



ON Semiconductor®

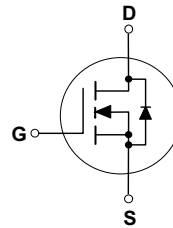
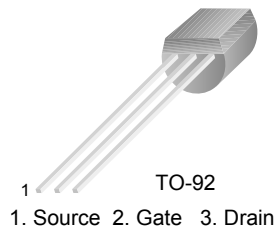
# 2N7000 / 2N7002 / NDS7002A N-Channel Enhancement Mode Field Effect Transistor

## Features

- High Density Cell Design for Low  $R_{DS(ON)}$
- Voltage Controlled Small Signal Switch
- Rugged and Reliable
- High Saturation Current Capability

## Description

These N-channel enhancement mode field effect transistors are produced using ON Semiconductor's proprietary, high cell density, DMOS technology. These products have been designed to minimize on-state resistance while providing rugged, reliable, and fast switching performance. They can be used in most applications requiring up to 400 mA DC and can deliver pulsed currents up to 2 A. 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.



## Ordering Information

| Part Number | Marking | Package   | Packing Method | Min Order Qty / Immediate Pack Qty |
|-------------|---------|-----------|----------------|------------------------------------|
| 2N7000      | 2N7000  | TO-92 3L  | Bulk           | 10000 / 1000                       |
| 2N7000-D74Z | 2N7000  | TO-92 3L  | Ammo           | 2000 / 2000                        |
| 2N7000-D75Z | 2N7000  | TO-92 3L  | Tape and Reel  | 2000 / 2000                        |
| 2N7000-D26Z | 2N7000  | TO-92 3L  | Tape and Reel  | 2000 / 2000                        |
| 2N7002      | 702     | SOT-23 3L | Tape and Reel  | 3000 / 3000                        |
| NDS7002A    | 712     | SOT-23 3L | Tape and Reel  | 3000 / 3000                        |

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

## 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  $T_C = 25^\circ\text{C}$  unless otherwise noted.

| Symbol         | Parameter   | Value      |        |            | Unit                       |
|----------------|---|------------|--------|------------|----------------------------|
|                |   | 2N7000     | 2N7002 | NDS7002A   |                            |
| $V_{DSS}$      | Drain-to-Source Voltage   | 60         |        |            | V                          |
| $V_{DGR}$      | Drain-Gate Voltage ( $R_{GS} \leq 1\text{ M}\Omega$ )                               | 60         |        |            | V                          |
| $V_{GSS}$      | Gate-Source Voltage - Continuous  | $\pm 20$   |        |            | V                          |
|                | Gate-Source Voltage - Non Repetitive ( $t_p < 50\ \mu\text{s}$ )                    | $\pm 40$   |        |            |                            |
| $I_D$          | Maximum Drain Current - Continuous  | 200        | 115    | 280        | mA                         |
|                | Maximum Drain Current - Pulsed  | 500        | 800    | 1500       |                            |
| $P_D$          | Maximum Power Dissipation Derated above $25^\circ\text{C}$                          | 400        | 200    | 300        | mW                         |
|                |   | 3.2        | 1.6    | 2.4        | $\text{mW}/^\circ\text{C}$ |
| $T_J, T_{STG}$ | Operating and Storage Temperature Range   | -55 to 150 |        | -65 to 150 | $^\circ\text{C}$           |
| $T_L$          | Maximum Lead Temperature for Soldering Purposes, 1/16-inch from Case for 10 Seconds | 300        |        |            | $^\circ\text{C}$           |

## Thermal Characteristics

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

| Symbol          | Parameter                               | Value  |        |          | Unit                      |
|-----------------|---|--------|--------|----------|---------------------------|
|                 |   | 2N7000 | 2N7002 | NDS7002A |                           |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient | 312.5  | 625    | 417      | $^\circ\text{C}/\text{W}$ |

