TOSHIBA Field Effect Transistor Silicon N, P Channel MOS Type (π−MOSVI/U−MOSII)

# TPC8402

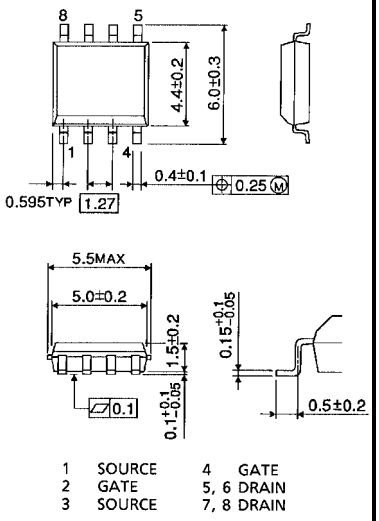
Lithium Ion Secondary Battery Applications

Notebook PCs

Portable Equipment Applications

- Low drain−source ON resistance
  : P Channel $R_{DS\ (ON)}$ = 27 mΩ (typ.)
  N Channel $R_{DS\ (ON)}$ = 37 mΩ (typ.)
- High forward transfer admittance
  : P Channel $|Y_{fs}|$ = 7 S (typ.)
  N Channel $|Y_{fs}|$ = 6 S (typ.)
- Low leakage current
  : P Channel $I_{DSS}$ = −10 μA ($V_{DS}$ = −30 V)
  N Channel $I_{DSS}$ = 10 μA ($V_{DS}$ = 30 V)
- Enhancement−mode
  : P Channel $V_{th}$ = −0.8~ −2.0 V ($V_{DS}$ = −10 V, $I_D$ = −1mA)
  N Channel $V_{th}$ = 0.8~2.0 V ($V_{DS}$ = 10 V, $I_D$ = 1mA)

Unit: mm



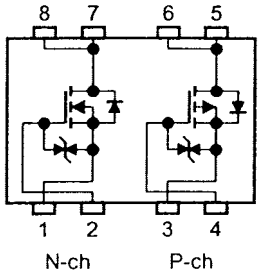

| | |
|---|---|
| JEDEC | — |
| JEITA | — |
| TOSHIBA | 2-6J1E |

Weight: 0.080 g (typ.)

## Maximum Ratings (Ta = 25°C)

| Characteristics | | Symbol | Rating | | Unit |
|---|---|---|---|---|---|
| | | | P Channel | N Channel | |
| Drain-source voltage | | $V_{DSS}$ | −30 | 30 | V |
| Drain-gate voltage ($R_{GS}$ = 20 kΩ) | | $V_{DGR}$ | −30 | 30 | V |
| Gate-source voltage | | $V_{GSS}$ | ±20 | ±20 | V |
| Drain current | DC (Note 1) | $I_D$ | −4.5 | 5 | A |
| | Pulse (Note 1) | $I_{DP}$ | −18 | 20 | |
| Drain power dissipation (t = 10s) (Note 2a) | Single-device operation (Note 3a) | $P_{D\ (1)}$ | 1.5 | 1.5 | W |
| | Single-device value at dual operation (Note 3b) | $P_{D\ (2)}$ | 1.0 | 1.0 | |
| Drain power dissipation (t = 10s) (Note 2b) | Single-device operation (Note 3a) | $P_{D\ (1)}$ | 0.75 | 0.75 | |
| | Single-device value at dual operation (Note 3b) | $P_{D\ (2)}$ | 0.45 | 0.45 | |
| Single pulse avalanche energy | | $E_{AS}$ | 26.3 (Note 4a) | 32.5 (Note 4b) | mJ |
| Avalanche current | | $I_{AR}$ | −4.5 | 5 | A |
| Repetitive avalanche energy Single-device value at operation (Note 2a, Note 3b, Note 5) | | $E_{AR}$ | 0.10 | | mJ |
| Channel temperature | | $T_{ch}$ | 150 | | °C |
| Storage temperature range | | $T_{stg}$ | −55~150 | | °C |

## Circuit Configuration



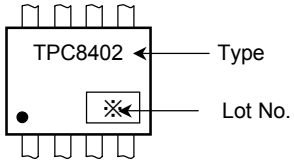

Note: For (Note 1), (Note 2a), (Note 2b), (Note 3a), (Note 3b), (Note 4a), (Note 4b) and (Note 5), please refer to the next page.

This transistor is an electrostatic sensitive device. Please handle with caution.

## Thermal Characteristics

| Characteristics | | Symbol | Max | Unit |
|---|---|---|---|---|
| Thermal resistance, channel to ambient (t = 10s) (Note 2a) | Single-device operation (Note 3a) | $R_{th\ (ch\text{-}a)\ (1)}$ | 83.3 | °C/W |
| | Single-device value at dual operation (Note 3b) | $R_{th\ (ch\text{-}a)\ (2)}$ | 125 | |
| Thermal resistance, channel to ambient (t = 10s) (Note 2b) | Single-device operation (Note 3a) | $R_{th\ (ch\text{-}a)\ (1)}$ | 167 | |
| | Single-device value at dual operation (Note 3b) | $R_{th\ (ch\text{-}a)\ (2)}$ | 278 | |

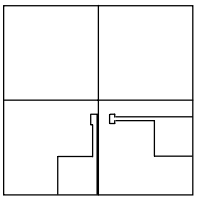
## Marking




Note 1: Please use devices on condition that the channel temperature is below 150°C.

Note 2:

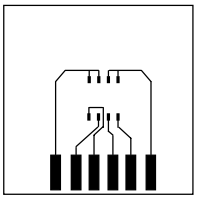
a) Device mounted on a glass-epoxy board (a)



FR-4
25.4 × 25.4 × 0.8
(unit: mm)

(a)

b) Device mounted on a glass-epoxy board (b)



FR-4
25.4 × 25.4 × 0.8
(unit: mm)

(b)

Note 3:

a) The power dissipation and thermal resistance values are shown for a single device (During single-device operation, power is only applied to one device.)

b) The power dissipation and thermal resistance values are shown for a single device (During dual operation, power is evenly applied to both devices.)

