AXYS® Intellivox - Grounding strategy

Introduction

The Intellivox ground system incorporates different ground signals GND, AGND and DGND. It is designed to offer maximum performance, reliability and safety under all operating conditions. Proper connection of these ground terminals on the signal and mains connectors of the Intellivox is an important issue. Although in theory the Intellivox ground system may appear to be complex, installation and connection in practice is quite straightforward and simple. For optimum performance and safety it is strongly advised to follow the guidelines in this technical note carefully.

Different ground terminals

Three different ground terminals can be found on the signal and mains connectors of the Intellivox, all three having different names and serving different purposes (Fig 1). The function and proper installation practice of each terminal is explained in the next three paragraphs.

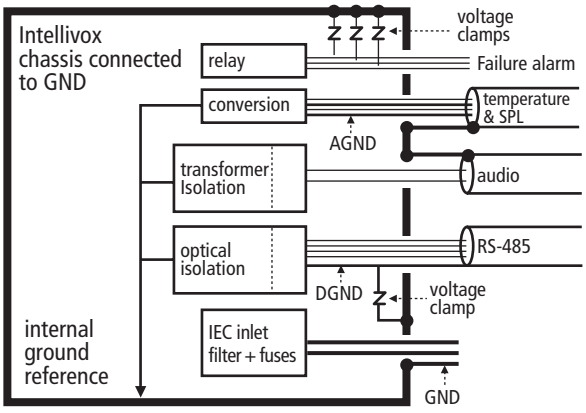

Fig 1 Ground configuration of the Intellivox chassis.

1 GND, safety terminal at the mains IEC connector

Since the Intellivox is a class 1 insulated device, the IEC mains connection should always include a safety ground. The IEC ground terminal located in the mains IEC connector provides a reliable low impedance path to all metal parts of the unit.

There are two important reasons for this connection:

A In case of insulation breakdown, this safety ground path will divert possible fault currents directly to ground, guaranteeing safe operating conditions under all circumstances. Although insulation breakdown is an extraordinary event, it can happen under unforeseen situations like severe mechanical damage, lightning, excessive moisture or fire.

B Similar to all class 1 devices like personal computers etc, the switched-mode power supply incorporated inside the unit, as well as some of the mains filter components, generate a small leakage current to ground. Although this leakage current is small enough to be harmless, the metal parts of the enclosure will float at half the mains voltage when a proper IEC mains ground termination is absent.

Note that the GND terminal is present on the audio input connectors and on the Ambient SPL/Temperature sensor connector as well. This is essentially the same ground which is also connected directly to the enclosure. The difference is that on these connectors the GND terminal is meant for connection of the cable shield and has no direct safety related function.

2 DGND, cable shield connection RS4-85

DGND ground is one of the signals of the RS-485 connector. The network interface incorporates a pair of transmit and receive signals and a DGND reference ground. In order to exclude possible ground loops, the RS-485 network port in each Intellivox is galvanically isolated from the rest of the electronics.

For reasons of safety the DGND terminal is clamped inside the module to a maximum of 50 V with respect to the enclosure (GND). The DGND signal is not a safety ground but serves only as a reference for the network differential receive and send signals.

When the RS-485 port is in use, it is mandatory to connect the DGND terminal to the shield of the RS-485 cables throughout the entire network. An open connection of the DGND signal on the RS-485 port of the Intellivox can result in permanent damage of the network interface electronics.

When using the AXYS® RS-232/USB to RS-485 adapter and interconnection cable, the DGND ground signals and shields are automatically connected to the safety ground at one single point of the installation, the host PC.

When the network wiring has been installed and a host PC will not be permanently connected then ensure that DGND as well as the host transmit lines are connected to the safety ground when the host PC is not present.

3 AGND, reference for Ambient SPL/Temperature sensor

The AGND ground terminals are located on the connector for the external Ambient SPL/Temperature sensor, being the reference input for these signals. In order to keep any noise away from the sensitive ambient SPL microphone input, the AGND signal together with the MIC signal should be run through a balanced shielded cable. For the temperature sensor, the same practice should be followed. Connect the cable shield to the GND terminal which is in turn tied to the metal enclosure directly.

Audio grounding

The Intellivox is equipped with high performance transformer balanced inputs. The extreme common mode range of this type of input ensures reliable operation under severe conditions. For distribution of the audio signal, the use of high quality, low capacitance balanced shielded cable is recommended. Use a balanced audio source featuring a low output impedance to drive the signal cable, especially for long cable runs (e.g. AXYS® Octadrive).

As mentioned previously, the analogue input connectors are equipped with a GND pin as well. This terminal is provided for a connection of the cable shield. By default, the audio inputs should be wired according to the schematic shown in Fig 2. In order to minimize any hum/noise caused by magnetically induced currents or compensation currents (more commonly known as "ground loop" artefacts) the audio cable should roughly follow the same physical trace as the mains safety ground.

Since GND terminal on the audio input connector is the only ground terminal that may introduce a "ground loop", strategies to reduce the effects of these loops will be restricted to this connector only.

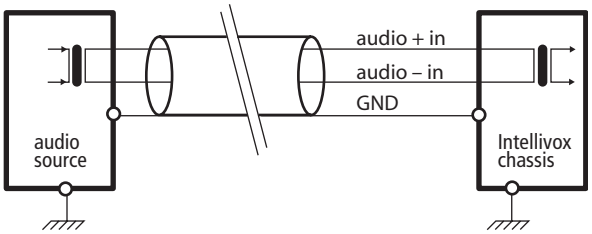

Fig 2 Standard grounding configuration.

