Transistor Output Optocouplers
Frequently Asked Questions (FAQs)

1. Q: WHAT IS AN OPTOCOUPLER?

A: Optocouplers are well known as optoisolators providing an isolated galvanic barrier between the input and output utilizing infrared light. On the input side an infrared light emitting diode is used with all optocoupler types. On the output a wide variety of actuators can be implemented. The most commonly known types are with transistor outputs. Other available outputs include TRIAC, MOSFET, highspeed, photovoltaic, or photodiodes as well as combinations of them.

www.vishay.com/doc?84256

2. Q: WHY SHOULD AN OPTOCOUPLER BE USED?

A: Optocouplers are commonly used if two separate circuits need to be isolated from each other for safety or regularity reasons and need to have an interaction in between. Additionally they can be used to suppress electrical noise effects and speed up development time. The mentioned reasons make optocouplers essential in circuit designs for isolation of critical parts.

3. Q: WHICH MAXIMUM PARAMETERS SHOULD BE TAKEN INTO CONSIDERATION WHEN USING A TRANSISTOR OUTPUT OPTOCOUPLER?

A: The input of optocouplers is defined with the forward current I_F of the emitting diode and the reverse voltage which should not be exceeded. The transistor on the output is defined by the collector current I_C and the voltage across the collector and emitter pins V_{CE}. Datasheets provide the maximum permissible ratings for these parameters as well as derating curves that visualize the effects of different operating temperatures. For a safe application the circuit surrounding the optocoupler must be designed not to exceed any of these maximum ratings.

4. Q: WHAT IS CTR?

A: CTR is the abbreviation for **C**urrent **T**ransfer **R**atio. It describes the two main parameters of optocouplers and is obtained by dividing the output current of the transistor by the forward current of the emitting diode and converting the result in a percentage value.

$$\text{CTR (\%)} = \frac{I_C(\text{mA})}{I_F(\text{mA})} \times 100\ \%$$

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5. Q: WHAT IS A CTR BIN?

A: Optocouplers are available in various CTR groups, called bins. They are produced with a variation caused by the sensitivity of the transistor and light emission of the diode. Depending on the variation, optocouplers are arranged in different groups or bins, defined with minimum and maximum CTR values for a specific forward current operation condition. All products are orderable in preferred bins. Customized binnings are available on special request.

6. Q: HOW SHOULD THE PARAMETERS BE ADJUSTED IN CASE OF A DIFFERENT OPERATION POINT IN THE APPLICATION?

A: Optocoupler datasheets provide a variety of information and graphs which should be used to determine the correct operation point. From the graph depicting forward current I_F across forward voltage V_F of the emitting diode, it is possible to determine a typical value in case of a change in forward voltage or operating temperature. (fig. 1)

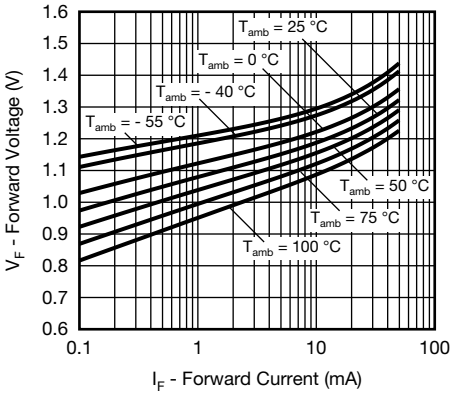

Fig. 1 - Forward Voltage vs. Forward Current

To adjust the output parameters, various graphs are available in datasheets, illustrating the collector current over collector emitter voltage (fig. 2 and fig. 3) as well as the CTR variation over forward current and temperature (fig. 4 and fig. 5) for the two major operation conditions, also known as saturated and non-saturated conditions.

