# High voltage, high current Darlington transistor array

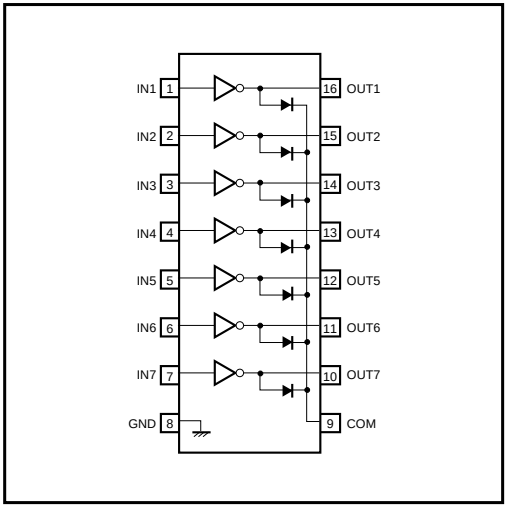
## BA12001B / BA12002 / BA12003B / BA12003BF / BA12004B

The BA12001B, BA12002, BA12003B, BA12003BF, and BA12004B are high current transistor arrays featuring high voltage withstand resistance and consisting of seven circuits of Darlington transistors.
Because it incorporates built-in surge-absorbing diodes and base current-control resistors needed when using inductive loads such as relay coils, attachments can be kept to a minimum.
With an output withstanding voltage as high as 60V (BA12001B, BA12003B, BA12003BF, and BA12004B) and an output current (sink current) of 500mA, this product is ideal for use with various drivers and as an interface with other elements.

●Applications
Drivers for LEDs, lamps, relays and solenoids
Interface with other elements

●Features
1) High output current. ($I_{OUT}$ = 500mA Max.)
2) High output voltage withstand resistance. ($V_{OUT}$ = 50V Max.)
3) Seven Darlington transistors built in.
4) Equipped with output surge-absorbing clamp diode. (Note: Refer to the "Reference items when using in application.")

●Block diagram



●Internal circuit configuration

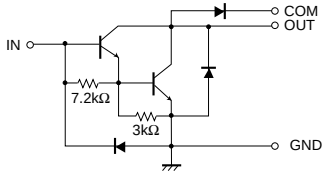



Fig.1 BA12001B

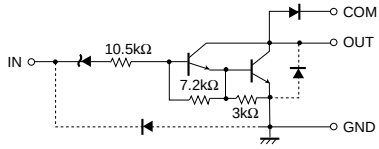



Fig.2 BA12002

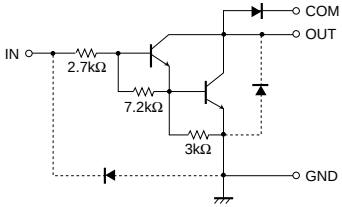



Fig.3 BA12003B / BF

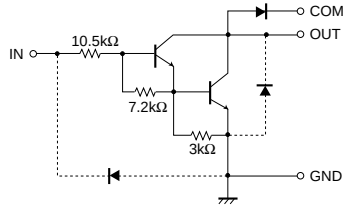



Fig.4 BA12004B

●Absolute maximum ratings (Ta = 25°C)

| Parameter | | Symbol | Limits | Unit |
|---|---|---|---|---|
| Power supply voltage | other than BA12002 | $V_{CE}$ | 60 | V |
| | BA12002 | | 50 | |
| Input voltage | other than BA12001B | $V_{IN}$ | – 0.5 ~ + 30 | V |
| Input current | BA12001B | $I_{IN}$ | 25 | mA / driver |
| Output current | | $I_{OUT}$ | 500 | mA / driver |
| Ground pin current | | $I_{GND}$ | 2.3*1 | A |
| Power dissipation | DIP package | Pd | 1250*2 | mW |
| | SOP package | | 625*3 | |
| Diode reverse voltage | | $V_R$ | 60 | V |
| Diode forward current | | $I_F$ | 500 | mA |
| Operating temperature | | Topr | – 25 ~ + 75 | °C |
| Storage temperature | | Tstg | – 55 ~ + 150 | °C |

∗1 Pulse width ≦ 20ms, duty cycle ≦ 10%, same current for all 7 circuits

∗2 Reduced by 10mW for each increase in Ta of 1°C over 25°C .

