
Avoiding EMI and ESD Problems in Basler Camera Link, IEEE 1394, and GigE Camera Installations

Application Notes

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1 Introduction

Basler Camera Link, IEEE 1394 and Gigabit Ethernet (GigE) cameras are frequently installed in industrial applications. These applications often include devices that generate electromagnetic interference (EMI) and environments prone to electro-static discharge (ESD). The purpose of this document is to provide guidelines for avoiding problems with EMI and ESD.

Section 2 of the document provides some guidelines that are applicable in all types of installations.

Section 3 provides guidelines that apply to certain specific types of installations.

2 General Guidelines for All Types of Installation

- If possible, choose an installation that will not create ground loops: Connect to earth ground on only one place.
- For optimum EMI protection, use functional earth ground (FE) in addition to protective earth ground (PE).



⚠ WARNING

Electric Shock

Electric shock may cause death or serious injury.

1. Functional earth ground does not protect against electric shock and therefore **must not** be used as a substitute for protective earth ground. You must provide for protective earth ground even though protective earth ground is not shown in the figures of this document.

- Consult technical literature for further information on functional earth ground. In particular, consider the following issues:
 - Materials and geometric properties (e.g. cross section, length, aspect ratio) of the conductors
 - Connections between conductors and components to be grounded
 - Design of the earth grounding system
 - Connecting functional earth ground to protective earth ground
 - Relevant regulations.
- Use a line filter on the main power supply.
- If possible, use a single multiple socket outlet for power supply.
- Install the camera and camera cables as far as possible from devices that generate magnetic fields or sparks. If necessary, use additional shielding.
- Always use high-quality, shielded cables.
- Avoid placing camera cables and I/O cables parallel to wires carrying high-current, switching voltages such as wires supplying stepper motors or electrical devices using switching technology.
- Run data- power- and I/O cables parallel to each other wherever possible. The cables should be run as close to each other as possible.
- Avoid coiling camera cables and I/O cables. Try to use cables that are as short as possible. If the cables are too long, use a meandering path rather than coiling the cables.

- Frequently, the electric contact between cable shield and other components, e.g. the PC chassis or the housing of a network switch must be improved. You can do this by using additional devices, e.g. conductive gaskets.

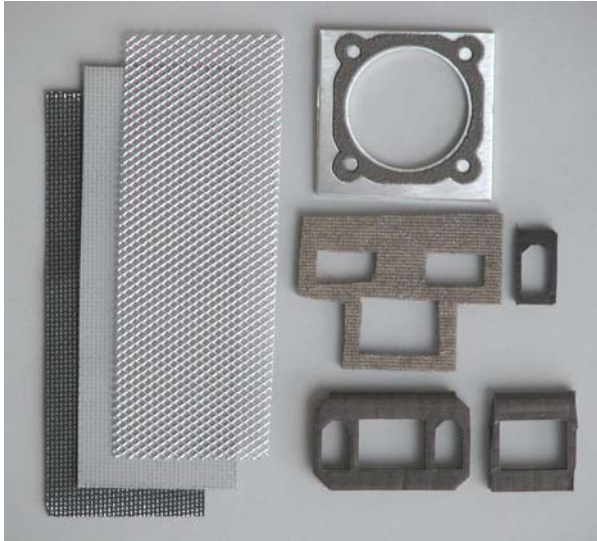


Figure 1:Conductive Gasket Materials and Gaskets

- Use ground straps for installations involving ground loops (for details, see the following sections).



Figure 2: Ground Strap



Ground loops will cause unwanted electric current in your installation.

If possible, avoid installations involving ground loops.

If you can not avoid ground loops:

- Use ground straps and follow the recommendations given in the sections below.
- Minimize the spatial extent of each circuit affected by a ground loop.

- Decrease the risk of electro-static discharge by taking the following measures:
 - Use conductive materials for the place of installation (e.g. floor, workplace).
 - Use suitable clothing (cotton) and shoes.
 - Control the humidity in your environment. Low humidity can cause ESD problems.

3 Guidelines for Specific Types of Installation

The installations listed below, consider the use of only one camera. The guidelines, however, apply in analogous ways also to multiple cameras.

3.1 Installations with Camera Link Cameras

3.1.1 Camera Attached Directly to PC, Camera Body Isolated From Ground

- Make sure that the camera and the power supply are mounted on an electrical insulators.
- Use a single multiple socket outlet for PC and power supply.
- Make sure that the PC chassis, the equipment, and the metal mounting plates for the electrical insulators and attached devices (camera, power supply, see [Figure 3](#)) are connected to functional earth ground.
- Route the Camera Link cable, the I/O cable, and the power cables as near to each other as possible.
- At the point where the camera cable is plugged into the PC's frame grabber, the cable shield must have a very good connection to the PC chassis. The connector on a typical interface card usually does not provide enough contact between the shield and the PC chassis. Usually, you must make this connection better by using an additional device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to the PC chassis and that makes good contact with the cable shield.
- The Camera Link connector on the camera is specially designed to provide good contact between the camera cable shield and the camera body. No modifications to this connection are necessary.
- The I/O ground in the camera is isolated from the camera ground. Therefore, the cable shielding on the I/O cable should only be connected at the camera **OR** at your equipment. We recommend connecting the cable shielding at the camera and insulating it from the equipment (see [Figure 3](#)).

If you choose to connect the I/O cable shield at your equipment, the cable shield must have a very good connection to the equipment. Typically, you must make this connection better by using a device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to your equipment and that makes good contact with the cable shield.

