



## N-Channel 60-V (D-S) MOSFET

| PRODUCT SUMMARY |                       |                               |                  |           |
|-----------------|-----------------------|-------------------------------|------------------|-----------|
| Part Number     | $V_{(BR)DSS}$ Min (V) | $r_{DS(on)}$ Max ( $\Omega$ ) | $V_{GS(th)}$ (V) | $I_D$ (A) |
| 2N7000          | 60                    | 5 @ $V_{GS} = 10$ V           | 0.8 to 3         | 0.2       |
| 2N7002          |                       | 7.5 @ $V_{GS} = 10$ V         | 1 to 2.5         | 0.115     |
| VQ1000J         |                       | 5.5 @ $V_{GS} = 10$ V         | 0.8 to 2.5       | 0.225     |
| VQ1000P         |                       | 5.5 @ $V_{GS} = 10$ V         | 0.8 to 2.5       | 0.225     |
| BS170           |                       | 5 @ $V_{GS} = 10$ V           | 0.8 to 3         | 0.5       |

## FEATURES

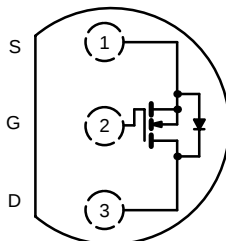
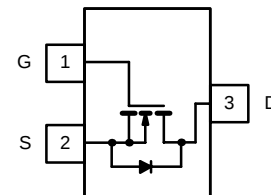
- Low On-Resistance: 2.5  $\Omega$
- Low Threshold: 2.1 V
- Low Input Capacitance: 22 pF
- Fast Switching Speed: 7 ns
- Low Input and Output Leakage

## BENEFITS

- Low Offset Voltage
- Low-Voltage Operation
- Easily Driven Without Buffer
- High-Speed Circuits
- Low Error Voltage

## APPLICATIONS

- Direct Logic-Level Interface: TTL/CMOS
- Drivers: Relays, Solenoids, Lamps, Hammers, Displays, Memories, Transistors, etc.
- Battery Operated Systems
- Solid-State Relays

TO-226AA  
(TO-92)Top View  
2N7000TO-236  
(SOT-23)

Top View

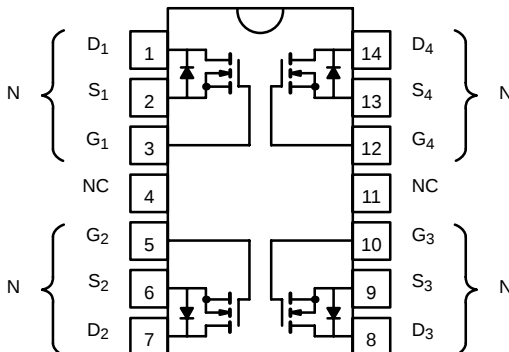
Marking Code: 72w//

72 = Part Number Code for 2N7002

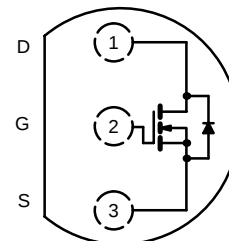
w = Week Code

// = Lot Traceability

Dual-In-Line



Top View

Plastic: VQ1000J  
Sidebrazed: VQ1000PTO-92-18RM  
(TO-18 Lead Form)