Note 4:

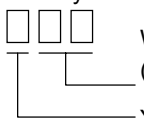
a) $V_{DD}$ = −24 V, $T_{ch}$ = 25°C (Initial), L = 1.0 mH, $R_G$ = 25 Ω, $I_{AR}$ = −4.5 A

b) $V_{DD}$ = 24 V, $T_{ch}$ = 25°C (Initial), L = 1.0 mH, $R_G$ = 25 Ω, $I_{AR}$ = 5.0 A

Note 5: Repetitive rating: pulse width limited by maximum channel temperature

Note 6: • on lower left of the marking indicates Pin 1.

※ Weekly code:(Three digits)

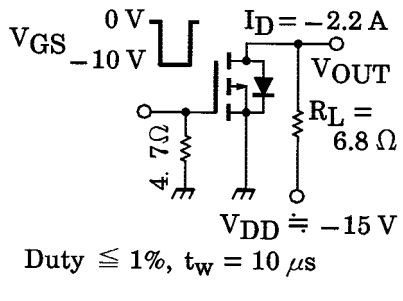


Week of manufacture
(01 for first week of year, continues up to 52 or 53)

Year of manufacture
(One low-order digits of calendar year)

## P-0ch

## Electrical Characteristics (Ta = 25°C)

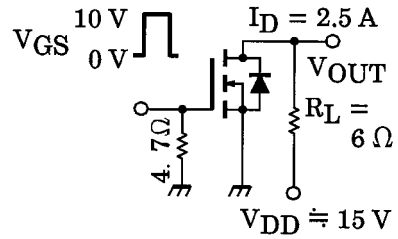
| Characteristics | | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Gate leakage current | | $I_{GSS}$ | $V_{GS}$ = ±16 V, $V_{DS}$ = 0 V | — | — | ±10 | μA |
| Drain cut−OFF current | | $I_{DSS}$ | $V_{DS}$ = −30 V, $V_{GS}$ = 0 V | — | — | −10 | μA |
| Drain−source breakdown voltage | | $V_{(BR)\ DSS}$ | $I_D$ = −10 mA, $V_{GS}$ = 0 V | −30 | — | — | V |
| | | $V_{(BR)\ DSX}$ | $I_D$ = −10 mA, $V_{GS}$ = 20 V | −15 | — | — | |
| Gate threshold voltage | | $V_{th}$ | $V_{DS}$ = −10 V, $I_D$ = −1 mA | −0.8 | — | −2.0 | V |
| Drain−source ON resistance | | $R_{DS\ (ON)}$ | $V_{GS}$ = −4 V, $I_D$ = −2.2 A | — | 55 | 65 | mΩ |
| | | $R_{DS\ (ON)}$ | $V_{GS}$ = −10 V, $I_D$ = −2.2 A | — | 27 | 35 | |
| Forward transfer admittance | | $\|Y_{fs}\|$ | $V_{DS}$ = −10 V, $I_D$ = −2.2 A | 3.5 | 7 | — | S |
| Input capacitance | | $C_{iss}$ | $V_{DS}$ = −10 V, $V_{GS}$ = 0 V, f = 1 MHz | — | 970 | — | pF |
| Reverse transfer capacitance | | $C_{rss}$ | | — | 180 | — | |
| Output capacitance | | $C_{oss}$ | | — | 370 | — | |
| Switching time | Rise time | $t_r$ |  | — | 17 | — | ns |
| | Turn−ON time | $t_{on}$ | | — | 20 | — | |
| | Fall time | $t_f$ | | — | 75 | — | |
| | Turn−OFF time | $t_{off}$ | | — | 160 | — | |
| Total gate charge (Gate−source plus gate−drain) | | $Q_g$ | $V_{DD}$ ≈ −24 V, $V_{GS}$ = −10 V, $I_D$ = −4.5 A | — | 28 | — | nC |
| Gate−source charge 1 | | $Q_{gs1}$ | | — | 6 | — | |
| Gate−drain (“miller”) charge | | $Q_{gd}$ | | — | 12 | — | |

## Source−Drain Ratings and Characteristics (Ta = 25°C)

| Characteristics | | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Drain reverse current | Pulse (Note 1) | $I_{DRP}$ | — | — | — | −18 | A |
| Forward voltage (diode) | | $V_{DSF}$ | $I_{DR}$ = −4.5 A, $V_{GS}$ = 0 V | — | — | 1.2 | V |

## N-ch

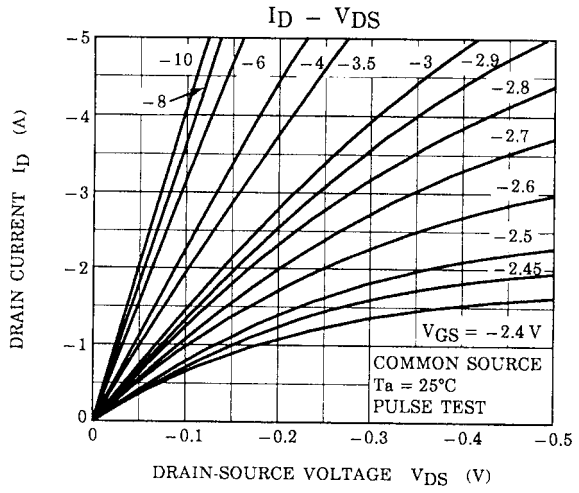
## Electrical Characteristics (Ta = 25°C)