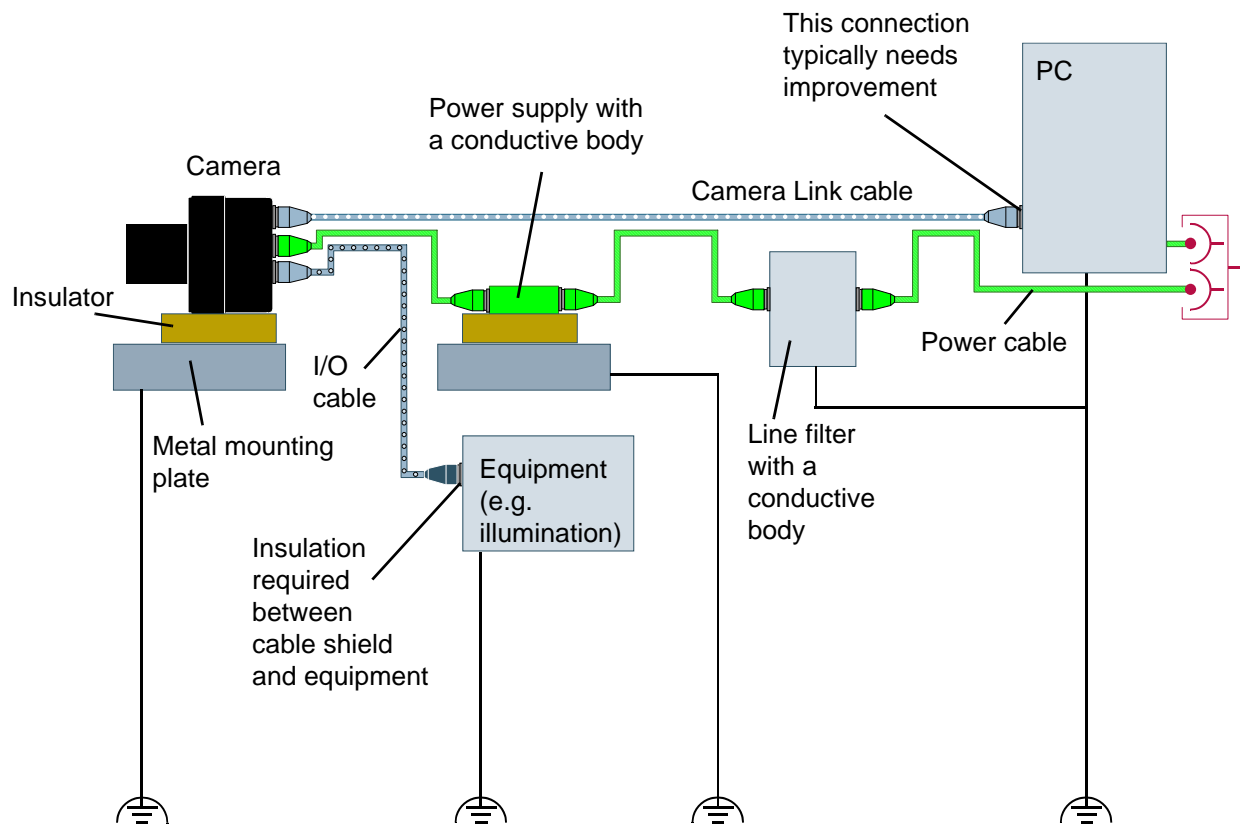


Figure 3: Isolated Camera Link Camera Attached Directly to PC

3.1.2 Camera Attached Directly to PC, Camera Body Connected to Ground

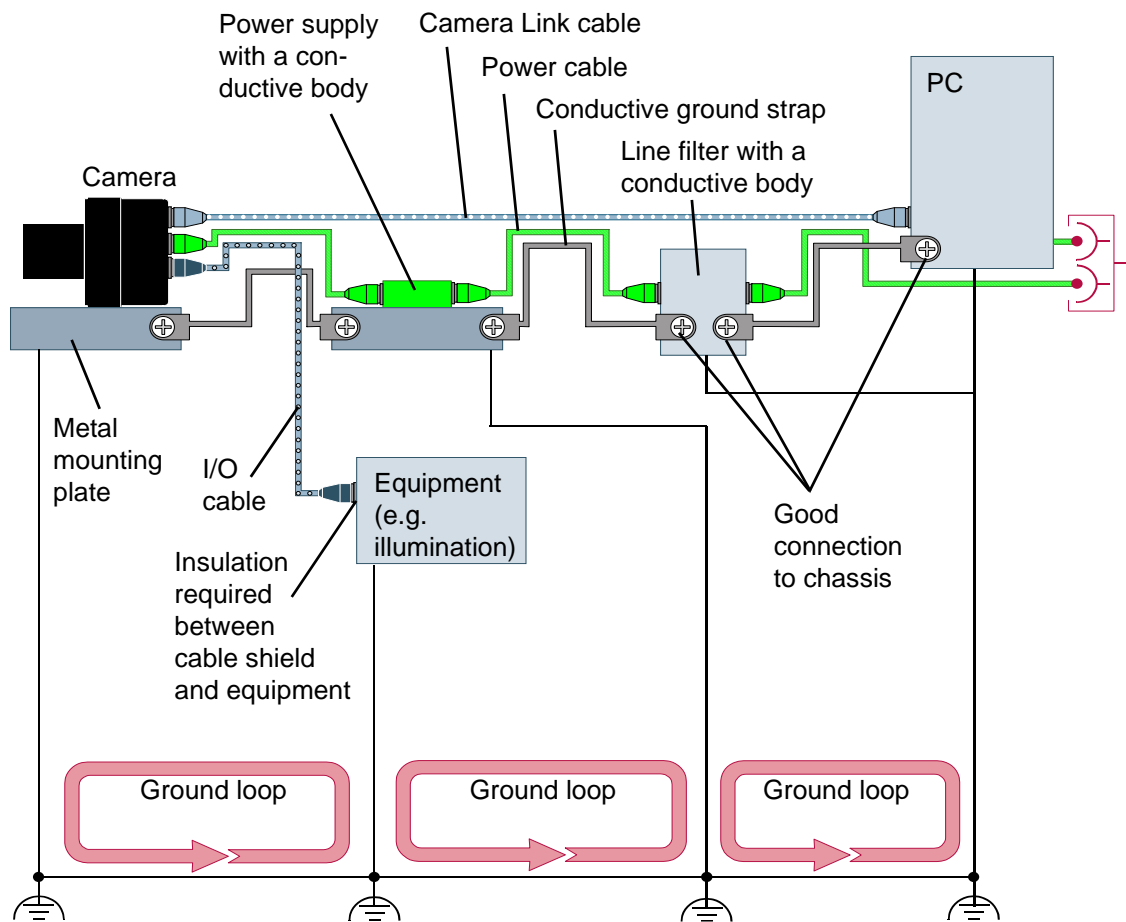


This type of installation creates earth ground loops and is very susceptible to EMI and ESD. We strongly recommend avoiding this type of installation in favour of an installation that will not create earth ground loops.

If you can not avoid ground loops, follow the instructions given below .

- Install highly conductive ground straps between the PC chassis, line filter chassis and the metal racks where the camera and the power supply are mounted (see Figures 2 and 4).
- Route the camera cable, the I/O cable, and the power cable as near to the ground straps as possible.
- Use a single multiple socket outlet for PC and power supply.
- Make sure that the equipment and the chassis of PC and line filter are connected to functional earth ground.
- At the point where the camera cable is plugged into the PC's frame grabber, the cable shield must have a very good connection to the PC chassis. The connector on a typical interface card usually does not provide enough contact between the shield and the PC chassis. Usually, you must make this connection better by using an additional device such as an electrically conductive gasket (see Figure 1) that is securely attached to the PC chassis and that makes good contact with the cable shield.
- The Camera Link connector on the camera is specially designed to provide good contact between the camera cable shield and the camera body. No modifications to this connection are necessary.
- The I/O ground in the camera is isolated from the camera ground. Therefore, the cable shielding on the I/O cable should only be connected at the camera **OR** at your equipment. We recommend connecting the cable shielding at the camera and insulating it from the equipment (see Figure 4).