## Electrical Characteristics

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

| Symbol                     | Parameter                       | Conditions   | Type               | Min. | Typ. | Max. | Unit          |
|----------------------------|---------------------------------|--|--------------------|------|------|------|---------------|
| <b>Off Characteristics</b> |                                 |  |                    |      |      |      |               |
| $BV_{DSS}$                 | Drain-Source Breakdown Voltage  | $V_{GS} = 0\text{ V}, I_D = 10\ \mu\text{A}$                         | All                | 60   |      |      | V             |
| $I_{DSS}$                  | Zero Gate Voltage Drain Current | $V_{DS} = 48\text{ V}, V_{GS} = 0\text{ V}$                          | 2N7000             |      |      | 1    | $\mu\text{A}$ |
|                            |                                 | $V_{DS} = 48\text{ V}, V_{GS} = 0\text{ V}, T_C = 125^\circ\text{C}$ |                    |      |      | 1    | mA            |
|                            |                                 | $V_{DS} = 60\text{ V}, V_{GS} = 0\text{ V}$                          | 2N7002<br>NDS7002A |      |      | 1    | $\mu\text{A}$ |
|                            |                                 | $V_{DS} = 60\text{ V}, V_{GS} = 0\text{ V}, T_C = 125^\circ\text{C}$ |                    |      |      | 0.5  | mA            |
| $I_{GSSF}$                 | Gate - Body Leakage, Forward    | $V_{GS} = 15\text{ V}, V_{DS} = 0\text{ V}$                          | 2N7000             |      |      | 10   | nA            |
|                            |                                 | $V_{GS} = 20\text{ V}, V_{DS} = 0\text{ V}$                          | 2N7002<br>NDS7002A |      |      | 100  | nA            |
| $I_{GSSR}$                 | Gate - Body Leakage, Reverse    | $V_{GS} = -15\text{ V}, V_{DS} = 0\text{ V}$                         | 2N7000             |      |      | -10  | nA            |
|                            |                                 | $V_{GS} = -20\text{ V}, V_{DS} = 0\text{ V}$                         | 2N7002<br>NDS7002A |      |      | -100 | nA            |

**Electrical Characteristics** (Continued)

| Symbol  | Parameter                         | Conditions   | Type                    | Min.  | Typ.   | Max. | Unit     |
|---|-----------------------------------|--|-------------------------|---|--------|------|----------|
| <b>On Characteristics</b>                     |                                   |  |                         |   |        |      |          |
| $V_{GS(th)}$                                  | Gate Threshold Voltage            | $V_{DS} = V_{GS}, I_D = 1 \text{ mA}$                                  | 2N7000                  | 0.8   | 2.1    | 3    | V        |
|   |                                   | $V_{DS} = V_{GS}, I_D = 250 \mu\text{A}$                               | 2N7002<br>NDS7002A      | 1   | 2.1    | 2.5  |          |
| $R_{DS(ON)}$                                  | Static Drain-Source On-Resistance | $V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$                          | 2N7000                  |   | 1.2    | 5    | $\Omega$ |
|   |                                   | $V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}, T_C = 125^\circ\text{C}$ |                         |   | 1.9    | 9    |          |
|   |                                   | $V_{GS} = 4.5 \text{ V}, I_D = 75 \text{ mA}$                          |                         |   | 1.8    | 5.3  |          |
|   |                                   | $V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$                          | 2N7002                  |   | 1.2    | 7.5  |          |
|   |                                   | $V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}, T_C = 100^\circ\text{C}$ |                         |   | 1.7    | 13.5 |          |
|   |                                   | $V_{GS} = 5 \text{ V}, I_D = 50 \text{ mA}$                            |                         |   | 1.7    | 7.5  |          |
|   |                                   | $V_{GS} = 5 \text{ V}, I_D = 50 \text{ mA}, T_C = 100^\circ\text{C}$   |                         |   | 2.4    | 13.5 |          |
|   |                                   | $V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$                          | NDS7002A                |   | 1.2    | 2    |          |
|   |                                   | $V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}, T_C = 125^\circ\text{C}$ |                         |   | 2      | 3.5  |          |
|   |                                   | $V_{GS} = 5 \text{ V}, I_D = 50 \text{ mA}$                            |                         |   | 1.7    | 3    |          |
|   |                                   | $V_{GS} = 5 \text{ V}, I_D = 50 \text{ mA}, T_C = 125^\circ\text{C}$   |                         |   | 2.8    | 5    |          |
|   |                                   | $V_{DS(ON)}$   | Drain-Source On-Voltage | $V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$ | 2N7000 |      |          |
| $V_{GS} = 4.5 \text{ V}, I_D = 75 \text{ mA}$ |                                   |  |                         | 0.14  |        | 0.4  |          |
| $V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$ | 2N7002                            |  |                         |   | 0.6    | 3.75 |          |
| $V_{GS} = 5.0 \text{ V}, I_D = 50 \text{ mA}$ |                                   |  |                         |   | 0.09   | 1.5  |          |
| $V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$ | NDS7002A                          |  |                         |   | 0.6    | 1    |          |
| $V_{GS} = 5.0 \text{ V}, I_D = 50 \text{ mA}$ |                                   |  |                         |   | 0.09   | 0.15 |          |
| $I_{D(ON)}$                                   | On-State Drain Current            | $V_{GS} = 4.5 \text{ V}, V_{DS} = 10 \text{ V}$                        | 2N7000                  | 75  | 600    |      | mA       |
|   |                                   | $V_{GS} = 10 \text{ V}, V_{DS} \geq 2 V_{DS(on)}$                      | 2N7002                  | 500   | 2700   |      |          |
|   |                                   | $V_{GS} = 10 \text{ V}, V_{DS} \geq 2 V_{DS(on)}$                      | NDS7002A                | 500   | 2700   |      |          |
| $g_{FS}$                                      | Forward Transconductance          | $V_{DS} = 10 \text{ V}, I_D = 200 \text{ mA}$                          | 2N7000                  | 100   | 320    |      | mS       |
|   |                                   | $V_{DS} \geq 2V_{DS(ON)}, I_D = 200 \text{ mA}$                        | 2N7002                  | 80  | 320    |      |          |
|   |                                   | $V_{DS} \geq 2V_{DS(ON)}, I_D = 200 \text{ mA}$                        | NDS7002A                | 80  | 320    |      |          |