∗3 Reduced by 50mW for each increase in Ta of 1°C over 25°C .

●Recommended operating conditions (Ta = 25°C)

| Parameter | | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| Output current | | $I_{OUT}$ | — | — | 350 | mA | Fig.9, 10 |
| Power supply voltage | Other than BA12002 | $V_{CE}$ | — | — | 55 | V | — |
| | BA12002 | | — | — | 50 | | — |
| Input voltage (excluding BA12001B) | | $V_{IN}$ | — | — | 30 | V | — |
| Input current (BA12001B only) | | $I_{IN}$ | — | — | 25 | mA / driver | — |

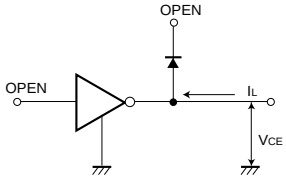
●Electrical characteristics (unless otherwise noted, Ta=25°C)

| Parameter | | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| Output leakage current | | $I_L$ | — | 0 | 10 | µA | $V_{CE}$ = 60V (only BA12002: $V_{CE}$ = 50V) |
| DC current transfer ratio | | $h_{FE}$ | 1000 | 2400 | — | V | $V_{CE}$ = 2V, $I_{OUT}$ = 350mA |
| Output saturation voltage | | $V_{CE(sat)}$ | — | 0.94 | 1.1 | V | $I_{OUT}$ = 100mA, $I_{IN}$ = 250µA |
| | | | | 1.14 | 1.3 | | $I_{OUT}$ = 200mA, $I_{IN}$ = 350µA |
| | | | | 1.46 | 1.6 | | $I_{OUT}$ = 350mA, $I_{IN}$ = 500µA |
| Input voltage | BA12002 | $V_{IN}$ | — | 10.2 | 11 | V | $V_{CE}$ = 2V, $I_{OUT}$ = 100mA |
| | BA12003B / BF | | | 1.75 | 2 | | |
| | BA12004B | | | 2.53 | 5 | | |
| | BA12002 | $V_{IN}$ | — | 10.4 | 12 | V | $V_{CE}$ = 2V, $I_{OUT}$ = 200mA |
| | BA12003B / BF | | | 1.91 | 2.4 | | |
| | BA12004B | | | 2.75 | 6 | | |
| | BA12002 | $V_{IN}$ | — | 10.7 | 13.5 | V | $V_{CE}$ = 2V, $I_{OUT}$ = 350mA |
| | BA12003B / BF | | | 2.17 | 3.4 | | |
| | BA12004B | | | 3.27 | 8 | | |
| Input current | BA12002 | $I_{IN}$ | — | 0.88 | 1.3 | mA | $V_{IN}$ = 17V |
| | BA12003B / BF | | | 0.90 | 1.35 | | $V_{IN}$ = 3.85V |
| | BA12004B | | | 0.39 | 0.5 | | $V_{IN}$ = 5V |
| Diode reverse current | | $I_R$ | — | 0 | 50 | µA | $V_R$ = 60V (only BA12002: $V_R$ = 50V) |
| Diode forward voltage | | $V_F$ | — | 1.73 | 2 | V | $I_F$ = 350mA |
| Input capacitance | | $C_{IN}$ | — | 30 | — | pF | $V_{IN}$ = 0V, f = 1MHz |

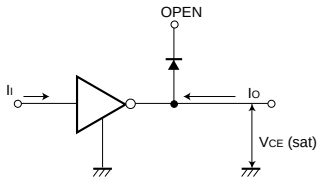
Note: Input voltage and input current for BA12001 vary based on external resistor.