If you choose to connect the I/O cable shield at your equipment, the cable shield must have a very good connection to the equipment. Typically, you must make this connection better by using a device such as an electrically conductive gasket (see Figure 1) that is securely attached to your equipment and that makes good contact with the cable shield.



We strongly recommend avoiding this type of installation involving ground loops

Figure 4: Grounded Camera Link Camera Attached Directly to PC

3.2 Installations with IEEE 1394 Cameras

3.2.1 Camera Attached Directly to PC, Camera Body Isolated From Ground

- Make sure that the camera is mounted on an electrical insulator.
- Make sure that the PC chassis, the equipment, and the metal mounting plate for the electrical insulator and the camera (see [Figure 5](#)) are connected to functional earth ground.
- At the point where the camera cable is plugged into the PC's 1394 interface card, the cable shield must have a very good connection to the PC chassis. The connector on a typical interface card usually does not provide enough contact between the shield and the PC chassis. Usually, you must make this connection better by using an additional device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to the PC chassis and that makes good contact with the cable shield.
- The IEEE 1394 connector on the camera is specially designed to provide good contact between the camera cable shield and the camera body. No modifications to this connection are necessary.
- The I/O ground in the camera is isolated from the camera ground. Therefore, the cable shielding on the I/O cable should only be connected at the camera **OR** at your equipment. We recommend connecting the cable shielding at the camera and insulating it from the equipment (see [Figure 5](#)).

If you choose to connect the I/O cable shield at your equipment, the cable shield must have a very good connection to the equipment. Typically, you must make this connection better by using a device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to your equipment and that makes good contact with the cable shield.

