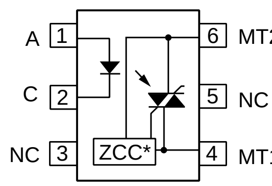
# Optocoupler, Phototriac Output, Zero Crossing


*Zero crossing circuit

## DESIGN SUPPORT TOOLS

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Related Documents

## DESCRIPTION

The BRT21, BRT22, BRT23 product family consists of AC switch optocouplers with zero voltage detectors with two electrically insulated lateral power ICs which integrate a thyrister system, a photo detector and noise suppression at the output and an IR GaAs diode input.

High input sensitivity is achieved by using an emitter follower phototransistor and a SCR predriver resulting in an LED trigger current of less than 2 mA or 3 mA (DC). Inverse parallel SCRs provide commutating dV/dt greater than 10 kV/μs.

The zero cross line voltage detection circuit consists of two MOSFETS and a photodiode.

The BRT21, BRT22, BRT23 product family isolates low-voltage logic from 120, 230, and 380 VAC lines to control resistive, inductive or capacitive loads including motors, solenoids, high current thyristors or TRIAC and relays.

## FEATURES

- High input sensitivity $I_{FT}$ = 1 mA
- $I_{TRMS}$ = 300 mA
- High static dV/dt 10 000 V/μs
- Electrically insulated between input and output circuit
- Microcomputer compatible
- Trigger current
  - ($I_{FT}$ < 1.2 mA) BRT22**F**, BRT23**F**
  - ($I_{FT}$ < 2 mA) BRT21**H**, BRT22**H**, BRT23**H**
  - ($I_{FT}$ < 3 mA) BRT21**M**, BRT22**M**, BRT23**M**
- Available surface mount an^d on tape and reel
- Zero voltage crossing detector
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free

e3

RoHS COMPLIANT

## APPLICATIONS

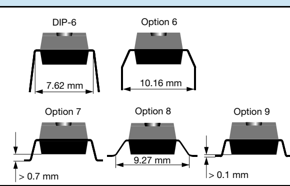
- Industrial controls
- Office equipment
- Consumer appliances

## AGENCY APPROVALS

- UL 1577
- cUL 1577
- DIN EN 60747-5-5 (VDE 0884-5) available with option 1

## ORDERING INFORMATION

| B | R | T | 2 | # | x | - | X | 0 | # | # | T |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PART NUMBER | | | | | | | PACKAGE OPTION | | | | TAPE AND REEL |




| AGENCY CERTIFIED/PACKAGE | $V_{DRM}$ (V) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ≤ 400 | | ≤ 600 | | | ≤ 800 | | |
| UL | $I_{FT}$ = 2 mA | $I_{FT}$ = 3 mA | $I_{FT}$ = 1.2 mA | $I_{FT}$ = 2 mA | $I_{FT}$ = 3 mA | $I_{FT}$ = 1.2 mA | $I_{FT}$ = 2 mA | $I_{FT}$ = 3 mA |
| DIP-6 | BRT21H | BRT21M | BRT22F | BRT22H | BRT22M | BRT23F | BRT23H | BRT23M |
| DIP-6, 400 mil, option 6 | - | - | BRT22F-X006 | - | - | BRT23F-X006 | BRT23H-X006 | - |
| SMD-6, option 7 | BRT21H-X007 | - | BRT22F-X007T (1) | BRT22H-X007T (1) | - | BRT23F-X007T (1) | BRT23H-X007T (1) | BRT23M-X007T |
| SMD-6, option 9 | - | - | BRT22F-X009T (1) | - | - | BRT23F-X009T | - | - |

| AGENCY CERTIFIED/PACKAGE | $V_{DRM}$ (V) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ≤ 400 | | ≤ 600 | | | ≤ 800 | | |
| **UL, VDE** | $I_{FT}$ = 2 mA | $I_{FT}$ = 3 mA | $I_{FT}$ = 1.2 mA | $I_{FT}$ = 2 mA | $I_{FT}$ = 3 mA | $I_{FT}$ = 1.2 mA | $I_{FT}$ = 2 mA | $I_{FT}$ = 3 mA |
| DIP-6 | - | - | BRT22F-X001 | BRT22H-X001 | - | - | BRT23H-X001 | - |
| DIP-6, option 6 | BRT21H-X016 | BRT21M-X016 | BRT22F-X016 | BRT22H-X016 | BRT22M-X016 | - | BRT22H-X016 | BRT23M-X016 |
| SMD-6, option 7 | - | - | BRT22F-X017T | BRT22H-X017 (1) | - | - | - | - |
| SMD-6, option 8 | - | - | - | - | - | - | BRT23H-X018T | - |

