RFP30N06LE, RF1S30N06LE, RF1S30N06LESM

30A, 60V, ESD Rated, Avalanche Rated, Logic Level N-Channel Enhancement-Mode Power MOSFETs

July 1995

Features
- 30A, 60V
- $r_{DS(ON)} = 0.047\, \Omega$
- 2kV ESD Protected
- Temperature Compensating PSPICE Model
- Peak Current vs Pulse Width Curve
- UIS Rating Curve

Description
The RFP30N06LE, RF1S30N06LE and RF1S30N06LESM are N-Channel power MOSFETs manufactured using the MegaFET process. This process, which uses feature sizes approaching those of LSI integrated circuits gives optimum utilization of silicon, resulting in outstanding performance. They were designed for use in applications such as switching regulators, switching converters, motor drivers and relay drivers. These transistors can be operated directly from integrated circuits.

These transistors incorporate ESD protection and are designed to withstand 2kV (Human Body Model) of ESD.

Absolute Maximum Ratings $T_C = +25^\circ C$

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE</th>
<th>BRAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFP30N06LE</td>
<td>TO-220AB</td>
<td>F30N06LE</td>
</tr>
<tr>
<td>RF1S30N06LE</td>
<td>TO-262AA</td>
<td>1S30N06L</td>
</tr>
<tr>
<td>RF1S30N06LESM</td>
<td>TO-263AB</td>
<td>1S30N06L</td>
</tr>
</tbody>
</table>

NOTE: When ordering use the entire part number. Add suffix, 9A, to obtain the TO-263 variant in tape and reel i.e. RF1S30N06LESM9A.

Formerly developmental type TA49027.

Symbol

Absolute Maximum Ratings

- Drain Source Voltage $V_{DSS}$
- Drain Gate Voltage $V_{DGR}$
- Gate Source Voltage $V_{GS}$
- Drain Current $I_D$
- RMS Continuous $I_{DM}$
- Pulsed Drain Current $I_{DM}$
- Pulsed Avalanche Rating $E_{AS}$
- Power Dissipation $P_D$
- Derate above $+25^\circ C$ $P_D$
- Electrostatic Discharge Rating, MIL-STD-883, Category B(2) $ESD$
- Operating and Storage Temperature $T_J$ $T_{STG}$
- Soldering Temperature of Leads for 10s $T_L$

RFP30N06LE, RF1S30N06LE, RF1S30N06LESM

UNITS

60 V
60 V
+10, -8 V
30 A
Refer to Peak Current Curve
Refer to UIS Curve
96 W
0.645 W/°C
2 kV
-55 to +175 °C
260 °C

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**Electrical Specifications**  \( T_C = +25^\circ C, \) Unless Otherwise Specified