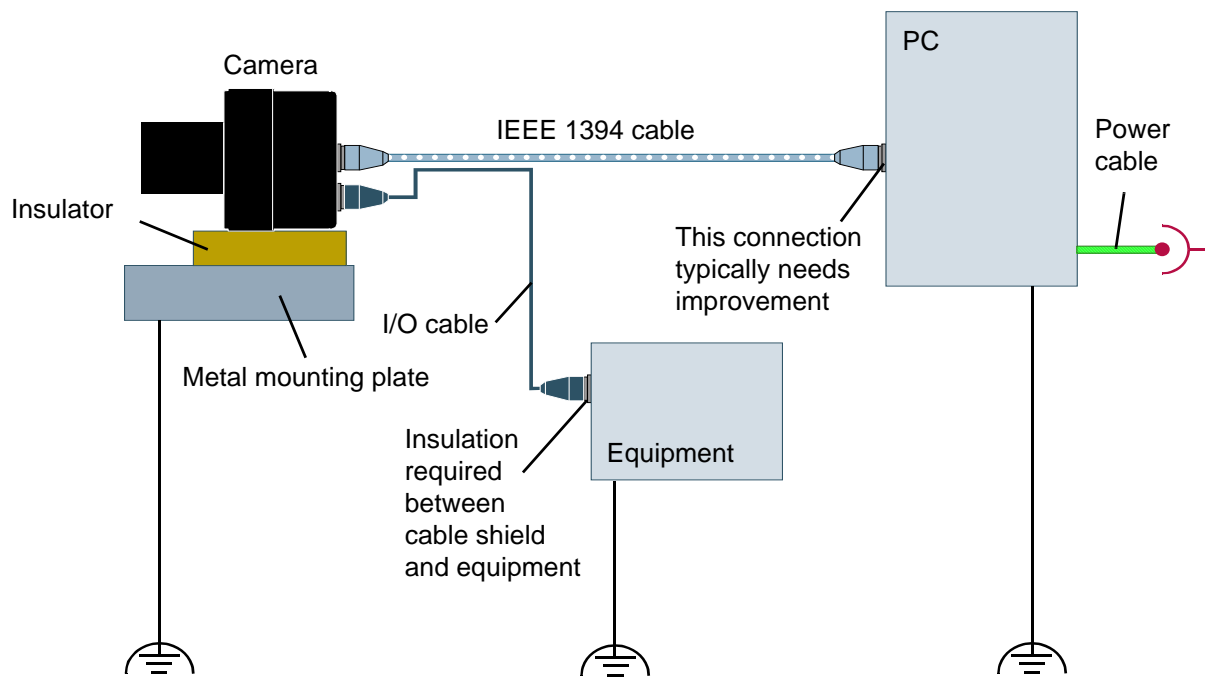


Figure 5: Isolated IEEE 1394 Camera Attached Directly to PC

3.2.2 Camera Attached Directly to PC, Camera Body Connected to Ground

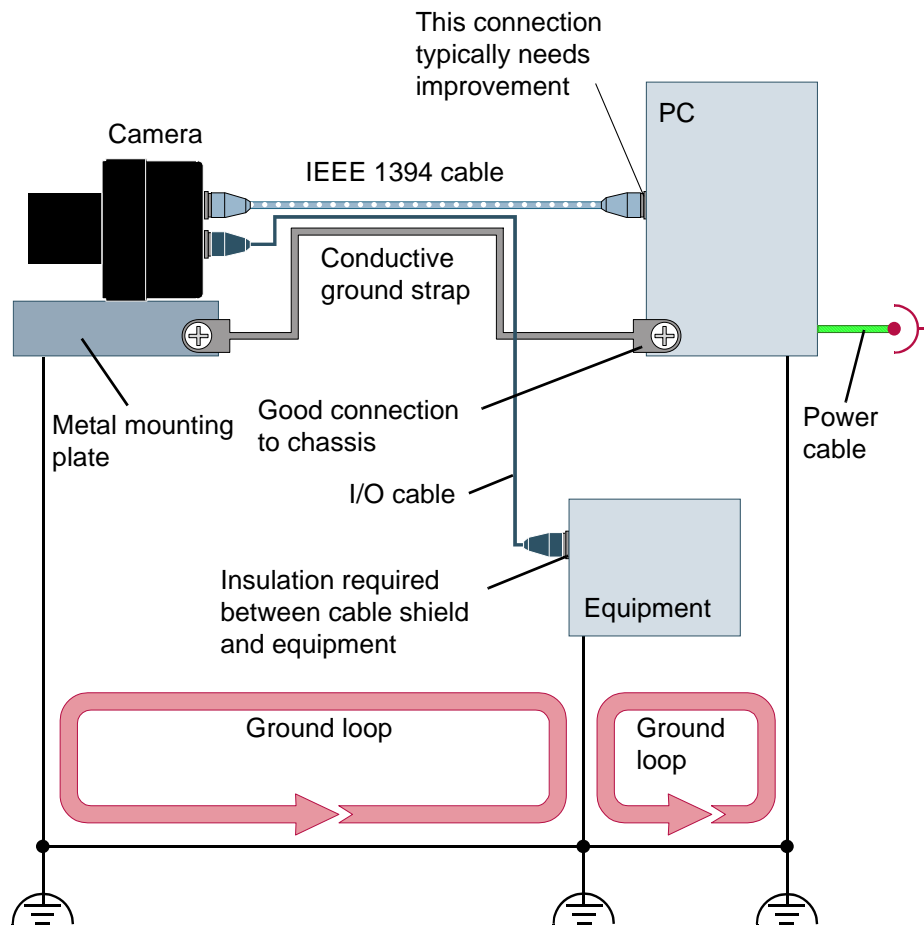


This type of installation creates earth ground loops and is very susceptible to EMI and ESD. We strongly recommend avoiding this type of installation in favour of an installation that will not create earth ground loops.

If you can not avoid ground loops, follow the instructions given below .

- Install a highly conductive ground strap between the PC chassis and the metal rack (see Figures 2 and 6).
- Route the camera cable and the I/O cable as near to the ground strap as possible.
- Make sure that the PC chassis, the equipment, and the metal rack are connected to functional earth ground.
- At the point where the camera cable is plugged into the PC's 1394 interface card, the cable shield must have a very good connection to the PC chassis. The connector on a typical interface card usually does not provide enough contact between the shield and the PC chassis. Usually, you must make this connection better by using an additional device such as an electrically conductive gasket (see Figure 1) that is securely attached to the PC chassis and that makes good contact with the cable shield.
- The IEEE 1394 connector on the camera is specially designed to provide good contact between the camera cable shield and the camera body. No modifications to this connection are necessary.
- The I/O ground in the camera is isolated from the camera ground. Therefore, the cable shielding on the I/O cable should only be connected at the camera **OR** at your equipment. We recommend connecting the cable shielding at the camera and insulating it from the equipment (see Figure 6).

If you choose to connect the I/O cable shield at your equipment, the cable shield must have a very good connection to the equipment. Typically, you must make this connection better by using a device such as an electrically conductive gasket (see Figure 1) that is securely attached to your equipment and that makes good contact with the cable shield.



We strongly recommend avoiding this type of installation involving ground loops

Figure 6: Grounded IEEE 1394 Camera Attached Directly to PC

3.2.3 Camera Attached to PC via Hub, Camera Body and Hub Isolated From Ground

- Make sure that the camera, the hub and its power supply are mounted on electrical insulators.
- Use a single multiple socket outlet for the PC and the power supply for the hub.
- Make sure that the PC chassis, the equipment, and the metal mounting plates for the electrical insulators and attached devices (camera, hub, power supply, see [Figure 7](#)) are connected to functional earth ground.
- Always use a hub and a power supply for the hob with conductive bodies. This will allow EMI or ESD to flow over the bodies of the devices rather than through their circuitry. If you can't get the devices with conductive bodies, see [Section 3.4](#).
- Make sure that the hub power supply is isolated, i.e., its AC input is not connected to earth ground. If the power supply has a metal body, mount the power supply on an electrical insulator.
- Make sure that the power supply for the hub and the power cables for the power supply are not routed near wires carrying high-current, switching voltages such as wires supplying stepper motors or electrical devices using switching technology. Place the power supply unit for the hub near to the camera cabling. Route the power cables for the hub power supply near to the camera cabling.
- At each point where a camera cable connects to the hub, the cable shield must have a very good connection to the hub housing. Typically, you must make this connection better by using an additional device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to the hub housing and that makes good contact with the cable shield.
- At the point where the camera cable is plugged into the PC's 1394 interface card, the cable shield must have a very good connection to the PC chassis. The connector on a typical interface card usually does not provide enough contact between the shield and the PC chassis. Usually, you must make this connection better by using an additional device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to the PC chassis and that makes good contact with the cable shield.
- The IEEE 1394 connector on the camera is specially designed to provide good contact between the camera cable shield and the camera body. No modifications to this connection are necessary.
- The I/O ground in the camera is isolated from the camera ground. Therefore, the cable shielding on the I/O cable should only be connected at the camera **OR** at your equipment. We recommend connecting the cable shielding at the camera and insulating it from the equipment (see [Figure 7](#)).

If you choose to connect the I/O cable shield at your equipment, the cable shield must have a very good connection to the equipment. Typically, you must make this connection better by using a device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to your equipment and that makes good contact with the cable shield.