**Note**

(1) Also available in tube, do not put T on the end

| **ABSOLUTE MAXIMUM RATINGS** ($T_{amb}$ = 25 °C, unless otherwise specified) | | | | | |
|---|---|---|---|---|---|
| **PARAMETER** | **TEST CONDITION** | **PART** | **SYMBOL** | **VALUE** | **UNIT** |
| **INPUT** | | | | | |
| Reverse voltage | $I_R$ = 10 μA | | $V_R$ | 6 | V |
| Forward current | | | $I_F$ | 60 | mA |
| Surge current | | | $I_{FSM}$ | 2.5 | A |
| Power dissipation | | | $P_{diss}$ | 100 | mW |
| Derate from 25 °C | | | | 1.33 | mW/°C |
| **OUTPUT** | | | | | |
| Peak off-state voltage | | BRT21 | $V_{DRM}$ | 400 | V |
| | | BRT22 | $V_{DRM}$ | 600 | V |
| | | BRT23 | $V_{DRM}$ | 800 | V |
| On state RMS current | | | $I_{TRM}$ | 300 | mA |
| Single cycle surge current | | | | 3 | A |
| Power dissipation | | | $P_{diss}$ | 600 | mW |
| Derate from 25 °C | | | | 6.6 | mW/°C |
| **COUPLER** | | | | | |
| Storage temperature range | | | $T_{stg}$ | -40 to +150 | °C |
| Ambient temperature range | | | $T_{amb}$ | -40 to +100 | °C |
| Soldering temperature | Max. ≤ 10 s dip soldering ≥ 0.5 mm from case bottom | | $T_{sld}$ | 260 | °C |

**Note**

- Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to absolute maximum ratings for extended periods of the time can adversely affect reliability

