# 2N7002E

# Small Signal MOSFET

## Single N−Channel, 60 V, 310 mA, 2.5 Ohm

### Features

- Low $R_{DS(on)}$
- Small Footprint Surface Mount Package
- Trench Technology
- S Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q101 Qualified and PPAP Capable
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

### Applications

- Low Side Load Switch
- Level Shift Circuits
- DC−DC Converter
- Portable Applications i.e. DSC, PDA, Cell Phone, etc.

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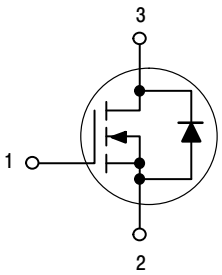
| $V_{(BR)DSS}$ | $R_{DS(on)}$ MAX | $I_D$ MAX (Note 1) |
|---|---|---|
| 60 V | 3.0 Ω @ 4.5 V | 310 mA |
| | 2.5 Ω @ 10 V | |

### Simplified Schematic

N−Channel




(Top View)

### MAXIMUM RATINGS ($T_J$ = 25°C unless otherwise stated)

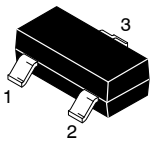
| Rating | | Symbol | Value | Unit |
|---|---|---|---|---|
| Drain−to−Source Voltage | | $V_{DSS}$ | 60 | V |
| Gate−to−Source Voltage | | $V_{GS}$ | ±20 | V |
| Drain Current (Note 1) | | $I_D$ | | mA |
| Steady State | $T_A$ = 25°C | | 260 | |
| | $T_A$ = 85°C | | 190 | |
| t < 5 s | $T_A$ = 25°C | | 310 | |
| | $T_A$ = 85°C | | 220 | |
| Power Dissipation (Note 1) | | $P_D$ | | mW |
| Steady State | | | 300 | |
| t < 5 s | | | 420 | |
| Pulsed Drain Current ($t_p$ = 10 μs) | | $I_{DM}$ | 1.2 | A |
| Operating Junction and Storage Temperature Range | | $T_J$, $T_{STG}$ | −55 to +150 | °C |
| Source Current (Body Diode) | | $I_S$ | 300 | mA |
| Lead Temperature for Soldering Purposes (1/8″ from case for 10 s) | | $T_L$ | 260 | °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.

### THERMAL CHARACTERISTICS

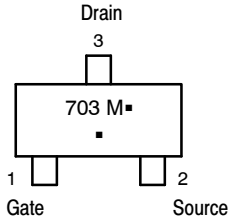
| Characteristic | Symbol | Max | Unit |
|---|---|---|---|
| Junction−to−Ambient − Steady State (Note 1) | $R_{\theta JA}$ | 417 | °C/W |
| Junction−to−Ambient − t ≤ 5 s (Note 1) | $R_{\theta JA}$ | 300 | |

1. Surface−mounted on FR4 board using 1 in sq pad size (Cu area = 1.127 in sq [1 oz] including traces)




**SOT−23**
**CASE 318**
**STYLE 21**

### MARKING DIAGRAM & PIN ASSIGNMENT




703 = Device Code
M = Date Code
▪ = Pb−Free Package

(Note: Microdot may be in either location)

### ORDERING INFORMATION

| Device | Package | Shipping† |
|---|---|---|
| 2N7002ET1G, S2N7002ET1G | SOT−23 (Pb−Free) | 3000 / Tape & Reel |
| 2N7002ET7G, S2N7002ET7G | SOT−23 (Pb−Free) | 3500 / Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

