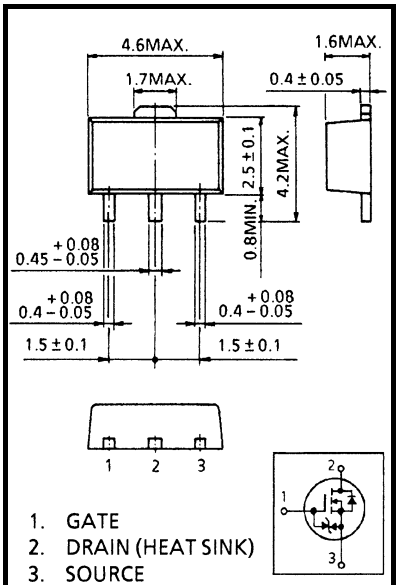
TOSHIBA Field Effect Transistor Silicon N Channel MOS Type ($L^2$-π-MOS V)

# 2SK2963

DC-DC Converter, Relay Drive and Motor Drive Applications

- 4-V gate drive
- Low drain-source ON-resistance: $R_{DS\ (ON)}$ = 0.5 Ω (typ.)
- High forward transfer admittance: $|Y_{fs}|$ = 1.2 S (typ.)
- Low leakage current: $I_{DSS}$ = 100 μA (max) ($V_{DS}$ = 100 V)
- Enhancement mode: $V_{th}$ = 0.8 to 2.0 V ($V_{DS}$ = 10 V, $I_D$ = 1 mA)

Unit: mm




| | |
|---|---|
| JEDEC | — |
| JEITA | — |
| TOSHIBA | 2-5K1B |

Weight: 0.05 g (typ.)

## Absolute Maximum Ratings (Ta = 25°C)

| Characteristics | | Symbol | Rating | Unit |
|---|---|---|---|---|
| Drain-source voltage | | $V_{DSS}$ | 100 | V |
| Drain-gate voltage ($R_{GS}$ = 20 kΩ) | | $V_{DGR}$ | 100 | V |
| Gate-source voltage | | $V_{GSS}$ | ±20 | V |
| Drain current | DC (Note 1) | $I_D$ | 1 | A |
| | Pulse (Note 1) | $I_{DP}$ | 3 | |
| Drain power dissipation | | $P_D$ | 0.5 | W |
| Drain power dissipation (Note 2) | | $P_D$ | 1.5 | W |
| Single pulse avalanche energy (Note 3) | | $E_{AS}$ | 137 | mJ |
| Avalanche current | | $I_{AR}$ | 1 | A |
| Repetitive avalanche energy (Note 4) | | $E_{AR}$ | 0.05 | mJ |
| Channel temperature | | $T_{ch}$ | 150 | °C |
| Storage temperature range | | $T_{stg}$ | −55 to 150 | °C |

Note 1: Ensure that the channel temperature does not exceed 150°C.

Note 2: Mounted on a ceramic board (25.4 mm × 25.4 mm × 0.8 mm)

Note 3: $V_{DD}$ = 25 V, $T_{ch}$ = 25°C (initial), L = 221 mH, $R_G$ = 25 Ω, $I_{AR}$ = 1 A

Note 4: Repetitive rating: pulse width limited by maximum junction temperature.

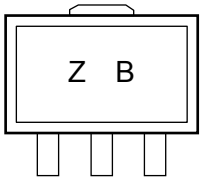
Note 5: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings. Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook (“Handling Precautions”/”Derating Concept and Methods”) and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

This transistor is an electrostatic-sensitive device.
Handle with care.

## Thermal Characteristics

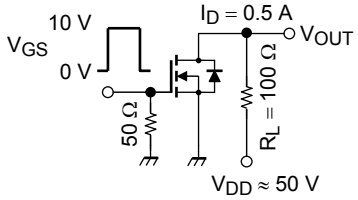
| Characteristics | Symbol | Max | Unit |
|---|---|---|---|
| Thermal resistance, channel to ambient | $R_{th\ (ch\text{-}a)}$ | 250 | °C/W |

## Marking




(The two digits represent the part number.)