| **ELECTRICAL CHARACTERISTICS** ($T_{amb}$ = 25 °C, unless otherwise specified) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **TEST CONDITION** | **PART** | **SYMBOL** | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| **INPUT** | | | | | | | |
| Forward voltage | $I_F$ = 10 mA | | $V_F$ | - | 1.16 | 1.35 | V |
| Reverse current | $V_R$ = 6 V | | $I_R$ | - | 0.1 | 10 | μA |
| Capacitance | f = 1 MHz, $V_F$ = 0 V | | $C_O$ | - | 25 | - | pF |
| Thermal resistance, junction to ambient | | | $R_{thJA}$ | - | 750 | - | K/W |
| **OUTPUT** | | | | | | | |
| Peak off-state voltage | $I_{D(RMS)}$ = 100 μA | BRT21 | $V_{DM}$ | - | 400 | - | V |
| | | BRT22 | | - | 600 | - | |
| | | BRT23 | | - | 800 | - | |
| Off-state current | $V_D = V_{DRM}$, $T_{amb}$ = 100 °C, $I_F$ = 0 mA | | $I_{D(RMS)}$ | - | 10 | 100 | μA |
| On-state voltage | $I_T$ = 300 mA | | $V_{TM}$ | - | 1.7 | 3 | V |
| On-state current | PF = 1, $V_{T(RMS)}$ = 1.7 V | | $I_{TM}$ | - | - | 300 | mA |
| Surge (non-repetitive), on-state current | f = 50 Hz | | $I_{TSM}$ | - | - | 3 | A |
| Trigger current temp. gradient | | | $\Delta I_{FT1}/\Delta T_j$ | - | 7 | 14 | μA/K |
| | | | $\Delta I_{FT2}/\Delta T_j$ | - | 7 | 14 | μA/K |
| Inhibit voltage temp. gradient | | | $\Delta V_{DINH}/\Delta T_j$ | - | -20 | - | mV/K |
| Off-state current in inhibit state | $I_F = I_{FT1}$, $V_{DRM}$ | | $I_{DINH}$ | - | 50 | 200 | μA |
| Holding current | | | $I_H$ | - | 65 | 500 | μA |
| Latching current | $V_T$ = 2.2 V | | $I_L$ | - | 5 | - | mA |
| Zero cross inhibit voltage | $I_F$ = rated $I_{FT}$ | | $V_{IH}$ | - | 15 | 25 | V |
| **OUTPUT** (continued) | | | | | | | |
| Turn-on time | $V_{RM} = V_{DM} = V_{D(RMS)}$ | | $t_{on}$ | - | 35 | - | μs |
| Turn-off time | PF = 1, $I_T$ = 300 mA | | $t_{off}$ | - | 50 | - | μs |
| Critical rate of rise of off-state voltage | $V_D$ = 0.67 $V_{DRM}$, $T_j$ = 25 °C | | $dV/dt_{cr}$ | 10 000 | - | - | V/μs |
| | $V_D$ = 0.67 $V_{DRM}$, $T_j$ = 80 °C | | $dV/dt_{cr}$ | 5000 | - | - | V/μs |
| Critical rate of rise of voltage at current commutation | $V_D$ = 230 $V_{RMS}$, $I_D$ = 300 $mA_{RMS}$, $T_j$ = 25 °C | | $dV/dt_{crq}$ | - | 8 | - | V/μs |
| | $V_D$ = 230 $V_{RMS}$, $I_D$ = 300 $mA_{RMS}$, $T_j$ = 85 °C | | $dV/dt_{crq}$ | - | 7 | - | V/μs |
| Critical rate of rise of on-state at current commutation | $V_D$ = 230 $V_{RMS}$, $I_D$ = 300 $mA_{RMS}$, $T_j$ = 25 °C | | $dI/dt_{crq}$ | - | 12 | - | A/ms |
| Thermal resistance, junction-to-ambient | | | $R_{thJA}$ | - | 125 | - | K/W |
| **COUPLER** | | | | | | | |
| Critical rate of rise of coupled input / output voltage | $I_T$ = 0 A, $V_{RM} = V_{DM} = V_{D(RMS)}$ | | $dV_{IO}/dt$ | - | 10 000 | - | V/μs |
| Common mode coupling capacitance | | | $C_{CM}$ | - | 0.01 | - | pF |
| Capacitance (input to output) | f = 1 MHz, $V_{IO}$ = 0 V | | $C_{IO}$ | - | 0.8 | - | pF |
| Trigger current | $V_D$ = 5 V, F - versions | | $I_{FT}$ | - | - | 1.2 | mA |
| | $V_D$ = 5 V, H - versions | | $I_{FT}$ | - | - | 2 | mA |
| | $V_D$ = 5 V, M - versions | | $I_{FT}$ | - | - | 3 | mA |

**Note**

- Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluation. Typical values are for information only and are not part of the testing requirements

| SAFETY AND INSULATION RATINGS | | | | |
|---|---|---|---|---|
| **PARAMETER** | **TEST CONDITION** | **SYMBOL** | **VALUE** | **UNIT** |
| Climatic classification | According to IEC 68 part 1 | | 40 / 100 / 21 | |
| Pollution degree | According to DIN VDE 0109 | | 2 | |
| Comparative tracking index | Insulation group IIIa | CTI | 175 | |
| Maximum rated withstanding isolation voltage | According to UL1577, t = 1 min | $V_{ISO}$ | 4420 | $V_{RMS}$ |
| Tested withstanding isolation voltage | According to UL1577, t = 1 s | $V_{ISO}$ | 5300 | $V_{RMS}$ |
| Maximum transient isolation voltage | According to DIN EN 60747-5-5 | $V_{IOTM}$ | 6000 | $V_{peak}$ |
| Maximum repetitive peak isolation voltage | According to DIN EN 60747-5-5 | $V_{IORM}$ | 630 | $V_{peak}$ |
| Isolation resistance | $V_{IO}$ = 500 V, $T_{amb}$ = 25 °C | $R_{IO}$ | $\geq 10^{12}$ | Ω |
| | $V_{IO}$ = 500 V, $T_{amb}$ = 100 °C | $R_{IO}$ | $\geq 10^{11}$ | Ω |
| Output safety power | | $P_{SO}$ | 200 | mW |
| Input safety current | | $I_{SI}$ | 400 | mA |
| Input safety temperature | | $T_S$ | 175 | °C |
| Creepage distance | DIP-6; SMD-6, option 7; SMD-6 option 9 | | ≥ 7 | mm |
| Clearance distance | | | ≥ 7 | mm |
| Creepage distance | DIP-6, option 6; SMD-6, option 8 | | ≥ 8 | mm |
| Clearance distance | | | ≥ 8 | mm |
| Insulation thickness | | DTI | ≥ 0.4 | mm |

