

# MOSFET – Power, N-Channel, SUPERFET® III, FRFET®

650 V, 20 A, 190 mΩ

## NTHL190N65S3HF

### Description

SUPERFET III MOSFET is onsemi's brand-new high voltage super-junction (SJ) MOSFET family that is utilizing charge balance technology for outstanding low on-resistance and lower gate charge performance. This advanced technology is tailored to minimize conduction loss, provide superior switching performance, and withstand extreme dv/dt rate.

Consequently, SUPERFET III MOSFET is very suitable for the various power system for miniaturization and higher efficiency.

SUPERFET III FRFET MOSFET's optimized reverse recovery performance of body diode can remove additional component and improve system reliability.

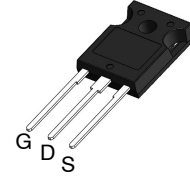
### Features

- 700 V @  $T_J = 150^{\circ}\text{C}$
- Typ.  $R_{DS(on)} = 165\text{ m}\Omega$
- Ultra Low Gate Charge (Typ.  $Q_g = 34\text{ nC}$ )
- Low Effective Output Capacitance (Typ.  $C_{oss(eff.)} = 316\text{ pF}$ )
- 100% Avalanche Tested
- These Devices are Pb-Free and are RoHS Compliant

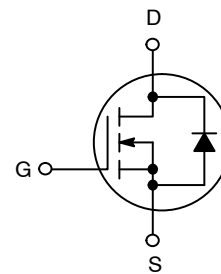
### Applications

- Telecom / Server Power Supplies
- Industrial Power Supplies
- EV Charger
- UPS / Solar

| $V_{DSS}$ | $R_{DS(on)}\text{ MAX}$ | $I_D\text{ MAX}$ |
|-----------|-------------------------|------------------|
| 650 V     | 190 mΩ @ 10 V           | 20 A             |



TO-247-3LD  
CASE 340CX



N-Channel MOSFET

### MARKING DIAGRAM



\$Y = onsemi Logo  
&Z = Assembly Plant Code  
&3 = Numeric Date Code  
&K = Lot Code  
NTHL190N65S3HF = Specific Device Code

### ORDERING INFORMATION

See detailed ordering and shipping information on page 8 of this data sheet.

# NTHL190N65S3HF

## ABSOLUTE MAXIMUM RATINGS ( $T_C = 25^\circ\text{C}$ , Unless otherwise specified)

| Symbol         | Parameter                                                      |                                          | Value       | Unit                |
|----------------|----------------------------------------------------------------|------------------------------------------|-------------|---------------------|
| $V_{DSS}$      | Drain to Source Voltage                                        |                                          | 650         | V                   |
| $V_{GSS}$      | Gate to Source Voltage                                         | DC                                       | $\pm 30$    | V                   |
|                |                                                                | AC ( $f > 1\text{ Hz}$ )                 | $\pm 30$    | V                   |
| $I_D$          | Drain Current                                                  | Continuous ( $T_C = 25^\circ\text{C}$ )  | 20          | A                   |
|                |                                                                | Continuous ( $T_C = 100^\circ\text{C}$ ) | 12.7        |                     |
| $I_{DM}$       | Drain Current                                                  | Pulsed (Note 1)                          | 50          | A                   |
| $E_{AS}$       | Single Pulsed Avalanche Energy (Note 2)                        |                                          | 220         | mJ                  |
| $I_{AS}$       | Avalanche Current (Note 2)                                     |                                          | 3.7         | A                   |
| $E_{AR}$       | Repetitive Avalanche Energy (Note 1)                           |                                          | 1.62        | mJ                  |
| dv/dt          | MOSFET dv/dt                                                   |                                          | 100         | V/ns                |
|                | Peak Diode Recovery dv/dt (Note 3)                             |                                          | 50          |                     |
| $P_D$          | Power Dissipation                                              | ( $T_C = 25^\circ\text{C}$ )             | 162         | W                   |
|                |                                                                | Derate Above $25^\circ\text{C}$          | 1.3         | W/ $^\circ\text{C}$ |
| $T_J, T_{STG}$ | Operating and Storage Temperature Range                        |                                          | -55 to +150 | $^\circ\text{C}$    |
| $T_L$          | Maximum Lead Temperature for Soldering, 1/8" from Case for 5 s |                                          | 300         | $^\circ\text{C}$    |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Repetitive rating: pulse-width limited by maximum junction temperature.

2.  $I_{AS} = 3.7\text{ A}$ ,  $R_G = 25\ \Omega$ , starting  $T_J = 25^\circ\text{C}$ .

3.  $I_{SD} \leq 10\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq 400\text{ V}$ , starting  $T_J = 25^\circ\text{C}$ .