## Electrical Characteristics (Ta = 25°C)

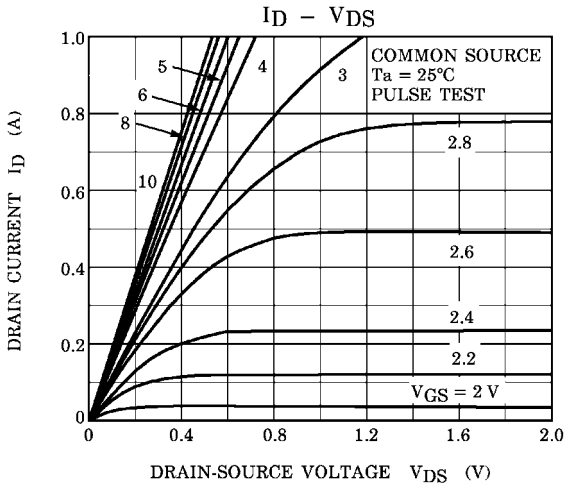
| Characteristics | | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Gate leakage current | | $I_{GSS}$ | $V_{GS}$ = ±16 V, $V_{DS}$ = 0 V | — | — | ±10 | μA |
| Drain cut-off current | | $I_{DSS}$ | $V_{DS}$ = 100 V, $V_{GS}$ = 0 V | — | — | 100 | μA |
| Drain-source breakdown voltage | | $V_{(BR)\ DSS}$ | $I_D$ = 10 mA, $V_{GS}$ = 0 V | 100 | — | — | 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, $I_D$ = 0.5 A | — | 0.65 | 0.95 | Ω |
| | | | $V_{GS}$ = 10 V, $I_D$ = 0.5 A | — | 0.5 | 0.7 | |
| Forward transfer admittance | | $\|Y_{fs}\|$ | $V_{DS}$ = 10 V, $I_D$ = 0.5 A | 0.6 | 1.2 | — | S |
| Input capacitance | | $C_{iss}$ | $V_{DS}$ = 10 V, $V_{GS}$ = 0 V, f = 1 MHz | — | 140 | — | pF |
| Reverse transfer capacitance | | $C_{rss}$ | $V_{DS}$ = 10 V, $V_{GS}$ = 0 V, f = 1 MHz | — | 20 | — | pF |
| Output capacitance | | $C_{oss}$ | $V_{DS}$ = 10 V, $V_{GS}$ = 0 V, f = 1 MHz | — | 45 | — | pF |
| Switching time | Rise time | $t_r$ |  | — | 8 | — | ns |
| | Turn-on time | $t_{on}$ | | — | 13 | — | |
| | Fall time | $t_f$ | | — | 45 | — | |
| | Turn-off time | $t_{off}$ | | — | 175 | — | |
| Total gate charge (gate-source plus gate-drain) | | $Q_g$ | $V_{DD}$ ≈ 80 V, $V_{GS}$ = 10 V, $I_D$ = 1 A | — | 6.3 | — | nC |
| Gate-source charge | | $Q_{gs}$ | $V_{DD}$ ≈ 80 V, $V_{GS}$ = 10 V, $I_D$ = 1 A | — | 4.3 | — | nC |
| Gate-drain (“miller”) charge | | $Q_{gd}$ | $V_{DD}$ ≈ 80 V, $V_{GS}$ = 10 V, $I_D$ = 1 A | — | 2 | — | nC |

