An ounce of Optocouplers is worth a pound of ferrites and shielding

Traditionally, optocouplers have found their greatest niche in providing "safety" isolation, mostly driven by domestic and international regulatory requirements. This traditional role finds applications in equipment such as power supplies where lethal high voltage potentials need to be isolated from low-voltage, "user accessible" circuitry, and in potentially explosive environments where infrared light is used for data transfer and switch signalling.

Optocouplers have satisfied this requirement effectively and economically by using a minimum of PCB real estate. What often go overlooked, however, are the benefits of optocouplers in providing isolation from electrical "noise" instead of, or in addition to, safety isolation.

Optocouplers can be used to mitigate the effects of noise at the board and system level. They separate noisy circuitry from more sensitive circuitry by allowing signals to cross boundaries without requiring the sensitive circuit to share a common ground reference with the offending circuit's noisy ground plane. The ability to easily and effectively separate sections of PCB boards can greatly reduce the design risks in systems that require sub-circuits of varying levels of noise generation and sensitivity. Most design engineers, given enough time, might achieve this without opto-isolation by optimising board layout, PCB portioning, effective filtering, component specification, clock frequency selection, etc. Optocouplers, however, greatly simplify this process to a matter of isolating noisy from clean circuits with the right coupler. Moreover, this is accomplished with a minimum of board spins, reducing design risk and design cycle time.

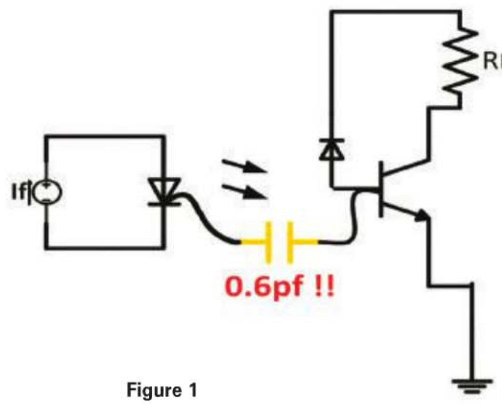
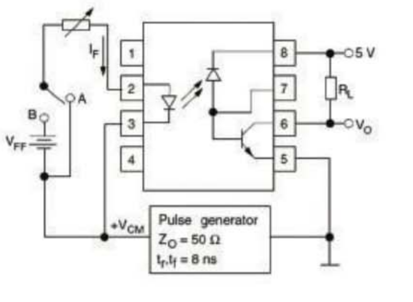


Figure 1

An optocoupler's isolation effectiveness has functional and regulatory aspects. The functional aspect is obvious. Given sufficient unwanted noise coupling, a circuit or electrical system will fail to operate, or operate intermittently. Another aspect of noise interference is regulatory. Domestic and international government agencies require that in addition to proper functional performance, electrical systems don't interfere with broadcast frequencies and other electrical equipment. Moreover, they require that electrical systems be immune to external electrical and magnetic fields. This EMI (electromagnetic interference) or RFI (radio frequency interference) will be the main focus of this document.

Many systems, whether inter or intra,



require the use of external communications ports using electrical cabling. All of this cabling constitutes potential antennae that can adversely affect electronic systems in two main ways. They can couple noise from the external environment into the target system in question, or the mirror effect whereby the RF coupling loops act as radiators of RF energy into the outside environment. In the first case, the unintentional RF coupling can adversely affect the performance of the target device. In the second case, the radiated RF can exceed the amount of radiated noise allowed by regulatory standards, or can interfere with the operation of external devices.

The methods used to mitigate these two undesirable phenomena fall into three categories: reducing the amount of noise generated by the emitting device, in the case of radiated emissions; decreasing the efficiency of the coupling antenna; and blocking noise from reaching sensitive equipment using various configurations of bulky, expensive filtering or shielding. The latter method suffers from limited effectiveness and prohibitively high costs.

Optocouplers provide very effective filters by preventing RF noise from getting into the cables where they can radiate, as well as preventing cable noise from being coupled into the target device. The noise isolation of optocouplers can be simply but effectively modelled as the effective capacitance from the primary side of an optocoupler to the secondary side of an optocoupler, as illustrated in Figure 1.

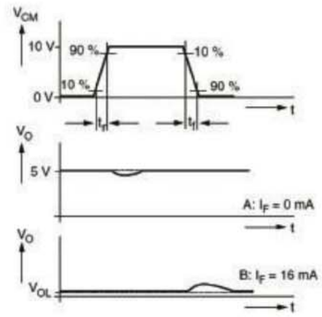


Figure 2

0.6 pF is small coupling impedance indeed. A very high level of common mode interference immunity, as illustrated in Figure 2, is the end product of this amazingly low coupling capacitance. Optocouplers are available to isolate I/O com ports ranging from low-speed RS-485, RS-232, I2C, CAN Bus, and 4 mA to 20 mA current loop applications, up to higher Mbit communication ports such as Profibus and other high-speed communications requiring a high level of noise immunity. This requirement for noise immunity is not limited to the harsh environments of industrial applications. Increasingly, optocouplers are being used in automotive applications, as well as less severe commercial and consumer applications. As coupler data rates increase, so do the number of communication applications to which they provide ideal EMI and RFI mitigation solutions.

There are other ways to mitigate EMI/RFI coupling into communications cables; however, the optocoupler is the most simple, predictable, compact, and cost-effective solution. As illustrated in Figure 3, an ounce of couplers can replace bulkier and more costly ferrites and copper shielding. When a project is governed by schedule, scope, and cost, optocouplers are unbeatable solutions in terms of communication port EMI/RFI mitigation.

Finally, it is important to note that, unlike competing isolation technologies that use high-frequency carrier signals to transfer signals across isolation barriers, "optically" based isolators do not produce electro-magnetic emissions themselves. Whether we are discussing magnetic- or capacitive-based isolation solutions, both of these isolation strategies require that a high-frequency electrical signal be generated internally in the isolator. These high-frequency signals can in themselves constitute a source of EMI/RFI emissions. The internal circuits that detect the high-frequency carrier signals can also be "susceptible" to external electromagnetic noise sources. This is an important point to keep in mind in industrial applications, where the presence of high-intensity magnetic and electric fields can be expected.

Given sufficient unwanted noise coupling, a circuit or electrical system will fail to operate

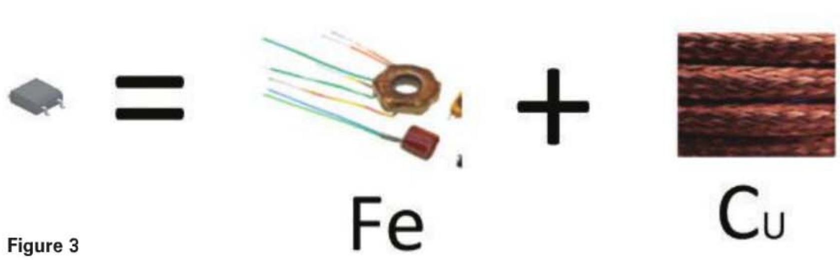


Figure 3

About the author:

Jose Espina is Product Marketing Engineer at Vishay, and formerly worked at NetLogic, Vicor, Nortel and NASA.