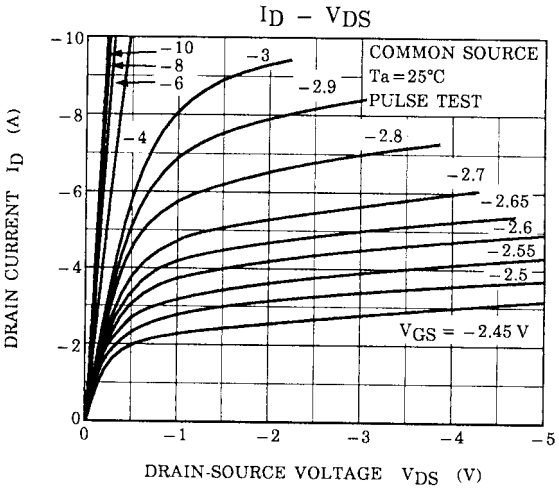
| Characteristics | | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Gate leakage current | | $I_{GSS}$ | $V_{GS}$ = ±16 V, $V_{DS}$ = 0 V | — | — | ±10 | μA |
| Drain cut−OFF current | | $I_{DSS}$ | $V_{DS}$ = 30 V, $V_{GS}$ = 0 V | — | — | 10 | μA |
| Drain−source breakdown voltage | | $V_{(BR)\ DSS}$ | $I_D$ = 10 mA, $V_{GS}$ = 0 V | 30 | — | — | V |
| Gate threshold voltage | | $V_{th}$ | $V_{DS}$ = 10 V, $I_D$ = 1 mA | 0.8 | — | 2.0 | V |
| Drain−source ON resistance | | $R_{DS\ (ON)}$ | $V_{GS}$ = 4 V, $I_D$ = 2.5 A | — | 58 | 80 | mΩ |
| | | $R_{DS\ (ON)}$ | $V_{GS}$ = 10 V, $I_D$ = 2.5 A | — | 37 | 50 | mΩ |
| Forward transfer admittance | | $\|Y_{fs}\|$ | $V_{DS}$ = 10 V, $I_D$ = 2.5 A | 3 | 6 | — | S |
| Input capacitance | | $C_{iss}$ | $V_{DS}$ = 10 V, $V_{GS}$ = 0 V, f = 1 MHz | — | 475 | — | pF |
| Reverse transfer capacitance | | $C_{rss}$ | | — | 85 | — | |
| Output capacitance | | $C_{oss}$ | | — | 270 | — | |
| Switching time | Rise time | $t_r$ |   | — | 10 | — | ns |
| | Turn−ON time | $t_{on}$ | | — | 16 | — | |
| | Fall time | $t_f$ | | — | 13 | — | |
| | Turn−OFF time | $t_{off}$ | | — | 70 | — | |
| Total gate charge (Gate−source plus gate−drain) | | $Q_g$ | $V_{DD}$ ≈ 24 V, $V_{GS}$ = 10 V, $I_D$ = 5 A | — | 16 | — | nC |
| Gate−source charge 1 | | $Q_{gs1}$ | | — | 11 | — | |
| Gate−drain (“miller”) charge | | $Q_{gd}$ | | — | 5 | — | |

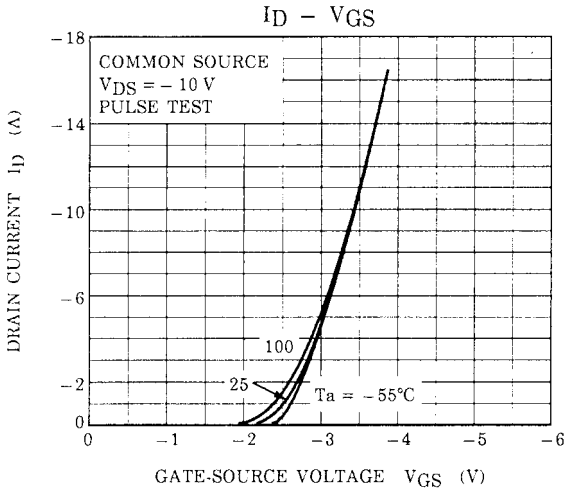
## Source−Drain Ratings and Characteristics (Ta = 25°C)

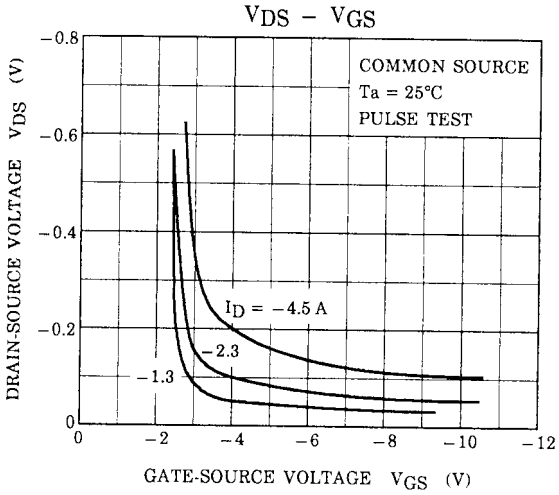
| Characteristics | | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Drain reverse current | Pulse (Note 1) | $I_{DRP}$ | — | — | — | 20 | A |
| Forward voltage (diode) | | $V_{DSF}$ | $I_{DR}$ = 6 A, $V_{GS}$ = 0 V | — | — | −1.2 | V |

