

# iC-GE100

## PWM RELAY/SOLENOID DRIVER

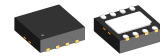
### FEATURES

- Current control for inductive actuators at 24 V (10 to 36 V)
- Power saving and power dissipation reduced switching
- Individual setting of energising and hold current
- Contact conserving switching of relays synchronous to the mains
- High efficient current control up to 100 mA
- Monitoring of coil current, supply voltage and temperature
- Shutdown with overtemperature and undervoltage
- Status indication via LED or logic output
- Fast demagnetising with 15 V countervoltage

### APPLICATIONS

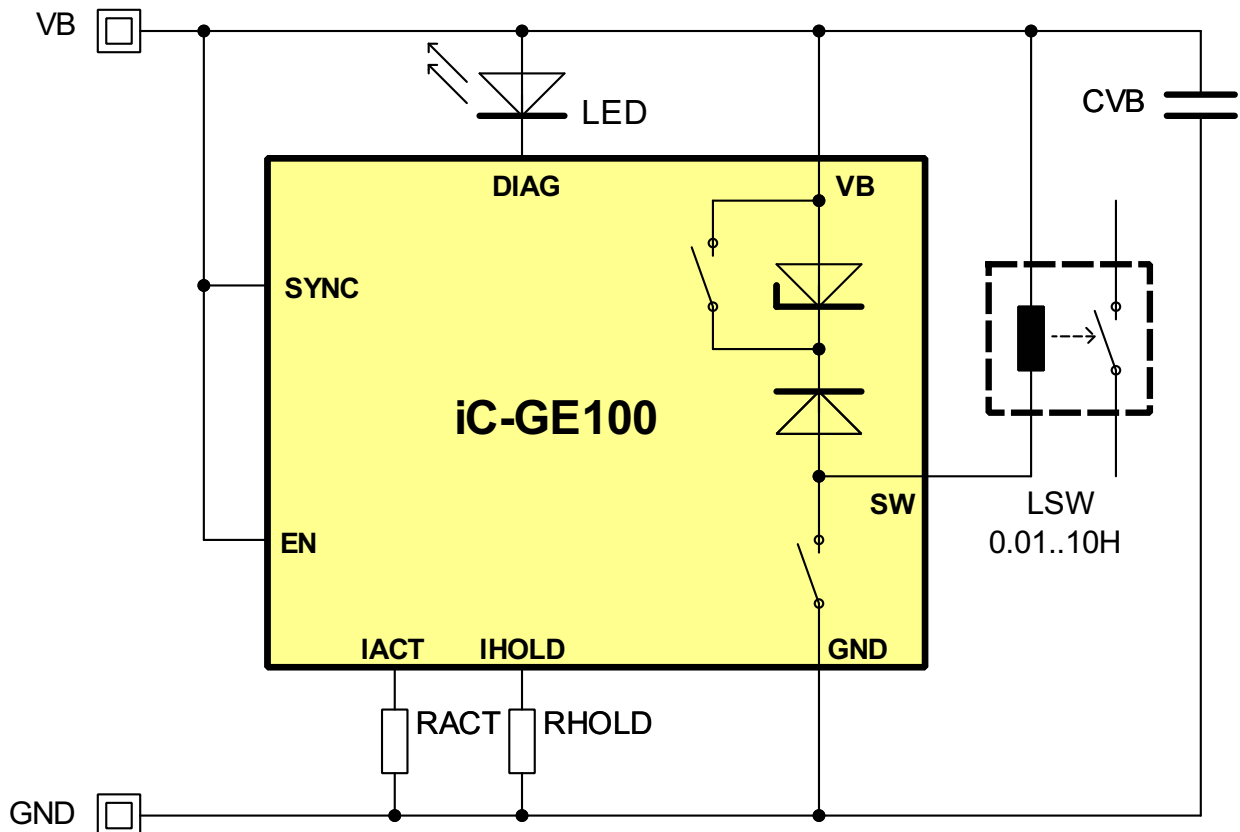
- PWM drive for inductive loads (e.g. 6/12 V relays, electrovalves) from 24 V
- Relay low-/high-side switch

### PACKAGES



DFN8 3x3

### BLOCK DIAGRAM



# iC-GE100

## PWM RELAY/SOLENOID DRIVER

### DESCRIPTION

iC-GE100 is a PWM driver for inductive loads, such as relay coils, solenoid valves and other inductive loads.

The setpoints for the coil's energising and hold current are pre-set by means of external resistors RACT and RHOLD. These currents can be set in a range from 10 to 100 mA. The iC-GE100 switches from energising to hold mode after 50 ms provided that the set energising current has been reached.