Top View

BS170

| ABSOLUTE MAXIMUM RATINGS ( $T_A = 25^\circ\text{C}$ UNLESS OTHERWISE NOTED) |                           |            |          |          |          |            |          |                    |
|-----------------------------------------------------------------------------|---------------------------|------------|----------|----------|----------|------------|----------|--------------------|
| Parameter                                                                   | Symbol                    | 2N7000     | 2N7002   | Single   |          | Total Quad | BS170    | Unit               |
|                                                                             |                           |            |          | VQ1000J  | VQ1000P  | VQ1000J/P  |          |                    |
| Drain-Source Voltage                                                        | $V_{DS}$                  | 60         | 60       | 60       | 60       |            | 60       | V                  |
| Gate-Source Voltage—Non-Repetitive                                          | $V_{GSM}$                 | $\pm 40$   | $\pm 40$ | $\pm 30$ |          |            | $\pm 25$ |                    |
| Gate-Source Voltage—Continuous                                              | $V_{GS}$                  | $\pm 20$   | $\pm 20$ | $\pm 20$ | $\pm 20$ |            | $\pm 20$ |                    |
| Continuous Drain Current<br>( $T_J = 150^\circ\text{C}$ )                   | $T_A = 25^\circ\text{C}$  | $I_D$      | 0.2      | 0.115    | 0.225    | 0.225      | 0.5      | A                  |
|                                                                             | $T_A = 100^\circ\text{C}$ |            | 0.13     | 0.073    | 0.14     | 0.14       | 0.175    |                    |
| Pulsed Drain Current <sup>a</sup>                                           | $I_{DM}$                  | 0.5        | 0.8      | 1        | 1        |            |          |                    |
| Power Dissipation                                                           | $T_A = 25^\circ\text{C}$  | $P_D$      | 0.4      | 0.2      | 1.3      | 1.3        | 2        | W                  |
|                                                                             | $T_A = 100^\circ\text{C}$ |            | 0.16     | 0.08     | 0.52     | 0.52       | 0.8      |                    |
| Thermal Resistance, Junction-to-Ambient                                     | $R_{thJA}$                | 312.5      | 625      | 96       | 96       | 62.5       | 156      | $^\circ\text{C/W}$ |
| Operating Junction and Storage Temperature Range                            | $T_J, T_{stg}$            | -55 to 150 |          |          |          |            |          | $^\circ\text{C}$   |

Notes

a. Pulse width limited by maximum junction temperature.

b.  $t_p \leq 50 \mu\text{s}$ .SPECIFICATIONS—2N7000 AND 2N7002 ( $T_A = 25^\circ\text{C}$  UNLESS OTHERWISE NOTED)

| Parameter                                     | Symbol               | Test Conditions                                              | Typ <sup>a</sup> | Limits |      |        |       | Unit |
|-----------------------------------------------|----------------------|--------------------------------------------------------------|------------------|--------|------|--------|-------|------|
|                                               |                      |                                                              |                  | 2N7000 |      | 2N7002 |       |      |
|                                               |                      |                                                              |                  | Min    | Max  | Min    | Max   |      |
| Static                                        |                      |                                                              |                  |        |      |        |       |      |
| Drain-Source Breakdown Voltage                | V <sub>(BR)DSS</sub> | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 10 μA                | 70               | 60     |      | 60     |       | V    |
| Gate-Threshold Voltage                        | V <sub>GS(th)</sub>  | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1 mA    | 2.1              | 0.8    | 3    |        |       |      |
|                                               |                      | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 0.25 mA | 2.0              |        |      | 1      | 2.5   |      |
| Gate-Body Leakage                             | I <sub>GSS</sub>     | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ± 15 V              |                  |        | ± 10 |        |       | nA   |
|                                               |                      | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ± 20 V              |                  |        |      |        | ± 100 |      |
| Zero Gate Voltage Drain Current               | I <sub>DSS</sub>     | V <sub>DS</sub> = 48 V, V <sub>GS</sub> = 0 V                |                  |        | 1    |        |       | μA   |
|                                               |                      | T <sub>C</sub> = 125°C                                       |                  |        | 1000 |        |       |      |
|                                               |                      | V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V                |                  |        |      |        | 1     |      |
|                                               |                      | T <sub>C</sub> = 125°C                                       |                  |        |      |        | 500   |      |
| On-State Drain Current <sup>b</sup>           | I <sub>D(on)</sub>   | V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 4.5 V              | 0.35             | 0.075  |      |        |       | A    |
|                                               |                      | V <sub>DS</sub> = 7.5 V, V <sub>GS</sub> = 10 V              | 1                |        |      | 0.5    |       |      |
| Drain-Source On-Resistance <sup>b</sup>       | r <sub>DS(on)</sub>  | V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 0.075 A            | 4.5              |        | 5.3  |        |       | Ω    |
|                                               |                      | V <sub>GS</sub> = 5 V, I <sub>D</sub> = 0.05 A               | 3.2              |        |      |        | 7.5   |      |
|                                               |                      | T <sub>C</sub> = 125°C                                       | 5.8              |        |      |        | 13.5  |      |
|                                               |                      | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 0.5 A               | 2.4              |        | 5    |        | 7.5   |      |
|                                               |                      | T <sub>J</sub> = 125°C                                       | 4.4              |        | 9    |        | 13.5  |      |
| Forward Transconductance <sup>b</sup>         | g <sub>fs</sub>      | V <sub>DS</sub> = 10 V, I <sub>D</sub> = 0.2 A               |                  | 100    |      | 80     |       | mS   |
| Common Source Output Conductance <sup>b</sup> | g <sub>os</sub>      | V <sub>DS</sub> = 5 V, I <sub>D</sub> = 0.05 A               | 0.5              |        |      |        |       |      |
| Dynamic                                       |                      |                                                              |                  |        |      |        |       |      |
| Input Capacitance                             | C <sub>iss</sub>     | V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V<br>f = 1 MHz   | 22               |        | 60   |        | 50    | pF   |
| Output Capacitance                            | C <sub>oss</sub>     |                                                              | 11               |        | 25   |        | 25    |      |
| Reverse Transfer Capacitance                  | C <sub>rss</sub>     |                                                              | 2                |        | 5    |        | 5     |      |