### Electrical Characteristics (Continued)

| Symbol  | Parameter   | Conditions   | Type               | Min. | Typ. | Max. | Unit |
|---|---|--|--------------------|------|------|------|------|
| <b>Dynamic Characteristics</b>                                |   |  |                    |      |      |      |      |
| $C_{iss}$   | Input Capacitance                                     | $V_{DS} = 25\text{ V}, V_{GS} = 0\text{ V},$<br>$f = 1.0\text{ MHz}$   | All                |      | 20   | 50   | pF   |
| $C_{oss}$   | Output Capacitance                                    |  | All                |      | 11   | 25   |      |
| $C_{rss}$   | Reverse Transfer Capacitance                          |  | All                |      | 4    | 5    |      |
| $t_{on}$  | Turn-On Time  | $V_{DD} = 15\text{ V}, R_L = 25\ \Omega,$<br>$I_D = 500\text{ mA}, V_{GS} = 10\text{ V},$<br>$R_{GEN} = 25\ \Omega$  | 2N7000             |      |      | 10   | ns   |
|   |   | $V_{DD} = 30\text{ V}, R_L = 150\ \Omega,$<br>$I_D = 200\text{ mA}, V_{GS} = 10\text{ V},$<br>$R_{GEN} = 25\ \Omega$ | 2N7002<br>NDS7002A |      |      | 20   |      |
| $t_{off}$   | Turn-Off Time   | $V_{DD} = 15\text{ V}, R_L = 25\ \Omega,$<br>$I_D = 500\text{ mA}, V_{GS} = 10\text{ V},$<br>$R_{GEN} = 25\ \Omega$  | 2N7000             |      |      | 10   | ns   |
|   |   | $V_{DD} = 30\text{ V}, R_L = 150\ \Omega,$<br>$I_D = 200\text{ mA}, V_{GS} = 10\text{ V},$<br>$R_{GEN} = 25\ \Omega$ | 2N7002<br>NDS7002A |      |      | 20   |      |
| <b>Drain-Source Diode Characteristics and Maximum Ratings</b> |   |  |                    |      |      |      |      |
| $I_S$   | Maximum Continuous Drain-Source Diode Forward Current |  | 2N7002             |      |      | 115  | mA   |
|   |   |  | NDS7002A           |      |      | 280  |      |
| $I_{SM}$  | Maximum Pulsed Drain-Source Diode Forward Current     |  | 2N7002             |      |      | 0.8  | A    |
|   |   |  | NDS7002A           |      |      | 1.5  |      |
| $V_{SD}$  | Drain-Source Diode Forward Voltage                    | $V_{GS} = 0\text{ V},$<br>$I_S = 115\text{ mA}^{(1)}$  | 2N7002             |      | 0.88 | 1.5  | V    |
|   |   | $V_{GS} = 0\text{ V},$<br>$I_S = 400\text{ mA}^{(1)}$  | NDS7002A           |      | 0.88 | 1.2  |      |