The changeover between energising and hold modes is suitable for typical relay drives which require a powerful initial energising current which can then be reduced after closing the air gap in a magnetic circuit. The quadratic dependence on the current intensity means that cutting the current by half reduces the power dissipation by ca. 75%.

Using PWM the output current is controlled to the values set at RACT and RHOLD. The internal fly-back diode maintains the current during the switch-

ing pauses. The switching frequency of ca. 80 kHz is provided by the internal oscillator.

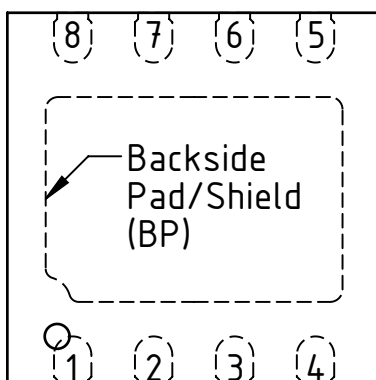
The device is shutdown by a Low signal at input EN or the removal of the power supply; the current reduction in the coil is supported by the changeover of the free-wheeling circuit. The Zener diode now active permits higher free-wheeling voltages and thus a quicker demagnetising of the coil.

The status indicator LED is constantly ON when hold mode is functioning correctly and flashes with low voltage, excessive temperature or when the coil current in energise mode has not reached the setpoint. The driver output is shutdown with low voltage or excessive temperature. Alternatively to using an LED output DIAG signals the correct operating by outputting a high signal.

The input signal at EN can be synchronised with the zero crossing at input SYNC. Thus by using an external R/C network, the switching of the coil can be synchronised with the load current of e.g. the relay.

### PACKAGES SO8, PDIP8 to JEDEC

#### PIN CONFIGURATION DFN8 3 mm x 3 mm



#### PIN FUNCTIONS

| No. | Name  | Function                  |
|-----|-------|---------------------------|
| 1   | GND   | Ground                    |
| 2   | SW    | PWM Output                |
| 3   | VB    | +10...36 V Supply Voltage |
| 4   | IHOLD | Hold Current Setup        |
| 5   | IACT  | Energising Current Setup  |
| 6   | DIAG  | Status Output             |
| 7   | SYNC  | Sync Input                |
| 8   | EN    | Enable Input              |

The *Thermal Pad* is to be connected to a Ground Plane (GND) on the PCB.

**Only pin 1 marking on top or bottom defines the package orientation (Ⓢ GE100 label and coding is subject to change).**

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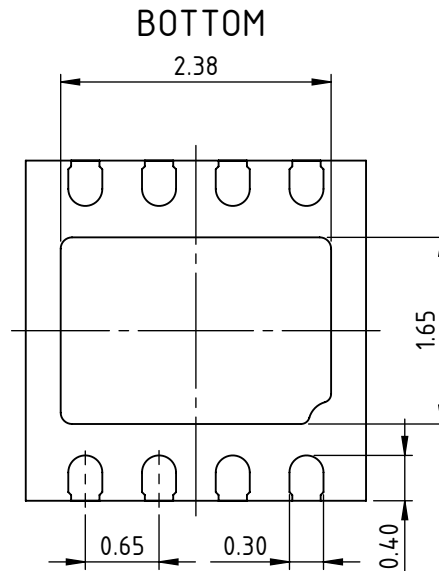
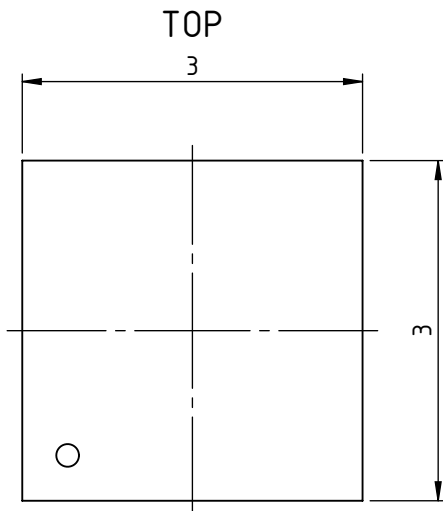
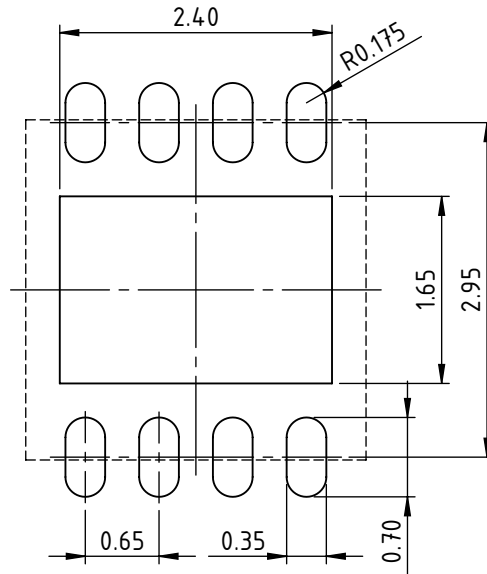
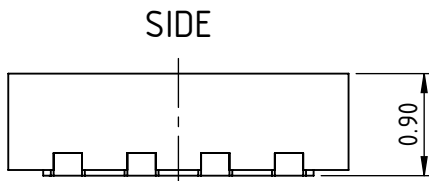
preliminary