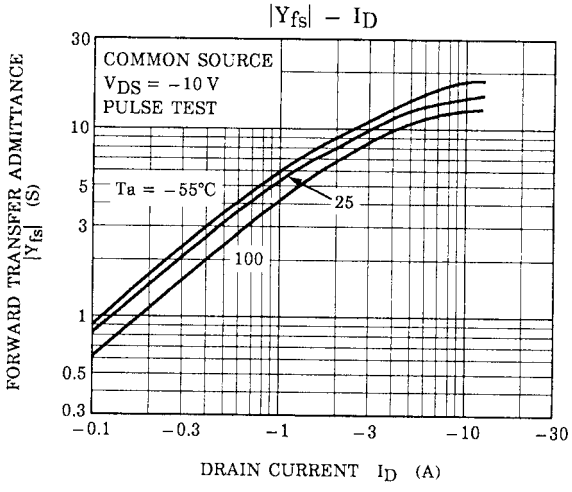
**P-ch**

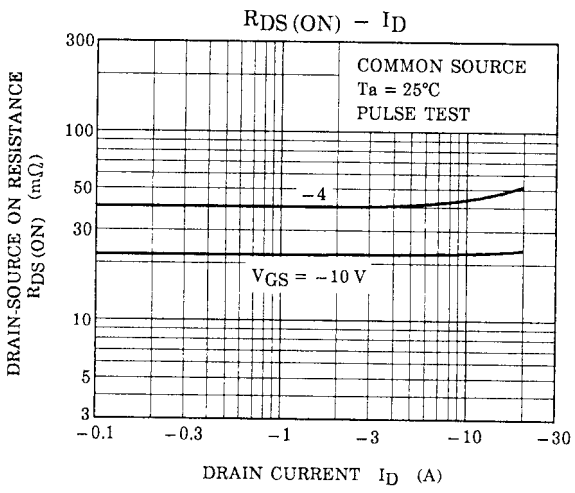

$I_D$ – $V_{DS}$
DRAIN CURRENT $I_D$ (A)
DRAIN-SOURCE VOLTAGE $V_{DS}$ (V)
−10
−8
−6
−4
−3.5
−3
−2.9
−2.8
−2.7
−2.6
−2.5
−2.45
$V_{GS}$ = −2.4 V
COMMON SOURCE
Ta = 25°C
PULSE TEST


$I_D$ – $V_{DS}$
DRAIN CURRENT $I_D$ (A)
DRAIN-SOURCE VOLTAGE $V_{DS}$ (V)
COMMON SOURCE
Ta = 25°C
PULSE TEST
−10
−8
−6
−4
−3
−2.9
−2.8
−2.7
−2.65
−2.6
−2.55
−2.5
$V_{GS}$ = −2.45 V


$I_D$ – $V_{GS}$
DRAIN CURRENT $I_D$ (A)
GATE-SOURCE VOLTAGE $V_{GS}$ (V)
COMMON SOURCE
$V_{DS}$ = − 10 V
PULSE TEST
100
25
Ta = −55°C

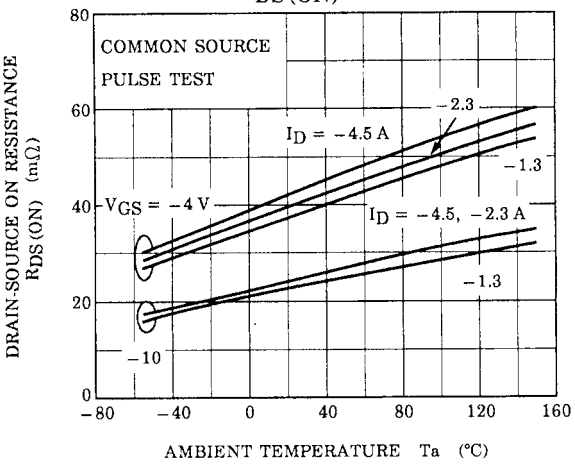

$V_{DS}$ – $V_{GS}$
DRAIN-SOURCE VOLTAGE $V_{DS}$ (V)
GATE-SOURCE VOLTAGE $V_{GS}$ (V)
COMMON SOURCE
Ta = 25°C
PULSE TEST
$I_D$ = −4.5 A
−2.3
−1.3


$|Y_{fs}|$ – $I_D$
FORWARD TRANSFER ADMITTANCE $|Y_{fs}|$ (S)
DRAIN CURRENT $I_D$ (A)
COMMON SOURCE
$V_{DS}$ = −10 V
PULSE TEST
Ta = −55°C
25
100

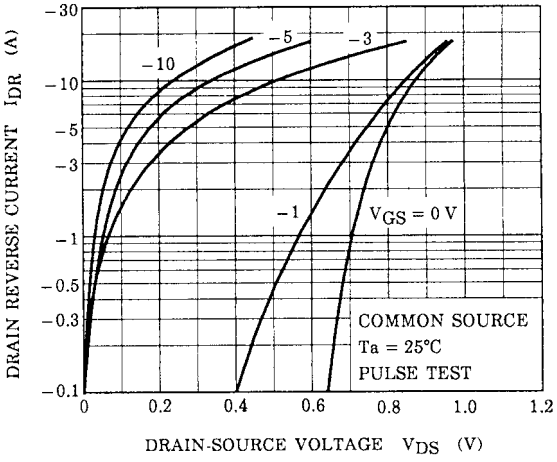

$R_{DS\,(ON)}$ – $I_D$
DRAIN-SOURCE ON RESISTANCE $R_{DS\,(ON)}$ (mΩ)
DRAIN CURRENT $I_D$ (A)
COMMON SOURCE
Ta = 25°C
PULSE TEST
−4
$V_{GS}$ = −10 V

