Application Note

USB Audio Isolation with Isolated USB 2.0 Redriver

Andrew Jackiw

ABSTRACT

Many applications have multiple paths to ground across the system. However, these ground paths can be the source of interference. The interference (called ground loop interference or a *ground loop*) is created when two or more devices in the same circuit have different ground potentials with respect to one another. Ground loop interference and shifting grounds can cause a variety of issues such as errors in data transmission or signal loss. The interference can even create a risk of electrical shock that can be hazardous to people or damage equipment in high-voltage applications.

While there are several methods of handling this interference, isolation is a common way to break the ground loop and eliminate the problem. The ISOUSB211 is an isolated USB 2.0 compliant repeater that can be used to isolate grounds and protect people and equipment.

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Trademarks

1 Ground Loop Interference

1.1 Common Sources of Noise Coupling

A ground loop is the name for the current return paths of any number devices connected to the same ground reference. However, since large or high-current ground loops are also common sources of noise, the term *ground loop* more commonly refers to ground loop interference. Ground loop interference happens when components drive large currents through the system ground. The resulting current fluctuations on the ground bus, which has a limited impedance, creates a potential difference between local grounds. We consider the resulting ground potential difference (GPD) between local grounds and the system ground to be ground loop interference.

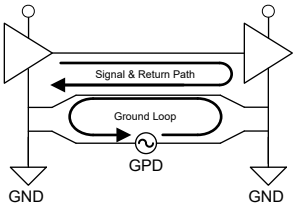

Figure 1-1. Typical Ground Loop

The ground potential difference shown in Figure 1-1 can range anywhere from a few milli-volts to the kilo-volt range depending on the application, and can create a range of undesirable effects. They can be as mild as digital communication errors and analog signal interference or as severe as a hazard of electrical shock that can harm instruments and operators. Many designers have to take into consideration the effects that ground loops can have on their end equipment. Industrial motor drives, power supplies, amplifiers, and vehicle alternators are all common applications that can produce switching noise or high currents that can cause ground loop interference if not properly accounted for.

Audio applications often suffer from similar ground loop problems. Here, ground loops are often created when connecting parts of the audio system using a shielded grounded cable, and can manifest as a hiss, whine, or hum that interferes with the signal within the audio signal range.

2 Why Isolation Helps

Whether in a commercial studio or a home audio set-up, non-ideal power supplies and electrical wiring can be a common cause for ground loop interference in audio. Eliminating the root cause may be time consuming or costly, and using a galvanic isolator can be an effective design to break a ground loop.

Most methods focus on limiting ground loop interference by attenuating the noise or making substantial system changes. The typical methods to solve ground loop interference consist of power conditioners, re-working AC power mains, audio transformers, or a ground loop break circuit. However due to time, money, and system constraints, these are not always options.

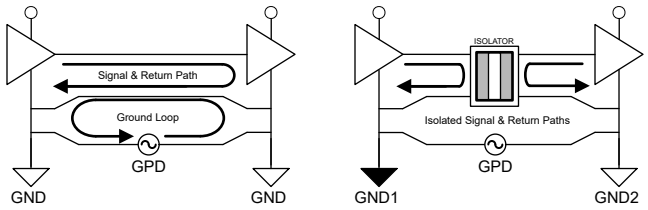

Figure 2-1. Typical Ground Loop vs. Isolated System

The left image in Figure 2-1 shows a large ground loop without isolation. Here, each device has two return paths. One is the device's respective local ground and the other is the local grounds with respect to each other. Each ground has their own fixed impedance and have a voltage drop on the return path that can cause the grounds to be at different potentials. After isolation, we see that the two sides of the isolator are independent as shown in the right image of Figure 2-1. The GPD is still there however, the two devices are on their own ground plane and are no longer affecting each other. The large ground loop is broken and each device has there own, independent return path.

Adding isolation to an application can be done several ways. One common method is to add isolation to use a 1:1 audio transformer. A transformer on the analog signal will decouple the system grounds and isolate the two sides of the system, however this process is not applicable to digital audio signal transfer. For digital signals, isolation is achieved through the use of digital isolators.

3 Why ISOUSB211 Can Help

Many applications now use digital ports when connecting other devices. Digital isolation becomes a useful tool that can increase system robustness and improve signal integrity by making sure the ground loop is broken. ISOUSB211 is critical when the USB signal is the only accessible point in the system and the USB host needs protection. Typically, the ISOUSB211 is used in non-audio applications where two grounds need to be completely isolated due to the risk of electric shock or damage to sensitive electronics. However, creating two independent grounds and isolating a USB signal can be helpful in eliminating ground loop noise in audio systems.