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## PACKAGE DIMENSIONS

### RECOMMENDED PCB-FOOTPRINT



dra\_dfn8-1\_pack\_1, 15:1

# iC-GE100

## PWM RELAY/SOLENOID DRIVER



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### ABSOLUTE MAXIMUM RATINGS

Beyond these values damage may occur; device operation is not guaranteed.

| Item No. | Symbol   | Parameter                         | Conditions                           | Limits |      | Unit |
|----------|----------|-----------------------------------|--------------------------------------|--------|------|------|
|          |          |                                   |                                      | Min.   | Max. |      |
| G001     | V(VB)    | Voltage at VB                     |                                      | -0.3   | 37   | V    |
| G002     | I(VB)    | Current in VB                     |                                      | -100   | 6    | mA   |
| G003     | V(SW)    | Voltage at OUT                    |                                      | -0.3   | 53   | V    |
| G004     | I(SW)    | Output Current in OUT             |                                      | -6     | 100  | mA   |
| G005     | V(DIAG)  | Voltage at LED                    |                                      | -0.3   | 37   | V    |
| G006     | I(DIAG)  | Current in LED                    |                                      | -6     | 8    | mA   |
| G007     | V(IACT)  | Voltage at ISET                   |                                      | -0.3   | 7    | V    |
| G008     | I(IACT)  | Current in ISET                   |                                      | -6     | 6    | mA   |
| G009     | V(IHOLD) | Voltage at IHOLD                  |                                      | -0.3   | 7    | V    |
| G010     | I(IHOLD) | Current in IHOLD                  |                                      | -6     | 6    | mA   |
| G011     | V(EN)    | Voltage at IN                     |                                      | -0.3   | 37   | V    |
| G012     | I(EN)    | Current in IN                     |                                      | -6     | 6    | mA   |
| G013     | V(SYNC)  | Voltage at SYNC                   |                                      | -6     | 37   | V    |
| G014     | I(SYNC)  | Current in SYNC                   |                                      | -6     | 6    | mA   |
| G015     | VD()     | Susceptibility to ESD at all pins | HBM 100 pf discharged through 1.5 kΩ |        | 2    | kV   |
| G016     | Tj       | Junction Temperature              |                                      | -40    | 150  | °C   |
| G017     | Ts       | Storage Temperature               |                                      | -40    | 150  | °C   |

### THERMAL DATA

Operating Conditions: VB = 10...36 V, LSW = 0.01...10 H, RACT = 6.2 k...62 kΩ, RHOLD = 6.2 k...62 kΩ

| Item No. | Symbol | Parameter                           | Conditions   | Limits |      |      | Unit |
|----------|--------|-------------------------------------|--|--------|------|------|------|
|          |        |                                     |  | Min.   | Typ. | Max. |      |
| T01      | Ta     | Operating Ambient Temperature Range |  | -40    |      | 85   | °C   |
| T02      | Rthja  | Thermal Resistance Chip/Ambient     | surface mounted, thermal pad soldered to ca. 2 cm <sup>2</sup> heat sink |        | 30   | 40   | K/W  |

All voltages are referenced to ground unless otherwise stated.

All currents flowing into the device pins are positive; all currents flowing out of the device pins are negative.

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### ELECTRICAL CHARACTERISTICS

Operating Conditions:  $V_B = 10...36\text{ V}$ ,  $LSW = 0.01...10\text{ H}$ ,  $RACT = 6.2\text{ k}\dots62\text{ k}\Omega$ ,  $RHOLD = 6.2\text{ k}\dots62\text{ k}\Omega$ ,  $T_j = -40...125\text{ }^\circ\text{C}$ .

