



Pages 1 to 14

TRANSISTORS, LOW POWER, NPN

BASED ON TYPE 2N3501

ESCC Detail Specification No. 5201/013

| | |
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| DCR No. | CHANGE DESCRIPTION |
|---------|---|
| 512 | Specification up issued to incorporate editorial changes per DCR. |

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1. GENERAL

1.1 SCOPE

This specification details the ratings, physical and electrical characteristics and test and inspection data for the component type variants and/or the range of components specified below. It supplements the requirements of, and shall be read in conjunction with, the ESCC Generic Specification listed under Applicable Documents.

1.2 APPLICABLE DOCUMENTS

The following documents form part of this specification and shall be read in conjunction with it:

- (a) ESCC Generic Specification No. 5000
- (b) MIL-STD-750, Test Methods and Procedures for Semiconductor Devices

1.3 TERMS, DEFINITIONS, ABBREVIATIONS, SYMBOLS AND UNITS

For the purpose of this specification, the terms, definitions, abbreviations, symbols and units specified in ESCC Basic Specification No. 21300 shall apply.

1.4 THE ESCC COMPONENT NUMBER AND COMPONENT TYPE VARIANTS

1.4.1 The ESCC Component Number

The ESCC Component Number shall be constituted as follows:

Example: 520101301

- Detail Specification Reference: 5201013
- Component Type Variant Number: 01 (as required)

1.4.2 Component Type Variants

The component type variants applicable to this specification are as follows:

| Variant Number | Based on Type | Case | Lead/Terminal Material and Finish | Weight max g |
|----------------|---------------|-------|-----------------------------------|--------------|
| 01 | 2N3501 | TO-5 | D2 | 1.2 |
| 02 | 2N3501 | TO-39 | D2 | 1.2 |

The lead/terminal material and finish shall be in accordance with the requirements of ESCC Basic Specification No. 23500.

1.5 MAXIMUM RATINGS

The maximum ratings shall not be exceeded at any time during use or storage.

Maximum ratings shall only be exceeded during testing to the extent specified in this specification and when stipulated in Test Methods and Procedures of the ESCC Generic Specification.

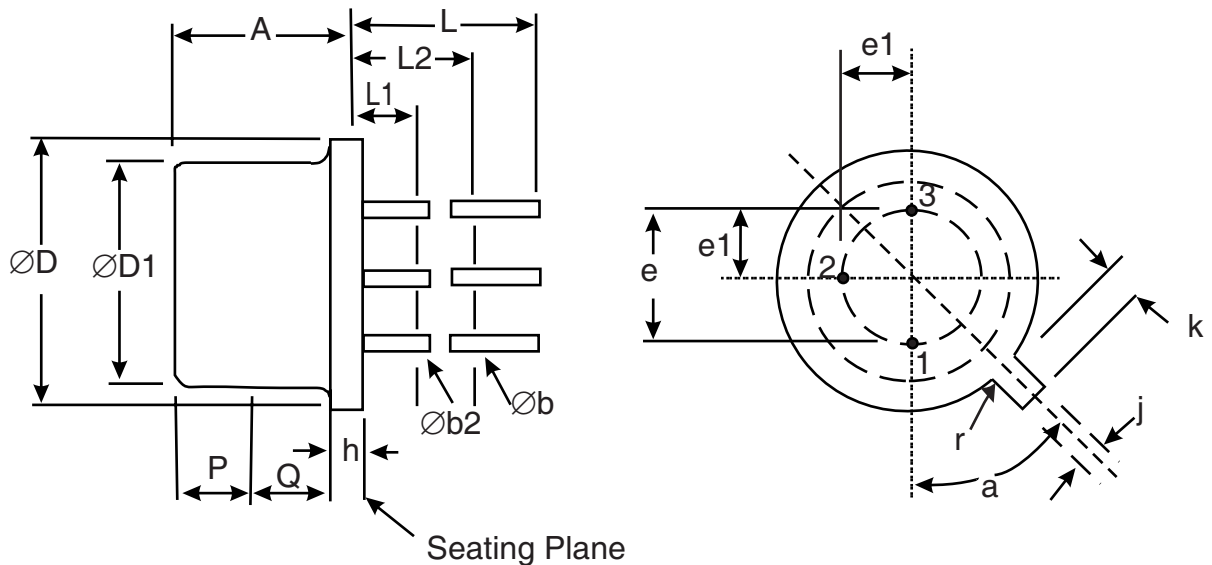
| Characteristics | Symbols | Maximum Ratings | Unit | Remarks |
|---|---------------|-----------------|---------------|---|
| Collector-Base Voltage | V_{CBO} | 150 | V | Over entire operating temperature range |
| Collector-Emitter Voltage | V_{CEO} | 150 | V | |
| Emitter-Base Voltage | V_{EBO} | 6 | V | |
| Collector Current | I_C | 300 | mA | |
| Power Dissipation | P_{tot1} | 1 | W | At $T_{amb} \leq +25^{\circ}C$ |
| | P_{tot2} | 5 | W | At $T_{case} \leq +25^{\circ}C$ |
| Thermal Resistance, Junction-to-Ambient | $R_{th(j-a)}$ | 175 | $^{\circ}C/W$ | |
| Thermal Resistance, Junction-to-Case | $R_{th(j-c)}$ | 35 | $^{\circ}C/W$ | |
| Operating Temperature Range | T_{op} | -65 to +200 | $^{\circ}C$ | Note 1 |
| Storage Temperature Range | T_{stg} | -65 to +200 | $^{\circ}C$ | Note 1 |
| Soldering Temperature | T_{sol} | +260 | $^{\circ}C$ | Note 2 |