Trouble shooting ground noise problems

The high common mode rejection of the Intellivox audio inputs will offer a high degree of suppression of noise signals. In some circumstances however, substantial ground compensation currents are induced in the cable shields which may cause audible artefacts.

In order to deal with these situations, the transformer coupled inputs allow disconnection of the audio ground. The noise current will be stopped and appear as a noise voltage source which is suppressed by the common mode rejection of the input transformers.

The drawback however is that the entire disconnection of the cable shield will degrade the immunity of the Intellivox for RF (Radio Frequency) signals. For this reason partial disconnection is preferred, a technique which is able to solve the ground noise problem while retaining most of the RF immunity of the Intellivox.

In order to solve ground noise problems the following 3-step strategy is proposed. In most cases these measures are necessary for each Intellivox that is physically connected to the same "leg" of the mains network or audio distribution.

Step 1

Partly LF (Low Frequencies) decoupled audio ground

This first step is to increase the impedance of the audio ground, while retaining a low impedance for RF signals. The basic circuit to accomplish this consists of a resistor and a capacitor and is shown in Fig 3 The solution leaves RF immunity almost unaffected, while the modest impedance at lower frequencies is sufficient to break the "ground loop". The normal ground leakage current will result in a negligible voltage drop over the resistor, so this solution may have the advantage of providing a secondary safety ground under normal conditions. Disconnect the audio ground close to the Intellivox and mount the components as shown in Fig 3.

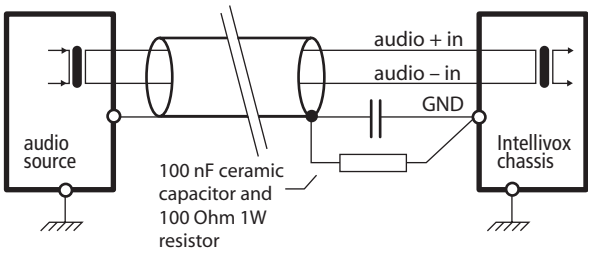

Fig 3 Ground configuration with audio ground partly decoupled for low frequencies.

Step 2

Complete LF decoupled audio ground

If the effect of the measures described in step 1 is not sufficient to solve the problem, it is possible to increase the loop impedance for low frequencies by removing the resistor. This results in the circuit shown in Fig 4. The RF immunity is still ensured by the presence of the 100 nF capacitor, while at low frequencies the very high impedance blocks compensation currents completely. Note that in this situation, the only return path for leakage current is through the mains safety ground connection.

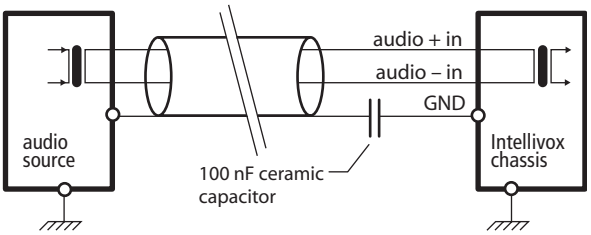

Fig 4 Grounding configuration with low frequency decoupled audio ground.

Step3

Completely disconnected audio ground

In exceptional situations, the measures presented in step 1 and step 2 may not lead to acceptable results. This will be the case when the ground compensation currents have a substantial high frequency content which is not sufficiently reduced due to the low impedance of the capacitor for higher frequencies. In an ultimate attempt to suppress the effects of this phenomenon, both resistor and capacitor may be removed. This leads to the situation shown in Fig 5. Although this configuration affects RF immunity in a negative way, the ground noise level may be reduced to acceptable values and overall results may be satisfactory, especially in an environment with low RF background levels.

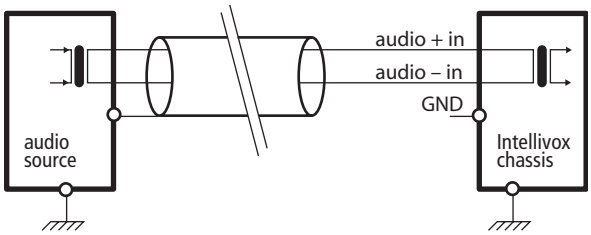

Fig 5 Grounding configuration with totally decoupled audio ground.

Conclusion

Proper installation practice is absolutely necessary to fulfil the safety requirements while ensuring high audio performance and reliability. In situations where a ground noise problem requires further action, carefully read the previous sections dealing with these problems and follow step 1,2 or 3. In addition to the material explained in this technical note, take notice of the tips stated below.

ALWAYS

1 Always operate the Intellivox on a mains supply including safety ground. Make sure that the safety ground connection (GND) has a low impedance connection to the mains ground terminal by means of proper install practice.

2 Always connect the RS-485 shields throughout the network and connect these to the DGND pins at the network connectors of all devices in the network. Make sure the RS-485 cable shield is not connected to any other ground, e.g. cable trays or metal parts of the building structure. The RS-485 DGND will be connected automatically to the safety ground at the host computer if the original AXYS® network converter and cabling are used.

NEVER

1 Never interrupt the mains safety ground connection in order to solve a ground loop issue. This may lead to potentially dangerous conditions under unforeseen situations.

2 Do not disconnect any of the DGND network grounds in order to solve loop problems. It is useless since the network ports are already isolated and this practice is likely to damage the RS-485 interface electronics.

3 Do not connect the AGND terminals on the Ambient SPL/Temperature connector to any other ground terminal, AGND is a reference input for the SPL and temperature signals only.