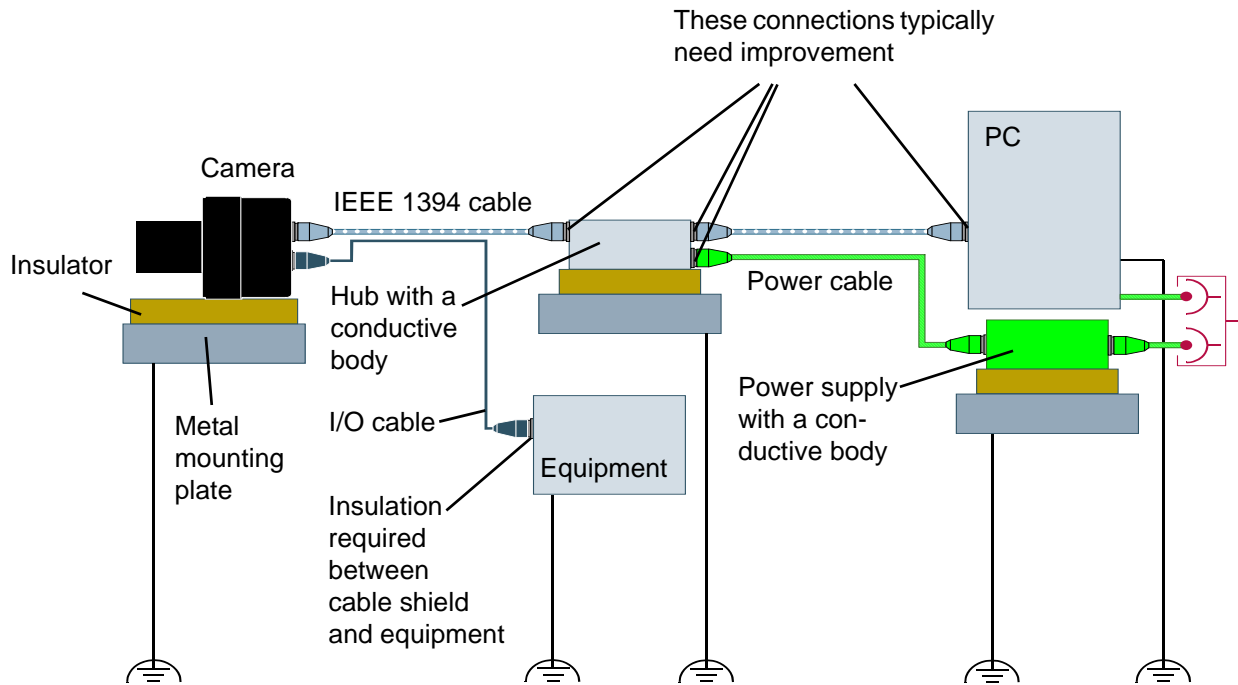


Figure 7: Isolated IEEE 1394 Camera Attached to PC via an Isolated Hub

3.2.4 Camera Attached to PC via Hub, Camera Body and Hub Connected to Ground

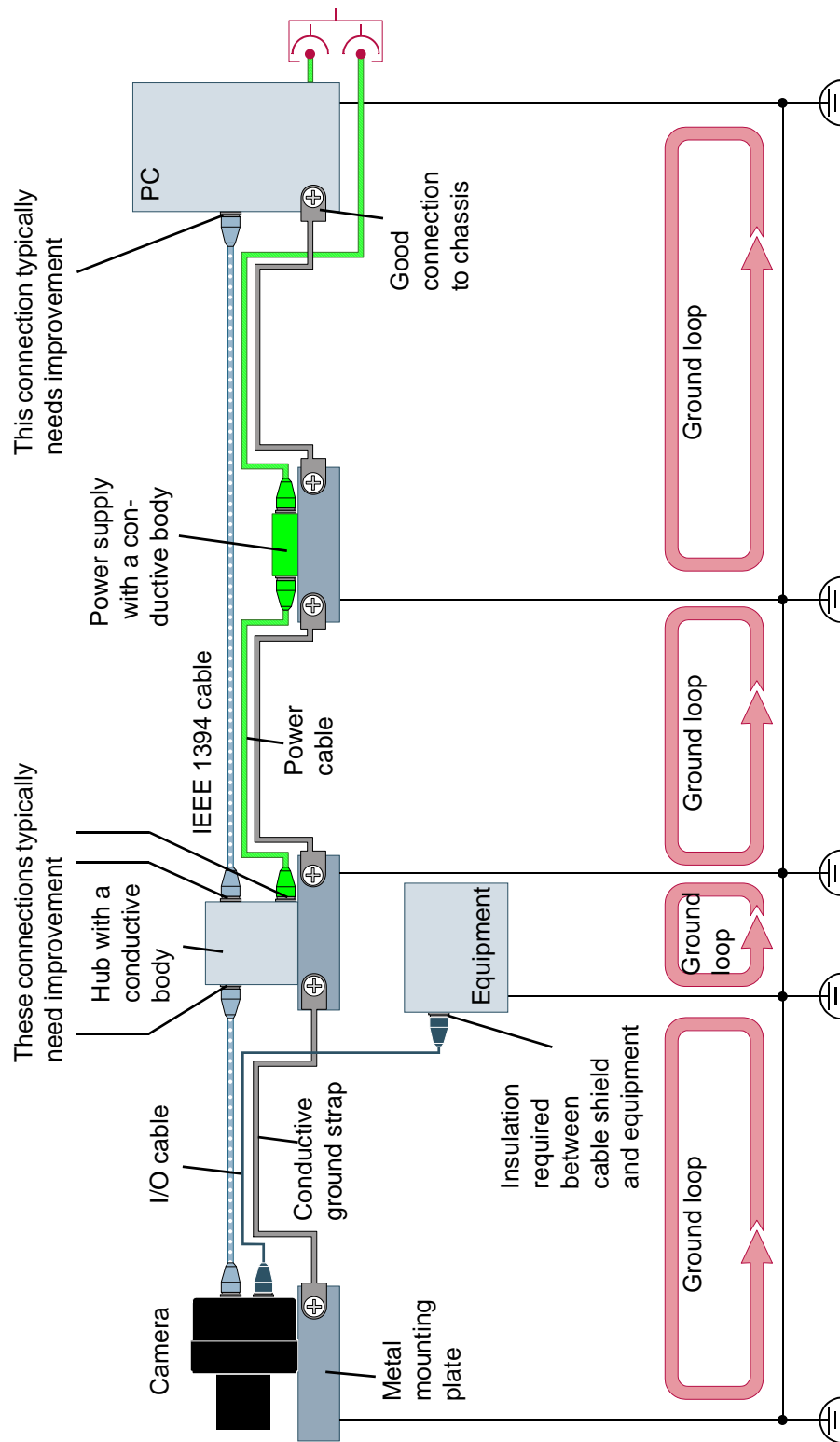


This type of installation creates earth ground loops and is very susceptible to EMI and ESD. We strongly recommend avoiding this type of installation in favour of an installation that will not create earth ground loops.

If you can not avoid ground loops, follow the instructions given below .

- Install highly conductive ground straps connecting the PC chassis and the metal racks where the camera, the hub, and the power supply for the hub are mounted (see Figures 2 and 8).
- Route the camera cables, the I/O cable, and the power cables as near to the ground straps as possible.
- Place the hub power supply near to the hub.
- Use a single multiple socket outlet for PC and power supply for the hub.
- Make sure that the PC chassis, the equipment, and the metal racks are connected to functional earth ground.
- Always use hubs and power supplies with conductive bodies. This will allow EMI or ESD to flow over the hub body rather than through their circuitry. If you can't get a hub or power supply with a conductive body, see Section 3.4.
- Make sure that the power supply for the hub and the power cable for the power supply are not routed near wires carrying high-current, switching voltages such as wires supplying stepper motors or electrical devices using switching technology.
- At each point where a camera cable connects to the hub, the cable shield must have a very good connection to the hub housing. Typically, you must make this connection better by using an additional device such as an electrically conductive gasket (see Figure 1) that is securely attached to the hub housing and that makes good contact with the cable shield.
- At the point where the camera cable is plugged into the PC's 1394 interface card, the cable shield must have a very good connection to the PC chassis. The connector on a typical interface card usually does not provide enough contact between the shield and the PC chassis. Usually, you must make this connection better by using an additional device such as an electrically conductive gasket (see Figure 1) that is securely attached to the PC chassis and that makes good contact with the cable shield.
- The IEEE 1394 connector on the camera is specially designed to provide good contact between the camera cable shield and the camera body. No modifications to this connection are necessary.
- The I/O ground in the camera is isolated from the camera ground. Therefore, the cable shielding on the I/O cable should only be connected at the camera **OR** at your equipment. We recommend connecting the cable shielding at the camera and insulating it from the equipment (see Figure 8).