●Measurement circuits

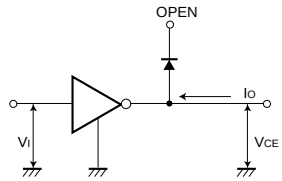
(1) Output leakage current $I_L$



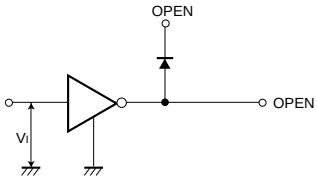

(2) DC current transfer ratio $h_{FE} = \frac{I_O}{I_I}$
Output saturation voltage $V_{CE}(sat)$



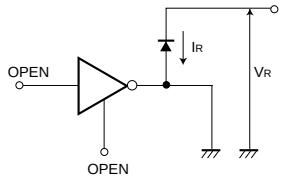

(3) Input voltage $V_{IN}$



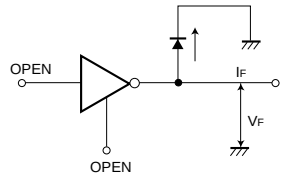

(4) Input current $I_{IN}$




(5) Diode reverse current $I_R$




(6) Diode forward voltage $I_F$




(7) Input capacitance $C_{IN}$

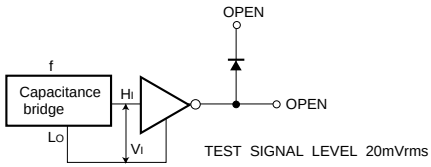
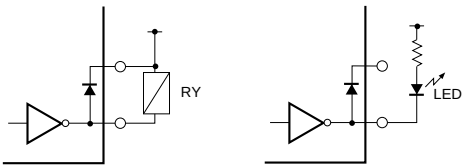



Fig.5

●Application example




(1) Relay driver (2) LED driver

Fig.6

●Reference items when using in application

The BA12001B is a transistor array which can be directly coupled to a general logic circuit such as PMOS, CMOS, or TTL.

Because the base current is limited to 25mA, a current limiting resistor needs to be connected in series with the input.

The BA12002 is designed for direct coupling with a 14 to 25V system PMOS. In order to limit the input current, a level shift diode (7V) and resistor are connected in series to each of the inputs.

The BA12003B / BF can be coupled directly to TTL or CMOS output (when operating at 5V). In order to limit the input current to a stable value, resistors are connected in series to each of the inputs.

The BA12004B is designed for direct coupling to CMOS or PMOS output using a 6 to 15V power supply voltage. In order to limit the input current to a stable value, resistors are connected in series to each of the inputs.

The load for each of these products should be connected between the driver output and the power supply. To protect the IC from excessive swing voltage, the COM pin (Pin 9) should be connected to the power supply.

Fig. 7 shows the configuration of the on-chip diode for surge absorption.

In the construction of the surge-absorbing diode, there is an N-P junction between the N-layer (N-well + BL) and the substrate (P-sub) so that when the diode is on, current flows from the output pin to the substrate. In terms of the vertical construction, this diode is configured similar to a PNP transistor. When using the surge-absorbing diode, take appropriate measures regarding the thermal characteristics of the design considering the current that will be handled.

Also, if motor back-rush current or other conditions that will result continued surge current to flow to the surge-absorbing diode can be foreseen, we strongly recommend connecting a Schottky barrier diode (or other type of diode with a low foward voltage) in parallel with the surge-absorbing diode to construct a bypass route for the surge current.