**P-ch**

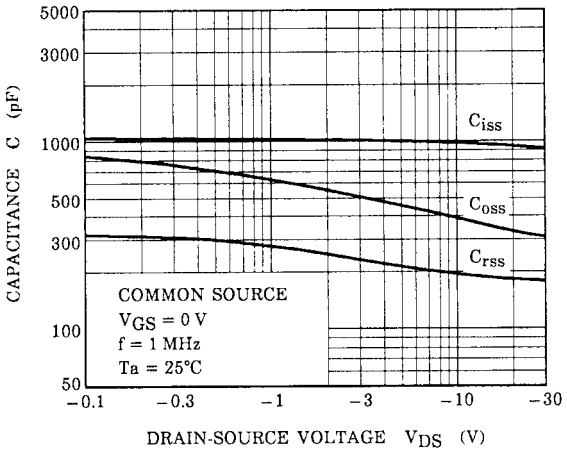
$R_{DS\,(ON)}$ – Ta



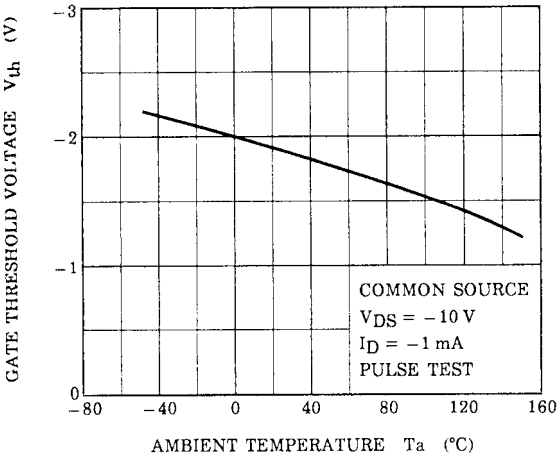

$I_{DR}$ – $V_{DS}$



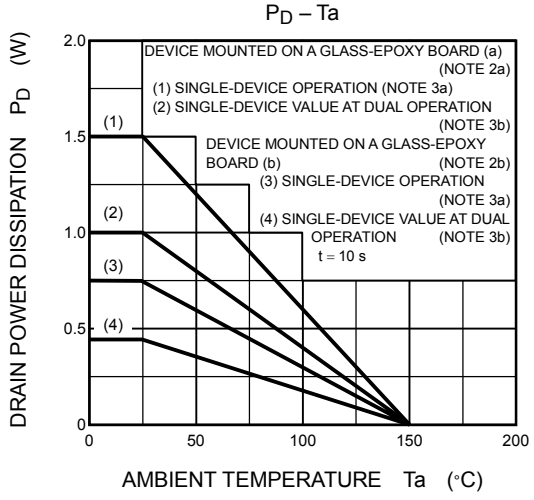

CAPACITANCE – $V_{DS}$



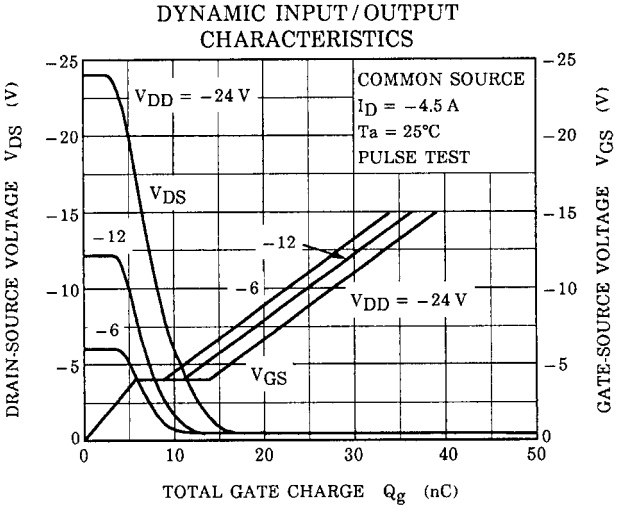

$V_{th}$ – Ta




$P_D$ – Ta

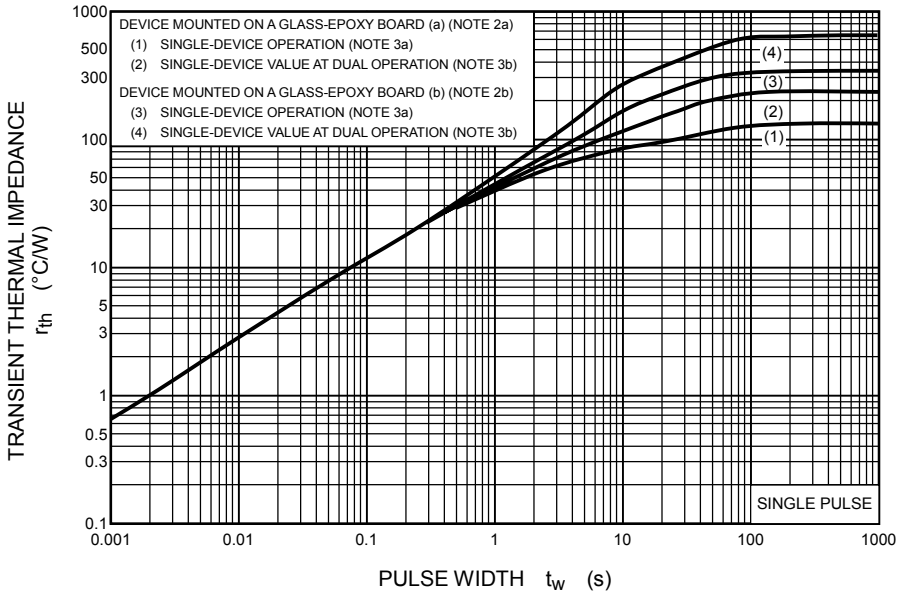



DYNAMIC INPUT / OUTPUT CHARACTERISTICS

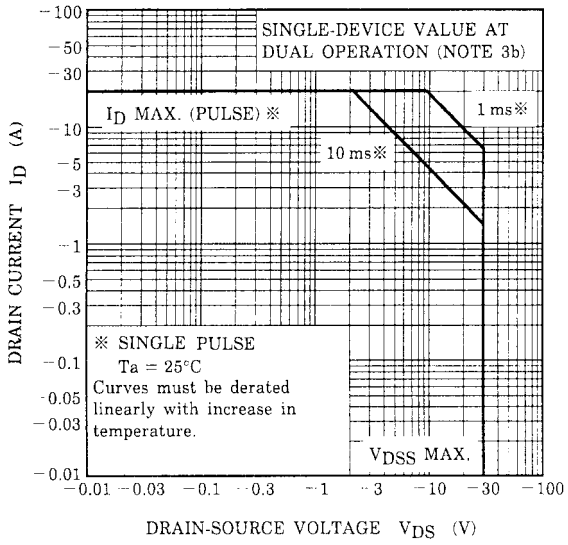


