

# Infrared Transceiver PC Board Layout for Noise Immunity

## Application Note 1114

### Introduction

Agilent Technologies' infrared transceivers require special board layout in order to maximize transceiver performance in the presence of noise. Types of noise that effect the transceiver can be either EMI (Electro-Magnetic Interference), PSN (Power Supply Noise), or ground loop noise. Board layout and passive component selection can be used to reduce the amount of noise that reaches the preamplifier. Noise present at the preamplifier stage of the transceiver will degrade transceiver sensitivity, and so decrease the effective receiving distance in the application.

### Measuring Noise

The presence of noise on the  $V_{CC}$  pin, Ground pin, or transceiver input of an infrared transceiver can reduce transceiver sensitivity. The effects of EMI, PSN, and ground loop noise can be observed by monitoring the infrared transceiver output pin (Rxd) with an oscilloscope. The transceiver output Rxd should be at a constant  $V_{OH}$  level with no infrared signal present. If pulses are observed on Rxd with no infrared signal sent to the transceiver, then the pulses are most likely generated by noise. These pulses on Rxd in the

absence of an infrared signal are referred to as 'dark bits'. See Figure 1.

The presence of a specific type of noise can often be determined by further measurements. PSN can often be observed by probing  $V_{CC}$  of the infrared transceiver with an oscilloscope. The following procedure should be used to determine the type of noise causing dark bits on the transceiver output Rxd:

1. Disconnect  $V_{CC}$  of the transceiver from the board. Connect  $V_{CC}$  of the transceiver to the

positive terminal of a 4.5 V battery (can use three 1.5 V batteries in series). Connect the negative terminal of the battery to the board ground. If the number of dark bits is reduced or eliminated with this hookup, then PSN is effecting transceiver sensitivity.

2. Connect a transceiver evaluation board to  $V_{CC}$  and Ground of the PC board with 6-inch wires. Move the evaluation board away from the PC board in position and observe the transceiver output Rxd. If the presence of dark bits is reduced as the evaluation board moves further from the PC board, then EMI noise is effecting transceiver sensitivity. The evaluation board can also be shielded with metallized tape to test for the effects of EMI noise.

3. To check the overall PC board layout as compared to the evaluation board layout, wire the evaluation board to the PC board  $V_{CC}$ , Ground, Rxd, Txid with as short wires as possible. Position the evaluation board in the same location as the transceiver on the PC board. Compare the amount of dark bits on the evaluation board Rxd with that seen on the PC

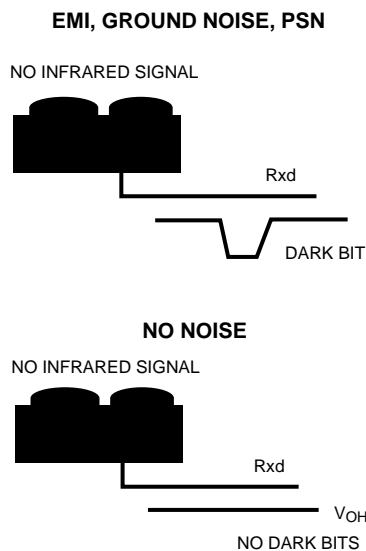


Figure 1.

board's transceiver. If the performance of the evaluation board exceeds that of the PC board, then the ground plane and placement of components on the PC board needs improvement.

## EMI (Electro-Magnetic Interference)

EMI is generated by the electromagnetic fields of signal lines, switched mode power supplies, DC-DC converters, or high voltage lines. The electric field component has the main effect on transceiver sensitivity. The primary contributors of EMI in infrared applications appear to be DC-DC converters, high voltage converters (for display lamps), and RF signal generators. In many applications such devices are placed on the same PC board and in close proximity to Agilent Technologies' infrared transceivers.

The reduction in infrared transceiver sensitivity is proportional to the EM field intensity present at the infrared transceiver. The EM field intensity present at the infrared transceiver depends upon the EMI source's signal amplitude, and the distance from the EMI source to the transceiver. The EM field intensity at the infrared transceiver is then expressed in volts per meter (V/m). As shown in Figure 2, the EM field intensity, EF (V/m), is equal to EMI signal amplitude,  $s$  (Volts), divided by EMI source to infrared transceiver distance,  $d$  (meters).  $EF = s/d$ .

The EM field intensity reaching the infrared transceiver can be reduced by:

- Decreasing the EMI source's signal amplitude
- Increasing the EMI source to infrared transceiver distance
- Shielding the infrared transceiver

The EM field intensity's effect on the transceiver sensitivity also can be reduced by improving the EMI immunity of the infrared transceiver.

The effective EMI source signal amplitude can be reduced by use of 'cleaner' transformers or coils used in power converters, or signal generators. The term 'cleaner' is defined as devices which emit a very small percentage of their power as EM noise outward into the surrounding instrument. Minimizing the EM noise emitted can be accomplished by higher permittivity cores for coils or transformers, by choice of a power converter with minimal noise

ripple, or by shielding the transformers or coils with a grounded shield.