**SPECIFICATIONS—2N7000 AND 2N7002 ( $T_A = 25^\circ\text{C}$  UNLESS OTHERWISE NOTED)**

| Parameter              | Symbol           | Test Conditions                                                                                                          | Typ <sup>a</sup> | Limits |     |        |     | Unit |
|------------------------|------------------|--------------------------------------------------------------------------------------------------------------------------|------------------|--------|-----|--------|-----|------|
|                        |                  |                                                                                                                          |                  | 2N7000 |     | 2N7002 |     |      |
|                        |                  |                                                                                                                          |                  | Min    | Max | Min    | Max |      |
| Switching <sup>d</sup> |                  |                                                                                                                          |                  |        |     |        |     |      |
| Turn-On Time           | t <sub>ON</sub>  | V <sub>DD</sub> = 15 V, R <sub>L</sub> = 25 Ω<br>I <sub>D</sub> ≅ 0.5 A, V <sub>GEN</sub> = 10 V, R <sub>G</sub> = 25 Ω  | 7                |        | 10  |        | ns  |      |
| Turn-Off Time          | t <sub>OFF</sub> |                                                                                                                          | 7                |        | 10  |        |     |      |
| Turn-On Time           | t <sub>ON</sub>  | V <sub>DD</sub> = 30 V, R <sub>L</sub> = 150 Ω<br>I <sub>D</sub> ≅ 0.2 A, V <sub>GEN</sub> = 10 V, R <sub>G</sub> = 25 Ω | 7                |        |     | 20     |     |      |
| Turn-Off Time          | t <sub>OFF</sub> |                                                                                                                          | 11               |        |     | 20     |     |      |