**P-ch**

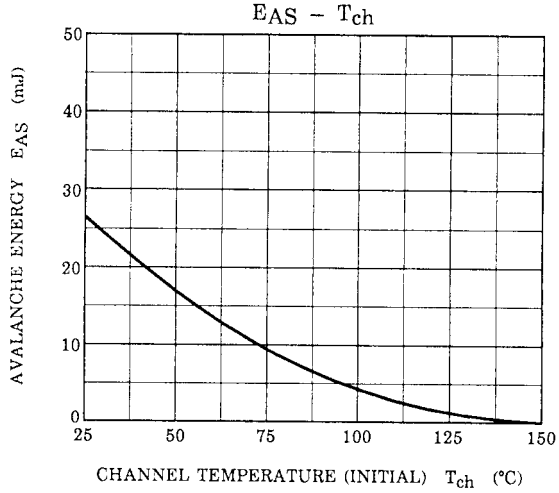
$r_{th} - t_w$

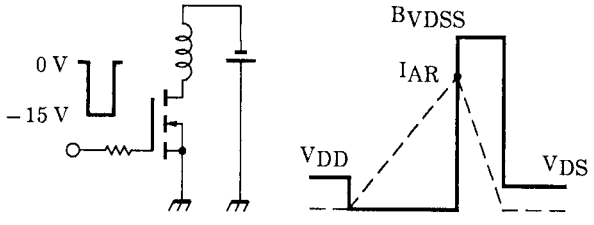



SAFE OPERATING AREA




$E_{AS} - T_{ch}$



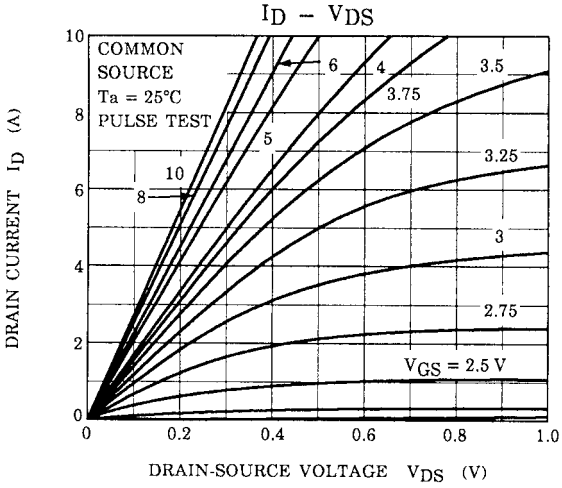




$T_{ch}$ = 25°C (Initial)
Peak $I_{AR}$ = −4.5 A, $R_G$ = 25 Ω
$V_{DD}$ = −24 V, L = 1.0 mH

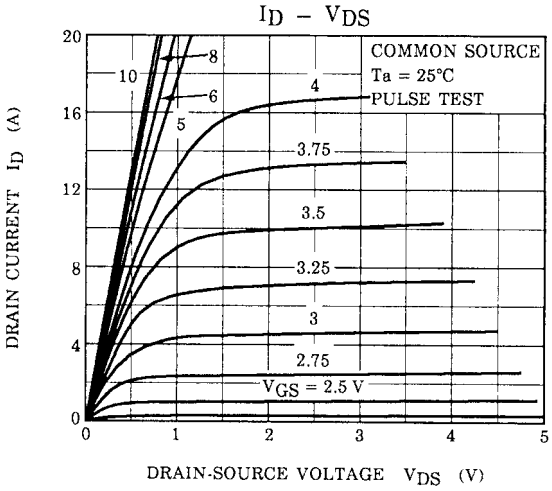
$$E_{AS} = \frac{1}{2} \cdot L \cdot I^2 \cdot \left( \frac{B_{VDSS}}{B_{VDSS} - V_{DD}} \right)$$