**Note:**

1. Pulse test : Pulse Width  $\leq 300\ \mu\text{s}$ , Duty Cycle  $\leq 2\%$ .

# Typical Performance Characteristics

2N7000 / 2N7002 / NDS7002A

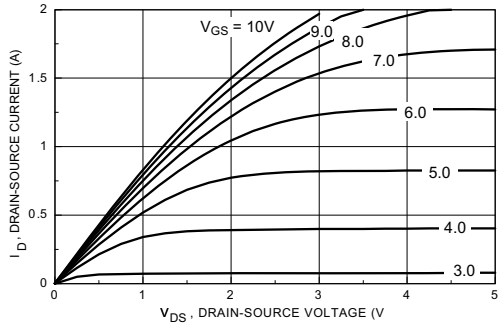


Figure 1. On-Region Characteristics

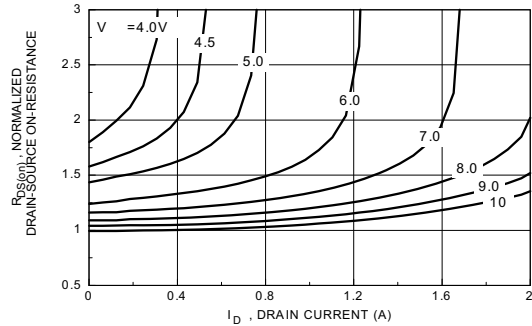


Figure 2. On-Resistance Variation with Gate Voltage and Drain Current

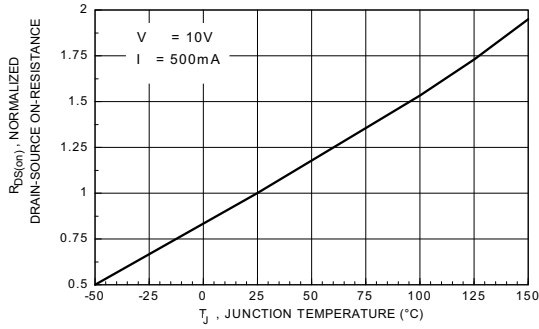


Figure 3. On-Resistance Variation with Temperature

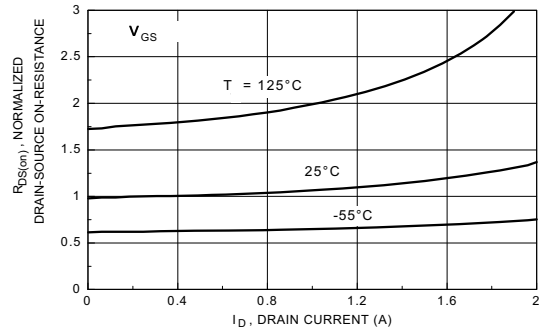


Figure 4. On-Resistance Variation with Drain Current and Temperature

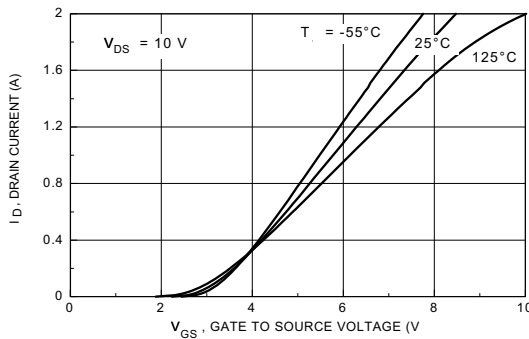


Figure 5. Transfer Characteristics

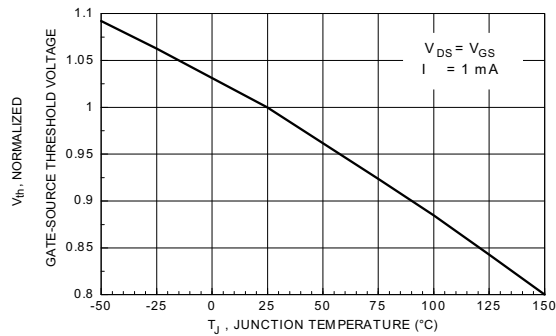
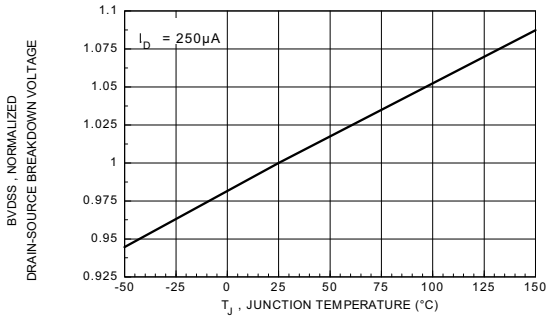