If you choose to connect the I/O cable shield at your equipment, the cable shield must have a very good connection to the equipment. Typically, you must make this connection better by using a device such as an electrically conductive gasket (see Figure 1) that is securely attached to your equipment and that makes good contact with the cable shield.



We strongly recommend avoiding this type of installation involving ground loops

Figure 8: Grounded IEEE 1394 Camera Connected to PC via a Grounded Hub

3.3 Installations with GigE Cameras

3.3.1 Camera Attached Directly to PC, Camera Body Isolated From Ground

- Make sure that the camera, the power supply, and the line filter are mounted on electrical insulators.
- Use a single multiple socket outlet for PC and power supply.
- Make sure that the PC chassis, the equipment and the metal mounting plates for the electrical insulators and attached devices (camera, power supply, line filter, see [Figure 9](#)) are connected to functional earth ground.
- Route the GigE cable, the I/O cable, and the power cables as near to each other as possible.
- At the point where the camera cable is plugged into the PC's GigE interface card, the cable shield must have a very good connection to the PC chassis. The connector on a typical interface card usually does not provide enough contact between the shield and the PC chassis. Usually, you must make this connection better by using an additional device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to the PC chassis and that makes good contact with the cable shield.
- The GigE connector (RJ-45) on the camera is specially designed to provide good contact between the camera cable shield and the camera body. No modifications to this connection are necessary.
- The I/O ground in the camera is isolated from the camera ground. Therefore, the cable shielding on the I/O cable should only be connected at the camera **OR** at your equipment. We recommend connecting the cable shielding at the camera and insulating it from the equipment (see [Figure 9](#)).

If you choose to connect the I/O cable shield at your equipment, the cable shield must have a very good connection to the equipment. Typically, you must make this connection better by using a device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to your equipment and that makes good contact with the cable shield.

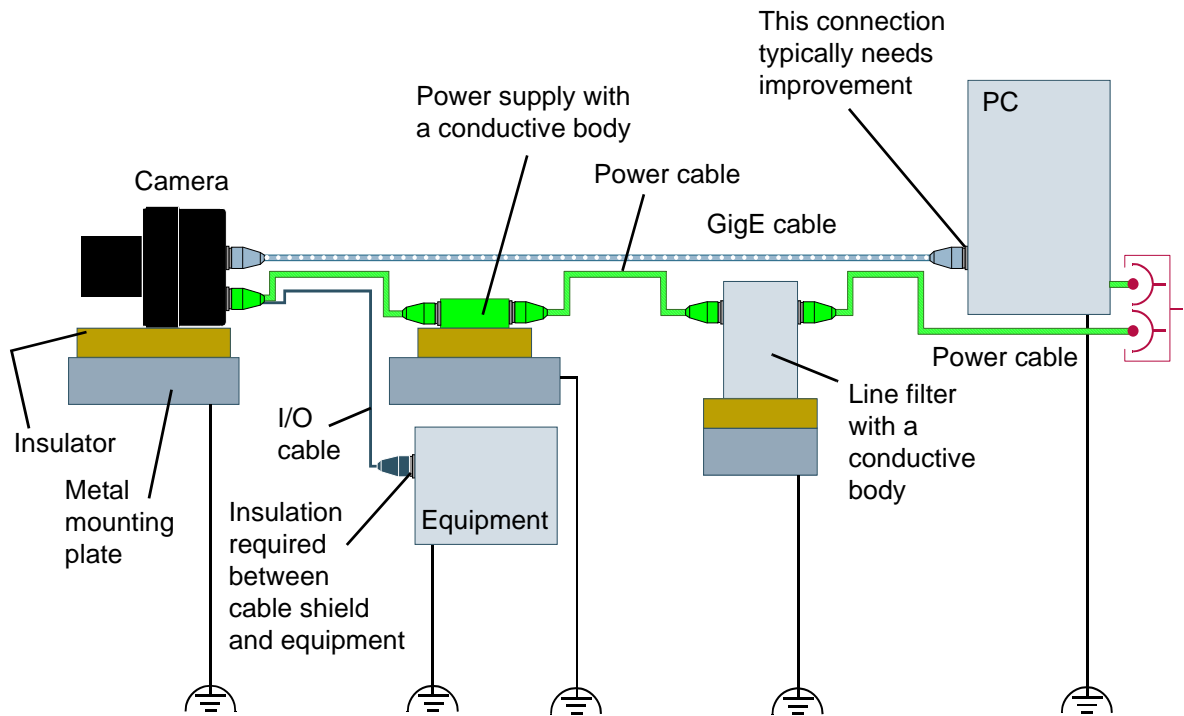


Figure 9: Isolated GigE Camera Attached Directly to PC

3.3.2 Camera Attached Directly to PC, Camera Body Connected to Ground



This type of installation creates earth ground loops and is very susceptible to EMI and ESD. We strongly recommend avoiding this type of installation in favour of an installation that will not create earth ground loops.

If you can not avoid ground loops, follow the instructions given below .

- Install highly conductive ground straps connecting the PC chassis, the line filter chassis, and the metal racks where the camera and the power supply are mounted (see Figures 2 and 10).
- Route the camera cable, the I/O cable, and the power cables as near to the ground straps as possible.
- Use a single multiple socket outlet for PC and power supply.
- Make sure that the PC chassis, the line filter chassis, the metal racks, and the equipment are connected to functional earth ground.
- At the point where the camera cable is plugged into the PC's GigE interface card, the cable shield must have a very good connection to the PC chassis. The connector on a typical interface card usually does not provide enough contact between the shield and the PC chassis. Usually, you must make this connection better by using an additional device such as an electrically conductive gasket (see Figure 1) that is securely attached to the PC chassis and that makes good contact with the cable shield.
- The GigE connector (RJ-45) on the camera is specially designed to provide good contact between the camera cable shield and the camera body. No modifications to this connection are necessary.
- The I/O ground in the camera is isolated from the camera ground. Therefore, the cable shielding on the I/O cable should only be connected at the camera **OR** at your equipment. We recommend connecting the cable shielding at the camera and insulating it from the equipment (see Figure 10).

If you choose to connect the I/O cable shield at your equipment, the cable shield must have a very good connection to the equipment. Typically, you must make this connection better by using a device such as an electrically conductive gasket (see Figure 1) that is securely attached to your equipment and that makes good contact with the cable shield.

