35A, 55V, 0.034 Ohm, N-Channel UltraFET Power MOSFETs

These N-Channel power MOSFETs are manufactured using the innovative UltraFET® process. This advanced process technology achieves the lowest possible on-resistance per silicon area, resulting in outstanding performance. This device is capable of withstanding high energy in the avalanche mode and the diode exhibits very low reverse recovery time and stored charge. It was designed for use in applications where power efficiency is important, such as switching regulators, switching converters, motor drivers, relay drivers, low-voltage bus switches, and power management in portable and battery-operated products.

Formerly developmental type TA75321.

Features
- 35A, 55V
- Simulation Models
  - Temperature Compensated PSPICE® and SABER™ Models
  - Thermal Impedance SPICE and SABER Models
    Available on the WEB at: www.fairchildsemi.com
- Peak Current vs Pulse Width Curve
- UIS Rating Curve
- Related Literature
  - TB334, “Guidelines for Soldering Surface Mount Components to PC Boards”

Symbol

Ordering Information

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE</th>
<th>BRAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUF75321P3</td>
<td>TO-220AB</td>
<td>75321P</td>
</tr>
<tr>
<td>HUF75321S3S</td>
<td>TO-263AB</td>
<td>75321S</td>
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</table>

NOTE: When ordering, use the entire part number. Add the suffix T to obtain the TO-263AB variant in tape and reel, e.g., HUF75321S3ST.

Packaging

JEDEC TO-220AB

JEDEC TO-263AB

Product reliability information can be found at http://www.fairchildsemi.com/products/discrete/reliability/index.html
For severe environments, see our Automotive HUFA series.
All Fairchild semiconductor products are manufactured, assembled and tested under ISO9000 and QS9000 quality systems certification.
**Absolute Maximum Ratings**  \( T_C = 25^\circ C, \text{ Unless Otherwise Specified} \)

- Drain to Source Voltage (Note 1) \( V_{DSS} \) .................................................. \( 55 \) \( V \)
- Drain to Gate Voltage (\( R_{GS} = 20k\Omega \)) (Note 1) \( V_{DGR} \) .................................. \( 55 \) \( V \)
- Gate to Source Voltage \( V_{GS} \) .................................................. \( \pm 20 \) \( V \)
- Drain Current
  - Continuous (Figure 2)  \( I_D \) .................................................. \( 35 \) \( A \)
  - Pulsed Drain Current \( I_{DM} \) .................................................. \( \) Figure 4
- Pulsed Avalanche Rating \( E_{AS} \) .................................................. \( 93 \) \( W \)
- Power Dissipation
  - Derate Above \( 25^\circ C \) .................................................. \( 0.625 \) \( W/^\circ C \)
- Operating and Storage Temperature \( T_J, T_{STG} \) .................................. \(-55 \) to \( 175^\circ C \)
- Maximum Temperature for Soldering
  - Leads at 0.063in (1.6mm) from Case for 10s \( T_L \) .................................. \( 300^\circ C \)
  - Package Body for 10s, See Techbrief 334 \( T_{pkg} \) .................................. \( 260^\circ C \)