## ELECTRICAL CHARACTERISTICS ($T_J$ = 25°C unless otherwise specified)

| Parameter | Symbol | Test Condition | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | | | |
| Drain−to−Source Breakdown Voltage | $V_{(BR)DSS}$ | $V_{GS}$ = 0 V, $I_D$ = 250 μA | | 60 | | | V |
| Drain−to−Source Breakdown Voltage Temperature Coefficient | $V_{(BR)DSS}/T_J$ | | | | 75 | | mV/°C |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | $V_{GS}$ = 0 V, $V_{DS}$ = 60 V | $T_J$ = 25°C | | | 1 | μA |
| | | | $T_J$ = 125°C | | | 500 | |
| Gate−to−Source Leakage Current | $I_{GSS}$ | $V_{DS}$ = 0 V, $V_{GS}$ = ±20 V | | | | ±100 | nA |
| **ON CHARACTERISTICS** (Note 2) | | | | | | | |
| Gate Threshold Voltage | $V_{GS(TH)}$ | $V_{GS}$ = $V_{DS}$, $I_D$ = 250 μA | | 1.0 | | 2.5 | V |
| Negative Threshold Temperature Coefficient | $V_{GS(TH)}/T_J$ | | | | 4.4 | | mV/°C |
| Drain−to−Source On Resistance | $R_{DS(on)}$ | $V_{GS}$ = 10 V, $I_D$ = 240 mA | | | 0.86 | 2.5 | Ω |
| | | $V_{GS}$ = 4.5 V, $I_D$ = 50 mA | | | 1.1 | 3.0 | |
| Forward Transconductance | $g_{FS}$ | $V_{DS}$ = 5 V, $I_D$ = 200 mA | | | 530 | | mS |
| **CHARGES AND CAPACITANCES** | | | | | | | |
| Input Capacitance | $C_{ISS}$ | $V_{GS}$ = 0 V, f = 1 MHz, $V_{DS}$ = 25 V | | | 26.7 | 40 | pF |
| Output Capacitance | $C_{OSS}$ | | | | 4.6 | | |
| Reverse Transfer Capacitance | $C_{RSS}$ | | | | 2.9 | | |
| Total Gate Charge | $Q_{G(TOT)}$ | $V_{GS}$ = 5 V, $V_{DS}$ = 10 V; $I_D$ = 240 mA | | | 0.81 | | nC |
| Threshold Gate Charge | $Q_{G(TH)}$ | | | | 0.31 | | |
| Gate−to−Source Charge | $Q_{GS}$ | | | | 0.48 | | |
| Gate−to−Drain Charge | $Q_{GD}$ | | | | 0.08 | | |
| **SWITCHING CHARACTERISTICS, $V_{GS}$ = V** (Note 3) | | | | | | | |
| Turn−On Delay Time | $t_{d(ON)}$ | $V_{GS}$ = 10 V, $V_{DD}$ = 30 V, $I_D$ = 200 mA, $R_G$ = 10 Ω | | | 1.7 | | ns |
| Rise Time | $t_r$ | | | | 1.2 | | |
| Turn−Off Delay Time | $t_{d(OFF)}$ | | | | 4.8 | | |
| Fall Time | $t_f$ | | | | 3.6 | | |
| **DRAIN−SOURCE DIODE CHARACTERISTICS** | | | | | | | |
| Forward Diode Voltage | $V_{SD}$ | $V_{GS}$ = 0 V, $I_S$ = 200 mA | $T_J$ = 25°C | | 0.79 | 1.2 | V |
| | | | $T_J$ = 85°C | | 0.7 | | |

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.

2. Pulse Test: pulse width ≤ 300 μs, duty cycle ≤ 2%
3. Switching characteristics are independent of operating junction temperatures