NOTES:

1. For Variants with tin-lead plating or hot solder dip lead finish all testing, and any handling, performed at $T_{amb} > +125^{\circ}C$ shall be carried out in a 100% inert atmosphere.
2. Duration 10 seconds maximum at a distance of not less than 1.5mm from the device body and the same lead shall not be resoldered until 3 minutes have elapsed.

1.6 PHYSICAL DIMENSIONS AND TERMINAL IDENTIFICATION

1.6.1 Metal Can Package (TO-5) - 3 lead

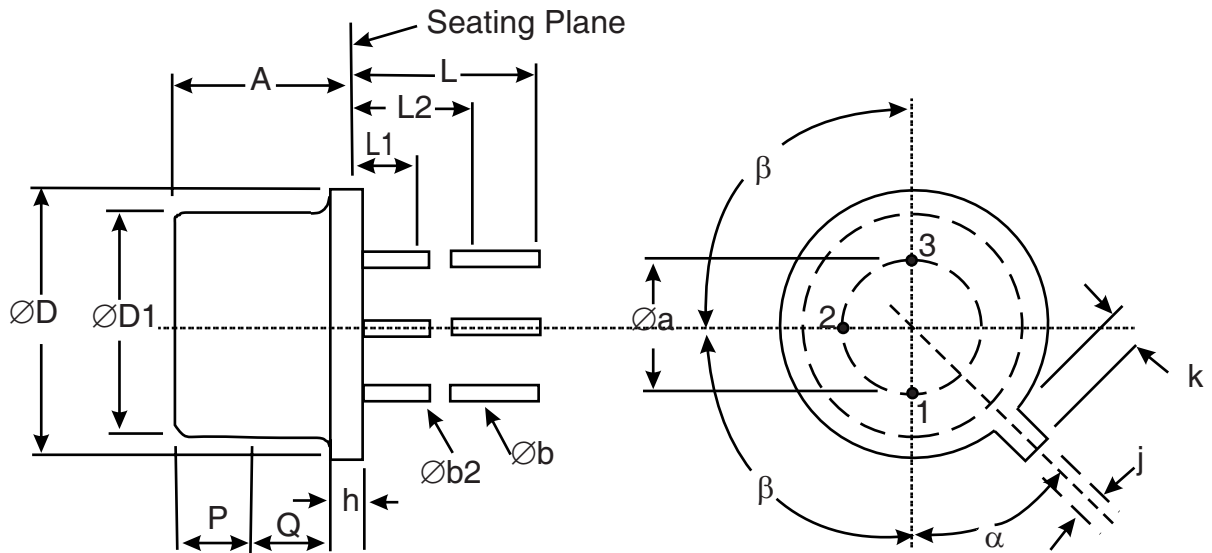


| Symbols | Dimensions mm | | Notes |
|---------|---------------|-------|-------|
| | Min | Max | |
| A | 6.1 | 6.6 | |
| Øb | 0.406 | 0.533 | 2, 3 |
| Øb2 | 0.406 | 0.483 | 2, 3 |
| ØD | 8.51 | 9.4 | |
| ØD1 | 7.75 | 8.51 | |
| e | 5.08 BSC | | 6 |
| e1 | 2.54 BSC | | |
| h | 0.229 | 3.18 | |
| j | 0.711 | 0.864 | |
| k | 0.737 | 1.14 | 4 |
| L | 38.1 | - | 2 |
| L1 | - | 1.27 | 2, 3 |
| L2 | 6.35 | - | 2, 3 |
| P | 2.54 | - | 5 |
| Q | - | - | 7 |
| r | - | 0.179 | 8 |
| a | 45° BSC | | 1, 9 |

NOTES:

1. Terminal identification is specified by reference to the tab position where Lead 1 = emitter, Lead 2 = base and Lead 3 = collector.
2. Applies to all leads.
3. Øb2 applies between L1 and L2. Øb applies between L2 and 38.1mm from the seating plane. Diameter is uncontrolled within L1 and beyond 38.1mm from the seating plane.
4. Measured from the maximum diameter of the actual device.
5. This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed 0.254mm.
6. Leads having maximum diameter 0.483mm measured in the gauging plane 1.37 (+0.025, -0)mm below the seating plane of the device shall be within 0.178mm of their true position relative to a maximum-width-tab.