**CAUTION:** Stresses above those listed in “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

**NOTE:**
1. \( T_J = 25^\circ C \) to \( 150^\circ C \).

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

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
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<td>OFF STATE SPECIFICATIONS</td>
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<tr>
<td>Drain to Source Breakdown Voltage</td>
<td>( B_{V_{DSS}} )</td>
<td>( I_D = 250\mu A, V_{GS} = 0V ) (Figure 11)</td>
<td>55</td>
<td>-</td>
<td>-</td>
<td>( V )</td>
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<tr>
<td>Zero Gate Voltage Drain Current</td>
<td>( I_{DSS} )</td>
<td>( V_{DS} = 50V, V_{GS} = 0V )</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>( \mu A )</td>
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<tr>
<td></td>
<td></td>
<td>( V_{DS} = 45V, V_{GS} = 0V, T_C = 150^\circ C )</td>
<td>-</td>
<td>-</td>
<td>250</td>
<td>( \mu A )</td>
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<tr>
<td>Gate to Source Leakage Current</td>
<td>( I_{GSS} )</td>
<td>( V_{GS} = \pm 20V )</td>
<td>-</td>
<td>-</td>
<td>( \pm 100 )</td>
<td>( nA )</td>
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<tr>
<td>ON STATE SPECIFICATIONS</td>
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</tr>
<tr>
<td>Gate to Source Threshold Voltage</td>
<td>( V_{GS(TH)} )</td>
<td>( V_{GS} = V_{DS}, I_D = 250\mu A ) (Figure 10)</td>
<td>2</td>
<td>-</td>
<td>4</td>
<td>( V )</td>
</tr>
<tr>
<td>Drain to Source On Resistance</td>
<td>( r_{DS(ON)} )</td>
<td>( I_D = 35A, V_{GS} = 10V ) (Figure 9)</td>
<td>-</td>
<td>0.028</td>
<td>0.034</td>
<td>( \Omega )</td>
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<tr>
<td>THERMAL SPECIFICATIONS</td>
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<tr>
<td>Thermal Resistance Junction to Case</td>
<td>( R_{JUC} )</td>
<td>(Figure 3)</td>
<td>-</td>
<td>-</td>
<td>1.6</td>
<td>( ^\circ C/W )</td>
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<tr>
<td>Thermal Resistance Junction to Ambient</td>
<td>( R_{JUA} )</td>
<td>TO-220, TO-263</td>
<td>-</td>
<td>-</td>
<td>62</td>
<td>( ^\circ C/W )</td>
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<td>SWITCHING SPECIFICATIONS ( (V_{GS} = 10V) )</td>
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<td>Turn-On Time</td>
<td>( t_{ON} )</td>
<td>( V_{DD} = 30V, I_D = 35A, R_L = 0.86\Omega, V_{GS} = 10V, R_{GS} = 25\Omega )</td>
<td>-</td>
<td>-</td>
<td>100</td>
<td>( ns )</td>
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<tr>
<td>Turn-On Delay Time</td>
<td>( t_{d(ON)} )</td>
<td>-</td>
<td>11</td>
<td>-</td>
<td>( ns )</td>
<td></td>
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<tr>
<td>Rise Time</td>
<td>( t_r )</td>
<td>-</td>
<td>55</td>
<td>-</td>
<td>( ns )</td>
<td></td>
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<tr>
<td>Turn-Off Delay Time</td>
<td>( t_{d(OFF)} )</td>
<td>-</td>
<td>47</td>
<td>-</td>
<td>( ns )</td>
<td></td>
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<tr>
<td>Fall Time</td>
<td>( t_f )</td>
<td>-</td>
<td>66</td>
<td>-</td>
<td>( ns )</td>
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<tr>
<td>Turn-Off Time</td>
<td>( t_{OFF} )</td>
<td>-</td>
<td>170</td>
<td>-</td>
<td>( ns )</td>
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<td>GATE CHARGE SPECIFICATIONS</td>
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<tr>
<td>Total Gate Charge</td>
<td>( Q_{g(TOT)} )</td>
<td>( V_{GS} = 0V ) to ( 20V )</td>
<td>-</td>
<td>36</td>
<td>44</td>
<td>( nC )</td>
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<tr>
<td>Gate Charge at 10V</td>
<td>( Q_{g(10)} )</td>
<td>( V_{GS} = 0V ) to ( 10V )</td>
<td>-</td>
<td>21</td>
<td>26</td>
<td>( nC )</td>
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<tr>
<td>Threshold Gate Charge</td>
<td>( Q_{g(TH)} )</td>
<td>( V_{GS} = 0V ) to ( 2V )</td>
<td>-</td>
<td>1.3</td>
<td>1.6</td>
<td>( nC )</td>
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<td>Gate to Source Gate Charge</td>
<td>( Q_{gs} )</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>( nC )</td>
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<tr>
<td>Reverse Transfer Capacitance</td>
<td>( Q_{gd} )</td>
<td>-</td>
<td>9</td>
<td>-</td>
<td>( nC )</td>
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Electrical Specifications  \( T_C = 25^\circ C \), Unless Otherwise Specified

<table>
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<th>PARAMETER</th>
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<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
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<tbody>
<tr>
<td>Input Capacitance</td>
<td>( C_{ISS} )</td>
<td>( V_{DS} = 25V, V_{GS} = 0V, f = 1MHz )</td>
<td>-</td>
<td>680</td>
<td>-</td>
<td>pF</td>
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<tr>
<td>Output Capacitance</td>
<td>( C_{OSS} )</td>
<td>(Figure 12)</td>
<td>-</td>
<td>270</td>
<td>-</td>
<td>pF</td>
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<tr>
<td>Reverse Transfer Capacitance</td>
<td>( C_{RSS} )</td>
<td>-</td>
<td>60</td>
<td>-</td>
<td>pF</td>
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Source to Drain Diode Specifications