## TYPICAL CHARACTERISTICS

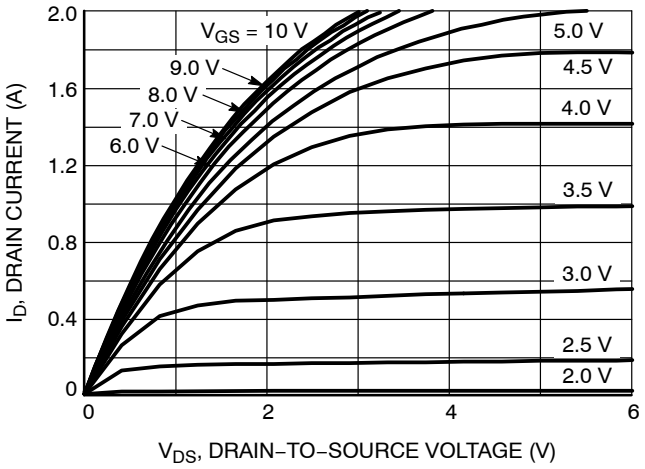



**Figure 1. On−Region Characteristics**

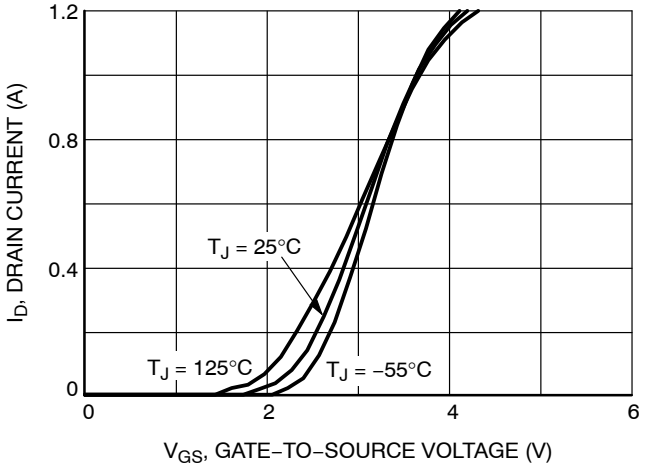



**Figure 2. Transfer Characteristics**

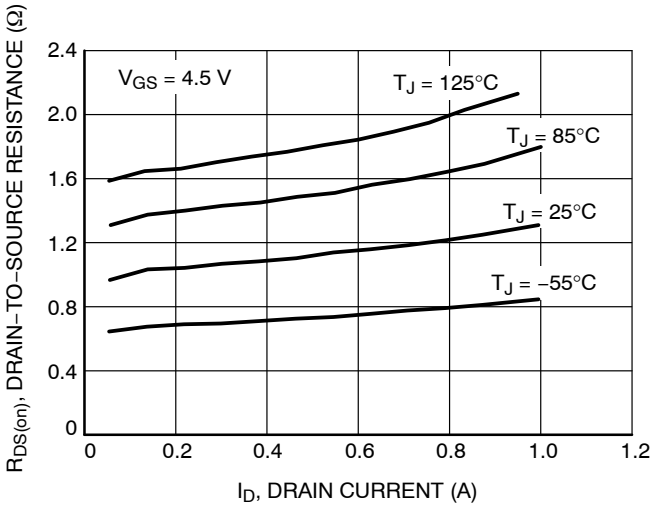



**Figure 3. On−Resistance vs. Drain Current and Temperature**

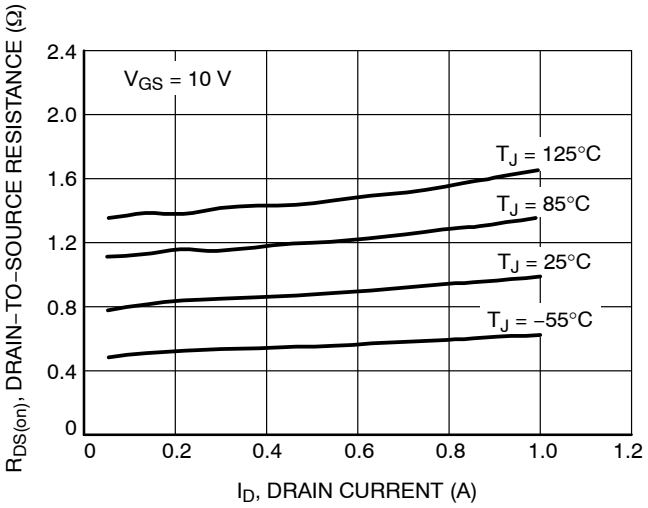



**Figure 4. On−Resistance vs. Drain Current and Temperature**

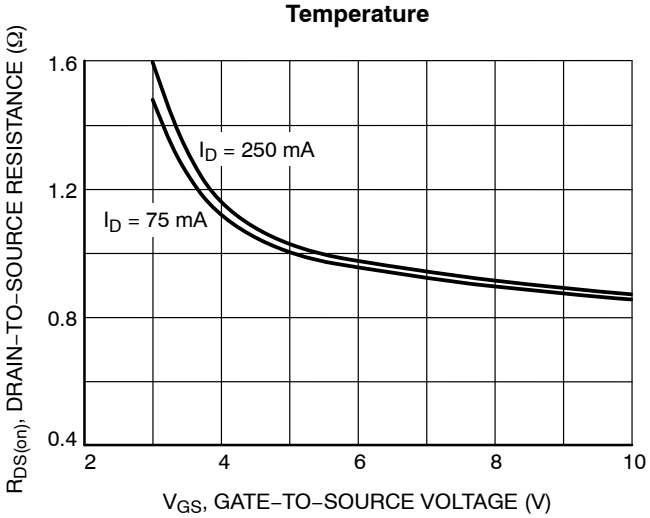