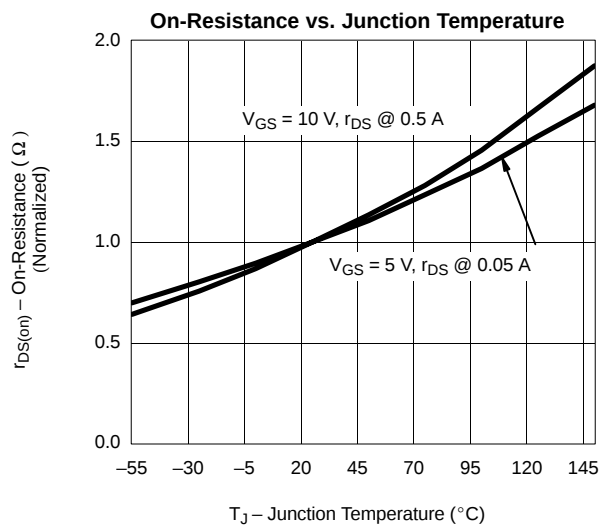
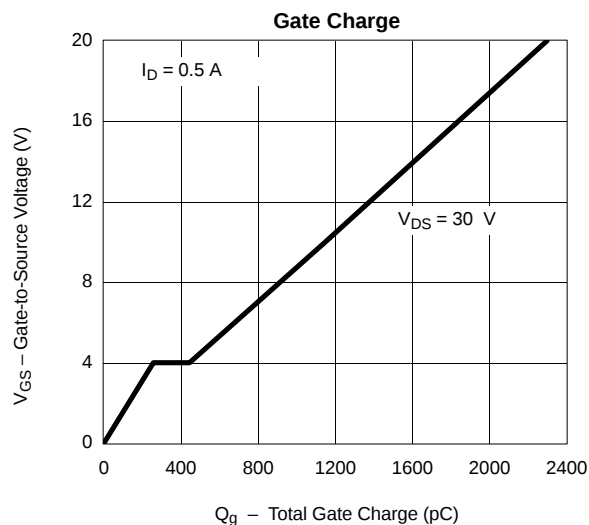
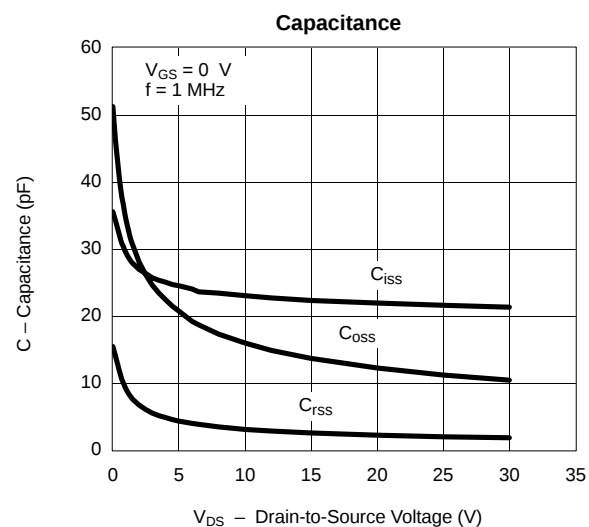
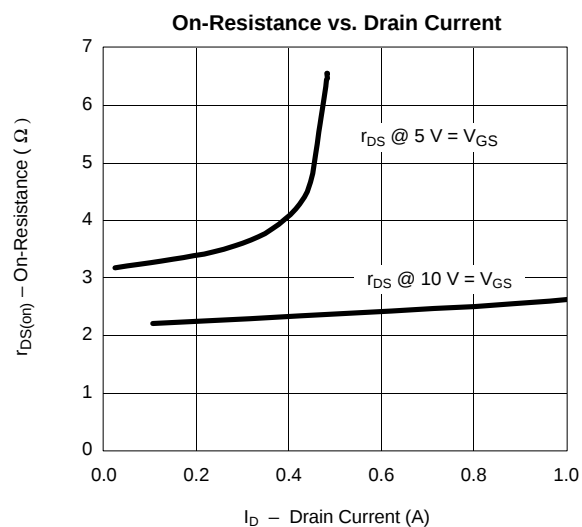