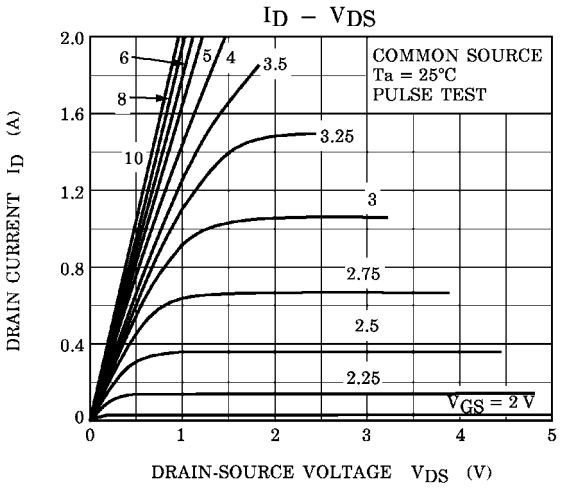


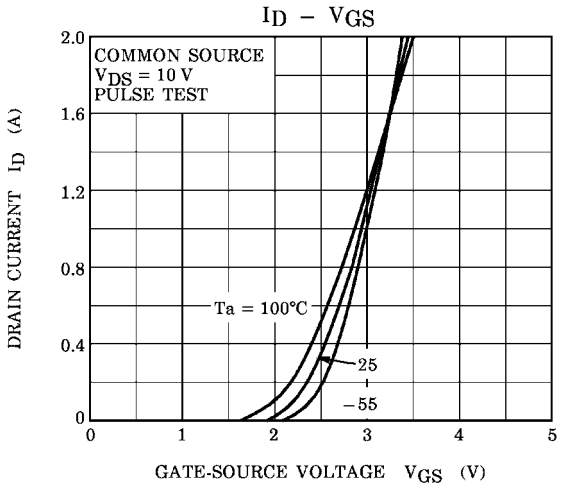
Duty ≤ 1%, $t_w$ = 10 μs

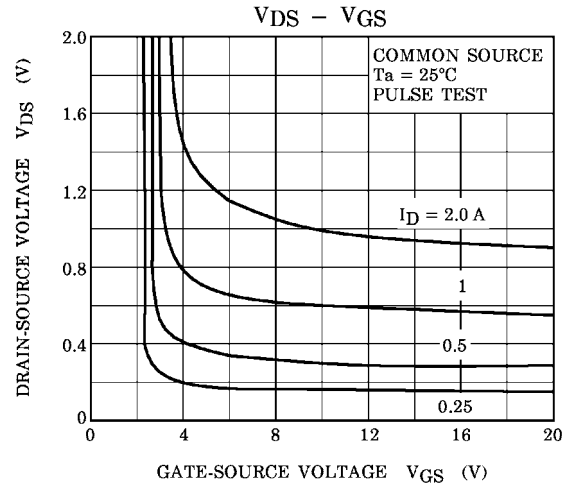
## Source-Drain Ratings and Characteristics (Ta = 25°C)

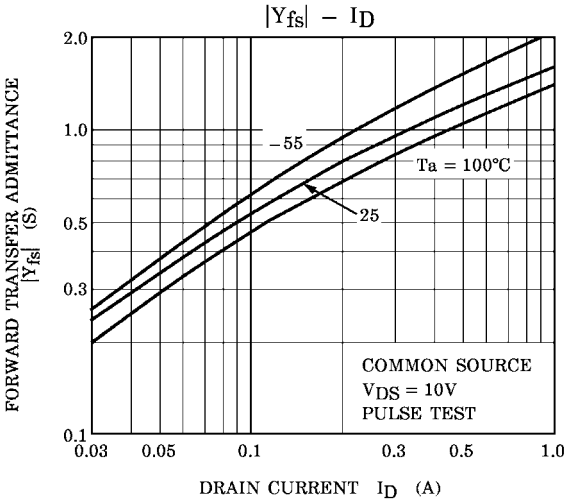
| Characteristics | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Continuous drain reverse current (Note 1) | $I_{DR}$ | — | — | — | 1 | A |
| Pulse drain reverse current (Note 1) | $I_{DRP}$ | — | — | — | 3 | A |
| Forward voltage (diode) | $V_{DSF}$ | $I_{DR}$ = 1 A, $V_{GS}$ = 0 V | — | — | −1.5 | V |
| Reverse recovery time | $t_{rr}$ | $I_{DR}$ = 1 A, $V_{GS}$ = 0 V, $dI_{DR}/dt$ = 50 A/μs | — | 80 | — | ns |
| Reverse recovery charge | $Q_{rr}$ | $I_{DR}$ = 1 A, $V_{GS}$ = 0 V, $dI_{DR}/dt$ = 50 A/μs | — | 140 | — | μC |