**Figure 5. On−Resistance vs. Gate−to−Source Voltage**

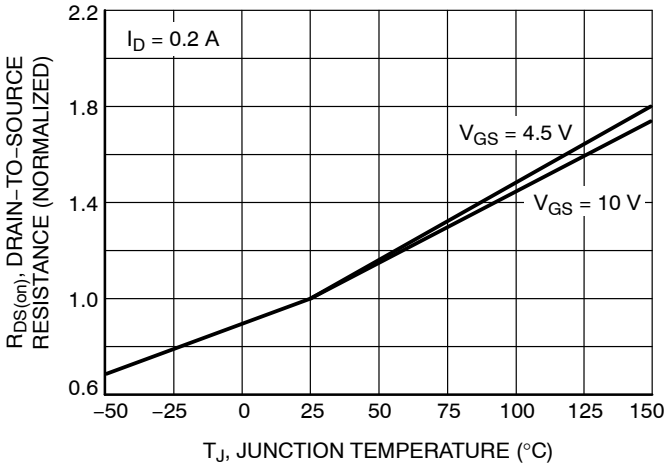



**Figure 6. On−Resistance Variation with Temperature**

## TYPICAL CHARACTERISTICS

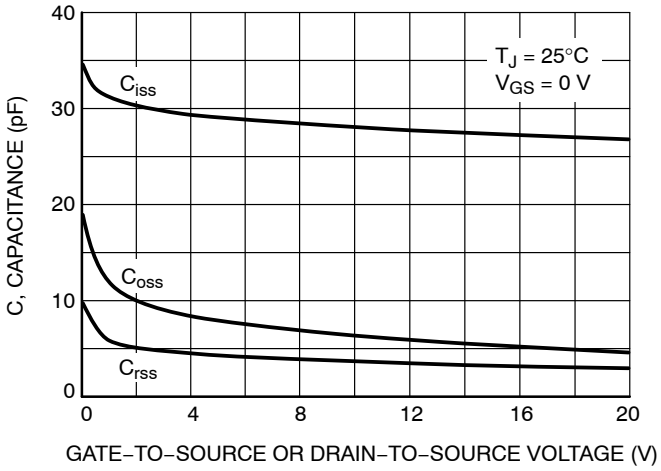



**Figure 7. Capacitance Variation**

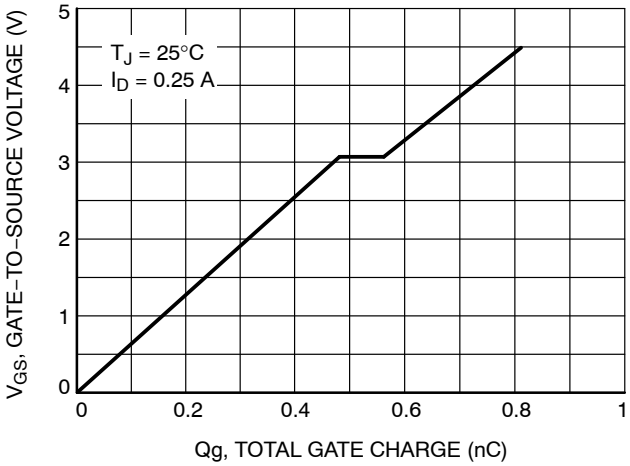