| Item No.                   | Symbol                       | Parameter   | Conditions   |      |      |      | Unit             |
|----------------------------|------------------------------|---|--|------|------|------|------------------|
|                            |                              |   |  | Min. | Typ. | Max. |                  |
| <b>Total Device</b>        |                              |   |  |      |      |      |                  |
| 001                        | $V_B$                        | Permissible Supply Voltage Range                      |  | 10   |      | 36   | V                |
| 002                        | $I(V_B)$                     | Supply Current in $V_B$                               | $EN < 0.8\text{ V}$  |      |      | 20   | $\mu\text{A}$    |
| 003                        | $I(V_B)$                     | Supply Current in $V_B$                               | $EN = \text{hi}$   | 0.5  |      | 4    | mA               |
| 004                        | $V_c(\text{lo})$             | Clamp Voltage lo at all Pins                          | $I() = -4\text{ mA}$ , other Pins open   | -1.4 |      | -0.3 | V                |
| 005                        | $V_c(\text{lo})$             | Clamp Voltage lo SYNC                                 | $I() = -4\text{ mA}$ , other pins open   | -6   |      | -0.3 | V                |
| 006                        | $V_c(\text{hi})$             | Clamp Voltage hi at $V_B$ , EN, DIAG, SYNC            | $I() = 4\text{ mA}$ , other Pins open  | 37   |      |      | V                |
| 007                        | $V_c(\text{hi})$             | Clamp Voltage hi at IACT, IHOLD                       | $I() = 4\text{ mA}$ , other pins open  | 7    |      |      | V                |
| 008                        | $V_c(\text{hi})$             | Clamp Voltage hi at IACT, IHOLD                       | $I() = 4\text{ mA}$ , other pins open  | 7    |      |      | V                |
| 009                        | $V_c(\text{hi})$             | Clamp Voltage hi at SW                                | $I(\text{SW}) = 4\text{ mA}$ , referenced to $V_B$ , other pins open   | 10   |      | 17   | V                |
| <b>Driver Output OUT</b>   |                              |   |  |      |      |      |                  |
| 101                        | $V_s(\text{lo})$             | Saturation Voltage lo                                 | $I(\text{SW}) = 100\text{ mA}$ (cf. Fig. 1)  |      |      | 600  | mV               |
| 102                        | $V_s(\text{lo})$             | Saturation Voltage lo                                 | $I(\text{SW}) = 10\text{ mA}$ (cf. Fig. 1)   |      |      | 100  | mV               |
| 103                        | $I(\text{SW})$               | PWM-Current Range                                     |  | 10   |      | 100  | mA               |
| 104                        | $I_{sc}()$                   | Short-circuit Current                                 | $V(\text{SW}) = V_B$   | 100  |      | tbd  | mA               |
| 105                        | $V_c(\text{hi})$             | Clamp Voltage hi at PWM-Free-Wheeling                 | $V_c(\text{hi}) = V(\text{SW}) - V_B$ ;<br>$EN = \text{hi}$ , $I(\text{SW}) = 100\text{ mA}$ (cf. Fig. 1)                      |      |      | 600  | mV               |
| 106                        | $V_c(\text{hi})$             | Clamp Voltage hi at PWM-Free-Wheeling                 | $V_c(\text{hi}) = V(\text{SW}) - V_B$ ;<br>$EN = \text{hi}$ , $I(\text{SW}) = 10\text{ mA}$ (cf. Fig. 1)                       |      |      | 100  | mV               |
| 107                        | $V_c(\text{off})$            | Clamp Voltage hi at Turn-off                          | $V_c(\text{hi}) = V(\text{SW}) - V_B$ ;<br>$EN: \text{hi} \rightarrow \text{lo}$ , $I(\text{SW}) = 100\text{ mA}$ (cf. Fig. 1) | 12   | 15   | 17   | V                |
| 108                        | $I_{IK}()$                   | Leakage Current                                       | $I_N = \text{lo}$ , $V(\text{SW}) = 0...V_B$   |      | 1    | 10   | $\mu\text{A}$    |