7. The details of outline in this zone are optional.
8. Radius.
9. Measured from the tab centreline.

1.6.2 Metal Can Package (TO-39) - 3 lead



| Symbols | Dimensions mm | | Notes |
|------------------|---------------|-------|-------|
| | Min | Max | |
| $\varnothing a$ | 4.83 | 5.35 | |
| A | 6 | 6.6 | |
| $\varnothing b$ | 0.4 | 0.533 | 2, 3 |
| $\varnothing b2$ | 0.4 | 0.483 | 2, 3 |
| $\varnothing D$ | 8.31 | 9.4 | |
| $\varnothing D1$ | 7.75 | 8.51 | 5 |
| h | 0.229 | 3.18 | |
| j | 0.711 | 0.864 | |
| k | 0.737 | 1.14 | 4 |
| L | 12.7 | 19 | 2 |
| L1 | - | 1.27 | 2, 3 |
| L2 | 6.35 | - | 2, 3 |
| P | 2.54 | - | 5 |
| Q | - | - | 6 |
| α | 45° BSC | | 1, 7 |
| β | 90° BSC | | 1 |

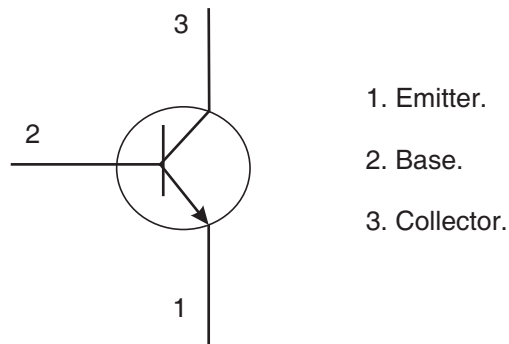
NOTES:

- Terminal identification is specified by reference to the tab position where Lead 1 = emitter, Lead 2

= base and Lead 3 = collector.

2. Applies to all leads.
3. $\varnothing b_2$ applies between L1 and L2. $\varnothing b$ applies between L2 and 12.7mm from the seating plane. Diameter is uncontrolled within L1 and beyond 12.7mm from the seating plane.
4. Measured from the maximum diameter of the actual device.
5. This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed 0.254mm.
6. The details of outline in this zone are optional.
7. Measured from the tab centreline.

1.7 FUNCTIONAL DIAGRAM



NOTES:

1. The collector is internally connected to the case.

1.8 MATERIALS AND FINISHES

Materials and finishes shall be as follows:

- a) Case
The case shall be hermetically sealed and have a metal body with hard glass seals.
- b) Leads/Terminals
As specified in Component Type Variants.