**Figure 8. Gate−to−Source and Drain−to−Source Voltage vs. Total Charge**

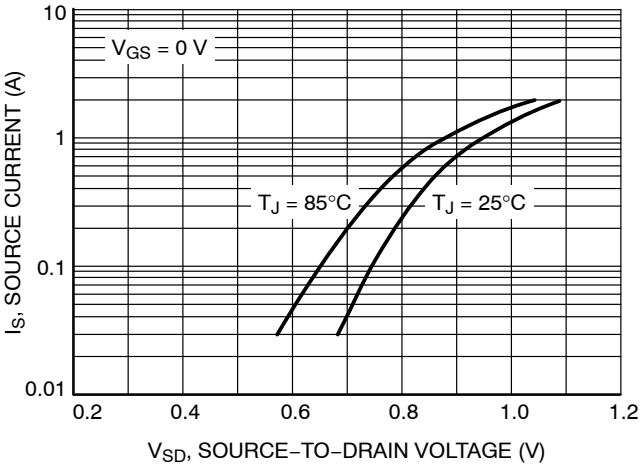



**Figure 9. Diode Forward Voltage vs. Current**

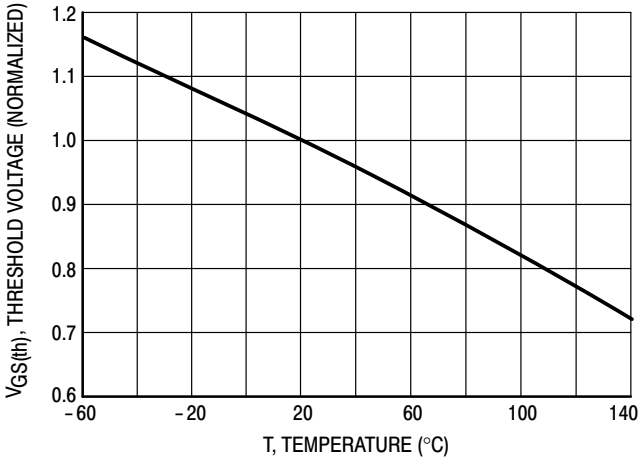



**Figure 10. Temperature versus Gate Threshold Voltage**

# MECHANICAL CASE OUTLINE
## PACKAGE DIMENSIONS

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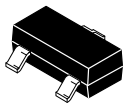
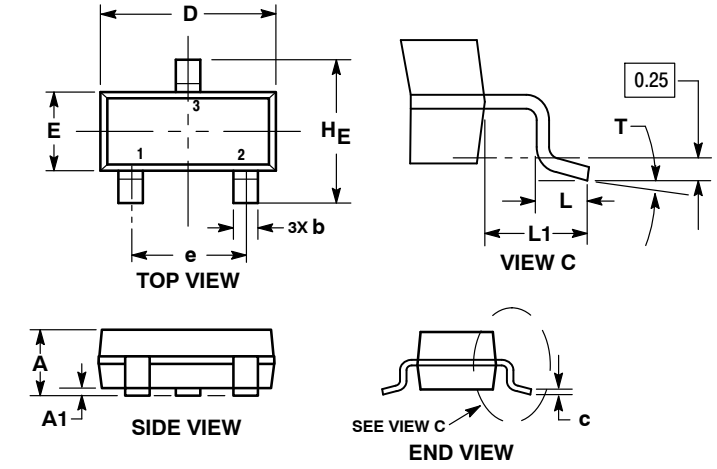