| 109                        | $t_{\text{won}}(\text{min})$ | Minimum PWM Turn-on Duration                          | $EN = \text{hi}$ , $I(\text{SW}) > I(\text{SW})_{\text{act}}$ resp. $I(\text{SW})_{\text{hold}}$ (cf. Figure 1)                | 250  |      | 1000 | ns               |
| <b>Input IN</b>            |                              |   |  |      |      |      |                  |
| 201                        | $V_t(\text{on})$             | Threshold Voltage hi                                  |  | 1.1  |      | 1.4  | V                |
| 202                        | $V_t(\text{off})$            | Threshold Voltage lo                                  |  | 0.8  |      | 1.1  | V                |
| 203                        | $V_t(\text{hys})$            | Hysteresis  | $V_t(\text{hys}) = V_t(\text{on}) - V_t(\text{off})$   | 200  |      | 400  | mV               |
| 204                        | $I_{pd}()$                   | Pull-down Current                                     | $V(EN) = 0.8...36\text{ V}$  |      |      | 20   | $\mu\text{A}$    |
| 205                        | $t_p(V_B\text{-SW})$         | Turn-on Delay after power-up                          | $EN = V_B$ , $V_B = V_{\text{Boff}} \rightarrow V_{\text{Bon}}$  |      |      | 40   | $\mu\text{s}$    |
| 206                        | $t_p(EN\text{-SW})$          | Turn-on Delay   | $EN: \text{lo} \rightarrow \text{hi}$ until SW active  | 30   |      |      | $\mu\text{s}$    |
| 207                        | $t_p(EN\text{-SW})$          | Turn-off Delay  | $EN: \text{hi} \rightarrow \text{lo}$ until SW inactive  | 10   |      |      | $\mu\text{s}$    |
| 208                        | $t_p(EN\text{-DIAG})$        | Delay Time from EN to DIAG = hi or LED permanently on | no error   | 20   |      |      | $\mu\text{s}$    |
| <b>Status Monitor DIAG</b> |                              |   |  |      |      |      |                  |
| 401                        | $I_{pd}()$                   | Pull-down Current                                     | $V(\text{DIAG}) = 6\text{ V}\dots V_B$ , SW active, no error   | 3    | 5    | 8    | mA               |
| 402                        | $V_{B\text{lo}}$             | Permissible Supply Voltage for LED operation at DIAG  |  | 6    |      | 36   | V                |
| 403                        | $V(\text{hi})$               | Hi-Level at DIAG                                      | without LED  | 5    |      | 6.5  | V                |
| 404                        | $f()$                        | Frequency on Error                                    |  | 1.8  | 2.4  | 3.6  | Hz               |
| 405                        | $V_s(\text{lo})$             | Saturation Voltage lo                                 | $I(\text{DIAG}) = 200\text{ }\mu\text{A}$ , without LED  |      |      | 0.4  | V                |
| 406                        | $I_{pu}()$                   | Pull-up Current                                       | $V(\text{DIAG}) = 0...4\text{ V}$  | -120 | -100 | -80  | $\mu\text{A}$    |
| 407                        | $V_{\text{Bon}}$             | Turn-on Threshold at $V_B$                            | $V(\text{DIAG}): \text{lo} \rightarrow \text{hi}$  | 8    | 8.5  | 9    | V                |
| 408                        | $V_{\text{Boff}}$            | Undervoltage Threshold at $V_B$                       | Decreasing voltage $V_B$ , $V(\text{DIAG}): \text{hi} \rightarrow \text{lo}$   | 7.5  | 8    | 8.5  | V                |
| 409                        | $V_{\text{Bhys}}$            | Hysteresis  | $V_{\text{Bhys}} = V_{\text{Bon}} - V_{\text{Boff}}$   | 200  | 500  | 800  | mV               |
| 410                        | $T_{\text{off}}$             | Thermal Shutdown Temperature                          |  | 140  |      | 170  | $^\circ\text{C}$ |
| 411                        | $T_{\text{on}}$              | Thermal Release Temperature                           | Decreasing temperature   | 120  |      | 150  | $^\circ\text{C}$ |
| 412                        | $T_{\text{hys}}$             | Thermal Shutdown Hysteresis                           | $T_{\text{hys}} = T_{\text{off}} - T_{\text{on}}$  | 10   | 20   | 30   | $^\circ\text{C}$ |