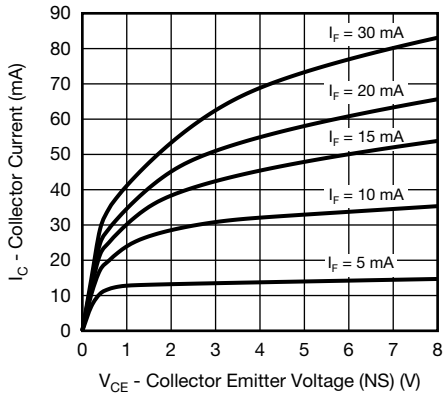

Fig. 2 - Collector Current vs. Collector Emitter Voltage (non-saturated)

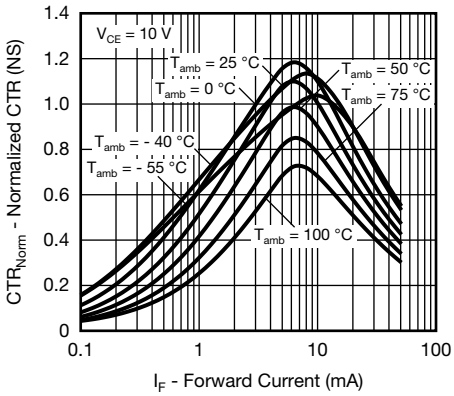

Fig. 4 - Normalized CTR vs. Forward Current (non-saturated)

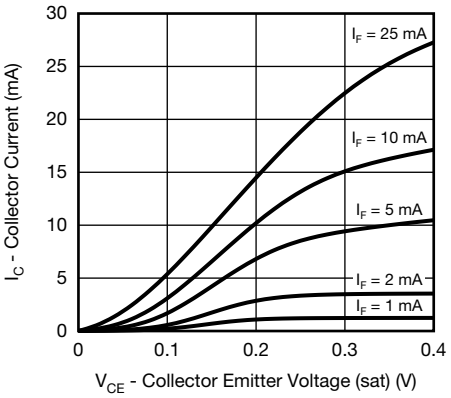

Fig. 3 - Collector Current vs. Collector Emitter Voltage (saturated)

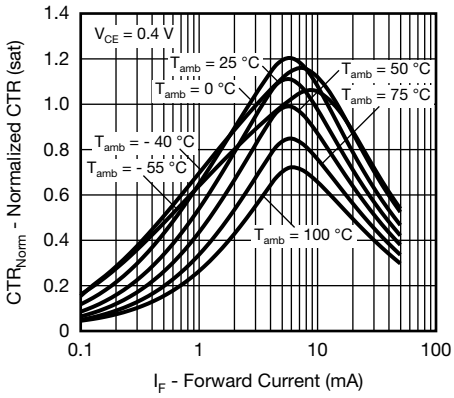

Fig. 5 - Normalized CTR vs. Forward Current (saturated)

We also have an application note available for further information: www.vishay.com/doc?83706

7. Q: WHAT IS THE SATURATION VOLTAGE?

A: Transistors operate as solid state switches which turn on and off with regard to the applied signal. In the saturation mode of the optocoupler, the emitted light from the diode is high enough to make the phototransistor conducting which results in non-linear collector current I_C followed by a minimum collector emitter voltage V_{CE}. Vishay optocouplers are typically specified with a saturation voltage $V_{CE,sat}$ of 0.25 V which can range up to a maximum of 0.4 V.

8. Q: HOW IS AN OPTOCOUPLER WITH A BASE CONNECTION USED?

A: Optocouplers with a base connection enable to externally control the base. It is a sensitive pin of the transistor which affects the CTR as well as the timing behavior of the optocoupler. The advantage of connecting the base pin is to speed up the turn-off time by creating an external conducting path for the base charge.

Letting the pin open, in case it is not used in the application, should not cause any trouble. However, possible electromagnetic distortions surrounding the part can cause some noise coupling to the high impedance base (antenna effect). Therefore the channel should better be grounded with a high value resistance.

9. Q: WHAT SHOULD BE CONSIDERED WHEN DRIVING A PWM THROUGH AN OPTOCOUPLER?

A: Optocoupler datasheets present in the timing section a table with values to calculate the typical timing behavior. There are typical values for t_{on}, t_{off}, rise and fall times available which can help estimate the definition of the PWM in frequency and duty cycle or the deformation of the incoming pulse.

10. Q: WHAT IS “CUT OFF FREQUENCY” OR “CTR FREQUENCY”?

A: The cut off frequency or CTR frequency is a measurement for small AC signal transmission through the optocoupler. Basically the frequency is measured at a DC bias operation point which is overlapped with an AC signal on the input side. The cut off frequency is the point at a system’s frequency response at which the power transmission reaches the -3 dB point.