**Note**

- As per IEC 60747-5-5, § 7.4.3.8.2, this optocoupler is suitable for “safe electrical insulation” only within the safety ratings. Compliance with the safety ratings shall be ensured by means of protective circuits

## POWER FACTOR CONSIDERATIONS

A snubber is not needed to eliminate false operation of the TRIAC driver because of the high static and commutating dV/dt with loads between 1.0 and 0.8 power factors. When inductive loads with power factors less than 0.8 are being driven, include a RC snubber or a single capacitor directly across the device to damp the peak commutating dV/dt spike. Normally a commutating dV/dt causes a turning-off device to stay on due to the stored energy remaining in the turning-off device.

But in the case of a zero voltage crossing optotriac, the commutating dV/dt spikes can inhibit one half of the TRIAC from turning on. If the spike potential exceeds the inhibit voltage of the zero cross detection circuit, half of the TRIAC will be heldoff and not turn-on. This hold-off condition can be eliminated by using a snubber or capacitor placed directly across the optotriac as shown in figure 1. Note that the value of the capacitor increases as a function of the load current.

The hold-off condition also can be eliminated by providing a higher level of LED drive current. The higher LED drive provides a larger photocurrent which causes the phototransistor to turn-on before the commutating spike has activated the zero cross network. Figure 2 shows the relationship of the LED drive for power factors of less than 1.0. The curve shows that if a device requires 1.5 mA for a resistive load, then 1.8 times 2.7 mA) that amount would be required to control an inductive load whose power factor is less than 0.3.