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## PWM RELAY/SOLENOID DRIVER

preliminary



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### ELECTRICAL CHARACTERISTICS

Operating Conditions:  $V_B = 10 \dots 36 \text{ V}$ ,  $L_{SW} = 0.01 \dots 10 \text{ H}$ ,  $R_{ACT} = 6.2 \text{ k} \dots 62 \text{ k}\Omega$ ,  $R_{HOLD} = 6.2 \text{ k} \dots 62 \text{ k}\Omega$ ,  $T_j = -40 \dots 125 \text{ }^\circ\text{C}$ .

| Item No.                        | Symbol    | Parameter  | Conditions  |      |      |      | Unit       |
|---------------------------------|-----------|--|---|------|------|------|------------|
|                                 |           |  |   | Min. | Typ. | Max. |            |
| <b>Reference IACT and IHOLD</b> |           |  |   |      |      |      |            |
| 701                             | V()       | Reference Voltage IACT and IHOLD   |   | 1.14 | 1.20 | 1.26 | V          |
| 702                             | Isc()     | Short-Circuit Current  | $V(\text{IHOLD}) = 0 \text{ V}$ or $V(\text{IACT}) = 0 \text{ V}$ | -2.5 | -1.8 | -0.3 | mA         |
| 703                             | K1        | Transfer Value for Energising Current<br>$R_{ACT} = K1 / I(\text{SW})_{act}$ | $I(\text{SW})_{act} = 10 \dots 100 \text{ mA}$                    | 560  | 620  | 680  | A $\Omega$ |
| 704                             | K2        | Transfer Value for Hold Current<br>$R_{HOLD} = K2 / I(\text{SW})_{hold}$     | $I(\text{SW})_{hold} = 10 \dots 100 \text{ mA}$                   | 560  | 620  | 680  | A $\Omega$ |
| <b>Oscillator</b>               |           |  |   |      |      |      |            |
| J01                             | fosc      | Mean Oscillator Frequency  | $(f_{max} + f_{min}) / 2$   | 60   | 80   | 120  | kHz        |
| J02                             | df        | Frequency Variation  | $(f_{max} - f_{min}) / (2 * f_{osc})$                             | 12   |      | 15   | %          |
| <b>Synchronisation SYNC</b>     |           |  |   |      |      |      |            |
| S01                             | Vth()sync | Trigger Threshold at SYNC  |   | -20  |      | 20   | mV         |
| S02                             | Iik()     | Leakage Current  | $V(\text{SYNC}) = -3 \text{ V} \dots 3 \text{ V}$                 | -10  |      | 10   | nA         |

**ELECTRICAL CHARACTERISTICS: Diagrams**

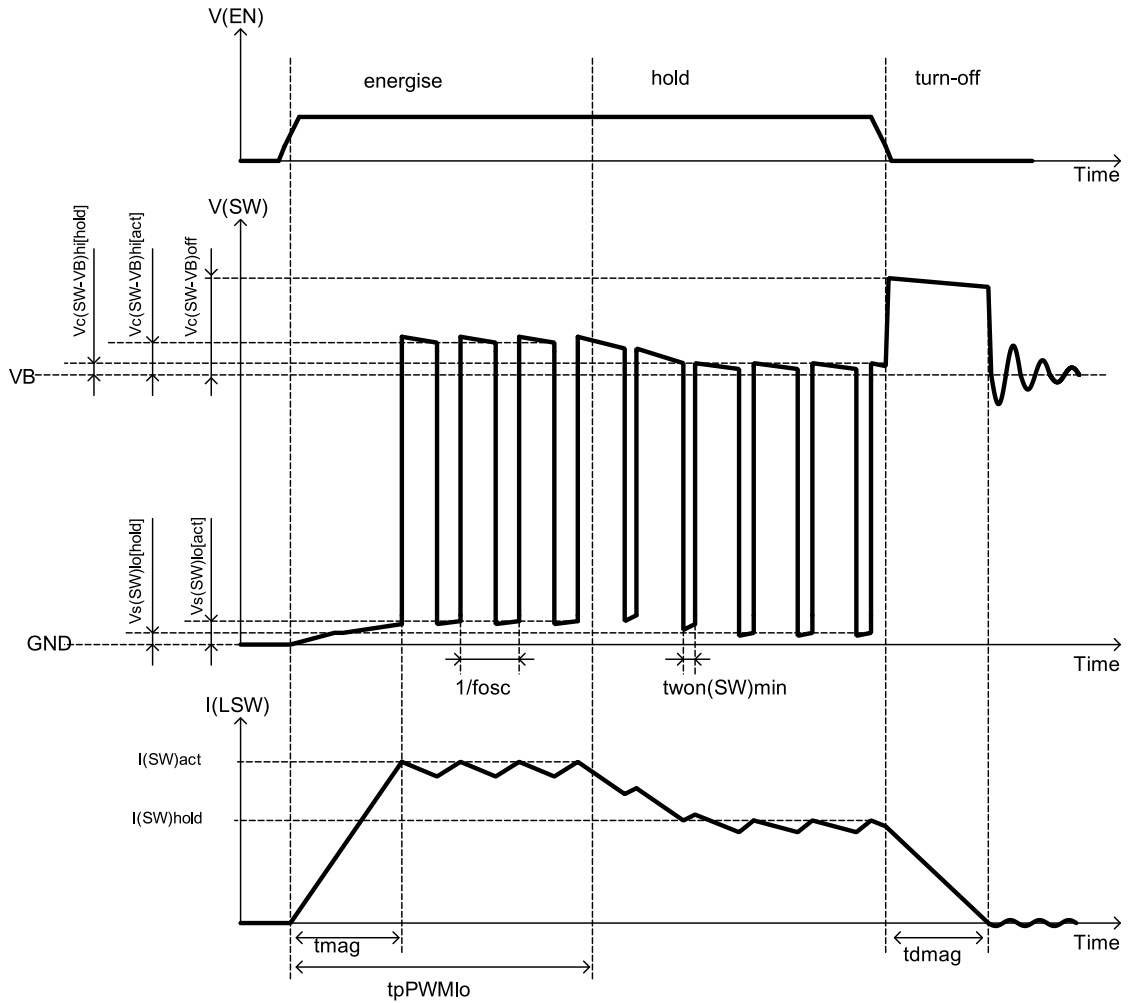


Figure 1: Operation modes: energise mode, hold mode and turn-off

$$t_{mag} \approx \frac{I(SW)_{act} \times LSW}{VB} \quad (1)$$

$$t_{dmag} \approx \frac{I(SW)_{hold} \times LSW}{V_c(SW - VB)_{off}} \quad (2)$$

