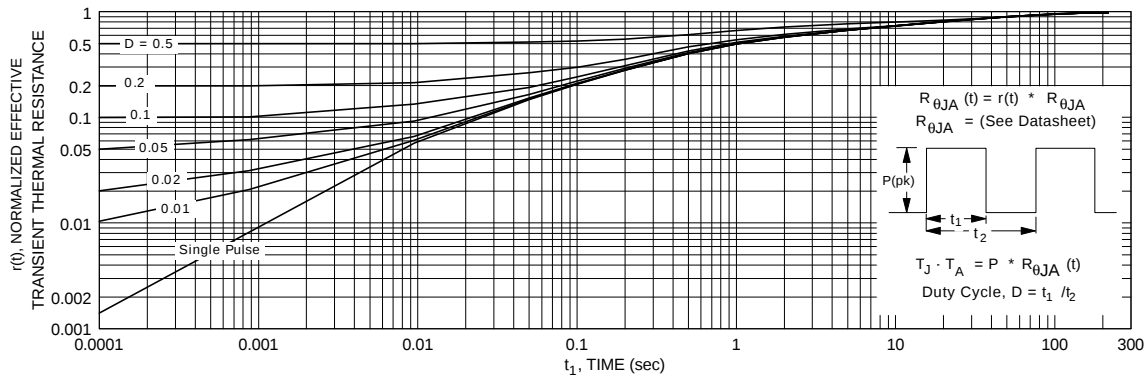
**Figure 14. 2N7002 Maximum Safe Operating Area**



**Figure 15. NDS7000A Maximum Safe Operating Area**



**Figure 16. TO-92, 2N7000 Transient Thermal Response Curve**



**Figure 17. SOT-23, 2N7002 / NDS7002A Transient Thermal Response Curve**

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| EnSigna <sup>™</sup>             | OPTOLOGIC <sup>™</sup>          | SMART START <sup>™</sup>        |                        |
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| FAST <sup>®</sup>                | POP <sup>™</sup>                | SuperSOT <sup>™</sup> -8        |                        |

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## PRODUCT STATUS DEFINITIONS

### Definition of Terms

| Datasheet Identification | Product Status         | Definition                                                                                                                                                                                                            |
|--------------------------|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Advance Information      | Formative or In Design | This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.                                                                                    |
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