## THERMAL CHARACTERISTICS

| Symbol          | Parameter                                     | Value | Unit                      |
|-----------------|-----------------------------------------------|-------|---------------------------|
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case, Max.    | 0.77  | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient, Max. | 40    |                           |

# NTHL190N65S3HF

## ELECTRICAL CHARACTERISTICS ( $T_C = 25^\circ\text{C}$ unless otherwise noted)

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|--------|-----------|-----------------|-----|-----|-----|------|
|--------|-----------|-----------------|-----|-----|-----|------|

### OFF CHARACTERISTICS

|                                     |                                           |                                                                      |     |      |      |      |
|-------------------------------------|-------------------------------------------|----------------------------------------------------------------------|-----|------|------|------|
| BV <sub>DSS</sub>                   | Drain to Source Breakdown Voltage         | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA, T <sub>J</sub> = 25°C  | 650 |      |      | V    |
|                                     |                                           | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA, T <sub>J</sub> = 150°C | 700 |      |      | V    |
| ΔBV <sub>DSS</sub> /ΔT <sub>J</sub> | Breakdown Voltage Temperature Coefficient | I <sub>D</sub> = 10 mA, Referenced to 25°C                           |     | 0.65 |      | V/°C |
| I <sub>DSS</sub>                    | Zero Gate Voltage Drain Current           | V <sub>DS</sub> = 650 V, V <sub>GS</sub> = 0 V                       |     |      | 10   | μA   |
|                                     |                                           | V <sub>DS</sub> = 520 V, T <sub>C</sub> = 125°C                      |     | 65   |      |      |
| I <sub>GSS</sub>                    | Gate to Body Leakage Current              | V <sub>GS</sub> = ±30 V, V <sub>DS</sub> = 0 V                       |     |      | ±100 | nA   |

### ON CHARACTERISTICS

|                     |                                      |                                                              |     |     |     |    |
|---------------------|--------------------------------------|--------------------------------------------------------------|-----|-----|-----|----|
| V <sub>GS(th)</sub> | Gate Threshold Voltage               | V <sub>GS</sub> = V <sub>DS</sub> , I <sub>D</sub> = 0.43 mA | 3.0 |     | 5.0 | V  |
| R <sub>DS(on)</sub> | Static Drain to Source On Resistance | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 10 A                |     | 165 | 190 | mΩ |
| g <sub>FS</sub>     | Forward Transconductance             | V <sub>DS</sub> = 20 V, I <sub>D</sub> = 10 A                |     | 11  |     | S  |

### DYNAMIC CHARACTERISTICS

|                        |                                   |                                                                                    |  |      |  |    |
|------------------------|-----------------------------------|------------------------------------------------------------------------------------|--|------|--|----|
| C <sub>iss</sub>       | Input Capacitance                 | V <sub>DS</sub> = 400 V, V <sub>GS</sub> = 0 V, f = 1 MHz                          |  | 1610 |  | pF |
| C <sub>oss</sub>       | Output Capacitance                |                                                                                    |  | 30   |  | pF |
| C <sub>oss(eff.)</sub> | Effective Output Capacitance      | V <sub>DS</sub> = 0 V to 400 V, V <sub>GS</sub> = 0 V                              |  | 316  |  | pF |
| C <sub>oss(er.)</sub>  | Energy Related Output Capacitance | V <sub>DS</sub> = 0 V to 400 V, V <sub>GS</sub> = 0 V                              |  | 59   |  | pF |
| Q <sub>g(tot)</sub>    | Total Gate Charge at 10 V         | V <sub>DS</sub> = 400 V, I <sub>D</sub> = 10 A, V <sub>GS</sub> = 10 V<br>(Note 4) |  | 34   |  | nC |
| Q <sub>gs</sub>        | Gate to Source Gate Charge        |                                                                                    |  | 11   |  | nC |
| Q <sub>gd</sub>        | Gate to Drain "Miller" Charge     |                                                                                    |  | 13   |  | nC |
| ESR                    | Equivalent Series Resistance      | f = 1 MHz                                                                          |  | 6.8  |  | Ω  |

### SWITCHING CHARACTERISTICS

|                     |                     |                                                                                                               |  |    |  |    |
|---------------------|---------------------|---------------------------------------------------------------------------------------------------------------|--|----|--|----|
| t <sub>d(on)</sub>  | Turn-On Delay Time  | V <sub>DD</sub> = 400 V, I <sub>D</sub> = 10 A,<br>V <sub>GS</sub> = 10 V, R <sub>g</sub> = 4.7 Ω<br>(Note 4) |  | 19 |  | ns |
| t <sub>r</sub>      | Turn-On Rise Time   |                                                                                                               |  | 19 |  | ns |
| t <sub>d(off)</sub> | Turn-Off Delay Time |                                                                                                               |  | 58 |  | ns |
| t <sub>f</sub>      | Turn-Off Fall Time  |                                                                                                               |  | 14 |  | ns |