2. REQUIREMENTS

2.1 GENERAL

The complete requirements for procurement of the components specified herein are as stated in this specification and the ESCC Generic Specification. Permitted deviations from the Generic Specification, applicable to this specification only, are listed below.

Permitted deviations from the Generic Specification and this Detail Specification, formally agreed with specific Manufacturers on the basis that the alternative requirements are equivalent to the ESCC requirement and do not affect the component's reliability, are listed in the appendices attached to this specification.

2.1.1 Deviations from the Generic Specification

- (a) Deviation from Screening Tests - Chart F3
High Temperature Reverse Bias Burn-in and the subsequent Final Measurements for HTRB shall be omitted.

2.2 MARKING

The marking shall be in accordance with the requirements of ESCC Basic Specification No. 21700 and as follows.

The information to be marked on the component shall be:

- (a) The ESCC qualified components symbol (for ESCC qualified components only).
- (b) The ESCC Component Number.
- (c) Traceability information.

2.3 TERMINAL STRENGTH

The test conditions for terminal strength, tested as specified in the ESCC Generic Specification, shall be as follows:

Test Condition: E, lead fatigue.

2.4 ELECTRICAL MEASUREMENTS AT ROOM, HIGH AND LOW TEMPERATURES

Electrical measurements shall be performed at room, high and low temperatures.

2.4.1 Room Temperature Electrical Measurements

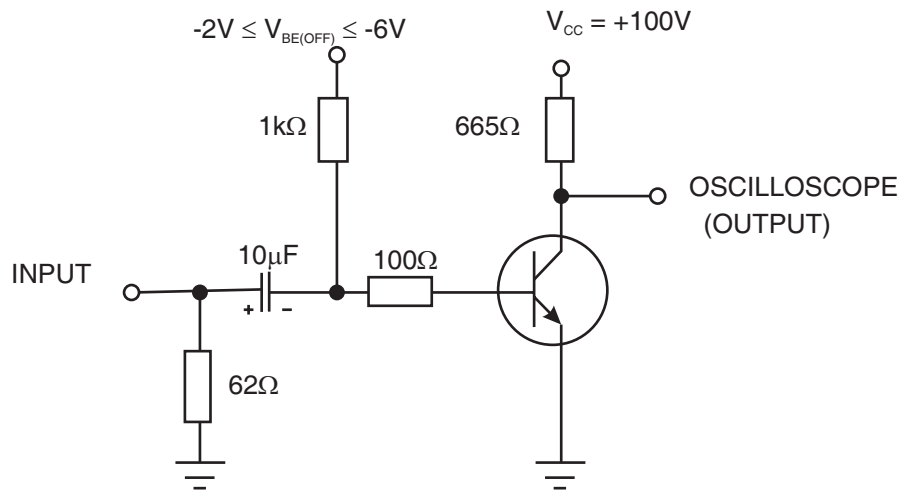
The measurements shall be performed at $T_{amb}=+22 \pm 3^{\circ}C$.

| Characteristics | Symbols | MIL-STD-750 Test Method | Test Conditions | Limits | | Units |
|-------------------------------------|---------------|-------------------------|---|--------|-----|-------|
| | | | | Min | Max | |
| Collector-Base Breakdown Voltage | $V_{(BR)CBO}$ | 3001 | $I_C = 10\mu A$, Bias Condition D | 150 | - | V |
| Collector-Emitter Breakdown Voltage | $V_{(BR)CEO}$ | 3011 | $I_C = 10mA$, Bias Condition D, Note 1 | 150 | - | V |
| Emitter-Base Breakdown Voltage | $V_{(BR)EBO}$ | 3026 | $I_E = 10\mu A$, Bias Condition D | 6 | - | V |
| Collector-Base Cut-off Current | I_{CBO} | 3036 | $V_{CB} = 75V$, Bias Condition D | - | 50 | nA |
| Emitter-Base Cut-off Current | I_{EBO} | 3061 | $V_{CB} = 4V$, Bias Condition D | - | 25 | nA |