**N-ch**

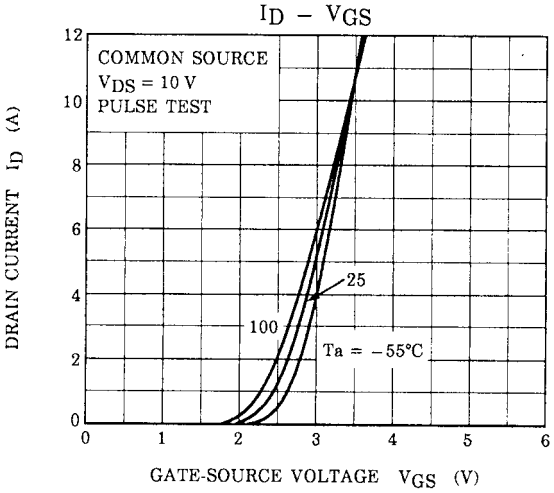
$I_D$ – $V_{DS}$



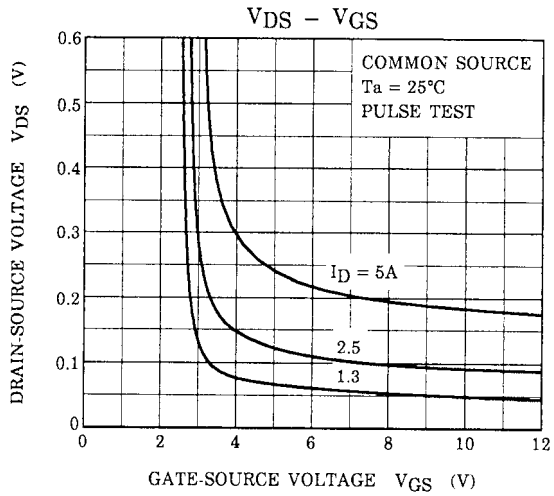

$I_D$ – $V_{DS}$



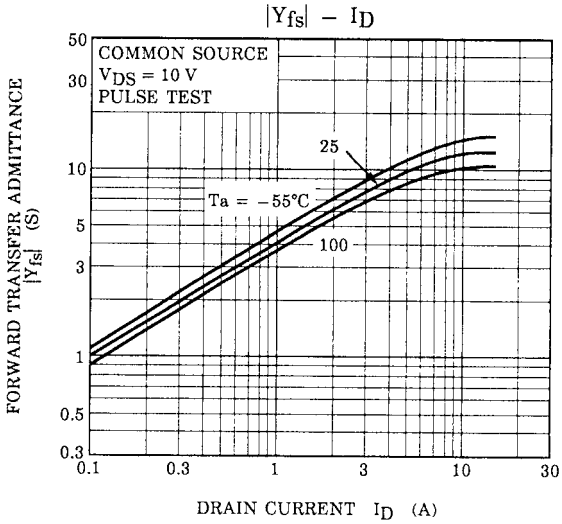

$I_D$ – $V_{GS}$



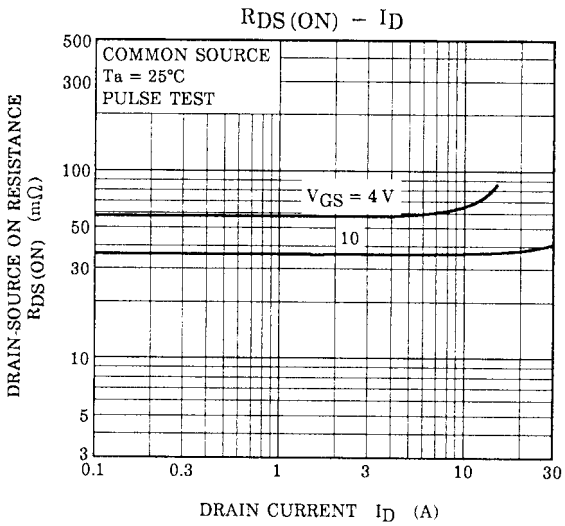

$V_{DS}$ – $V_{GS}$




$|Y_{fs}|$ – $I_D$

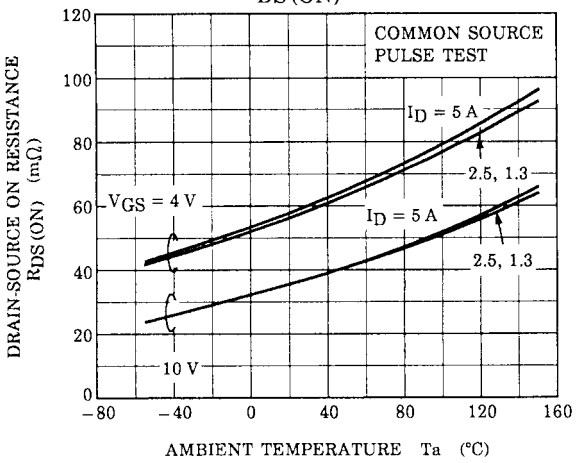



$R_{DS\,(ON)}$ – $I_D$

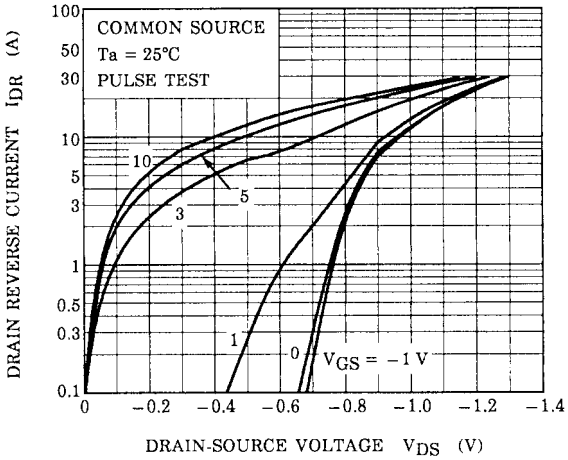


**N-ch**

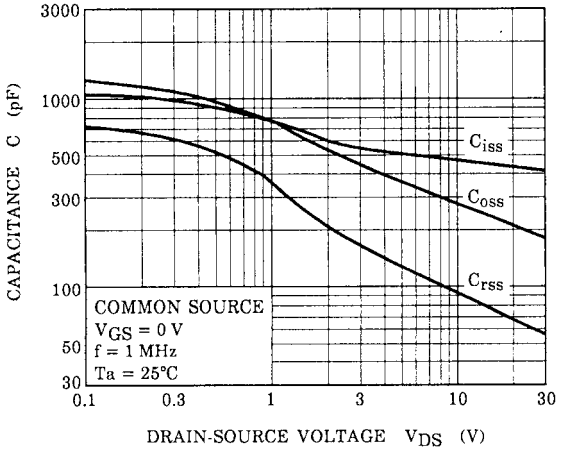
$R_{DS\,(ON)}$ – Ta



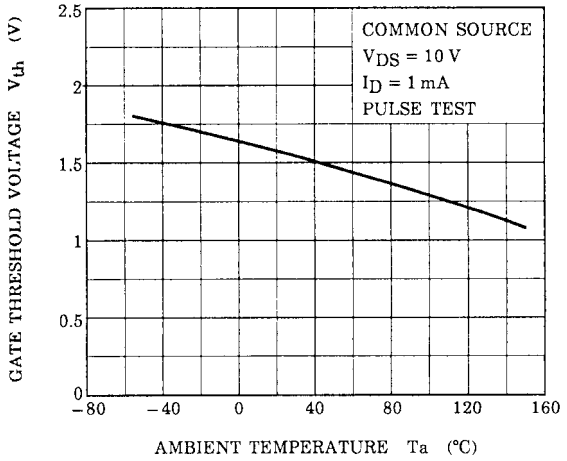

$I_{DR}$ – $V_{DS}$



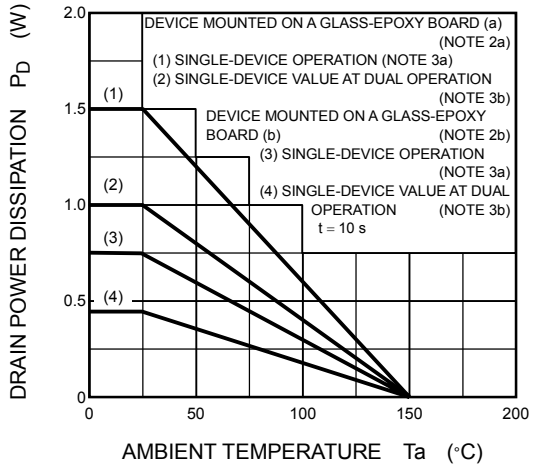

CAPACITANCE – $V_{DS}$