### SOURCE-DRAIN DIODE CHARACTERISTICS

|                 |                                                          |                                                                                    |  |     |    |
|-----------------|----------------------------------------------------------|------------------------------------------------------------------------------------|--|-----|----|
| I <sub>S</sub>  | Maximum Continuous Source to Drain Diode Forward Current |                                                                                    |  | 20  | A  |
| I <sub>SM</sub> | Maximum Pulsed Source to Drain Diode Forward Current     |                                                                                    |  | 50  | A  |
| V <sub>SD</sub> | Source to Drain Diode Forward Voltage                    | V <sub>GS</sub> = 0 V, I <sub>SD</sub> = 10 A                                      |  | 1.3 | V  |
| t <sub>rr</sub> | Reverse Recovery Time                                    | V <sub>DD</sub> = 400 V, I <sub>SD</sub> = 10 A,<br>dI <sub>F</sub> /dt = 100 A/μs |  | 80  | ns |
| Q <sub>rr</sub> | Reverse Recovery Charge                                  |                                                                                    |  | 264 | nC |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

4. Essentially independent of operating temperature typical characteristics.

TYPICAL CHARACTERISTICS

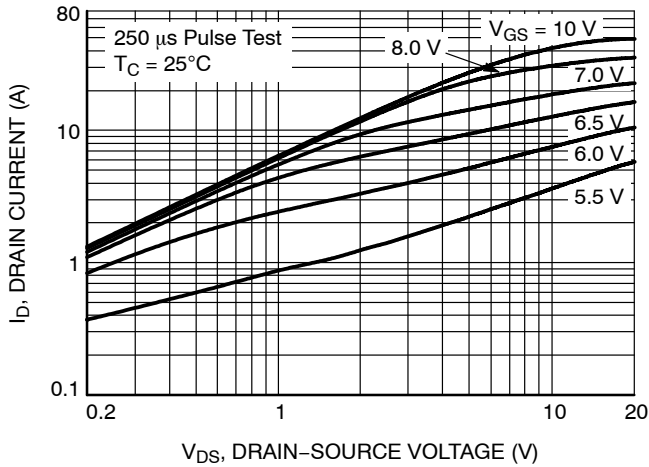


Figure 1. On-Region Characteristics

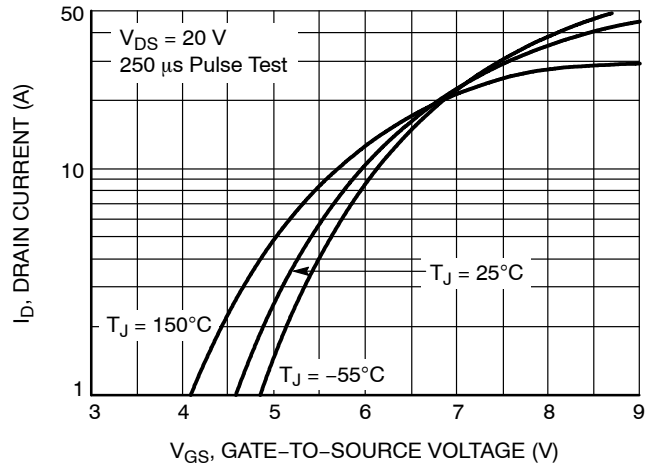


Figure 2. Transfer Characteristics

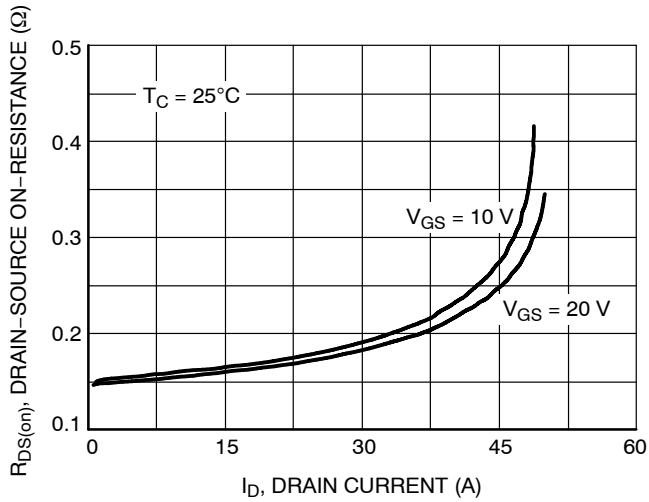


Figure 3. On-Resistance Variation vs. Drain Current and Gate Voltage

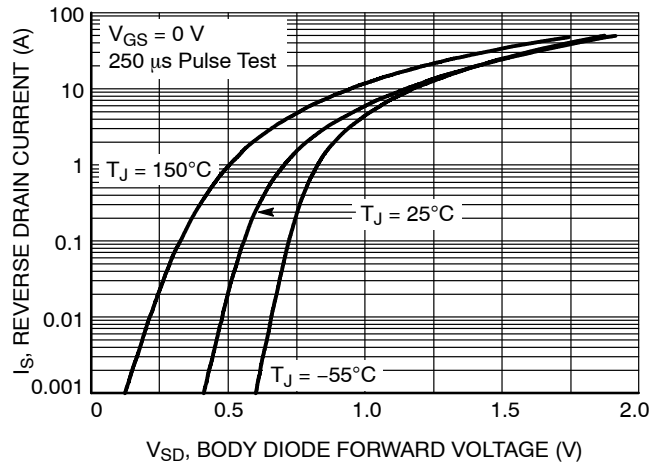


Figure 4. Body Diode Forward Voltage Variation vs. Source Current and Temperature

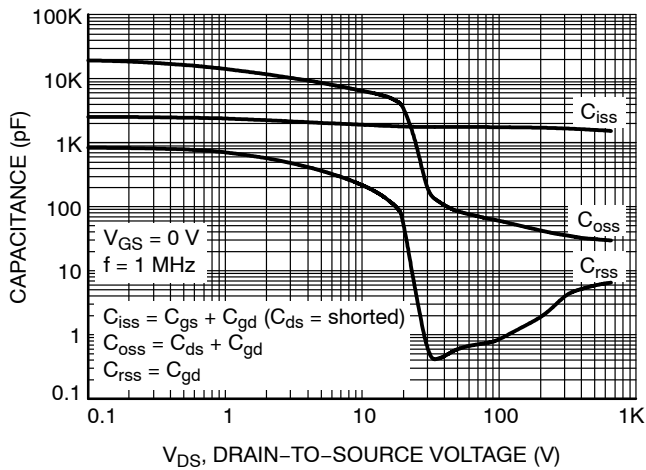


Figure 5. Capacitance Characteristics

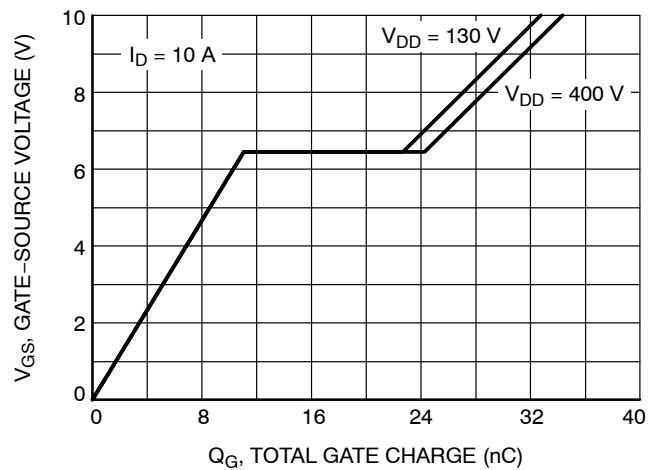


Figure 6. Gate Charge Characteristics

TYPICAL CHARACTERISTICS (continued)