We strongly recommend avoiding this type of installation involving ground loops

Figure 10: Grounded GigE Camera Attached Directly to PC

3.3.3 Camera Attached to PC via Network Switch, Camera Body and Network Switch Isolated From Ground

- Make sure that the camera, the power supply, the network switch, and the line filter are mounted on electrical insulators.
- Use a single multiple socket outlet for PC, network switch, and power supply.
- Make sure that the PC chassis, the equipment, and the metal mounting plates for the electrical insulators and attached devices (camera, power supply, network switch, line filter, see [Figure 11](#)) are connected to functional earth ground.
- Route the GigE cable, the I/O cable, and the power cables as near to each other as possible.
- Always use a power supply, a network switch, and a line filter with conductive bodies. This will allow EMI or ESD to flow over the bodies of the devices rather than through their circuitry. If you can't get a power supply, a network switch, or a line filter with conductive bodies, see [Section 3.4](#).
- Make sure that the network switch power supply is isolated, i.e., its AC input is not connected to earth ground. If the power supply has a metal body, mount the power supply on an electrical insulator.
- Make sure that the power supplies for the network switch and for the camera and the power cables for the power supply are not routed near wires carrying high-current, switching voltages such as wires supplying stepper motors or electrical devices using switching technology. Place the power supply units for the network switch and for the camera near to the camera cabling. Route the power cables for the power supply and for the network switch near to the camera cabling.
- At each point where a camera cable connects to the network switch, the cable shield must have a very good connection to the network switch housing. Typically, you must make this connection better by using an additional device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to the network switch housing and that makes good contact with the cable shield.
- At each point where a power cable connects to the power supply, the cable shield must have a very good connection to the power supply housing. Typically, you must make this connection better by using an additional device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to the power supply housing and that makes good contact with the cable shield.
- At the point where the camera cable is plugged into the PC's interface card, the cable shield must have a very good connection to the PC chassis. The connector on a typical interface card usually does not provide enough contact between the shield and the PC chassis. Usually, you must make this connection better by using an additional device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to the PC chassis and that makes good contact with the cable shield.
- The GigE connector (RJ-45) on the camera is specially designed to provide good contact between the camera cable shield and the camera body. No modifications to this connection are necessary.
- The I/O ground in the camera is isolated from the camera ground. Therefore, the cable shielding on the I/O cable should only be connected at the camera **OR** at your equipment. We recommend connecting the cable shielding at the camera and insulating it from the equipment (see [Figure 11](#)).

If you choose to connect the I/O cable shield at your equipment, the cable shield must have a very good connection to the equipment. Typically, you must make this connection better by using a device such as an electrically conductive gasket (see [Figure 1](#)) that is securely attached to your equipment and that makes good contact with the cable shield.

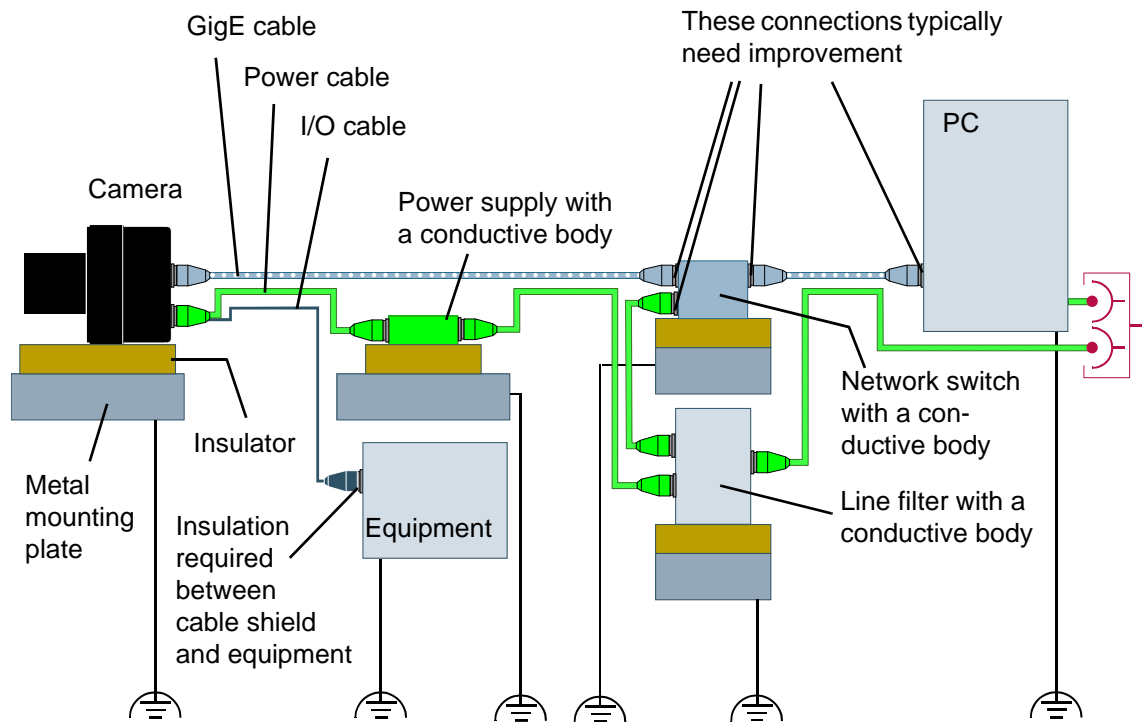


Figure 11: Isolated GigE Camera Attached to PC via an Isolated Network Switch

3.3.4 Camera Attached to PC via Network Switch, Camera Body and Network Switch Connected to Ground



This type of installation creates earth ground loops and is very susceptible to EMI and ESD. We strongly recommend avoiding this type of installation in favour of an installation that will not create earth ground loops.

If you can not avoid ground loops, follow the instructions given below .

- Install highly conductive ground straps connecting the PC chassis, the line filter chassis, and the metal racks where the camera, the power supply, and the network switch are mounted (see Figures 2 and 12).
- Route the camera cable, the I/O cable, and the power cables as near to the ground straps as possible.
- Place the network switch power supply near to the network switch.
- Use a single multiple socket outlet for PC, network switch, and power supply.
- Make sure that the PC chassis, the line filter chassis, the metal racks, and the equipment are connected to functional earth ground.
- Always use power supplies, network switches, and line filters with conductive bodies. This will allow EMI or ESD to flow over the bodies of the devices rather than through their circuitry. If you can't get the devices with conductive bodies, see Section 3.4.
- Make sure that the power supply for the camera and the power cables for the power supply and the network switch are not routed near wires carrying high-current, switching voltages such as wires supplying stepper motors or electrical devices using switching technology.
- At each point where a camera cable connects to the network switch, the cable shield must have a very good connection to the network switch housing. Typically, you must make this connection better by using an additional device such as an electrically conductive gasket (see Figure 1) that is securely attached to the network switch housing and that makes good contact with the cable shield.
- At the point where the camera cable is plugged into the PC's interface card, the cable shield must have a very good connection to the PC chassis. The connector on a typical interface card usually does not provide enough contact between the shield and the PC chassis. Usually, you must make this connection better by using an additional device such as an electrically conductive gasket (see Figure 1) that is securely attached to the PC chassis and that makes good contact with the cable shield.
- The GigE connector (RJ-45) on the camera is specially designed to provide good contact between the camera cable shield and the camera body. No modifications to this connection are necessary.