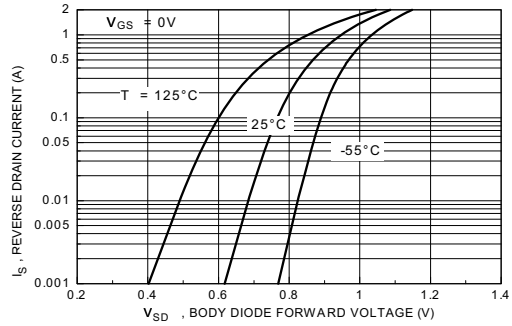
Figure 6. Gate Threshold Variation with Temperature

## Typical Performance Characteristics (Continued)

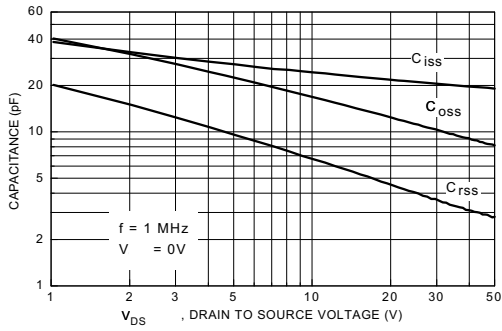
### 2N7000 / 2N7002 / NDS7002A



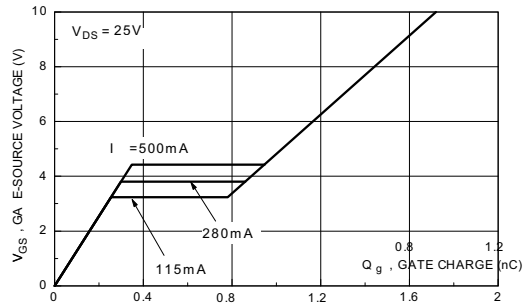
**Figure 7. Breakdown Voltage Variation with Temperature**



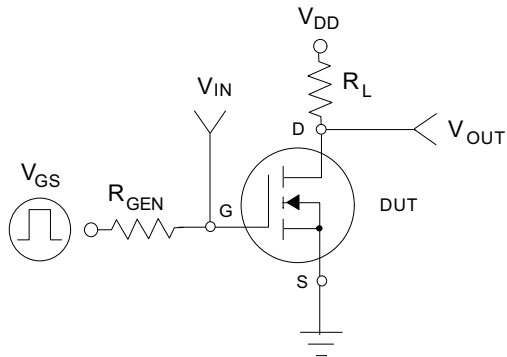
**Figure 8. Body Diode Forward Voltage Variation with Temperature**



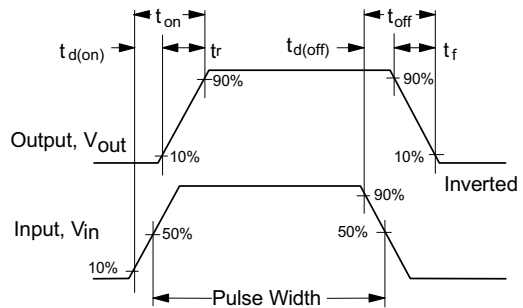
**Figure 9. Capacitance Characteristics**



**Figure 10. Gate Charge Characteristics**



**Figure 11. Switching Test Circuit**



**Figure 12. Switching Waveforms**

Typical Performance Characteristics (Continued)