### APPLICATIONS INFORMATION

#### Setting the coil current

The following equations can be given for the energise and hold modes of the PWM control using Electrical Characteristics Nos. 703 resp. 704:

$$RACT = \frac{K1}{I(SW)_{act}} \quad (3)$$

$$RHOLD = \frac{K2}{I(SW)_{hold}} \quad (4)$$

#### Example

For a relay with a starting current of 70 mA and 40 mA hold current the following applies:

$$RACT = \frac{620 \Omega A}{0.07 A} = 8.8 k\Omega \quad (5)$$

$$RHOLD = \frac{620 \Omega A}{0.04 A} = 15.5 k\Omega \quad (6)$$

#### Application circuits

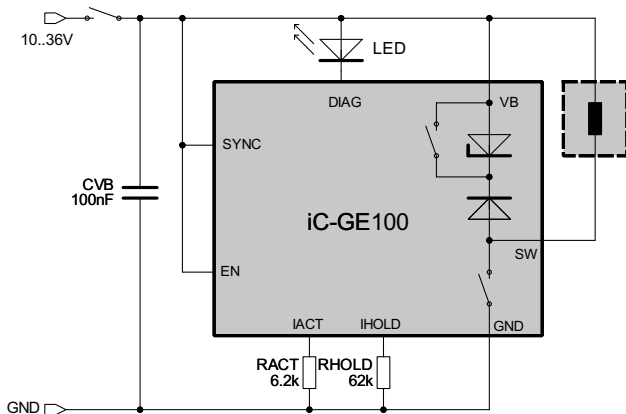


Figure 2: Activation by switching VB

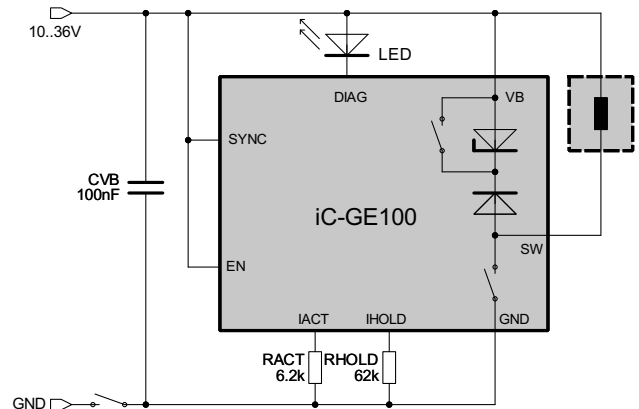


Figure 3: Activation by switching GND

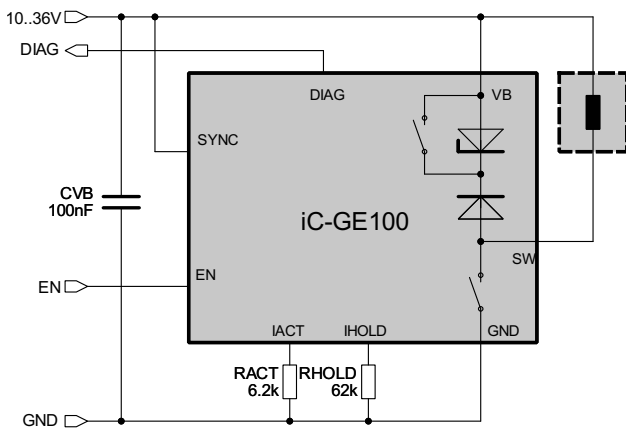


Figure 4: Activation via EN  
feedback from DIAG with 5 V logic levels



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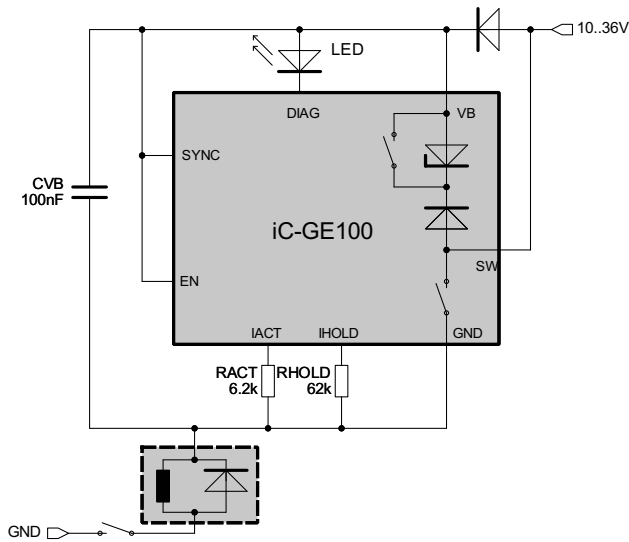