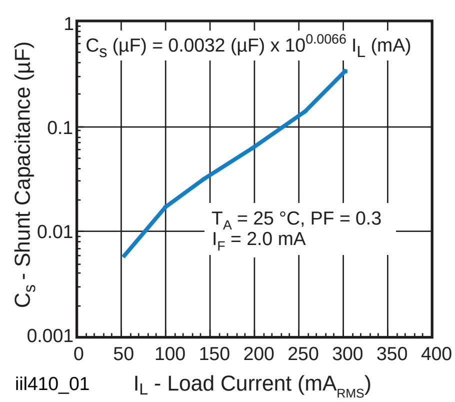



Fig. 1 - Shunt Capacitance vs. Load Current

**TYPICAL CHARACTERISTICS** ($T_{amb}$ = 25 °C, unless otherwise specified)

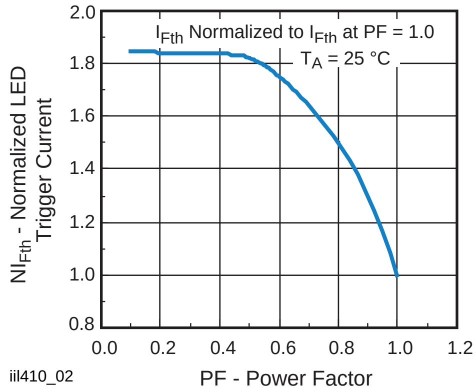



Fig. 2 - Normalized LED Trigger Current vs. Power Factor

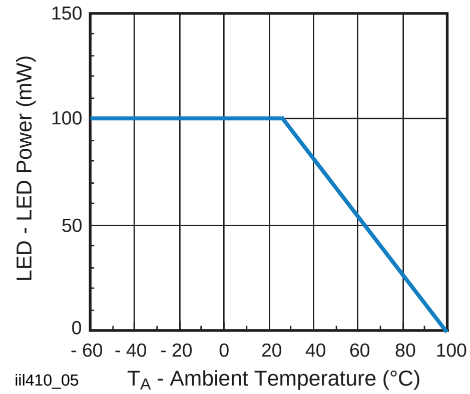



Fig. 5 - Maximum LED Power Dissipation

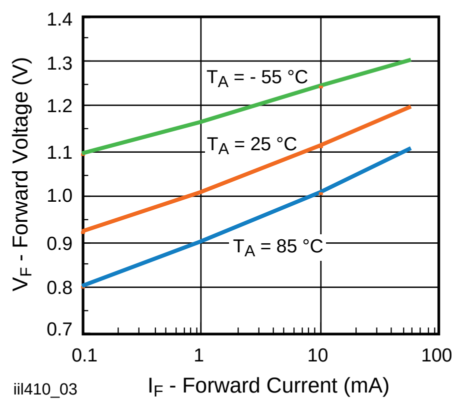



Fig. 3 - Forward Voltage vs. Forward Current

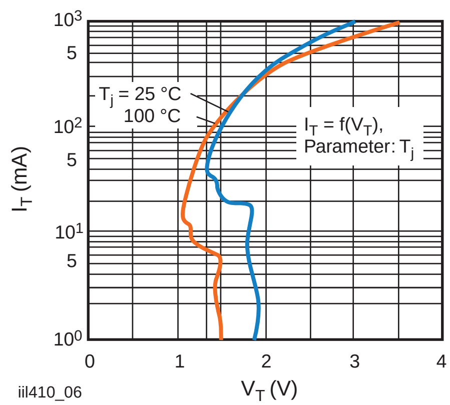



Fig. 6 - Typical Output Characteristics

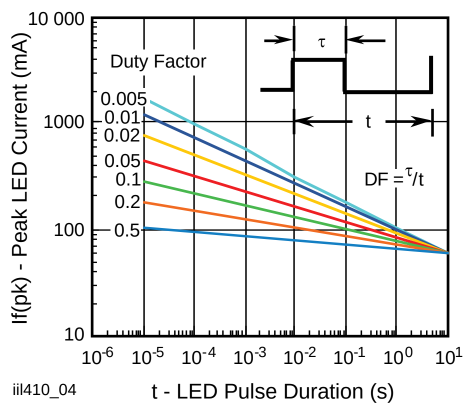



Fig. 4 - Peak LED Current vs. Duty Factor, τ

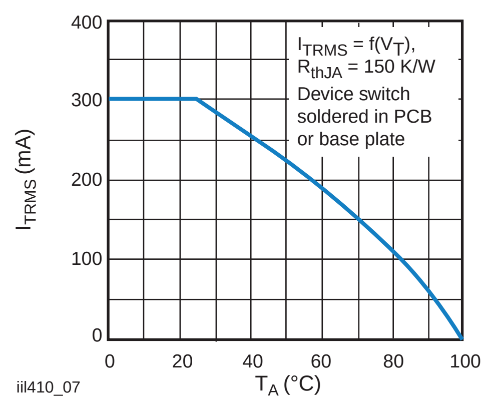



Fig. 7 - Current Reduction

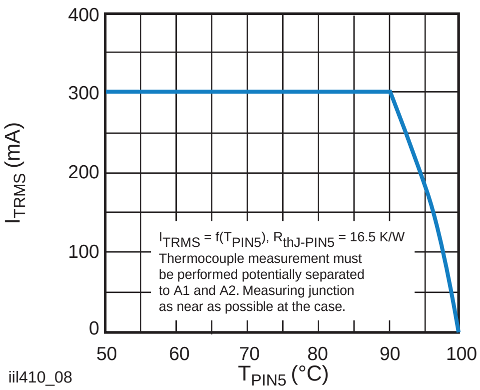



Fig. 8 - Current Reduction

