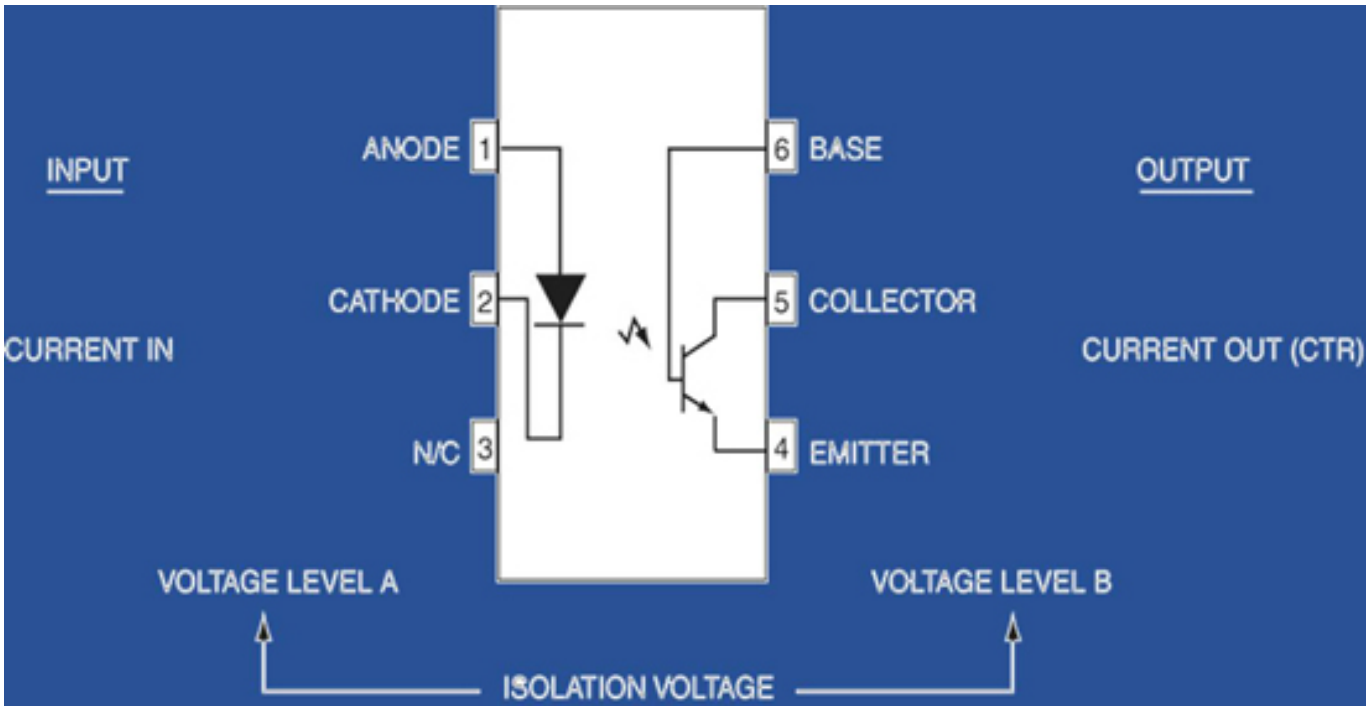
Optocouplers Protect Patients, Operators Using Medical Equipment

Optocouplers are used in many industries to isolate an electrical signal between two elements of a circuit. There are many situations where signals and data need to be transferred from one system to another within a piece of electronic equipment without making a direct electrical connection. This is often driven by different components in a system operating at significantly different voltage potentials. Optocouplers convert an electrical signal to an optical signal using an LED and sensor to transmit across an air gap. The transmitted signal is then converted back from an optical to an electrical signal. This serves several purposes, including preventing unnecessary noise and voltage spikes in many applications. Below is a basic optocoupler configuration.



While most optocouplers are used in the industrial market including in power supply and light switch applications, there is a growing market for optocouplers in industries that require strict safety regulations. For example, optocouplers are being implemented in medical equipment to protect both the patient and operator from unnecessary voltage spikes, noise or electric shock. Some of the common safety functions that an optocoupler performs include:

- Safety through separation of electrical circuits
- Managing of different voltages
- Managing of different impedances
- Suppression of electrical noise

- Suppression of transient interference
- Elimination of “ground loops”

For example, EKG/ECG instruments use optocouplers. EKG or Electrocardiography is a system that uses electrical activity to measure the heart rate in a human being. This is done through the use of electrical diodes that are placed on the skin of the human. It is very important that the equipment is set up to be non-invasive of the person. Therefore, optocouplers are used to ensure isolation of the voltage. The optocouplers are primarily used in two areas with this type of medical equipment: on the power supply side and on the digital circuit. In this case, the optocouplers are employed to protect the patient from high voltage spikes that may occur in the instrumentation.