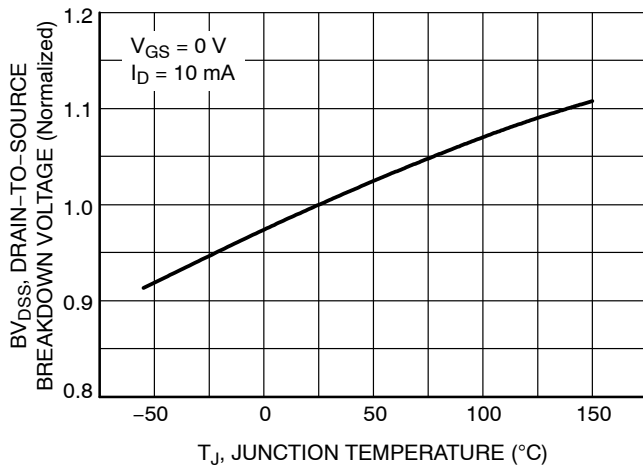


Figure 7. Breakdown Voltage Variation vs. Temperature

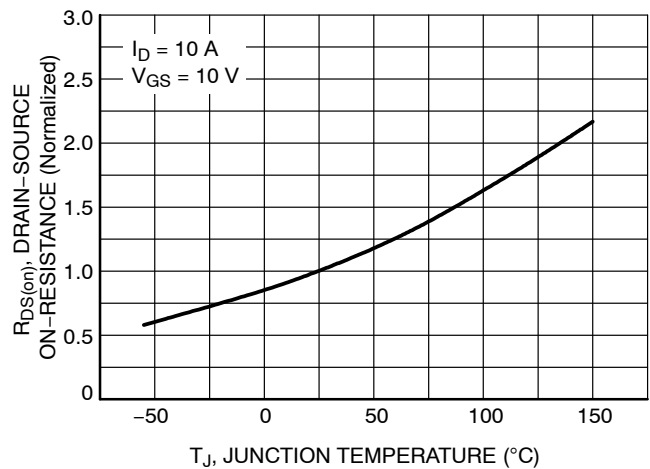


Figure 8. On-Resistance Variation vs. Temperature

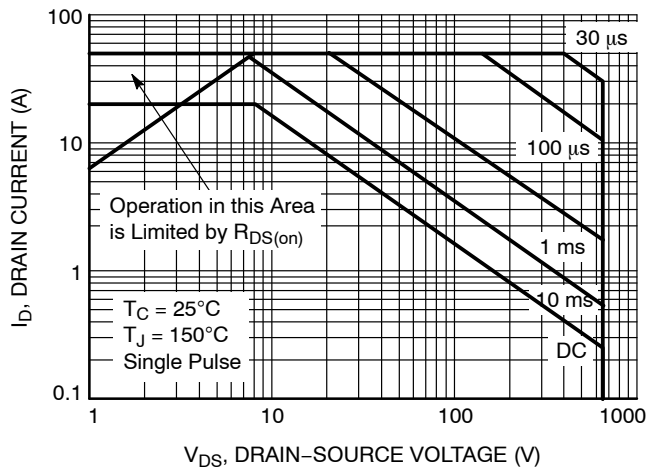


Figure 9. Maximum Safe Operating Area

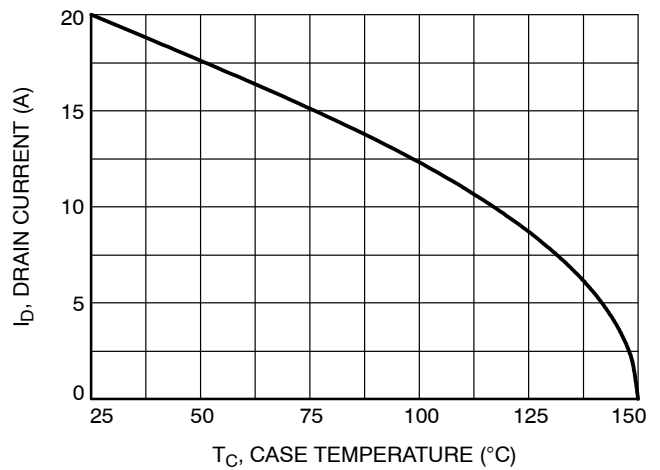


Figure 10. Maximum Drain Current vs. Case Temperature

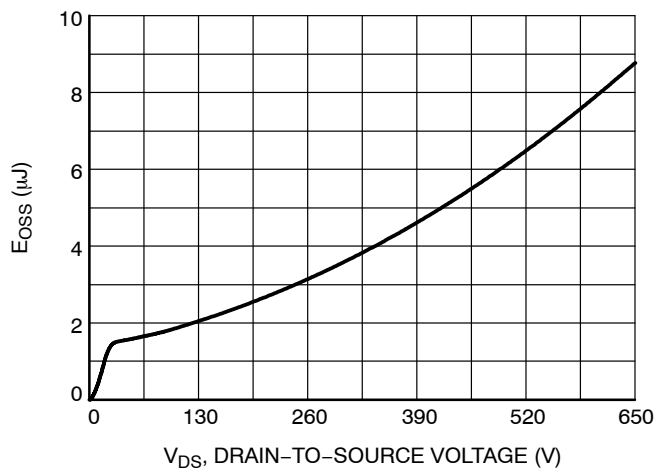


Figure 11.  $E_{OSS}$  vs. Drain-to-Source Voltage

TYPICAL CHARACTERISTICS (continued)