The infrared transceiver can be shielded with a grounded metal shield, in order to block the EM field from reaching the transceiver. A grounded shield will terminate the EM field before it reaches the infrared transceiver. Agilent Technologies provides EM shields for some of the infrared transceivers. Contact your Agilent Sales Representative for more information.

## Design Guidelines EMI (Electro-Magnetic Interference)

The EM field intensity's effect on the transceiver sensitivity also can be reduced by improving the EMI immunity of the infrared transceiver. EMI immunity is defined as the maximum EM field intensity that can be present at the infrared transceiver before transceiver sensitivity is significantly impacted. A significant impact on

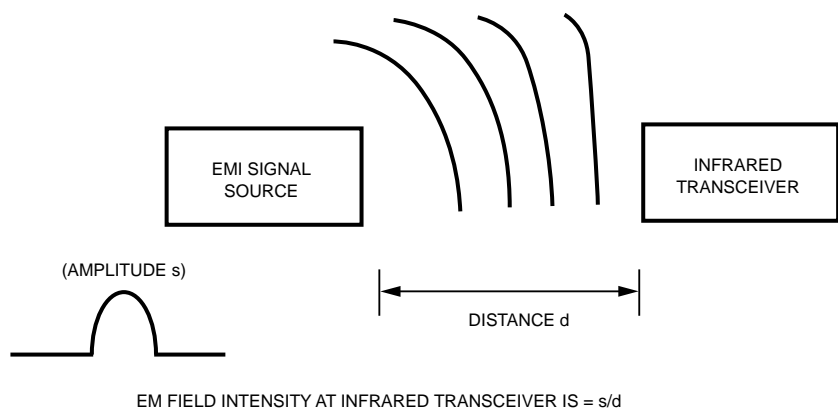


Figure 2.

| EMI Signal Amplitude (s) | EMI Source to Agilent's Transceiver Distance (d) | EM Field Intensity (Volts/meter) |
|--------------------------|--|----------------------------------|
| 3 volts                  | 2 cm   | 150 V/m                          |
| 3 volts                  | 5 cm   | 60 V/m                           |
| 5 volts                  | 2 cm   | 250 V/m                          |
| 5 volts                  | 5 cm   | 100 V/m                          |

transceiver sensitivity is measured by the presence of pulses on the transceiver output (Rxd) with no infrared signal present at the infrared transceiver lens. These noise induced pulses are called 'dark bits'.

The EMI immunity of the infrared transceiver on a given board layout can be measured by observing the infrared transceiver Rxd output on an oscilloscope. The EM field intensity at which 'dark bits' begin to appear on the infrared transceiver output Rxd is taken as the EMI immunity of the infrared transceiver.

Increasing the EMI immunity of the infrared transceiver can be accomplished by:

- Placing the  $V_{CC}$  bypass capacitors as close as possible to the pins of the infrared transceiver (preferably within 0.5 cm of the pins)
  - Cx2, Cx3 for the HSDL-1000
  - Cx3 for the HSDL-1001
  - Cx1, Cx5 for the HSDL-1100
  - Cx5, Cx6 for the HSDL-2100
  - Cx1, Cx2 for the HSDL-2200, HSDL-2300
  - Cx1 for the HSDL-3200
- Providing a ground plane island beneath the infrared transceiver. The extent of the ground plane should cover at least 1 cm outward from the infrared transceiver. It should cover all of the recommended passive components, but not under the shield trace. The shield trace should be a wide and low inductance trace. The ground plane and the shield trace should then be connected to a clean (<20 mV noise) system

ground (could be the system's analog ground). Note that the EMI immunity of the infrared transceiver can be significantly improved by not connecting the shield trace directly to the transceiver ground plane.

### PSN (Power Supply Noise)

Power supply noise can be coupled into the preamplifier of the infrared transceiver, and can degrade transceiver sensitivity. Power supply ripple present at the preamplifier reduces the infrared transceiver's ability to distinguish an infrared signal from noise. Power supply noise can be observed with an oscilloscope, and is usually measured in 10's of millivolts.

Power supply rejection (PSR) is a measure of the noise rejection capability of the infrared transceiver. PSR is the maximum amount of power supply noise (p-p mV) that can be tolerated on the  $V_{CC}$  pin of the transceiver before a dark bit is measured on the output Rxd. Note that PSR is measured without the presence of the  $V_{CC}$  bypass capacitors.

The measured power supply noise (PSN) or ripple on  $V_{CC}$  should be less than the PSR for a given

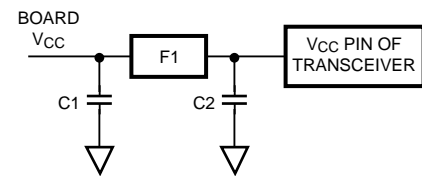
infrared transceiver in order to achieve full transceiver sensitivity in the design. If the PSN is above the PSR in the design, then further design measures must be taken to reduce the PSN present at the  $V_{CC}$  pin of the transceiver.