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<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
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<tbody>
<tr>
<td>Source to Drain Diode Voltage</td>
<td>( V_{SD} )</td>
<td>( I_{SD} = 35A )</td>
<td>-</td>
<td>-</td>
<td>1.25</td>
<td>V</td>
</tr>
<tr>
<td>Reverse Recovery Time</td>
<td>( t_{tr} )</td>
<td>( I_{SD} = 35A, \frac{dI_{SD}}{dt} = 100A/\mu s )</td>
<td>-</td>
<td>-</td>
<td>59</td>
<td>ns</td>
</tr>
<tr>
<td>Reverse recovered Charge</td>
<td>( Q_{RR} )</td>
<td>( I_{SD} = 35A, \frac{dI_{SD}}{dt} = 100A/\mu s )</td>
<td>-</td>
<td>-</td>
<td>82</td>
<td>nC</td>
</tr>
</tbody>
</table>

Typical Performance Curves

![Normalized Power Dissipation vs Case Temperature](image1)

![Maximum Continuous Drain Current vs Case Temperature](image2)

![Normalized Maximum Transient Thermal Impedance](image3)

**FIGURE 1.** NORMALIZED POWER DISSIPATION vs CASE TEMPERATURE

**FIGURE 2.** MAXIMUM CONTINUOUS DRAIN CURRENT vs CASE TEMPERATURE

**FIGURE 3.** NORMALIZED MAXIMUM TRANSIENT THERMAL IMPEDANCE

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HUF75321P3, HUF75321S3S Rev. B
Typical Performance Curves (Continued)

FIGURE 4. PEAK CURRENT CAPABILITY

FOR TEMPERATURES ABOVE 25°C DERATE PEAK CURRENT AS FOLLOWS:

\[ I = I_{25} \times \left( \frac{150 - T_C}{175 - T_C} \right) \]

NOTE: Refer to Fairchild Application Notes AN9321 and AN9322.

FIGURE 5. FORWARD BIAS SAFE OPERATING AREA

FIGURE 6. UNCLAMPED INDUCTIVE SWITCHING CAPABILITY

FIGURE 7. SATURATION CHARACTERISTICS

FIGURE 8. TRANSFER CHARACTERISTICS
**Typical Performance Curves** (Continued)

**FIGURE 9.** NORMALIZED DRAIN TO SOURCE ON RESISTANCE vs JUNCTION TEMPERATURE

**FIGURE 10.** NORMALIZED GATE THRESHOLD VOLTAGE vs JUNCTION TEMPERATURE

**FIGURE 11.** NORMALIZED DRAIN TO SOURCE BREAKDOWN VOLTAGE vs JUNCTION TEMPERATURE

**FIGURE 12.** CAPACITANCE vs DRAIN TO SOURCE VOLTAGE

**FIGURE 13.** GATE CHARGE WAVEFORMS FOR CONSTANT GATE CURRENT

**NOTE:** Refer to Fairchild Application Notes AN7254 and AN7260.

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HUF75321P3, HUF75321S3S Rev. B
Test Circuits and Waveforms