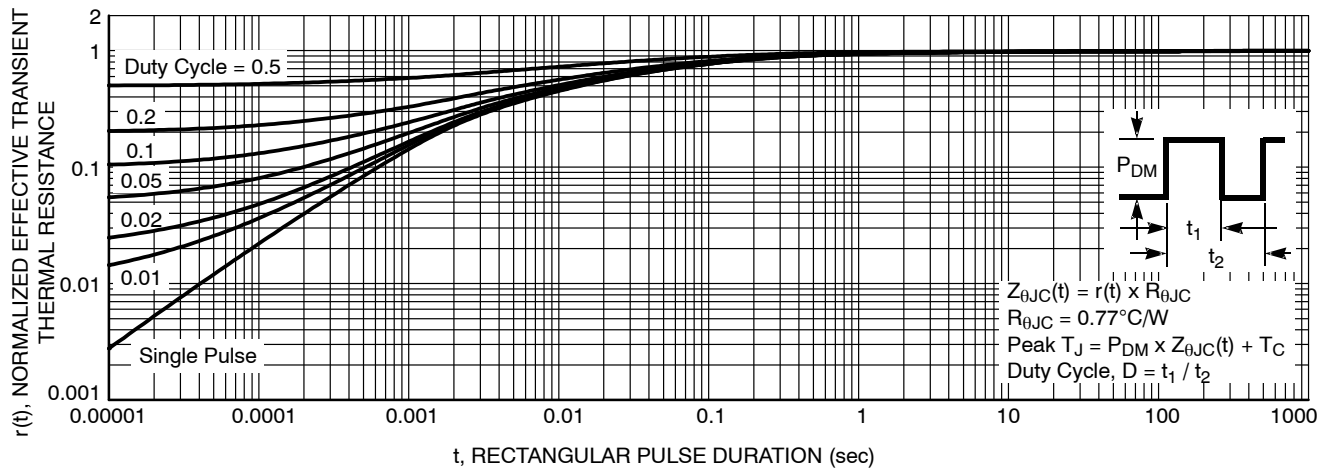


Figure 12. Transient Thermal Response Curve

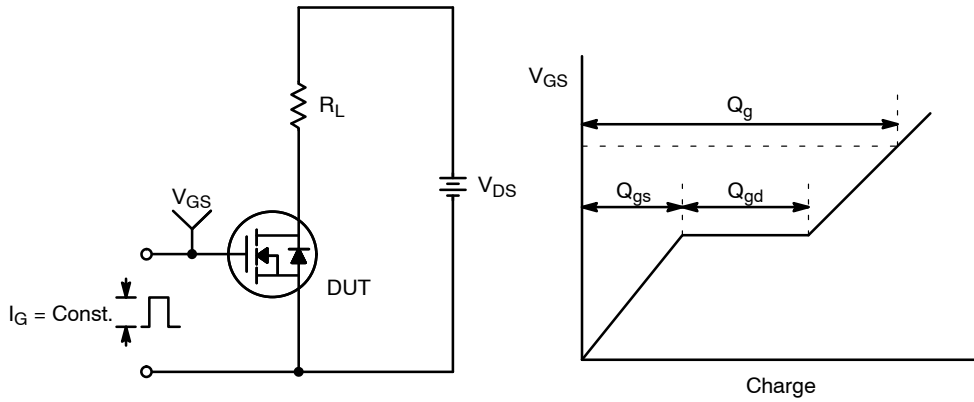


Figure 13. Gate Charge Test Circuit & Waveform