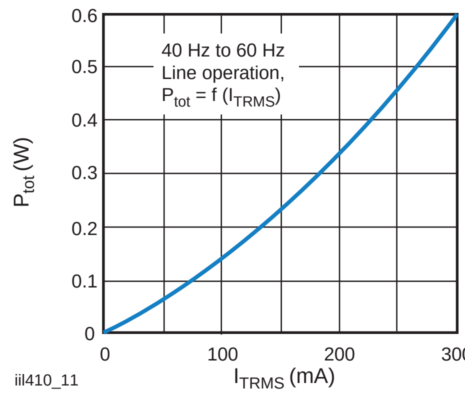



Fig. 11 - Power Dissipation 40 Hz to 60 Hz Line Operation

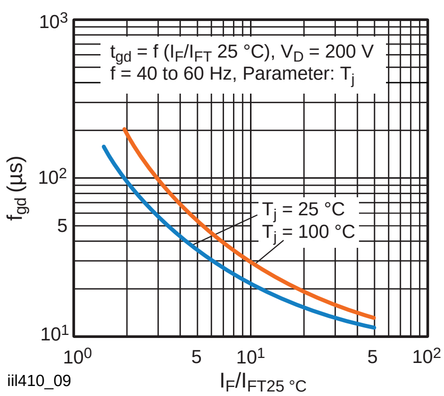



Fig. 9 - Typical Trigger Delay Time

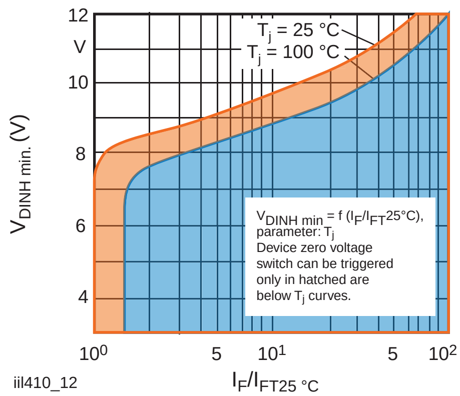



Fig. 12 - Typical Static Inhibit Voltage Limit

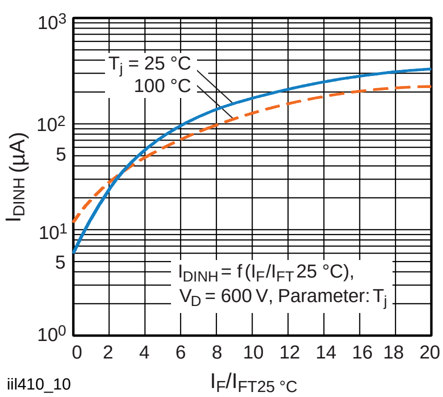



Fig. 10 - Typical Inhibit Current

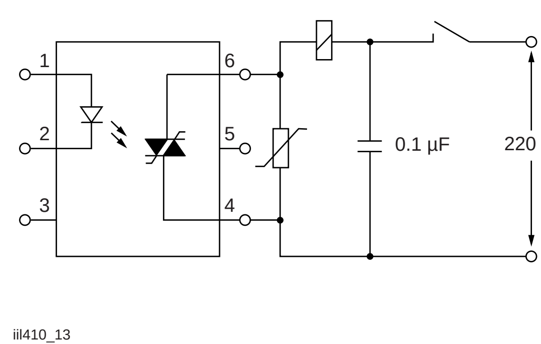



Fig. 13 - Apply a Capacitor to the Supply Pins at the Load-Side


For technical questions, contact: optocoupleranswers@vishay.com

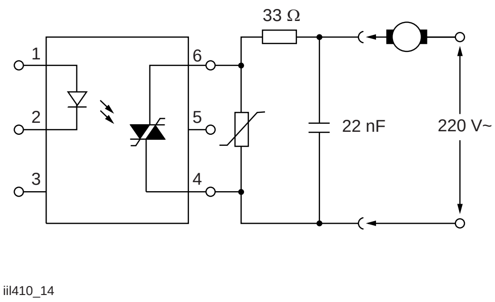



Fig. 14 - Connect a Series Resistor to the Output and Bridge Both by a Capacitor

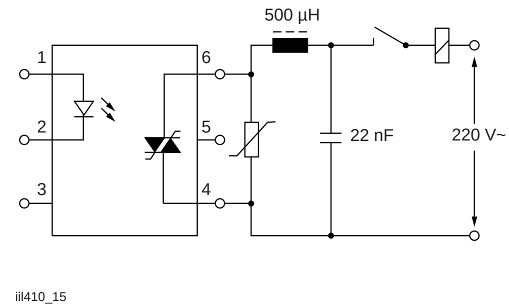
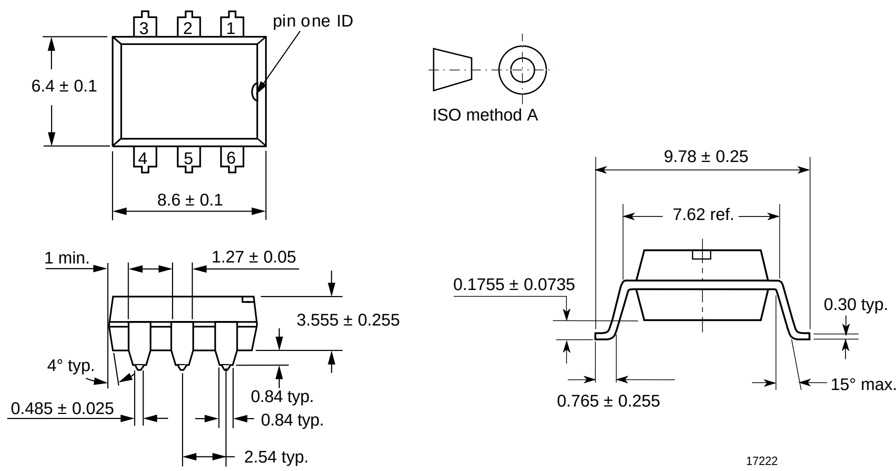