FIGURE 14. UNCLAMPED ENERGY TEST CIRCUIT

FIGURE 15. UNCLAMPED ENERGY WAVEFORMS

FIGURE 16. GATE CHARGE TEST CIRCUIT

FIGURE 17. GATE CHARGE WAVEFORM

FIGURE 18. SWITCHING TIME TEST CIRCUIT

FIGURE 19. RESISTIVE SWITCHING WAVEFORMS


PSPICE Electrical Model

```
.SUBCKT HUF75321P 2 1 3 ; rev 4/29/98

CA  12  8 9.96e-10
CB  15  14 9.83e-10
CIN 6  8 6.18e-10
DBODY 7 5 DBODYMOD
DBREAK 11 12 DBREAKMOD
DPLCAP 10 5 DPLCAPMOD

EBREAK 11 17 18 59.54
EDS  14  8 9 1
EGS 13  8 6 8 1
ESG  6 10 6 8 1
EVTHRES 6 21 19 8 1
EVTEMP 20 6 18 22 1

IT  8 17 1
LDRAIN 2.5 1e-9
LGATE 1 9 3.57e-9
LSOURCE 3 7 4.25e-9

MMED 16 8 8 MMEDMOD
MSTRO 16 8 8 MSTROMOD
MWEAK 16 21 8 8 MWEAKMOD

RBREAK 17 18 RBREAKMOD 1
RDRN 50 16 RDRNMOD 5.50e-3
RGLATE 9 9 2.25
RLDRAIN 2 5 10
RLSOURCE 3 7 42.5
RSCLC1 5 51 RSCLCMOD 1e-6
RSCLC2 5 50 1e3
RSOURCE 8 7 RSOURCMOD 16.30e-3
RVTHRES 22 8 RVTHRESMOD 1
RVTEMP 18 19 RVTEMPMOD 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 22 19 DC 1

ESLC 51 50 VALUE={(V(5,51)/ABS(V(5,51)))*(PWR(V(5,51)/(1e-6*101),2.5))}

.MODEL DBODYMOD D (IS = 7.47e-13 RS = 6.45e-3 TRS1 = 2.01e-3 TRS2 = 1.21e-6 CJO = 1.02e-9 TT = 3.21e-8 M = 0.50)
.MODEL DBREAKMOD D (RS = 2.01e-1 TRS1 = 3.62e-3 TRS2 = 6.01e-7)
.MODEL DPLCAPMOD D (CJO = 9.0e-10 IS = 1e-30 N = 10 M = 0.85)
.MODEL MMEDMOD NMOS (VTO = 3.25 KP = 1.75 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 2.25)
.MODEL MSTROMOD NMOS (VTO = 3.65 KP = 32.00 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u)
.MODEL MWEAKMOD NMOS (VTO = 2.91 KP = 0.07 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 22.5 RS = 0.1)
.MODEL RBREAKMOD RES (TC1 = 1.05e-1 TC2 = 1.21e-7)
.MODEL RDRNMOD RES (TC1 = 2.40e-2 TC2 = 1.02e-6)
.MODEL RSCLCMOD RES (TC1 = 2.07e-4 TC2 = 4.67e-5)
.MODEL RSOURCMOD RES (TC1 = 0 TC2 = 0)
.MODEL RVTHRESMOD RES (TC = -3.01e-3 TC2 = -8.85e-6)
.MODEL RVTEMPMOD RES (TC = -1.96e-3 TC2 = 1.39e-6)

.MODEL S1AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -7.85 VOFF = -8.85)
.MODEL S1BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -4.85 VOFF = -7.85)
.MODEL S2AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 0.00 VOFF = 3.00)
.MODEL S2BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 3.00 VOFF = 0.00)

.ENDS


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HUF75321P3, HUF75321S3S Rev. B
SABER Electrical Model

REV April 1998

template huf75321p n2, n1, n3
electrical n2, n1, n3

\{
  \text{var iscl}
  \text{d..model dbodymod = (is = 7.47e-13, cjo = 1.02e-9, tt = 3.21e-8, m = 0.5)}
  \text{d..model dbreakmod = ()}
  \text{d..model dplcapmod = (cjo = 9e-10, is = 1e-30, n = 10, m = 0.85)}
  \text{m..model mmedmod = (type = _n, vto = 3.25, kp = 1.75, is = 1e-30, tox = 1)}
  \text{m..model mstrongmod = (type = _n, vto = 3.65, kp = 32, is = 1e-30, tox = 1)}
  \text{m..model mweakmod = (type = _n, vto = 2.91, kp = 0.07, is = 1e-30, tox = 1)}
  \text{sw_vcsp..model s1amod = (ron = 1e-5, roff = 0.1, von = -7.85, voff = -4.85)}