### Design Guidelines

#### PSN (Power Supply Noise)

PSN at the  $V_{CC}$  pin can be reduced by:

- Placing the  $V_{CC}$  bypass capacitors as close as possible to the pins of the infrared transceiver (preferably within 0.5 cm of the pins)
  - Cx2, Cx3 for the HSDL-1000
  - Cx3 for the HSDL-1001
  - Cx1, Cx5 for the HSDL-1100
  - Cx5, Cx6 for the HSDL-2100
  - Cx1, Cx2 for the HSDL-2200, HSDL-2300
  - Cx1 for the HSDL-3200
- Placing a 10-50 ohm resistor in the  $V_{CC}$  path between  $V_{CC}$  bypass capacitors. Alternatively, a ferrite bead can be placed in the  $V_{CC}$  path. See Figure 3.



F1 = 10-50 OHM RESISTOR OR FERRITE BEAD

Figure 3.

The power supply rejection capability of Agilent Technologies' infrared transceivers is shown below:

| Infrared Transceiver | Power Supply Rejection (p-p mV) |
|----------------------|---------------------------------|
| HSDL-1000            | 20                              |
| HSDL-1001            | 50                              |
| HSDL-1100            | 90                              |
| HSDL-2100            | 90                              |
| HSDL-2200            | 60                              |
| HSDL-2300            | 40                              |
| HSDL-3200            | 40                              |

- Routing the  $V_{CC}$  and ground on successive and parallel layers on a multi-layer PC board. The parallel placement will provide short return paths to ground for any  $V_{CC}$  transients or noise. See Figure 4.
- Increasing the values of the  $V_{CC}$  bypass capacitors.
- Providing a ground plane island beneath the infrared transceiver. The extent of the ground plane should cover at least 1 cm outward from the infrared transceiver. It should cover all of the recommended passive components, but not under the

shield trace. The shield trace should be a wide and low inductance trace. The ground plane and the shield trace should then be connected to a clean (<20 mV noise) system ground (could be the system's analog ground). See Figure 5.

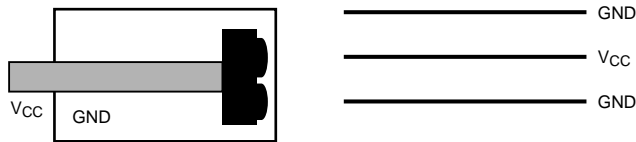
#### Ground Loop Noise

Similarly to power supply noise, ground noise can reduce the infrared transceiver sensitivity. Usually the ground noise is due to transient ground currents that cause voltage drops across the ground line impedance. Large transient ground currents can be produced by fast switching, high

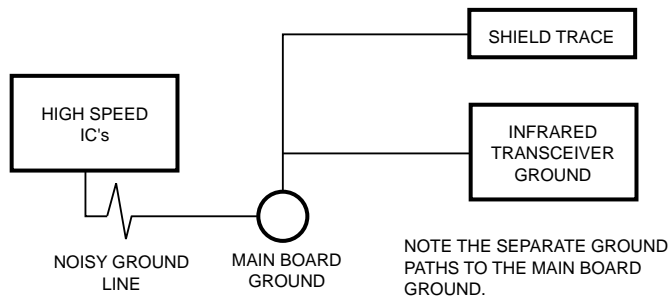
current ICs such as microprocessors, I/O chips, or other dynamic logic devices. These ICs require a short, low impedance path to ground in order to minimize voltage transients on the ground line.

The following design guidelines should be followed in order to minimize ground loop noise:

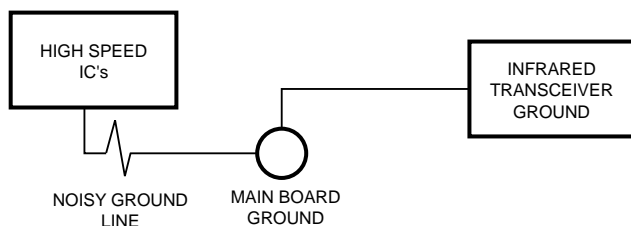
- The infrared transceiver ground path should be separate from such fast switching, high current ICs. The separate path should insure minimal voltage transients on the transceiver ground pin. See Figure 6.
- Routing the  $V_{CC}$  and ground on successive and parallel layers on a multi-layer PC board. The parallel placement will provide short return paths to ground for any  $V_{CC}$  transients or noise. See Figure 4.



**Figure 4.**



**Figure 5.**



**Figure 6.**

The parallel placement should also be used for the ground and  $V_{CC}$  lines for the fast switching, high current ICs. Return paths to ground from  $V_{CC}$  can then be minimized.

**Agilent Technologies infrared transceiver evaluation boards can be obtained which demonstrate correct board layout. Contact your local Agilent Technologies sales representative for more information.**