The I/O ground in the camera is isolated from the camera ground. Therefore, the cable shielding on the I/O cable should only be connected at the camera **OR** at your equipment. We recommend connecting the cable shielding at the camera and insulating it from the equipment (see Figure 12).

If you choose to connect the I/O cable shield at your equipment, the cable shield must have a very good connection to the equipment. Typically, you must make this connection better by using a device such as an electrically conductive gasket (see Figure 1) that is securely attached to your equipment and that makes good contact with the cable shield.

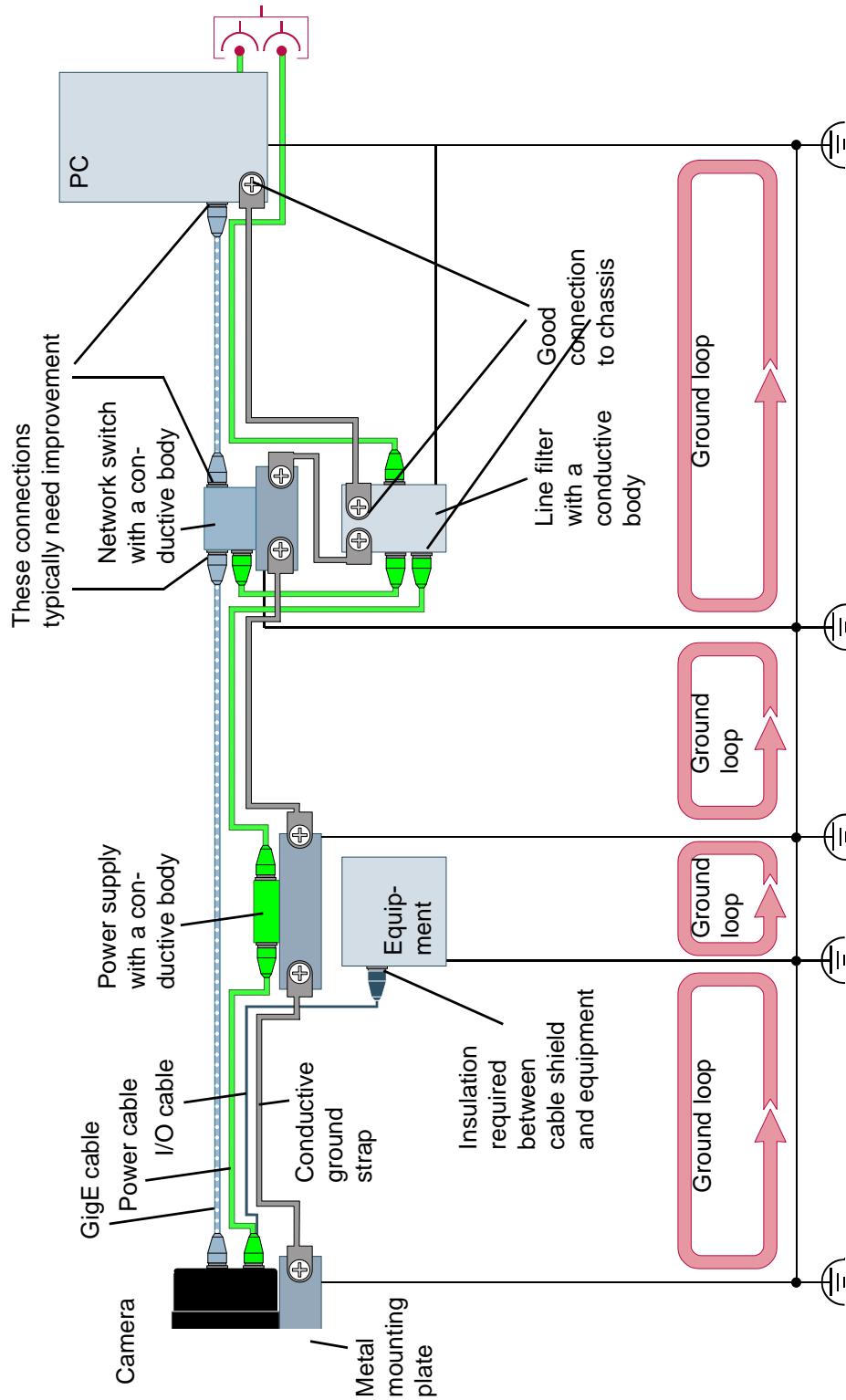


Figure 12: Grounded GigE Camera Connected to PC via a Grounded Network Switch

3.4 Using a Hub, Network Switch, Power Supply or Line Filter with a Non-conductive Body

If you use a hub, a network switch, a power supply, or a line filter, we strongly recommend using these devices with conductive bodies. This will allow EMI or ESD to flow over the bodies of the devices rather than through their circuitry. In some areas, however, it may be very difficult to purchase the devices with conductive bodies. If you find that you must use a device with a non-conductive body, you can modify the device so that it will have reasonable EMI and ESD resistance.

When making the modification, your goal is to provide a highly conductive path between the cable shields on the incoming connectors and the cable shield on the outgoing connector on the device. Typically, you can do this by using something such as a piece of electrically conductive gasket that runs between the incoming and the outgoing connectors (see [Figure 13](#)). The conductor must make good contact with each of the connectors.

Note: You may find that the device has an internal connection that runs between the incoming connectors and the outgoing connector. This internal connection **is not** sufficient to avoid EMI or ESD problems with the device.

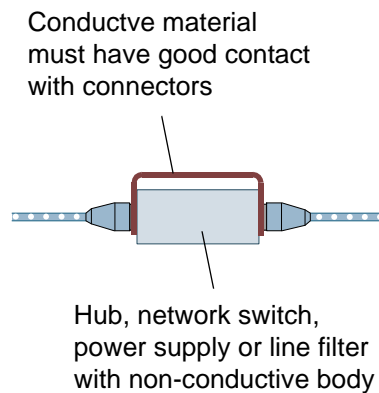


Figure 13: Modifying a Non-conductive Hub, Network Switch or Power Supply

Revision History

Document Number	Date	Changes
DD00005301	11 Oct 2005	Initial release of this document.
DD00005302	19 Dec 2008	Updated the contact addresses. Expanded the general guidelines (Section 2) and the guidelines for IEEE 1394 cameras (Section 3). Added guidelines for Camera Link and GigE cameras (Section 3).