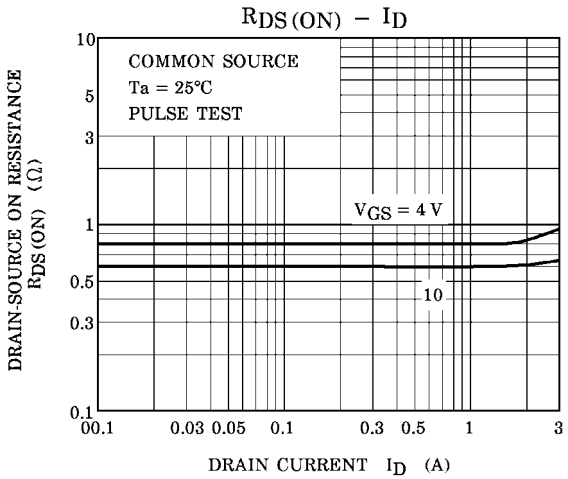

$I_D$ – $V_{DS}$
COMMON SOURCE
Ta = 25°C
PULSE TEST
5
4
3
6
8
10
2.8
2.6
2.4
2.2
$V_{GS}$ = 2 V
DRAIN CURRENT $I_D$ (A)
DRAIN-SOURCE VOLTAGE $V_{DS}$ (V)
0
0.2
0.4
0.6
0.8
1.0
1.2
1.6
2.0
0.4
0.8
1.2
1.6
2.0


$I_D$ – $V_{DS}$
COMMON SOURCE
Ta = 25°C
PULSE TEST
6
5
4
3.5
8
10
3.25
3
2.75
2.5
2.25
$V_{GS}$ = 2 V
DRAIN CURRENT $I_D$ (A)
DRAIN-SOURCE VOLTAGE $V_{DS}$ (V)
0
0.4
0.8
1.2
1.6
2.0
1
2
3
4
5

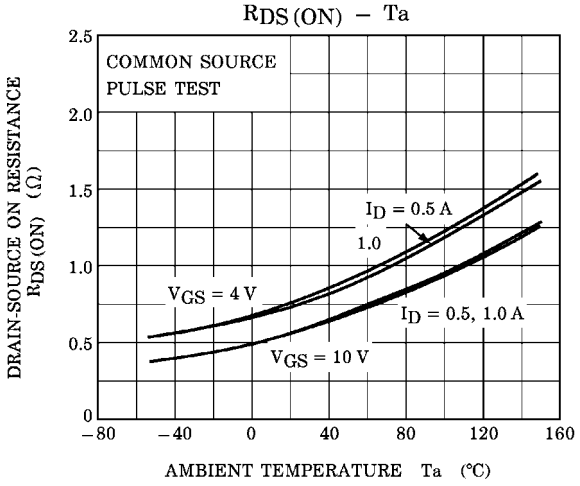

$I_D$ – $V_{GS}$
COMMON SOURCE
$V_{DS}$ = 10 V
PULSE TEST
Ta = 100°C
25
−55
DRAIN CURRENT $I_D$ (A)
GATE-SOURCE VOLTAGE $V_{GS}$ (V)
0
0.4
0.8
1.2
1.6
2.0
1
2
3
4
5


$V_{DS}$ – $V_{GS}$
COMMON SOURCE
Ta = 25°C
PULSE TEST
$I_D$ = 2.0 A
1
0.5
0.25
DRAIN-SOURCE VOLTAGE $V_{DS}$ (V)
GATE-SOURCE VOLTAGE $V_{GS}$ (V)
0
0.4
0.8
1.2
1.6
2.0
4
8
12
16
20

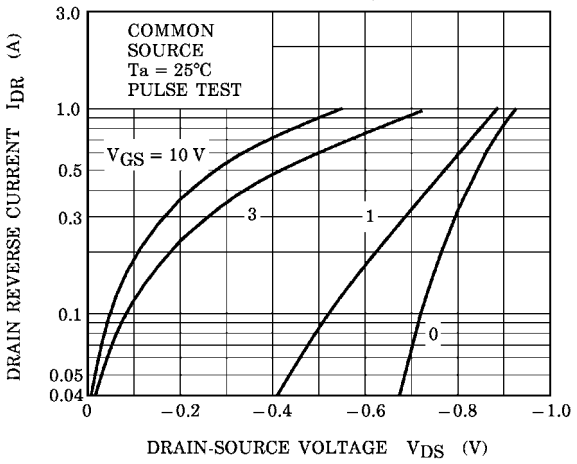

$|Y_{fs}|$ – $I_D$
−55
Ta = 100°C
25
COMMON SOURCE
$V_{DS}$ = 10V
PULSE TEST
FORWARD TRANSFER ADMITTANCE $|Y_{fs}|$ (S)
DRAIN CURRENT $I_D$ (A)
0.1
0.3
0.5
1.0
2.0
0.03
0.05
0.1
0.3
0.5
1.0