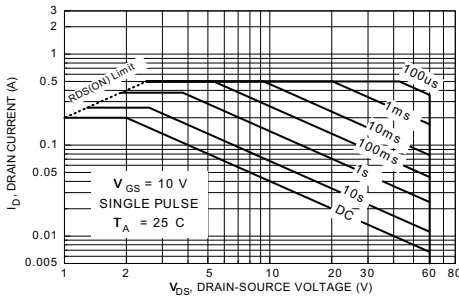


Figure 13. 2N7000 Maximum Safe Operating Area

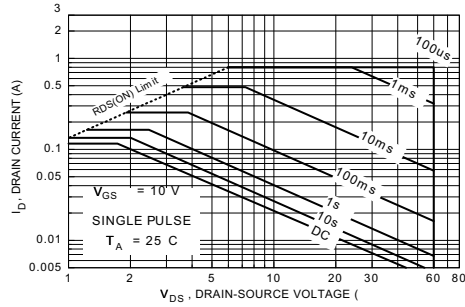


Figure 14. 2N7002 Maximum Safe Operating Area

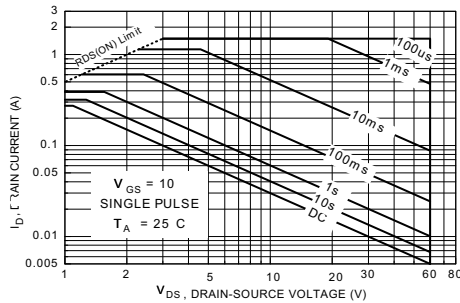


Figure 15. NDS7000A Maximum Safe Operating Area

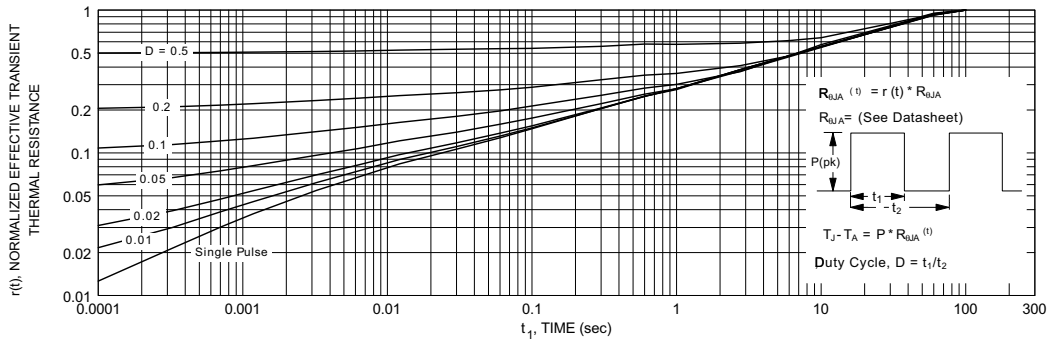


Figure 16. TO-92, 2N7000 Transient Thermal Response Curve

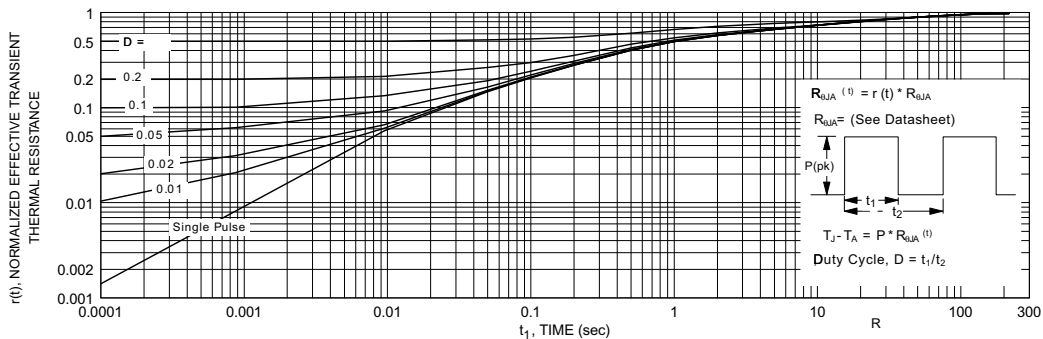


Figure 17. SOT-23, 2N7002 / NDS7002A Transient Thermal Response Curve

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