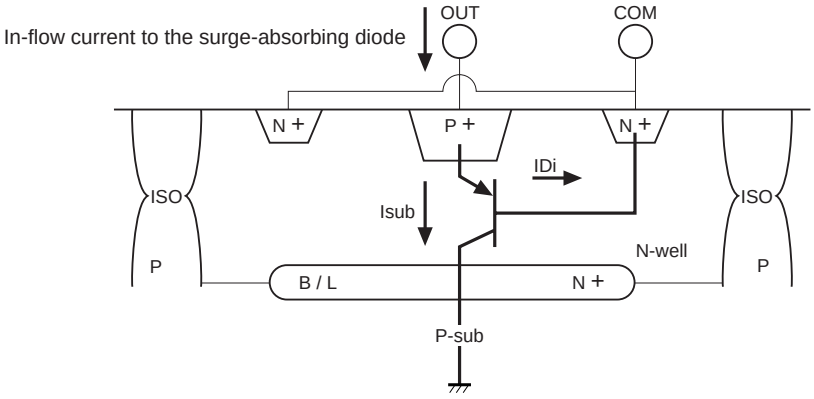



Fig. 7 Vertical construction of the surge-absorbing diode

●Electrical characteristic curves

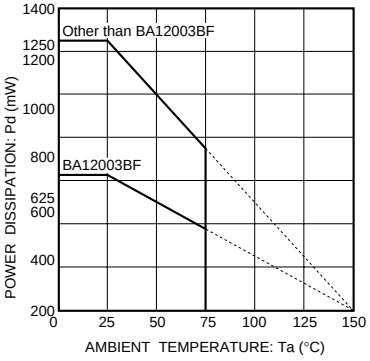



Fig. 8 Power dissipation vs. ambient temperature


Fig. 9 Output conditions (Ⅰ)

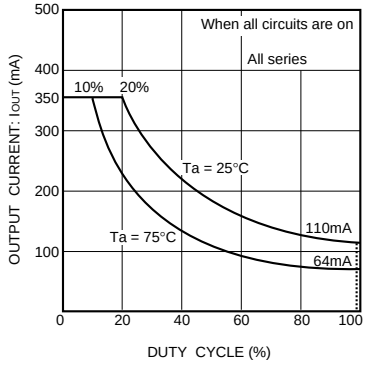



Fig. 10 Output conditions (Ⅱ)

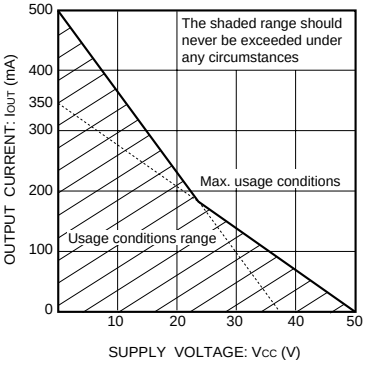



Fig. 11 Usage conditions range per circuit

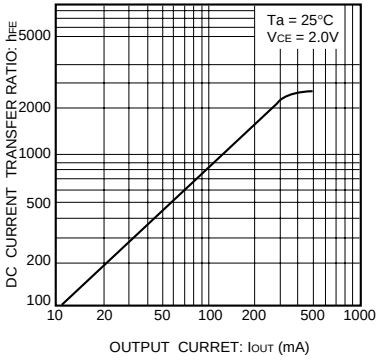



Fig. 12 DC current transfer ratio vs. output current

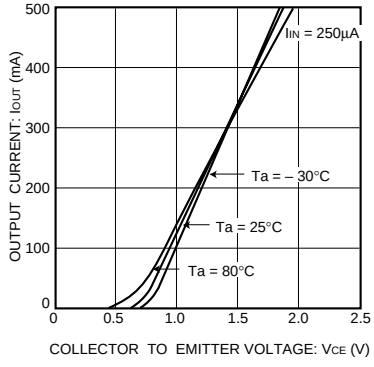



Fig. 13 Output current vs. voltage between collector and emitter

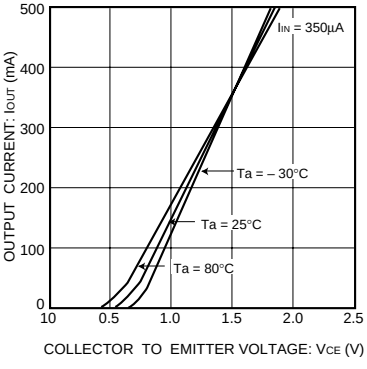



Fig. 14 Output current vs. voltage between collector and emitter

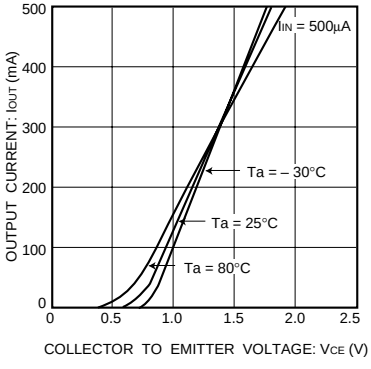



Fig. 15 Output current vs. voltage between collector and emitter

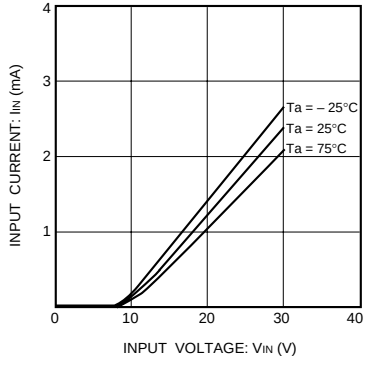



Fig. 16 Input current vs. input voltage (BA12002)