Figure 5: High-side driver for relays with free-wheeling diode

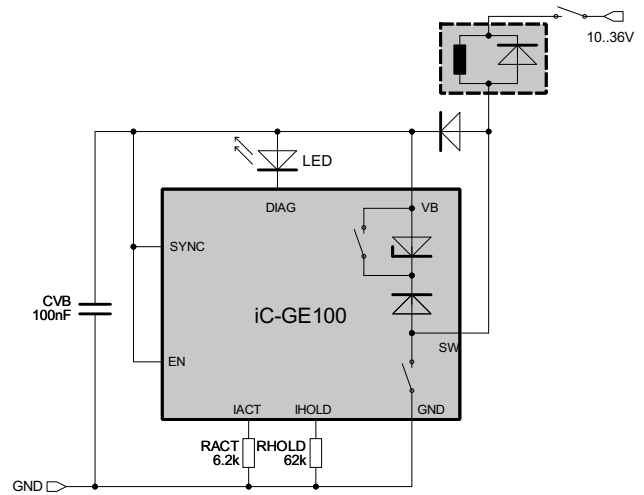


Figure 6: Low-side driver for relays with free-wheeling diode

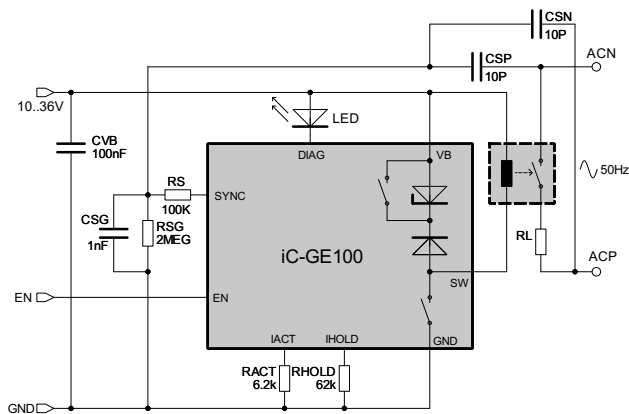


Figure 7: Utilising the SYNC input

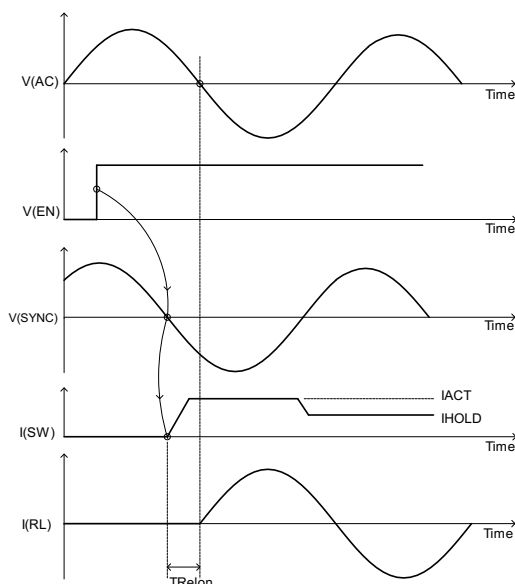


Figure 8: Utilising the SYNC input

By means of resistors  $RS^*$  and capacitors  $CS^*$  a phase shifted signal at SYNC is derived from the 50 Hz load supply.

Thus the relay is activated resp. deactivated with zero crossing of the load supply after working EN.

The phase shift is used to compensate the switching delay of the relay so that the load can be switched at zero current.

The benefit from synchronous switching may be utilised, if the switching times are short and reproducible.

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We understand suitable application of our published designs to be state-of-the-art technology which can no longer be classed as inventive under the stipulations of patent law. Our explicit application notes are to be treated only as mere examples of the many possible and extremely advantageous uses our products can be put to.

# iC-GE100

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## ORDERING INFORMATION

| Type     | Package          | Order Designation |
|----------|------------------|-------------------|
| iC-GE100 | DFN8 3 mm x 3 mm | iC-GE100 DFN8-3x3 |

For technical support, information about prices and terms of delivery please contact:

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