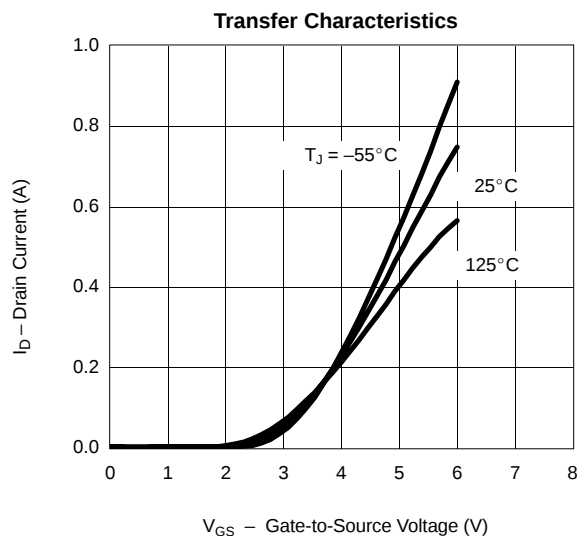
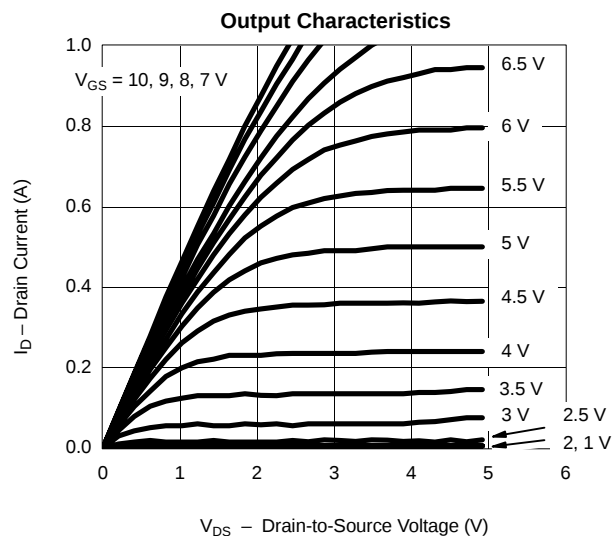
**SPECIFICATIONS—VQ1000J/P AND BS170 ( $T_A = 25^\circ\text{C}$  UNLESS OTHERWISE NOTED)**