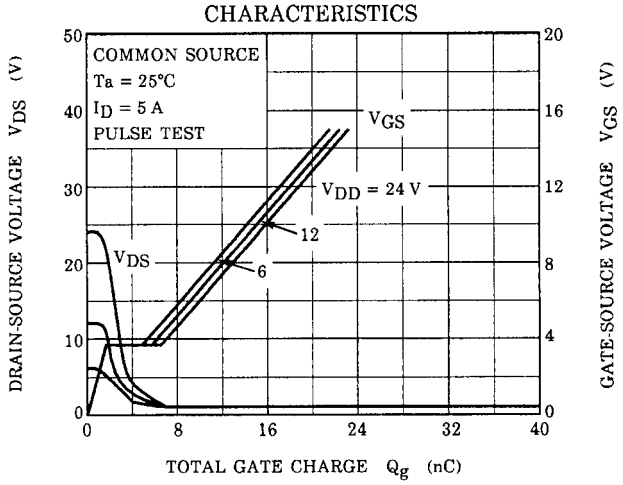

$V_{th}$ – Ta




$P_D$ – Ta

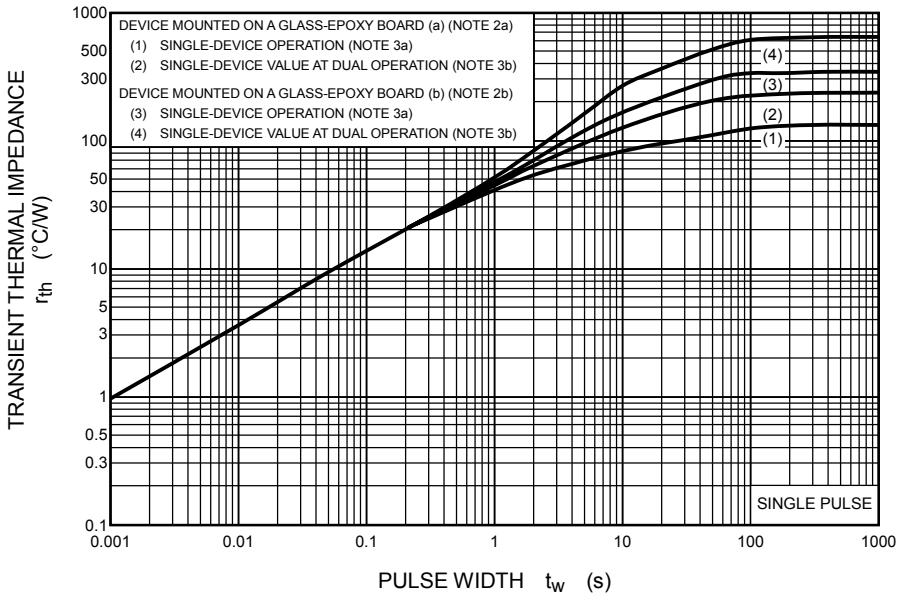



DYNAMIC INPUT / OUTPUT CHARACTERISTICS

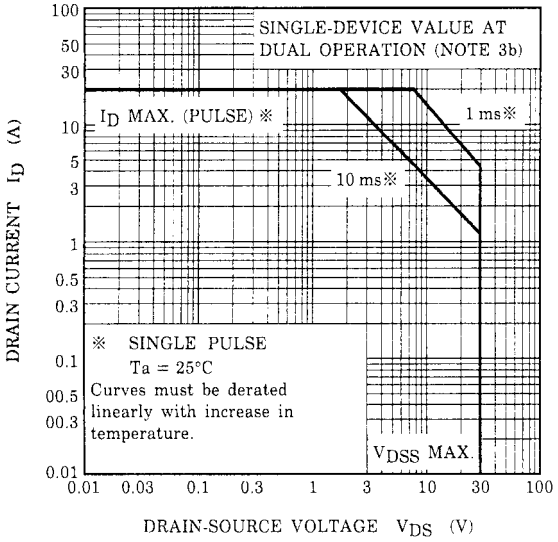


**N-ch**

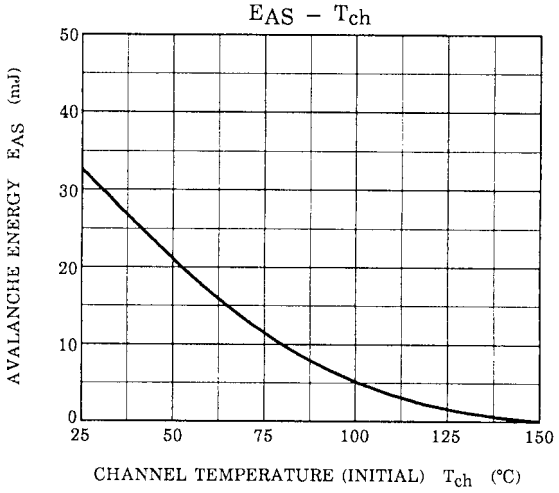
$r_{th} - t_w$

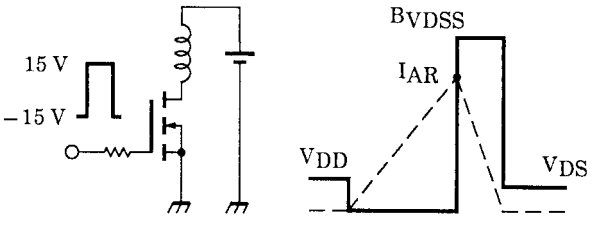



SAFE OPERATING AREA




$E_{AS} - T_{ch}$




TEST CIRCUIT WAVE FORM

$T_{ch}$ = 25°C (Initial)
Peak $I_{AR}$ = 5 A, $R_G$ = 25 Ω
$V_{DD}$ = 24 V, L = 1.0 mH

$$E_{AS} = \frac{1}{2} \cdot L \cdot I^2 \cdot \left(\frac{B_{VDSS}}{B_{VDSS} - V_{DD}}\right)$$

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