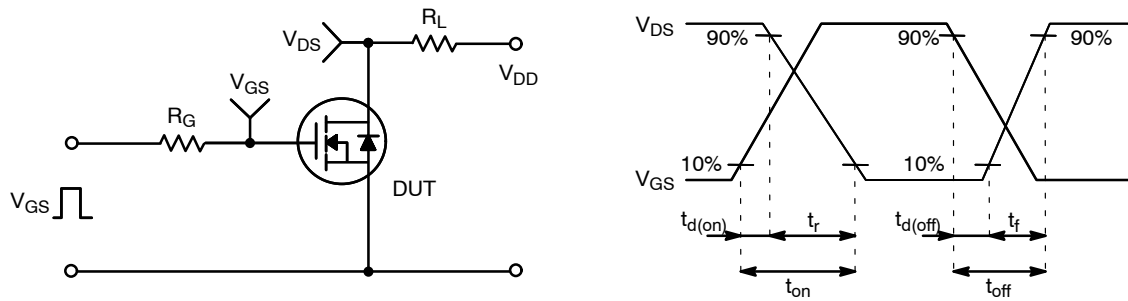


Figure 14. Resistive Switching Test Circuit & Waveforms

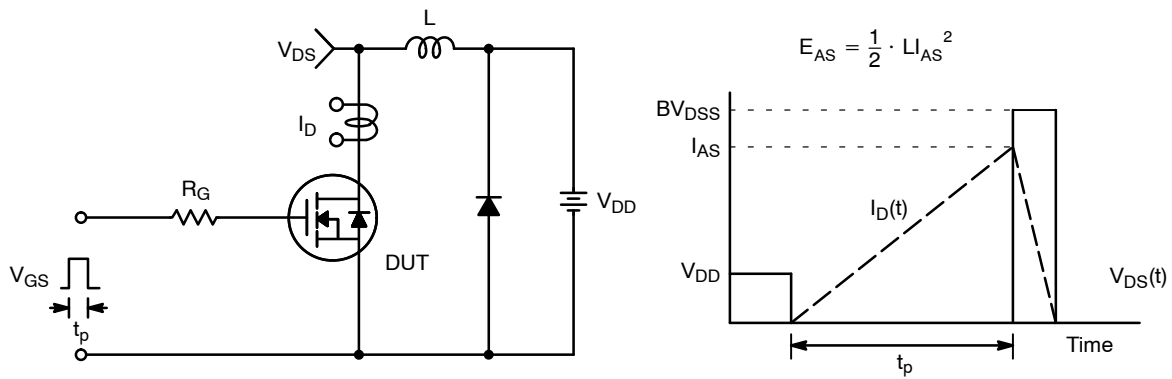
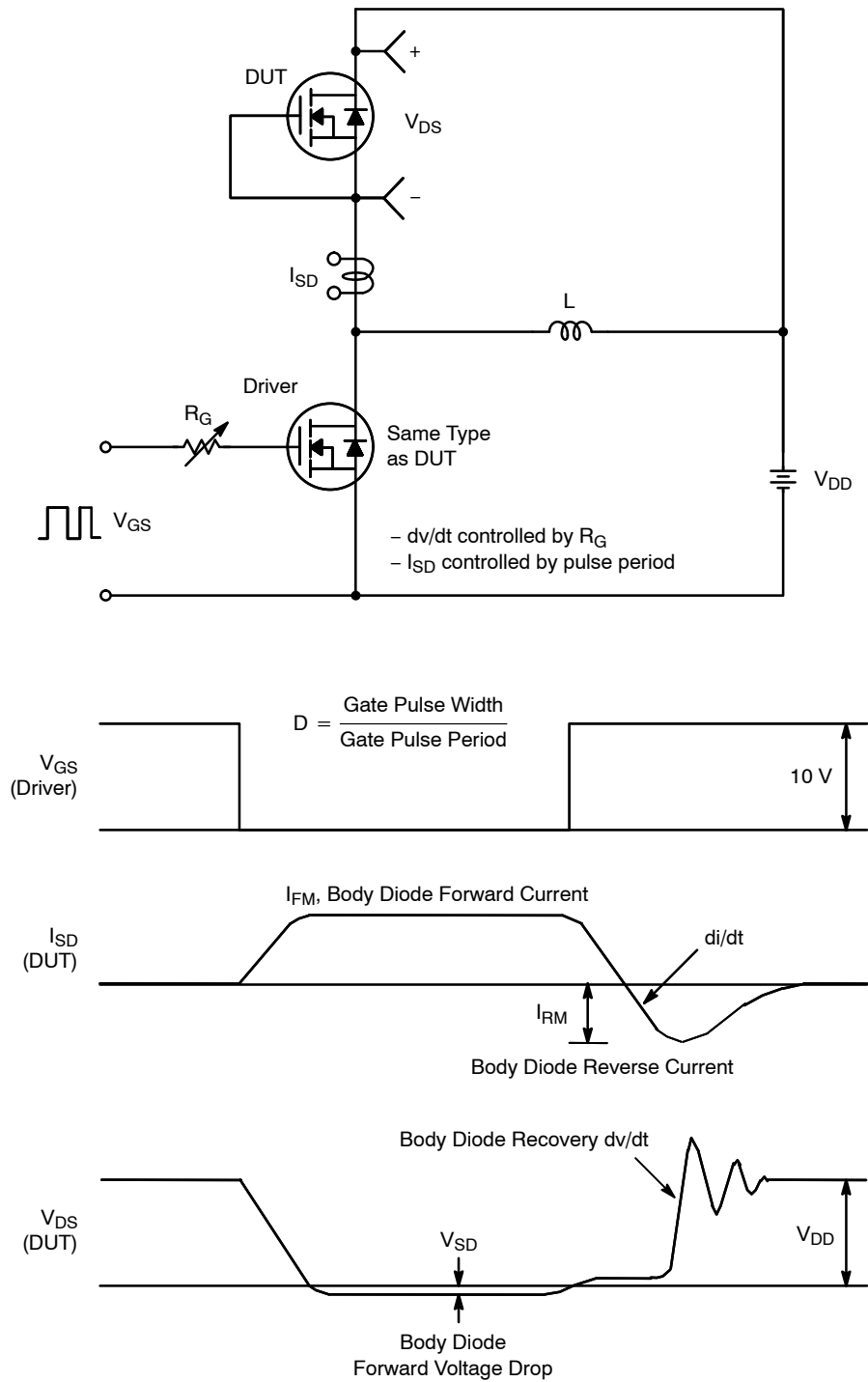