11. Q: WHICH PARAMETERS HAVE AN EFFECT ON THE LIFETIME OF THE APPLICATION?

A: Optocouplers consist of an input and an output side. Since there is a lot of energy being converted into light and power, the input side is more critical in terms of the lifetime. Furthermore the long term temperature surrounding the optocoupler has to be taken into account. The lifetime of an optocoupler depends on the forward current I_F, the long term operating temperature as well as the natural degradation of the LED. For low power and low temperature applications, a longer lifetime can be estimated.

12. Q: WHERE CAN OPTOCOUPLER PSPICE MODELS BE FOUND?

A: Most simulation software provide within their standard library a basic set of optocoupler PSpice models. These generic type of models are mostly made for ambient temperatures of 25 °C and serve as a straight forward bias between input and output circuit. Vishay provides on their webpage an optocoupler PSpice library.

www.vishay.com/optocouplers/related/#spice

13. Q: HOW IS THE ISOLATION CAPABILITY OF OPTOCOUPLERS SPECIFIED?

A: The isolation characteristics of optocouplers are specified in different forms. There are values defined in Isolation rating (V_{ISO}), maximum transient isolation voltage (V_{IOTM}) and maximum working voltage (V_{IORM}). These are the most common definitions together with the DTI which is the minimum distance through the insulation barrier. Have a look into the application note for more details:

www.vishay.com/doc?83743

14. Q: WHAT IS THE DIFFERENCE BETWEEN THE WORKING VOLTAGE AND THE ISOLATION VOLTAGE?

A: The working voltage is described as the repetitive peak voltage that can be applied in operational mode along the lifetime of the product. The transient isolation voltage is derived out of a failure condition in a certain system. Up to the point of a failure the optocoupler must sustain this voltage level providing its safety function. For more information see the application note:

www.vishay.com/doc?83743

15. Q: WHAT IS CREEPAGE, CLEARANCE, AND DTI (DISTANCE THROUGH INSULATION)?

A: The creepage is defined as the shortest distance between two conducting parts along the surface of non-conductive insulating material. The clearance is defined as the shortest possible distance between two conducting parts measured through air path. The distance through insulation is the internal distance from any conducting part on the input to any conducting part of the output. For detailed information see application note:

www.vishay.com/doc?83743

16. Q: WHAT IS REINFORCED, DOUBLE, AND BASIC INSULATION?

A: The definition of a basic insulation is an isolating material in between two circuits separating the input from the output with a defined voltage level. The double insulation is a security requirement of the approval agencies having the double security with an additional fault-protection mode. The reinforced insulation is a single level insulation which fulfills the requirements of its constructional and performance levels with a minimum insulation thickness of about 0.4 mm for optocouplers. For further information check our application note:

www.vishay.com/doc?83743

17. Q: WHAT IS IMPORTANT IN HANDLING OPTOCOUPLERS?

A: There are basically three main areas in the handling of the optocouplers. Protection against electrostatic damage, mechanical sensitivity and handling of the leads on post assembly cleaning. These three items are clearly described in the handling instructions which are available for all optocoupler products:

www.vishay.com/doc?80060

18. Q: IS WAVE SOLDERING ALLOWED?

A: Wave soldering is allowed for SMD packages up to a temperature of 260 °C. The soldering temperature profile needs to be strictly controlled over temperature in order not to exceed the maximum ratings. Please check the datasheet first for specific information and have a look into the assembly instructions of Vishay's optocoupler parts for additional information:

www.vishay.com/doc?80054

19. Q: IS THERE A CERTAIN CLEANING SOLUTION OR PROCESS?

A: Cleaning may not be needed if the flux in the solder is non-aggressive and the residues are guaranteed to be non-corrosive. Otherwise we recommend cleaning with high purity ethyl or isopropyl alcohol. Non-recommended cleaning processes are brushing, steam, or ultrasonic. For detailed information see the handling instructions:

www.vishay.com/doc?80060

20. Q: WHAT IS THE LEAD TERMINATION?

A: Optocoupler frames and leads are plated with pure tin (Sn) (except for CNY6xx series, which have silver (Ag) frames and leads).