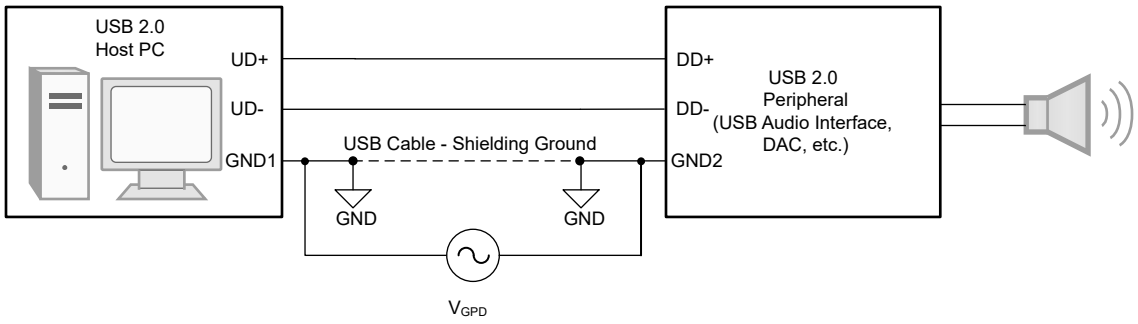

Figure 3-1. USB 2.0 Common Application

USB enabled receivers, DACs, and audio interfaces are common in many set-ups and are often share a common ground over a length of cable and can be susceptible to noise injection from PC power supplies or wall power as shown in Figure 3-1

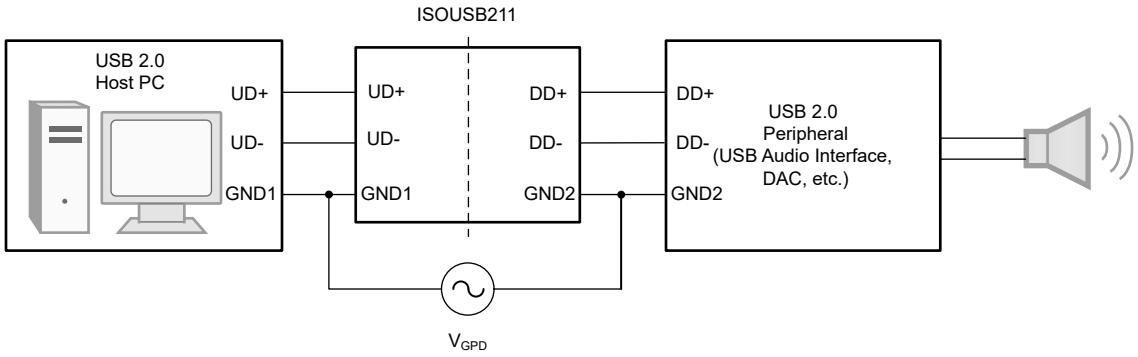

Figure 3-2. USB 2.0 Isolated Application

After adding the ISOUSB211 to the signal chain as shown in Figure 3-2, the ground loop is broken and the upstream and downstream ports are now separate. The grounds can now be considered to be completely independent. The ISOUSB211 also redrives the signal across the isolation barrier letting the device handle longer cable lengths while still remaining USB 2.0 compliant.

4 EVM Setup and Noise Injection

The ISOUSB211DPEVM can be used to test the effects of ground loops on USB transmissions. The EVM features a typical ISOUSB211 application and includes an non-isolated port USB connection on the same PCB for comparison. A test configuration can be easily created by following the set up shown in Figure 4-1. The V_{GDP} in the diagram can be simulated in audio applications by a 10 V_{RMS}signal from a function generator connected to the GND1 and GND2 pins of the EVM.

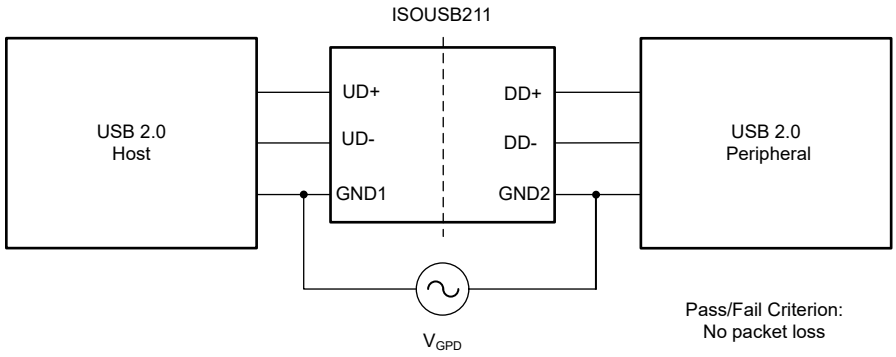

Figure 4-1. ISOUSB211 Example Test Configuration

5 Summary

The ISOUSB211 is a galvanically-isolated USB 2.0 compliant repeater that supports high-speed (480 Mbps) signaling rates intended for use as an isolator for USB peripherals and cables. Ground loops can cause signal interference and are common in applications where there are multiple devices, interconnected, and with common grounds. The difference in ground potentials is usually the result of supply current ripple or current draw from normal operation that creates a potential over the ground line's limited impedance, causing local grounds to shift with respect to system ground. In audio, a ground loop can show up within the audible range as a persistent hum or hiss in the music. The ISOUSB211 USB isolator adds a level of robustness to your signal chain, in the event of ground loop interference while keeping your hardware USB 2.0 compliant.

6 References

- Texas Instruments, *Low Emissions, High Full Low Speed Isolated USB Repeater*, data sheet.
- Texas Instruments, *Ground Loop Break Circuits and Their Operation*, application note.

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