Figure 15. Unclamped Inductive Switching Test Circuit & Waveforms

## NTHL190N65S3HF



**Figure 16. Peak Diode Recovery dv/dt Test Circuit & Waveforms**

### PACKAGE MARKING AND ORDERING INFORMATION

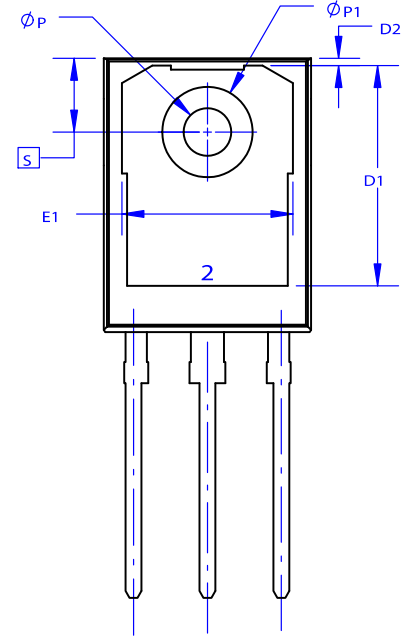
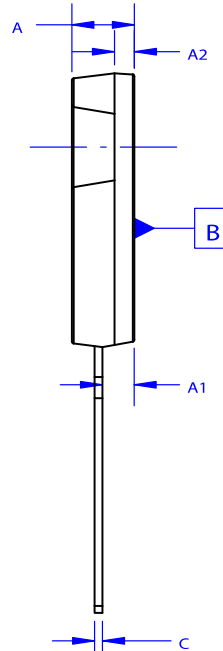
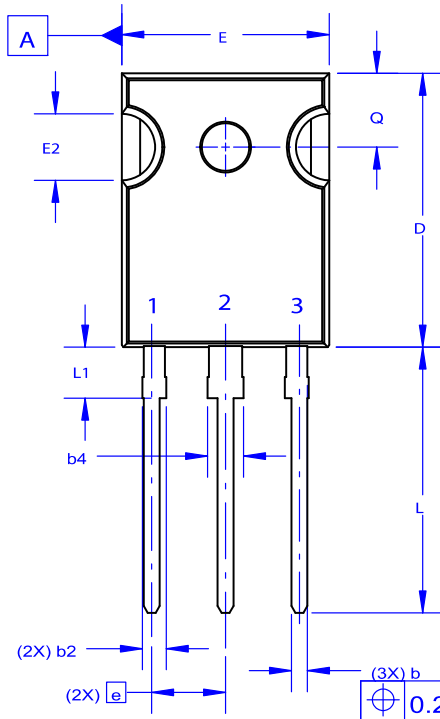
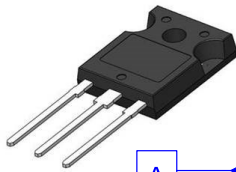
| Part Number    | Top Marking    | Package | Packing Method | Reel Size | Tape Width | Quantity |
|----------------|----------------|---------|----------------|-----------|------------|----------|
| NTHL190N65S3HF | NTHL190N65S3HF | TO-247  | Tube           | N/A       | N/A        | 30 Units |

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**TO-247-3LD**  
**CASE 340CX**  
**ISSUE A**

DATE 06 JUL 2020



NOTES: UNLESS OTHERWISE SPECIFIED.

- A. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.  
B. ALL DIMENSIONS ARE IN MILLIMETERS.  
C. DRAWING CONFORMS TO ASME Y14.5 - 2009.  
D. DIMENSION A1 TO BE MEASURED IN THE REGION DEFINED BY L1.  
E. LEAD FINISH IS UNCONTROLLED IN THE REGION DEFINED BY L1.

**GENERIC**  
**MARKING DIAGRAM\***


XXXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN         | NOM   | MAX   |
| A   | 4.58        | 4.70  | 4.82  |
| A1  | 2.20        | 2.40  | 2.60  |
| A2  | 1.40        | 1.50  | 1.60  |
| D   | 20.32       | 20.57 | 20.82 |
| E   | 15.37       | 15.62 | 15.87 |
| E2  | 4.96        | 5.08  | 5.20  |
| e   | ~           | 5.56  | ~     |
| L   | 19.75       | 20.00 | 20.25 |
| L1  | 3.69        | 3.81  | 3.93  |
| ØP  | 3.51        | 3.58  | 3.65  |
| Q   | 5.34        | 5.46  | 5.58  |
| S   | 5.34        | 5.46  | 5.58  |
| b   | 1.17        | 1.26  | 1.35  |
| b2  | 1.53        | 1.65  | 1.77  |
| b4  | 2.42        | 2.54  | 2.66  |
| c   | 0.51        | 0.61  | 0.71  |
| D1  | 13.08       | ~     | ~     |
| D2  | 0.51        | 0.93  | 1.35  |
| E1  | 12.81       | ~     | ~     |
| ØP1 | 6.60        | 6.80  | 7.00  |

|                         |                    |                                                                                                                                                                                     |
|-------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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