$R_{DS\,(ON)}$ – $I_D$
COMMON SOURCE
Ta = 25°C
PULSE TEST
$V_{GS}$ = 4 V
10
DRAIN-SOURCE ON RESISTANCE $R_{DS(ON)}$ (Ω)
DRAIN CURRENT $I_D$ (A)
0.1
0.3
0.5
1
3
5
10
00.1
0.03
0.05
0.1
0.3
0.5
1
3

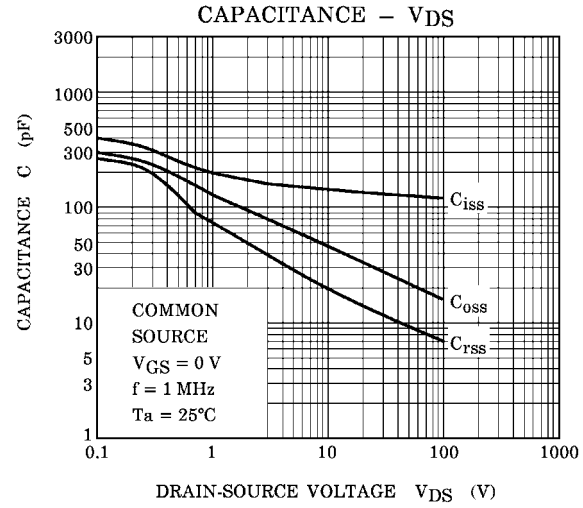
$R_{DS\,(ON)}$ – Ta



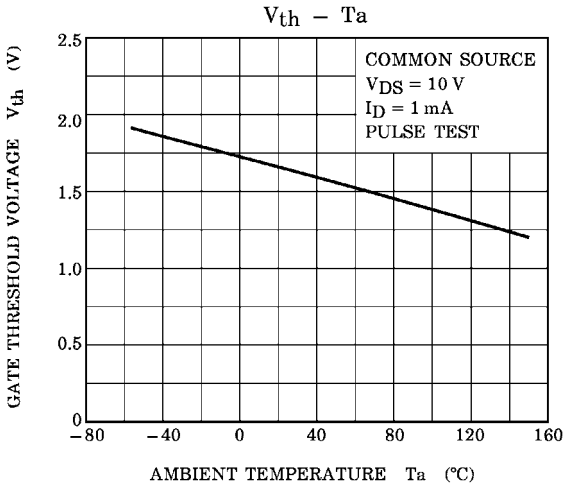

$I_{DR}$ – $V_{DS}$



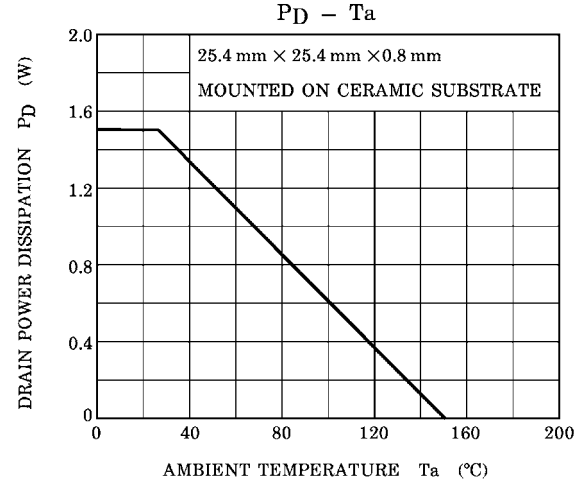

CAPACITANCE – $V_{DS}$



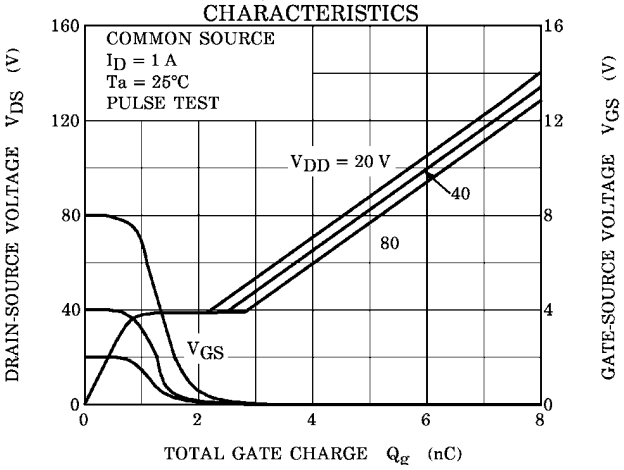