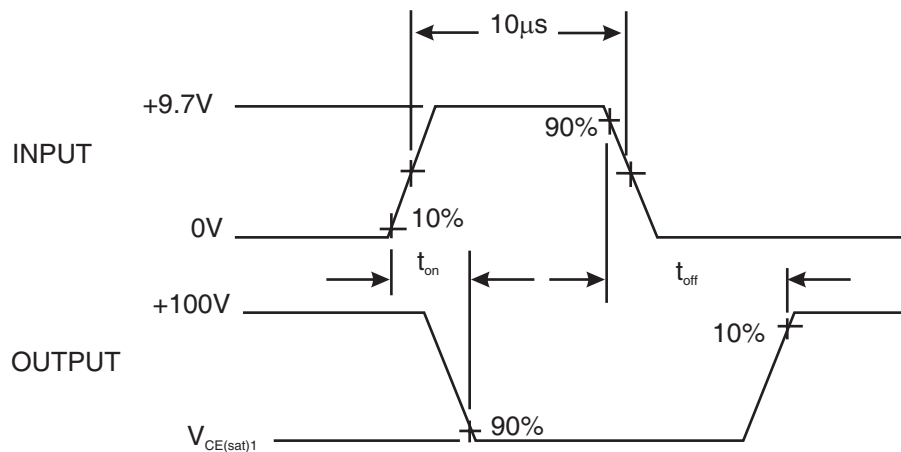
| Characteristics | Symbols | MIL-STD-750 Test Method | Test Conditions | Limits | | Units |
|--|----------------|----------------------------|---|--------|-----|-------|
| | | | | Min | Max | |
| Collector-Emitter Saturation Voltage | $V_{CE(sat)1}$ | 3071 | $I_C = 150mA, I_B = 15mA,$ Note 1 | - | 400 | mV |
| | $V_{CE(sat)2}$ | 3071 | $I_C = 10mA$ $I_B = 1mA$ Note 1 | - | 200 | mV |
| Base-Emitter Saturation Voltage | $V_{BE(sat)1}$ | 3066 | $I_C = 150mA$ $I_B = 15mA$ Test Condition A Note 1 | - | 1.2 | V |
| | $V_{BE(sat)2}$ | 3066 | $I_C = 10mA$ $I_B = 1mA$ Test Condition A Note 1 | - | 800 | mV |
| Forward-Current Transfer Ratio | h_{FE1} | 3076 | $V_{CE} = 10V ; I_C = 100\mu A,$ Note 1 | 35 | - | - |
| | h_{FE2} | 3076 | $V_{CE} = 10V ; I_C = 150mA,$ Note 1 | 100 | 300 | - |
| | h_{FE3} | 3076 | $V_{CE} = 10V ; I_C = 300mA,$ Note 1 | 20 | - | - |
| Input Capacitance | C_{ibo} | 3240 | $V_{EB} = 500mV$ $I_C = 0A$ $f = 100kHz$ Note 2 | - | 80 | pF |
| Output Capacitance | C_{obo} | 3236 | $V_{CB} = 10V,$ $I_E = 0A$ $f = 100kHz$ Note 2 | - | 8 | pF |
| Small-Signal Short-Circuit Forward-Current Transfer Ratio | h_{fe} | 3306 | $V_{CE} = 10V,$ $I_C = 10mA$ $f = 1kHz$ Note 2 | 75 | 375 | - |
| Magnitude of Small-Signal Short-Circuit Forward Current Transfer Ratio | $ h_{fe} $ | 3306 | $V_{CE} = 20V$ $I_C = 20mA$ $f = 100MHz$ Note 2 | 1.5 | 8 | - |
| Gain Bandwidth Product | f_T | 3261 | $V_{CE} = 20V$ $I_C = 20mA$ $f = 100MHz$ Note 2 | 150 | - | MHz |
| Turn-on Time | t_{on} | - | $I_B = 15mA$ Notes 2, 3 | - | 70 | ns |
| Turn-off Time | t_{off} | - | $I_{B1} = I_{B2} = 15mA$ Notes 2, 3 | - | 240 | ns |

NOTES:

1. Pulsed measurement: Pulse Width $\leq 300\mu\text{s}$, Duty Cycle $\leq 2\%$.
2. For AC characteristics read and record measurements shall be performed on a sample of 32 components with 0 failures allowed. Alternatively a 100% inspection may be performed.
3. t_{on} and t_{off} shall be measured using the following test circuit. The input waveforms for t_{on} and t_{off} shall be supplied by a pulse generator with the following characteristics: $Z_{\text{OUT}}=50\Omega$, $t_r = t_f \leq 20\text{ns}$, Pulse Width $\geq 10\mu\text{s}$, Duty Cycle $\leq 2\%$. The output waveforms shall be monitored on an oscilloscope with the following characteristics: $t_r \leq 1\text{ns}$, $Z_{\text{IN}} = 50\Omega$.