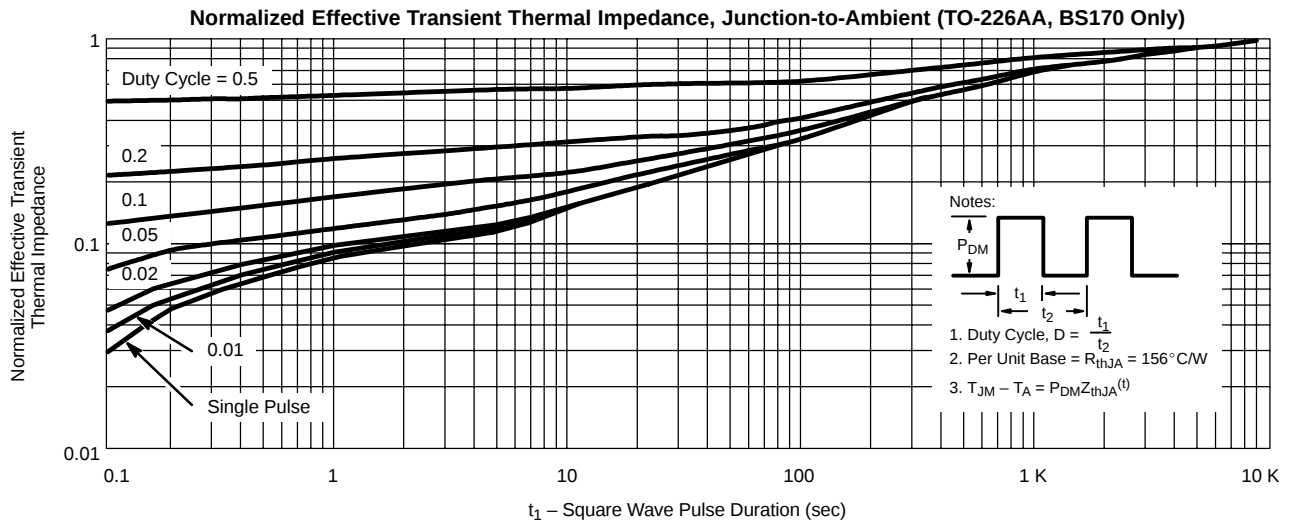
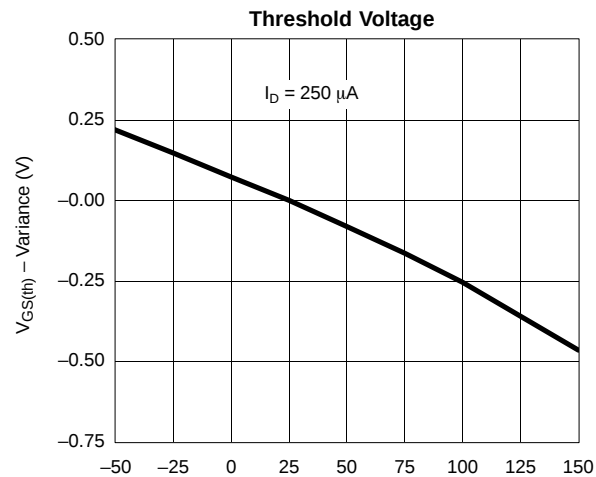
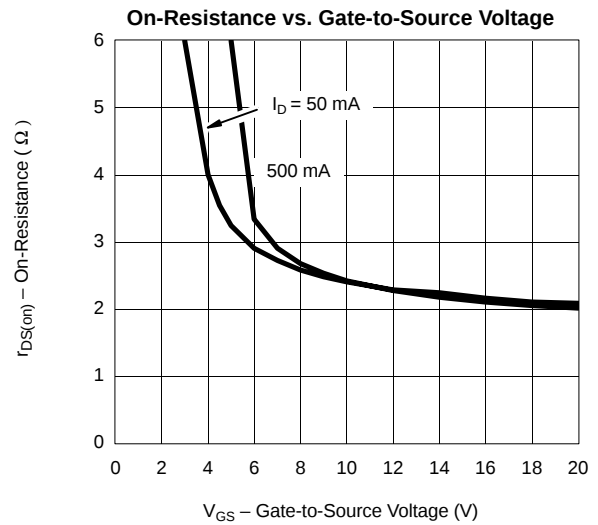
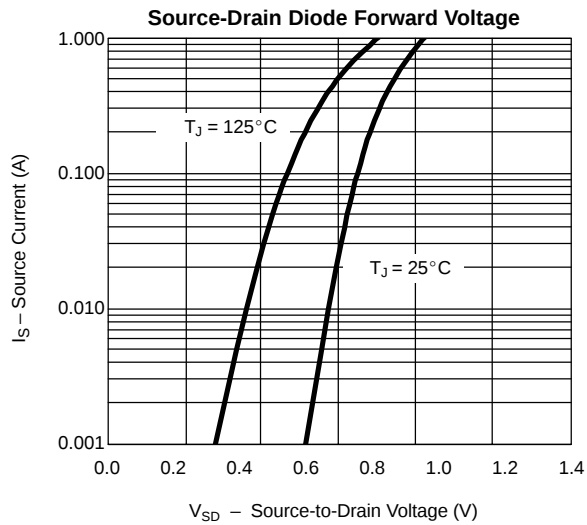
| Parameter                                     | Symbol               | Test Conditions                                                                                                          | Typ <sup>a</sup> | Limits    |       |       |      | Unit |
|-----------------------------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------|------------------|-----------|-------|-------|------|------|
|                                               |                      |                                                                                                                          |                  | VQ1000J/P |       | BS170 |      |      |
|                                               |                      |                                                                                                                          |                  | Min       | Max   | Min   | Max  |      |
| Static                                        |                      |                                                                                                                          |                  |           |       |       |      |      |
| Drain-Source Breakdown Voltage                | V <sub>(BR)DSS</sub> | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 100 μA                                                                           | 70               | 60        |       | 60    |      | V    |
| Gate-Threshold Voltage                        | V <sub>GS(th)</sub>  | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1 mA                                                                | 2.1              | 0.8       | 2.5   | 0.8   | 3    |      |
| Gate-Body Leakage                             | I <sub>GSS</sub>     | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ± 10 V                                                                          |                  |           | ± 100 |       |      | nA   |
|                                               |                      | T <sub>J</sub> = 125°C                                                                                                   |                  |           | ± 500 |       |      |      |
| Zero Gate Voltage Drain Current               | I <sub>DSS</sub>     | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ± 15 V                                                                          |                  |           |       |       | ± 10 | μA   |
|                                               |                      | V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V                                                                            |                  |           |       |       | 0.5  |      |
|                                               |                      | V <sub>DS</sub> = 48 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125°C                                                    |                  |           | 500   |       |      |      |
|                                               |                      | V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V                                                                            |                  |           | 10    |       |      |      |
| On-State Drain Current <sup>b</sup>           | I <sub>D(on)</sub>   | V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 10 V                                                                           | 1                | 0.5       |       |       |      | A    |
| Drain-Source On-Resistance <sup>b</sup>       | r <sub>DS(on)</sub>  | V <sub>GS</sub> = 5 V, I <sub>D</sub> = 0.2 A                                                                            | 4                |           | 7.5   |       |      | Ω    |
|                                               |                      | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 0.2 A                                                                           | 2.3              |           |       |       | 5    |      |