$V_{th}$ – Ta

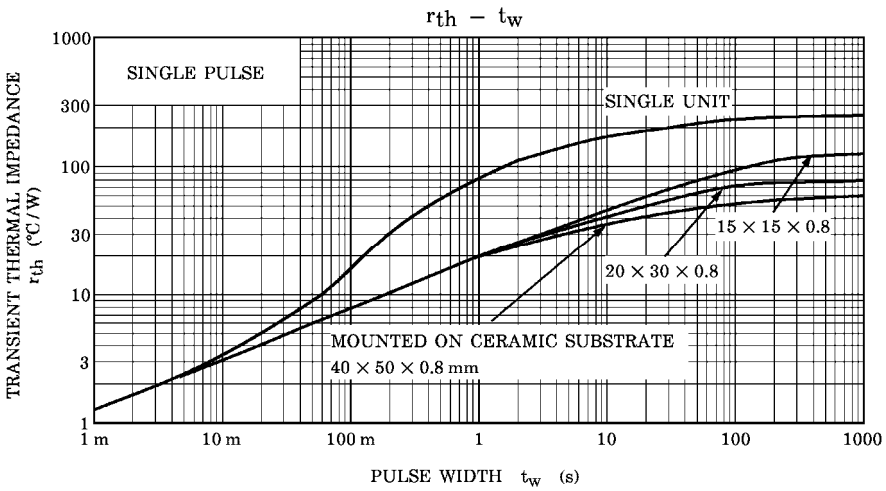


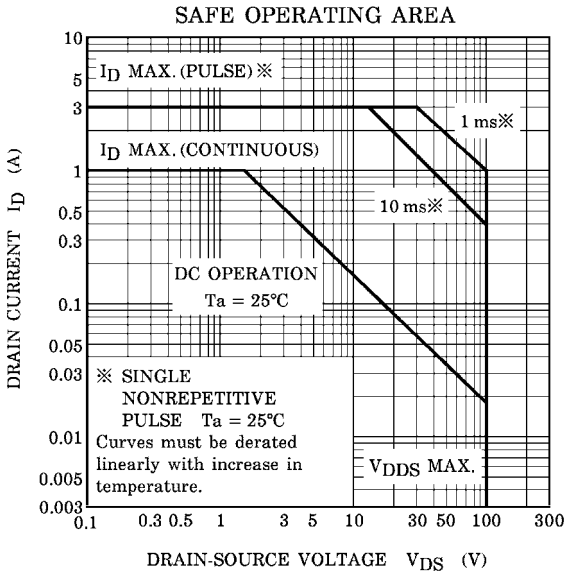

$P_D$ – Ta

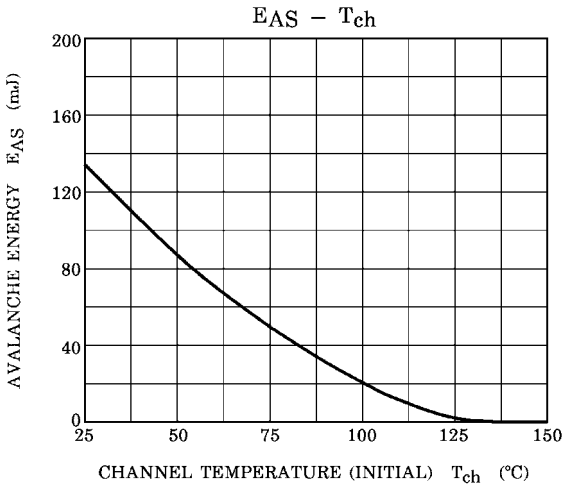


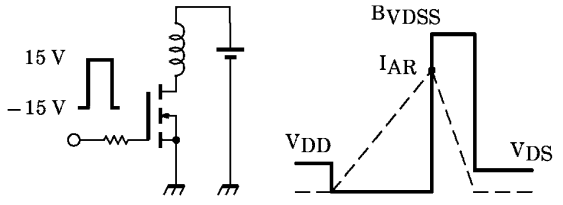

DYNAMIC INPUT/OUTPUT CHARACTERISTICS






TEST CIRCUIT WAVE FORM

$R_G = 25\ \Omega$
$V_{DD} = 25$ V, L = 221 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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