VOLTAGE WAVEFORMS



2.4.2 High and Low Temperatures Electrical Measurements

| Characteristics | Symbols | MIL-STD-750 Test Method | Test Conditions Note 1 | Limits | | Units |
|--------------------------------|------------------|-------------------------|---|--------|-----|---------------|
| | | | | Min | Max | |
| Collector-Base Cut-off Current | I_{CBO} | 3036 | $T_{\text{amb}}=+150(+0-5)^{\circ}\text{C}$ $V_{\text{CB}}=75\text{V}$, Bias Condition D | - | 50 | μA |

| Characteristics | Symbols | MIL-STD-750 Test Method | Test Conditions Note 1 | Limits | | Units |
|-------------------------------------|-----------|----------------------------|---|--------|-----|-------|
| | | | | Min | Max | |
| Forward-Current Transfer Ratio 2 | h_{FE2} | 3076 | $T_{amb}=-55(+5-0)^{\circ}C$ $V_{CE}=10V$ $I_C=150mA$ Note 2 | 50 | - | - |

NOTES:

1. Read and record measurements shall be performed on a sample of 5 components with 0 failures allowed. Alternatively a 100% inspection may be performed.
2. Pulsed measurement: Pulse Width $\leq 300\mu s$, Duty Cycle $\leq 2\%$.

2.5

PARAMETER DRIFT VALUES

Unless otherwise specified, the measurements shall be performed at $T_{amb}=+22 \pm 3^{\circ}C$.

The test methods and test conditions shall be as per the corresponding test defined in Room Temperature Electrical Measurements.

The drift values (Δ) shall not be exceeded for each characteristic specified. The corresponding absolute limit values for each characteristic shall not be exceeded.

| Characteristics | Symbols | Limits | | | Units |
|---|----------------|-----------------------------------|----------|-----|-------|
| | | Drift Value Δ | Absolute | | |
| | | | Min | Max | |
| Collector-Base Cut-off Current | I_{CBO} | ± 10 or (1) $\pm 100\%$ | - | 50 | nA |
| Collector-Emitter Saturation Voltage 1 | $V_{CE(sat)1}$ | ± 50 or (1) $\pm 15\%$ | - | 400 | mV |
| Forward-Current Transfer Ratio 2 | h_{FE2} | $\pm 15\%$ | 100 | 300 | - |

NOTES:

1. Whichever is the greater referred to the initial value.

2.6

INTERMEDIATE AND END-POINT ELECTRICAL MEASUREMENTS

Unless otherwise specified, the measurements shall be performed at $T_{amb}=+22 \pm 3^{\circ}C$.

The test methods and test conditions shall be as per the corresponding test defined in Room Temperature Electrical Measurements.

The limit values for each characteristic shall not be exceeded.

| Characteristics | Symbols | Limits | | Units |
|---|----------------|--------|-----|-------|
| | | Min | Max | |
| Collector-Base Cut-off Current | I_{CBO} | - | 50 | nA |
| Collector-Emitter Saturation Voltage 1 | $V_{CE(sat)1}$ | - | 400 | mV |
| Forward-Current Transfer Ratio 2 | h_{FE2} | 100 | 300 | - |

2.7 POWER BURN-IN CONDITIONS

| Characteristics | Symbols | Conditions | Units |
|------------------------|-----------|------------|-------|
| Ambient Temperature | T_{amb} | +22 ±3 | °C |
| Power Dissipation | P_{tot} | 1 | W |
| Collector-Base Voltage | V_{CB} | 100 | V |

2.8 OPERATING LIFE CONDITIONS

The conditions shall be as specified for Power Burn-in.