  \text{sw_vcsp..model s1bmod = (ron = 1e-5, roff = 0.1, von = -4.85, voff = -7.85)}
  \text{sw_vcsp..model s2amod = (ron = 1e-5, roff = 0.1, von = 0, voff = 3.0)}
  \text{sw_vcsp..model s2bmod = (ron = 1e-5, roff = 0.1, von = 3.0, voff = 0)}
\}

c.ca n12 n8 = 9.96e-10
    c.cb n15 n14 = 9.83e-10
    c.cin n6 n8 = 6.18e-10

d.dbody n7 n71 = model=dbodymod
d.dbreak n72 n11 = model=dbreakmod
d.dplcap n10 n5 = model=dplcapmod

i.it n8 n17 = 1

l.ldrain n2 n5 = 1e-9
    l.lgate n1 n9 = 3.57e-9
    l.lsourc n3 n7 = 4.25e-9

m.mmed n16 n6 n8 n8 = model=mmedmod, l = 1u, w = 1u
    m.mstrong n16 n6 n8 n8 = model=mstrongmod, l = 1u, w = 1u
    m.mweak n16 n21 n8 n8 = model=mweakmod, l = 1u, w = 1u

res.dbreak n17 n18 = 1, t cl = 1.05e-3, t c2 = 1.21e-7
    res.rbody n7 n5 = 6.45e-3, t cl = 2.01e-3, t c2 = 1.21e-6
    res.rdbreak n72 n5 = 2.01e-1, t cl = 3.62e-3, t c2 = 6.01e-7
    res.rdrain n50 n16 = 5.5e-3, t cl = 2.4e-2, t c2 = 1.02e-6
    res.rgate n9 n20 = 2.25
    res.rfdrain n2 n5 = 10
    res.rfgate n1 n9 = 35.7
    res.rlsourc n3 n7 = 42.5
    res.rlscl n5 n51 = 1e-6, t cl = 2.07e-4, t c2 = 4.67e-5
    res.rlscl2 n5 n50 = 1e3
    res.rsource n8 n7 = 16.3e-3, t cl = 0, t c2 = 0
    res.rvtemp n18 n19 = 1, t cl = -1.96e-3, t c2 = 1.39e-6
    res.rvthres n22 n8 = 1, t cl = -3.01e-3, t c2 = -8.85e-6

spe.ebreak n11 n7 n17 n18 = 59.54
    spe.eds n14 n8 n5 n8 = 1
    spe.egs n13 n8 n6 n8 = 1
    spe.esg n6 n10 n6 n8 = 1
    spe.evtemp n20 n8 n18 n22 = 1
    spe.evthres n6 n21 n19 n8 = 1

sw_vcsp.s1a n6 n12 n13 n8 = model=s1amod
    sw_vcsp.s1b n6 n12 n13 n8 = model=s1bmod
    sw_vcsp.s2a n6 n15 n14 n13 = model=s2amod
    sw_vcsp.s2b n13 n15 n14 n13 = model=s2bmod

v.vbat n22 n19 = dc = 1

\text{equations} \{
  \text{i (n51->n50) + = iscl}
  \text{iscl: v(n51,n50) = ((v(n5,n51)/(1e-9+abs(v(n5,n51))))*abs(v(n5,n51)*1e6/101)**2.5))}
\}\
**SPICE Thermal Model**

REV 24 February 1999

HUF75321P

CTHERM1 th 6 2.7e-3
CTHERM2 6 5 3.7e-3
CTHERM3 5 4 1.2e-2
CTHERM4 4 3 3.8e-3
CTHERM5 3 2 1.4e-2
CTHERM6 2 tl 10.55

RTHERM1 th 6 1.10e-2
RTHERM2 6 5 2.72e-2
RTHERM3 5 4 7.67e-2
RTHERM4 4 3 4.30e-1
RTHERM5 3 2 6.49e-1
RTHERM6 2 tl 8.61e-2

**SABER Thermal Model**

SABER thermal model HUF75321P

template thermal._model th tl
thermal_c th, tl
{
ctherm.ctherm1 th 6 = 2.7e-3
ctherm.ctherm2 6 5 = 3.7e-3
ctherm.ctherm3 5 4 = 1.2e-2
ctherm.ctherm4 4 3 = 3.8e-3
ctherm.ctherm5 3 2 = 1.4e-2
ctherm.ctherm6 2 tl = 10.55

rtherm.rtherm1 th 6 = 1.10e-3
rtherm.rtherm2 6 5 = 2.72e-2
rtherm.rtherm3 5 4 = 7.67e-2
rtherm.rtherm4 4 3 = 4.30e-1
rtherm.rtherm5 3 2 = 6.49e-1
rtherm.rtherm6 2 tl = 8.61e-2
}

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HUF75321P3, HUF75321S3S Rev. B
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### PRODUCT STATUS DEFINITIONS

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<td>This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.</td>
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