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain-Source Breakdown Voltage</td>
<td>( B_{VDS} )</td>
<td>( I_D = 250\mu A, \ V_{GS} = 0V )</td>
<td>60</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Gate Threshold Voltage</td>
<td>( V_{GS(TH)} )</td>
<td>( V_{GS} = V_{DS}, \ I_D = 250\mu A )</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>V</td>
</tr>
<tr>
<td>Zero Gate Voltage Drain Current</td>
<td>( I_{DSS} )</td>
<td>( V_{DS} = 60V, \ V_{GS} = 0V )</td>
<td>T_C = +25°C</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( T_C = +150°C )</td>
<td>-</td>
<td>-</td>
<td>50</td>
<td>µA</td>
</tr>
<tr>
<td>Gate-Source Leakage Current</td>
<td>( I_{GSS} )</td>
<td>( V_{GS} = +10, -8V )</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>µA</td>
</tr>
<tr>
<td>On Resistance</td>
<td>( r_{DS(ON)} )</td>
<td>( I_D = 30A, \ V_{GS} = 5V )</td>
<td>-</td>
<td>-</td>
<td>0.047</td>
<td>Ω</td>
</tr>
<tr>
<td>Turn-On Time</td>
<td>( t_{ON} )</td>
<td>( V_{DD} = 30V, \ I_D = 30A, \ R_L = 1\Omega, \ V_{DS} = 5V, \ V_{GS} = 2.5\Omega )</td>
<td>-</td>
<td>-</td>
<td>140</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-On Delay Time</td>
<td>( t_{D(ON)} )</td>
<td>-</td>
<td>11</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Rise Time</td>
<td>( t_R )</td>
<td>-</td>
<td>88</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Turn-Off Delay Time</td>
<td>( t_{D(OFF)} )</td>
<td>-</td>
<td>30</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Fall Time</td>
<td>( t_F )</td>
<td>-</td>
<td>40</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Turn-Off Time</td>
<td>( t_{OFF} )</td>
<td>-</td>
<td>-</td>
<td>100</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Total Gate Charge</td>
<td>( Q_{G(TOT)} )</td>
<td>( V_{GS} = 0V ) to ( 10V )</td>
<td>( V_{DD} = 48V, \ I_D = 30A, \ R_L = 1.6\Omega )</td>
<td>51</td>
<td>62</td>
<td>nC</td>
</tr>
<tr>
<td>Gate Charge at 5V</td>
<td>( Q_{G(5)} )</td>
<td>( V_{GS} = 0V ) to ( 5V )</td>
<td>-</td>
<td>28</td>
<td>34</td>
<td>nC</td>
</tr>
<tr>
<td>Threshold Gate Charge</td>
<td>( Q_{G(TH)} )</td>
<td>( V_{GS} = 0V ) to ( 1V )</td>
<td>-</td>
<td>1.8</td>
<td>2.6</td>
<td>nC</td>
</tr>
<tr>
<td>Input Capacitance</td>
<td>( C_{ISS} )</td>
<td>( V_{DS} = 25V, \ V_{GS} = 0V, \ f = 1MHz )</td>
<td>-</td>
<td>1350</td>
<td>-</td>
<td>pF</td>
</tr>
<tr>
<td>Output Capacitance</td>
<td>( C_{OSS} )</td>
<td>-</td>
<td>290</td>
<td>-</td>
<td>pF</td>
<td></td>
</tr>
<tr>
<td>Reverse Transfer Capacitance</td>
<td>( C_{RSS} )</td>
<td>-</td>
<td>85</td>
<td>-</td>
<td>pF</td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance Junction to Case</td>
<td>( R_{JUC} )</td>
<td>-</td>
<td>-</td>
<td>1.55 ( ^\circ C/W )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance Junction to Ambient</td>
<td>( R_{JUA} )</td>
<td>-</td>
<td>-</td>
<td>80 ( ^\circ C/W )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Source-Drain Diode Specifications**

<table>
<thead>
<tr>
<th>PARAMETER</th>
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<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Voltage</td>
<td>( V_{SD} )</td>
<td>( I_{SD} = 30A )</td>
<td>-</td>
<td>-</td>
<td>1.5</td>
<td>V</td>
</tr>
<tr>
<td>Reverse Recovery Time</td>
<td>( t_{RR} )</td>
<td>( I_{SD} = 30A, \ dI_{SD}/dt = 100A/\mu s )</td>
<td>-</td>
<td>-</td>
<td>125</td>
<td>ns</td>
</tr>
</tbody>
</table>
Typical Performance Curves

**FIGURE 1. SAFE OPERATING AREA CURVE**

**FIGURE 2. NORMALIZED MAXIMUM TRANSIENT THERMAL IMPEDANCE**

**FIGURE 3. MAXIMUM CONTINUOUS DRAIN CURRENT vs TEMPERATURE**

**FIGURE 4. PEAK CURRENT CAPABILITY**

**FIGURE 5. TYPICAL SATURATION CHARACTERISTICS**

**FIGURE 6. TYPICAL TRANSFER CHARACTERISTICS**
Typical Performance Curves (Continued)

- **Figure 7.** Normalized \( r_{DS(ON)} \) vs Junction Temperature
- **Figure 8.** Normalized Gate Threshold Voltage vs Temperature
- **Figure 9.** Normalized Drain Source Breakdown Voltage vs Temperature
- **Figure 10.** Normalized Power Dissipation vs Temperature Derating Curve
- **Figure 11.** Typical Capacitance vs Drain-To-Source Voltage
- **Figure 12.** Normalized Switching Waveforms for Constant Gate Current. Refer to Harris Application Notes AN7254 and AN7260
Typical Performance Curves (Continued)

\[ t_{AV} = \frac{(L)}{(I_{AS})/(1.3 \times \text{Rated BVDS} - V_{DD})} \]