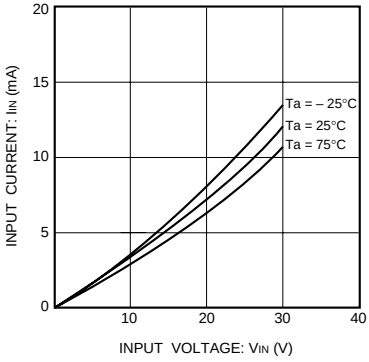



Fig. 17 Input current vs. input voltage (BA12003B / BF)

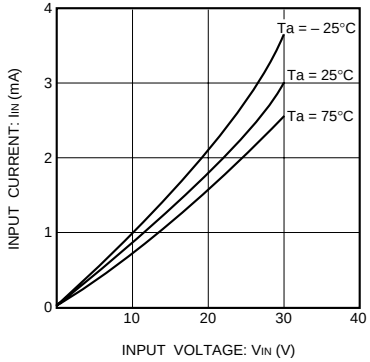



Fig. 18 Input current vs. input voltage (BA12004B)

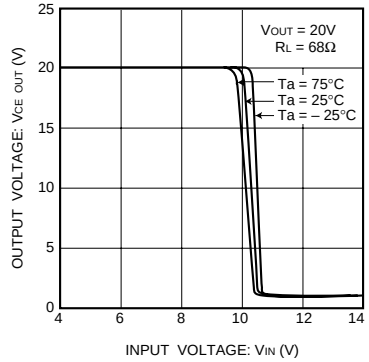



Fig.19 Output voltage vs. input voltage (BA12002)

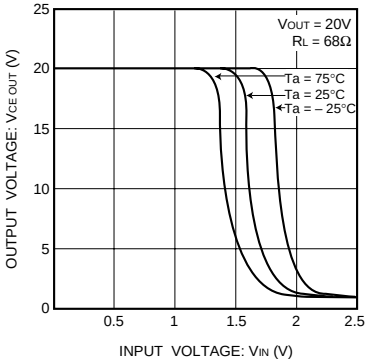



Fig. 20 Output voltage vs. input voltage (BA12003B / BF)

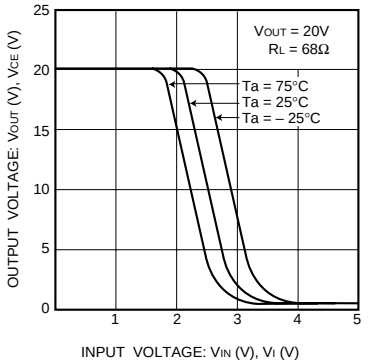
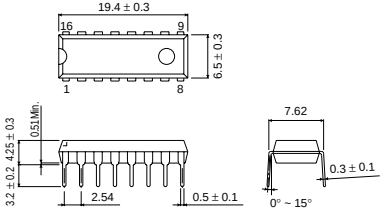



Fig. 21 Output voltage vs. input voltage (BA12004B)

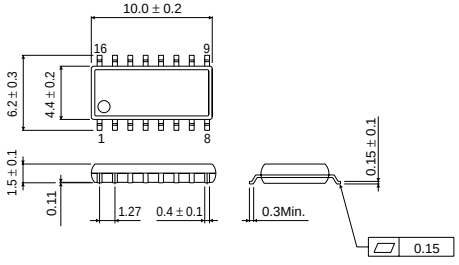
●External dimensions (Units: mm)

BA12001B / BA12002 / BA12003B / BA12004B




DIP16

BA12003BF




SOP16