|                                               |                      | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 0.3 A                                                                           | 2.3              |           | 5.5   |       |      |      |
|                                               |                      | T <sub>J</sub> = 125°C                                                                                                   | 4.2              |           | 7.6   |       |      |      |
| Forward Transconductance <sup>b</sup>         | g <sub>fs</sub>      | V <sub>DS</sub> = 10 V, I <sub>D</sub> = 0.2 A                                                                           |                  |           |       | 100   |      | mS   |
|                                               |                      | V <sub>DS</sub> = 10 V, I <sub>D</sub> = 0.5 A                                                                           |                  | 100       |       |       |      |      |
| Common Source Output Conductance <sup>b</sup> | g <sub>os</sub>      | V <sub>DS</sub> =5 V, I <sub>D</sub> = 0.05 A                                                                            | 0.5              |           |       |       |      |      |
| Dynamic                                       |                      |                                                                                                                          |                  |           |       |       |      |      |
| Input Capacitance                             | C <sub>iss</sub>     | V <sub>DS</sub> =25 V, V <sub>GS</sub> = 0 V<br>f = 1 MHz                                                                | 22               |           | 60    |       | 60   | pF   |
| Output Capacitance                            | C <sub>oss</sub>     |                                                                                                                          | 11               |           | 25    |       |      |      |
| Reverse Transfer Capacitance                  | C <sub>rss</sub>     |                                                                                                                          | 2                |           | 5     |       |      |      |
| Switching <sup>d</sup>                        |                      |                                                                                                                          |                  |           |       |       |      |      |
| Turn-On Time                                  | t <sub>ON</sub>      | V <sub>DD</sub> = 15 V, R <sub>L</sub> = 23 Ω<br>I <sub>D</sub> ≅ 0.6 A, V <sub>GEN</sub> = 10 V, R <sub>G</sub> = 25 Ω  | 7                |           | 10    |       |      | ns   |
| Turn-Off Time                                 | t <sub>OFF</sub>     |                                                                                                                          | 7                |           | 10    |       |      |      |
| Turn-On Time                                  | t <sub>ON</sub>      | V <sub>DD</sub> = 25 V, R <sub>L</sub> = 125 Ω<br>I <sub>D</sub> ≅ 0.2 A, V <sub>GEN</sub> = 10 V, R <sub>G</sub> = 25 Ω | 7                |           |       |       | 10   |      |
| Turn-Off Time                                 | t <sub>OFF</sub>     |                                                                                                                          | 7                |           |       |       | 10   |      |

## Notes

- a. For DESIGN AID ONLY, not subject to production testing.  
b. Pulse test:  $PW \leq 80\ \mu\text{s}$  duty cycle  $\leq 1\%$ .  
c. This parameter not registered with JEDEC.  
d. Switching time is essentially independent of operating temperature.

VNBF06

**TYPICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$  UNLESS OTHERWISE NOTED)**

**TYPICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$  UNLESS OTHERWISE NOTED)**



### Disclaimer

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