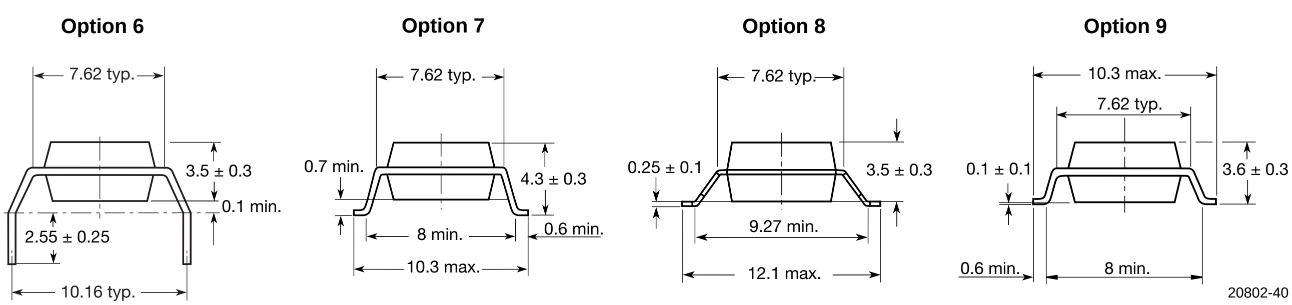

Fig. 15 - Connect a Choke of Low Winding Cap. in Series, e.g., a Ringcore Choke, with Higher Load Currents

## TECHNICAL INFORMATION

See Application Note for additional information.

## PACKAGE DIMENSIONS in millimeters




## PACKAGE MARKING (example)

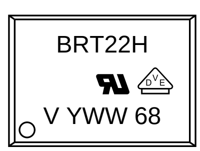



Fig. 16 - Example of BRT22H-X017

**Notes**

- "YWW" is the date code marking (Y = year code, WW = week code)
- VDE logo is only marked on option 1 parts
- Tape and reel suffix (T) is not part of the package marking

## SOLDER PROFILES

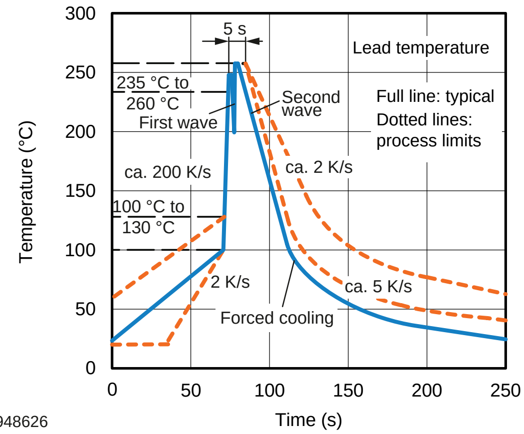



Fig. 17 - Wave Soldering Double Wave Profile According to J-STD-020 for DIP Devices

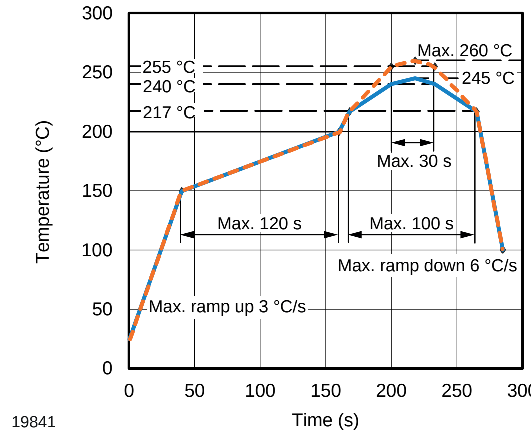



Fig. 18 - Lead (Pb)-free Reflow Solder Profile According to J-STD-020 for SMD Devices

## HANDLING AND STORAGE CONDITIONS

ESD level: HBM class 2

Floor life: unlimited

Conditions: $T_{amb}$ < 30 °C, RH < 85 %

Moisture sensitivity level 1, according to J-STD-020

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