BROADCOM®

White Paper

Calculate Reliable LED Lifetime Performance in Optocouplers

Introduction

Optocouplers are used for high-voltage isolation and electrical noise rejection—important requirements for transmitting correct information between different voltage potentials within an electrical system. Such systems must be able to operate reliably for many years in industrial, medical, renewable energy environments, and any system that has a long expected operating lifetime.

Broadcom® optocouplers use high-reliability LEDs to fulfill the critical system reliability requirements. LED technology has matured over 40 years, and Broadcom has continually enhanced the manufacturing process to improve and refine LED performance. This allows Broadcom's optocouplers to be suitable in industrial, renewable energy, automotive, and even ultra-high mission critical applications, such as military and aerospace applications.

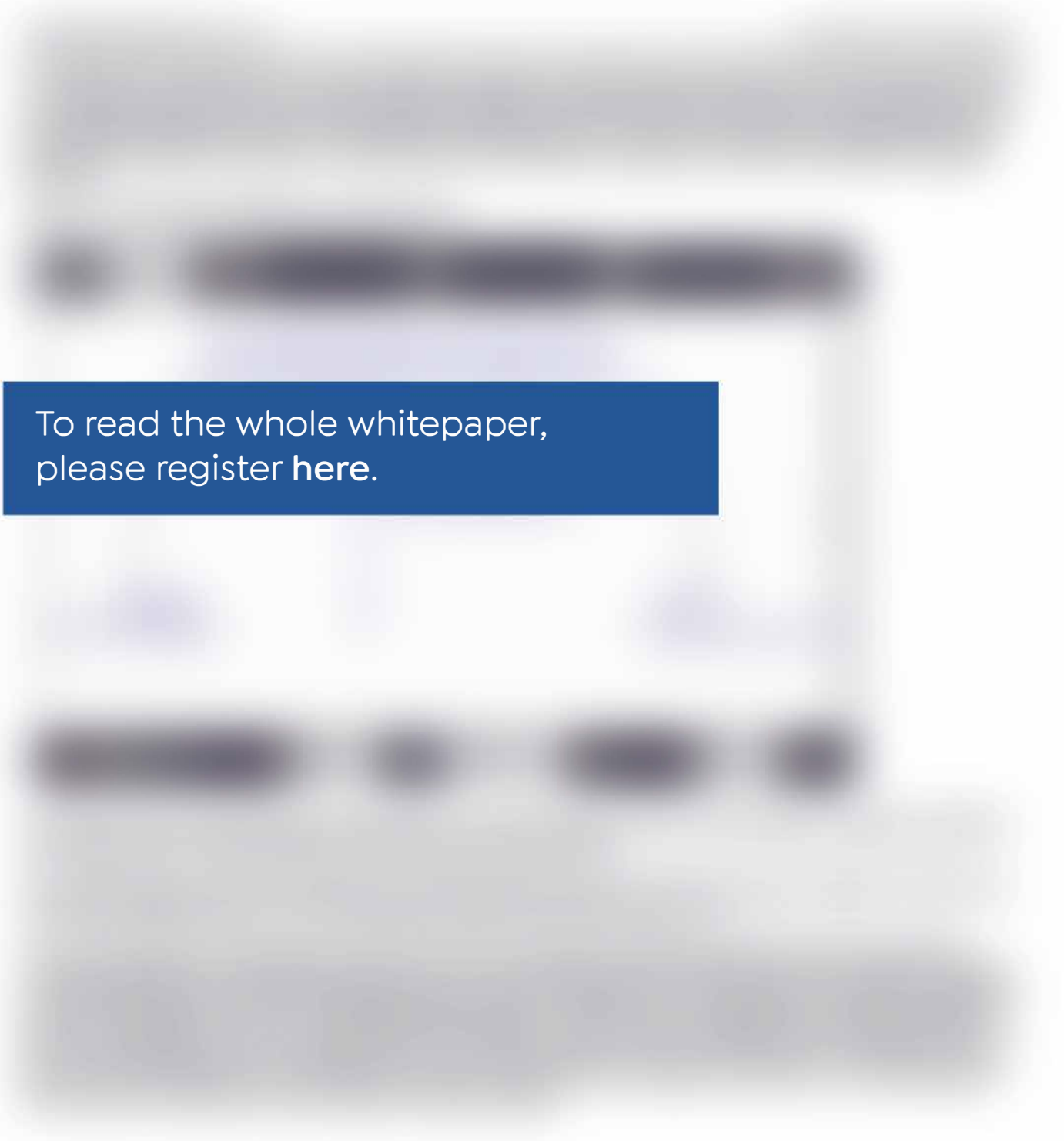
Despite harsh application uses, there are still concerns regarding the optocoupler operating lifetime. This may be valid for the inferior cheap phototransistors, but it does not apply to a high-performance optocoupler with photo-IC output. This white paper explains how Broadcom, an industry leader in optocouplers, uses LED reliability stress data under accelerated conditions to project expected lifetime performance based on Black Model (an accepted empirical model by J.R Black to estimate the mean-time-to-failure (MTTF) of wire associated with electro-migration[1]). The analysis gives designers the assurance and design flexibility so they can choose the most appropriate LED forward input current for their application.

LED Reliability Stress Tests

Optocouplers use LED to transmit digital or analog information across an isolation (or insulation) barrier. On the barrier's other side is a light-sensing detector that converts the optical signal into an electrical signal. Input current-limiting resistor defines a recommended input drive current (I_F) to the LED. However, the optocoupler's LED quantum efficiency (total photons per electron of input current) decreases over time due to thermal and electrical stressing of the LED PN junction[2]. Broadcom performs stress testing for thousands of hours of continuous operation to determine LED reliability. A High Temperature Operating Life (HTOL) test is performed with the LED operating at 125°C and a continuous I_F of 20 mA.

The Current Transfer Ratio (CTR) is an electrical parameter of an optocoupler. CTR, as a percentage, is defined as the ratio of the output collector current (IC) caused by the light detected from the photodiode to the forward LED input current (I_F). Designers can use the change in CTR over time to gauge the LED reliability.

Current Transfer Ratio, $CTR = (I_C / I_F) \times 100\%$



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