**SOT−23 (TO−236)**
CASE 318−08
ISSUE AS

DATE 30 JAN 2018

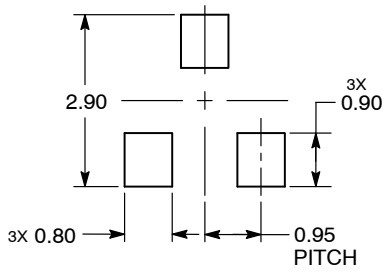
SCALE 4:1




NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF THE BASE MATERIAL.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

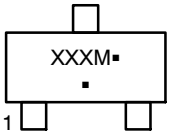
| | MILLIMETERS | | | INCHES | | |
|---|---|---|---|---|---|---|
| DIM | MIN | NOM | MAX | MIN | NOM | MAX |
| A | 0.89 | 1.00 | 1.11 | 0.035 | 0.039 | 0.044 |
| A1 | 0.01 | 0.06 | 0.10 | 0.000 | 0.002 | 0.004 |
| b | 0.37 | 0.44 | 0.50 | 0.015 | 0.017 | 0.020 |
| c | 0.08 | 0.14 | 0.20 | 0.003 | 0.006 | 0.008 |
| D | 2.80 | 2.90 | 3.04 | 0.110 | 0.114 | 0.120 |
| E | 1.20 | 1.30 | 1.40 | 0.047 | 0.051 | 0.055 |
| e | 1.78 | 1.90 | 2.04 | 0.070 | 0.075 | 0.080 |
| L | 0.30 | 0.43 | 0.55 | 0.012 | 0.017 | 0.022 |
| L1 | 0.35 | 0.54 | 0.69 | 0.014 | 0.021 | 0.027 |
| $H_E$ | 2.10 | 2.40 | 2.64 | 0.083 | 0.094 | 0.104 |
| T | 0° | −−− | 10° | 0° | −−− | 10° |

### RECOMMENDED SOLDERING FOOTPRINT




DIMENSIONS: MILLIMETERS

### GENERIC MARKING DIAGRAM*




XXX = Specific Device Code
M = Date Code
▪ = 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.

STYLE 1 THRU 5:
CANCELLED

STYLE 6:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 7:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 8:
PIN 1. ANODE
2. NO CONNECTION
3. CATHODE

STYLE 9:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 10:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 11:
PIN 1. ANODE
2. CATHODE
3. CATHODE−ANODE

STYLE 12:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 13:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 14:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 15:
PIN 1. GATE
2. CATHODE
3. ANODE

STYLE 16:
PIN 1. ANODE
2. CATHODE
3. CATHODE

STYLE 17:
PIN 1. NO CONNECTION
2. ANODE
3. CATHODE

STYLE 18:
PIN 1. NO CONNECTION
2. CATHODE
3. ANODE

STYLE 19:
PIN 1. CATHODE
2. ANODE
3. CATHODE−ANODE

STYLE 20:
PIN 1. CATHODE
2. ANODE
3. GATE

STYLE 21:
PIN 1. GATE
2. SOURCE
3. DRAIN

STYLE 22:
PIN 1. RETURN
2. OUTPUT
3. INPUT

STYLE 23:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 24:
PIN 1. GATE
2. DRAIN
3. SOURCE

STYLE 25:
PIN 1. ANODE
2. CATHODE
3. GATE

STYLE 26:
PIN 1. CATHODE
2. ANODE
3. NO CONNECTION

STYLE 27:
PIN 1. CATHODE
2. CATHODE
3. CATHODE

STYLE 28:
PIN 1. ANODE
2. ANODE
3. ANODE

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