Devices used for measuring a patient’s blood content also utilize optocouplers. Pulse oximeters measure the saturation of oxygen in a patient’s blood, and because pulse oximeters can be hooked up to other medical equipment in a hospital room, they can run the risk for high voltage spikes, creating a danger to the patient. Although the process for blood oximetry is non-invasive, equipment used in parallel with the pulse oximeter can pose a danger. Therefore, UL-approved optocouplers are used with certain pulse oximeter applications, isolating the patient from the electrical equipment.

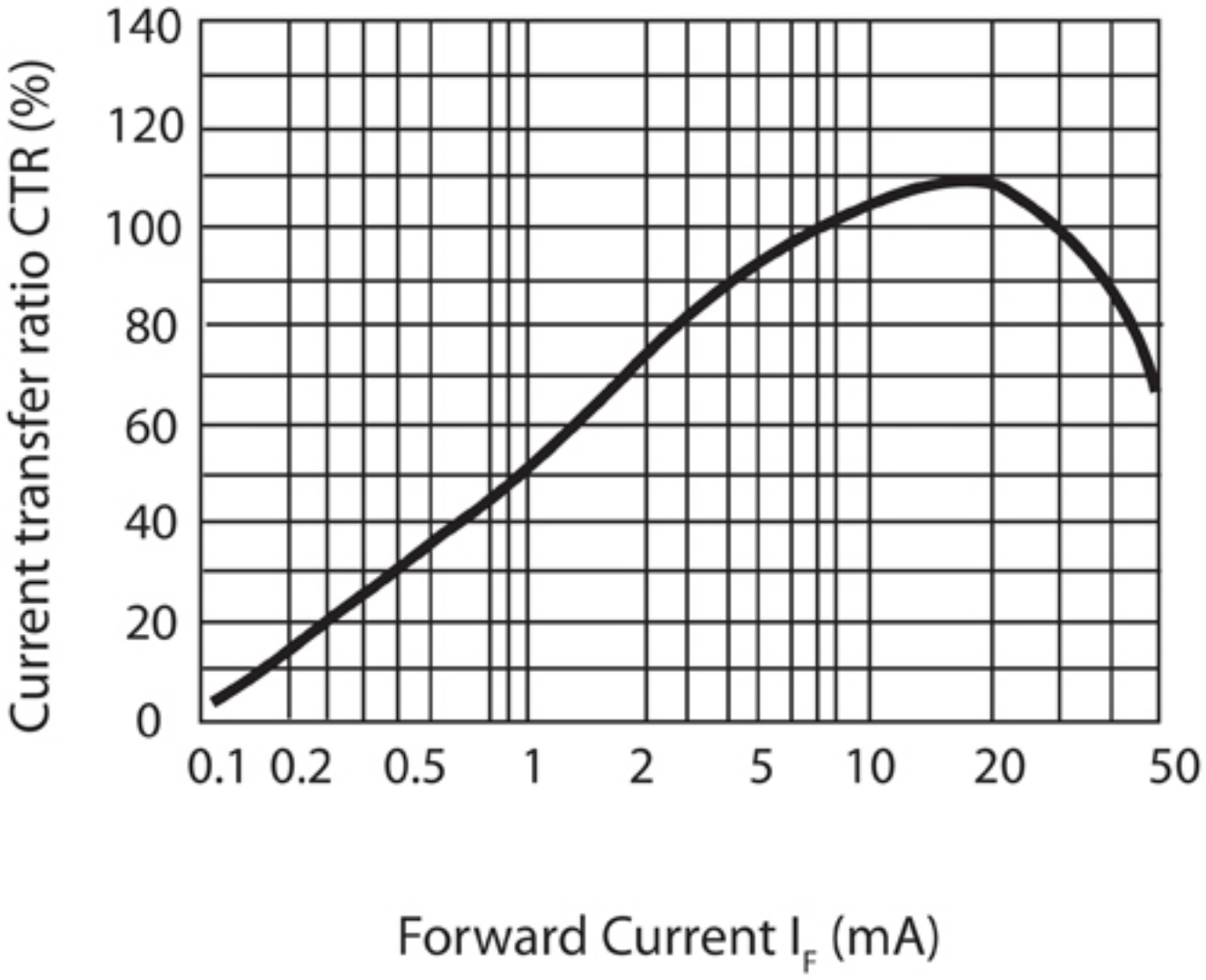
As discussed, the reliability of components in medical applications is imperative, thus medical equipment is held to specific safety standards. For example, UL 60601-1 provides guidelines that are necessary for electrical equipment – including optocouplers – to be used in the medical field. There are a series of tests that are done by UL so these parts can be considered safe for medical use. Components used in medical equipment are also often required to meet VDE standards. The figure below contains an example of some quality measurements that are performed to ensure that optocouplers are meeting safety regulations:

Parameter	Failure Criteria	Conditions
HTRB D $I_{C(OFF)}$	± 10%	11 samples after 500Hrs
	0 Fail	@ VCE = 5.0VDC, Ta = 70°C
HTFB D $I_{C(ON)}$	± 10%	50 samples after 96Hrs
	0 Fail	@ Max P_D, Ta = 25°C
MTTF @ 90% confidence	150,000 Min.	@ 25°C, 25mADC
Moisture Sensitivity Level	MSL 1	per JDEC stnd J-STD-020B
Lead Solderability	0 Fail	per Method 208 of MIL-STD-202.
Glass Transition of body	125°C Min.	DSC test method
Temperature Humidity-Bias	± 20%	85°C, 85%RH, 500Hrs, 80% min Iceo
Temperature Cycle	± 20%	per Method 1010.7 of MIL-STD-883E
High Temperature Storage	± 20%	85°C, 500Hrs
Autoclave	0 Fail	T_A = 121°C, Pressure = 15psi, Humidity = 100%, Time = 96Hrs

Another basic parameter that is considered when using optocouplers in a piece of

equipment is current transfer ratio (CTR). This is the measurement of the output current to the input current (CTR(%)=(IC/IF) x 100). The figure below is an example of the CTR vs. the forward current taken on an optocoupler device.

Fig.1 Current Transfer Ratio vs. Forward Current



CTR ranges can change over the life of the optocoupler. This is normally due to the efficiency of the LED and the temperature at operation. As the LED efficiency decreases over time, the CTR will decrease. This is also true for temperature. The higher the temperature, the faster the CTR decreases over time. Many medical applications are used at room temperature, however, for those applications used in warmer climates, such as with portable medical equipment used in the field, the efficiency of the optocoupler over temperature needs to be considered.

For temperature and humidity concerns, the packaging of optocouplers comes into consideration. The most common package styles are plastic DIP, SMD, SOP, and SSOP. The common pin types are 4-, 5-, 6-, and 8-pin configurations. Using ceramic packages to withstand high temperature or erratic temperature changing environments is also an option.

Because many medical specifications are developed based on a custom design, it is appropriate to turn to the automotive market for specification parameters. With the growing market for hybrid electric vehicles, more emphasis is being placed on the optocouplers themselves. Operating conditions for these hybrid applications have become more difficult for manufacturers of isolators. However, the need for optocouplers has grown in this market and manufacturers are adapting to the newer tests that are required to pass the safety regulations. An older but important test in the high-speed train industry for the optocoupler, for example, is the dv/dt test (change in voltage over change in time). This has become an important parameter due to the mixing of high voltage hybrid type applications and safety regulations that are placed on transportation systems that are put in place as protection to the people and equipment. This same quality test can be applied to the medical market as well.

Additionally, the ISO/TS 16949 quality specification is the preferred technical specification used in the automotive industry for optocoupler requirements. These strict requirements ensure that safety regulations are met for higher temperature applications. Medical applications are also using this specification as a means to guarantee components will pass higher temperature requirements.

Depending on the application, there are several key differences in testing optocouplers for high temperature use. For example, the maximum temperature range for industrial grade optocouplers is -40ºC ? TA ? +105ºC and for automotive grade is -40ºC ? TA ? +125ºC. The difference in the qualification plan is JEDEC47 for industrial and AEC-Q100 for automotive grade. The automotive grade will also require a larger qualification sample size and extended date code marking (Power Systems Design (2009), Automotive Optocouplers, Retrieved October 5, 2009). Additional information can be found here: http://www.powersystemsdesign.com/index.php?option=com_content&view=article&id=255&Itemid=113 [1])

There are many parameters that need to be met when designing and manufacturing optocouplers for the medical market, and reliability is of utmost importance to adequately isolate the patient and the medical equipment operator from unnecessary voltage spikes and electrical shock. Certain tests are important when measuring the reliability of optocouplers. For example, HTRB D IC(OFF), glass transition of body (Tg), and MSL levels are important parameters that are not always measured for other optoelectronic components. In addition, autoclave is also performed with optocouplers, however, it is not as common on other component reliability specifications. Through the design of the optocoupler and the use of a variety of industry standards and testing qualifications, a highly reliable, qualified device ideal for use in medical equipment can be achieved.

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