If \( R = 0 \)

\[ t_{AV} = \frac{(L)}{(R)} \ln \left( \frac{(I_{AS} \times R)}{(1.3 \times \text{Rated BVDS} - V_{DD}) + 1} \right) \]

FIGURE 13. UNCLAMPED INDUCTIVE SWITCHING

Test Circuits and Waveforms

FIGURE 14. UNCLAMPED ENERGY TEST CIRCUIT

FIGURE 15. UNCLAMPED ENERGY WAVEFORMS

FIGURE 16. RESISTIVE SWITCHING TEST CIRCUIT

FIGURE 17. RESISTIVE SWITCHING WAVEFORMS
Temperature Compensated PSPICE Model for the RFP30N06LE, RF1S30N06LE, RF1S30N06LESM

SUBCKT RFP30N06LE 2 1 3; rev 6/2/93

CA 12 8 1 3.34e-9
CB 15 14 3.44e-9
CIN 6 8 0 1.343e-9

DBODY 7 5 DBMOD
DBREAK 5 11 DBKMOD
DESD1 91 9 DESD1MOD
DESD2 91 7 DESD2MOD
DPLCAP 10 5 DPLCAPMOD

EBREAK 11 7 17 18 75.39
EDS 14 8 5 8 1
EGS 13 8 6 8 1
ESG 6 10 6 8 1
EVTO 20 6 18 8 1

IT 8 17 1

LDRAIN 2 5 1e-9
LGATE 1 9 7.22e-9
LSOURCE 3 7 6.31e-9

MOS1 16 6 8 8 MOSMOD M = 0.99
MOS2 16 21 8 8 MOSMOD M = 0.01

RBREAK 17 18 RBKMOD 1
RDRAIN 50 16 RDSMOD 11.86e-3
RGATE 9 20 2.52
RIN 6 8 1e9
RSCL1 5 51 RSLVCMOD 1e-6
RSCL2 5 50 1e3
RSOURCE 8 7 RDSMOD 26.6e-3
RVTO 18 19 RVTOMOD 1

S1A 6 12 13 8 S1AMOD
S1B 13 12 13 8 S1BMOD
S2A 6 15 14 13 S2AMOD
S2B 13 15 14 13 S2BMOD

VBAT 8 19 DC 1
VTO 21 6 0.5

ESCL 51 50 VALUE = (V(V(5,51)/ABS(V(5,51)))*(PWR(V(5,51)*1e6/89,7))

.MODEL DBDMOD D (IS = 3.80e-13 RS = 1.12e-2 TRS1 = 1.61e-3 TRS2 = 6.08e-6 CJO = 1.05e-9 TT = 3.84e-8)
.MODEL DBKMOD D (RS = 1.82e-1 TRS1 = 7.50e-3 TRS2 = 4.0e-5)
.MODEL DESD1MOD D (BV = 13.54 TRB1 = 0.00 TRB2 = 0.00 RS = 1.75e-3 TRS1 = 0.00 TRS2 = 0.00)
.MODEL DESD2MOD D (BV = 11.46 TRB1 = -1.50 TRB2 = -1.50 RS = 4.00e-3 TRS1 = 0.00 TRS2 = 0.00)
.MODEL DPLCAPMOD D (CJO = 0.591e-9 RS = 1.12e-2 TRS1 = 0.00 TRS2 = 0.00)
.MODEL MOSMOD NMOS (VTO = 1.94 KP = 139.2 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u)
.MODEL RBKMOD RES (TC1 = 1.07e-3 TC2 = -3.03e-7)
.MODEL RDSMOD RES (TC1 = 5.38e-3 TC2 = -1.64e-5)
.MODEL RSLVCMD5 RES (TC1 = 1.75e-3 TC2 = 3.90e-6)
.MODEL RVTO RES (TC1 = 2.15e-3 TC2 = -5.43e-6)
.MODEL S1AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -4.05 VOFF = -1.5)
.MODEL S1BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -1.5 VOFF = -4.05)
.MODEL S2AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 2.8 VOFF = 2.8)
.MODEL S2BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 2.8 VOFF = -2.2)

.ENDS