

Implementing an isolated USB 2.0 On-the-Go port

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Introduction

USB is becoming increasingly popular as an interface in industrial systems for human-machine interactions, diagnostics, firmware downloads, connections of peripherals and data-logging. Given the presence of noise and harsh transients present in the industrial world, as well as for electrical safety, systems designers prefer to isolate the USB port. Having one USB port that can connect to both a host (such as a laptop) or a peripheral (such as a USB drive), instead of separate ports for host and peripheral connections increases flexibility and reduces costs.

USB On-the-Go (OTG) offers this flexibility, while also allowing host and peripheral roles to be swapped through Host Negotiation Protocol (HNP). However, there is no solution available currently to isolate an USB OTG port. In this article, the key considerations on implementing an isolated USB OTG port with HNP and the corresponding requirements from an isolated USB repeater are described, along with an application diagram and test results implementing Isolated USB OTG port with TI's [ISOUSB211](#) isolated USB repeater.

Existing implementation of OTG USB applications

Existing approach for implementing isolated USB platforms have been with recommendations around providing dedicated host and peripheral ports for establishing the datalink as shown in [Figure 1](#). The upstream-facing (peripheral) port has the D+ pulled up (indicating a full or high-speed peripheral) or D- pulled

up (indicating a low-speed peripheral) through a 1.5-k Ω resistor. The downstream facing (host) device has the 15-k Ω pull-down resistors as per USB2.0 standard. Downstream-facing port powers the 5-V VBUS rail and does not draw power from the upstream facing port. Once the connect is established, the presence of VBUS is detected after which pullup identification and packet transactions occur. Therefore, for an isolated OTG implementation in which the port must assume either a host or a peripheral role, the isolator must be transparent to the connection.

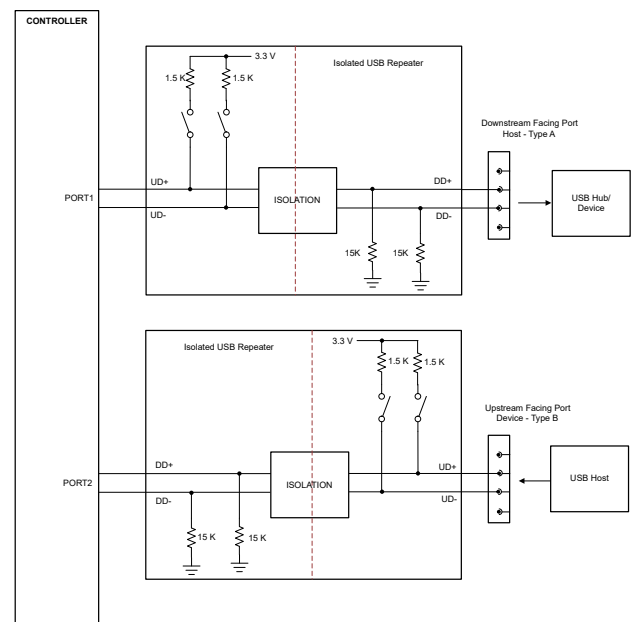


Figure 1. Separate host and peripheral implementation.

On-the-go operation

OTG ports have an additional fifth pin tagged as the *ID* pin. The status on this ID pin governs the initial host and peripheral roles when the connect occurs, as shown

in **Figure 2**. The port connected to the cable end with ID shorted to ground assumes the initial host (A-device) role and the device connected to the other end of cable with ID left floating assumes the initial peripheral role (B-device). The ID pull-up on the OTG module helps determine the status of ID pin on connect. In a situation where the B device wants to take over the host role, OTG defines an HNP that enables devices to exchange roles seamlessly without unplugging and exchanging the cable connections. For HNP to work seamlessly, the isolated USB repeater should have the ability to switch any side to be upstream- or downstream-facing on the fly. The Session Request Protocol that enables the initiation of sessions on the A device by pulsing on the VBUS is not a topic that is covered in this article.

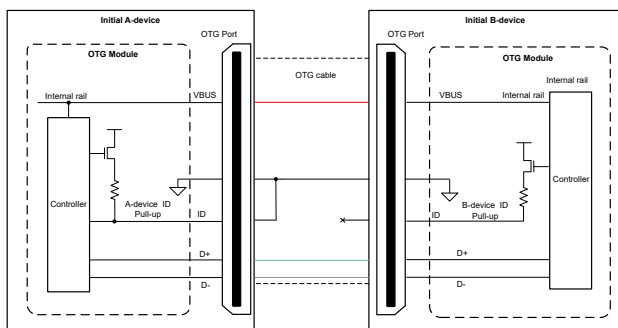


Figure 2. Initial Host or peripheral roles determined by ID pin.

Implementation of isolated OTG

Figure 3 shows that the isolated repeater needs to have flexibility for any side to operate as host or peripheral. During operation, the isolated repeater introduces a 15-kΩ pull down at power up. The side that provides the external 1.5-kΩ pull up will establish the connect. The other side, which assumes the host role, introduces the internal 1.5-kΩ pull up in the repeater to mirror the downstream connect. The end plugged in with the micro-A plug takes on the initial A-device role and the end plugged in with the micro-B plug assumes the initial B-device role. After the initial role assignment, HNP has a defined set of transitions in a scenario where the devices wish to exchange roles: the initial A-device suspends the bus and initial B-device transitions to wait-for-connect state by disconnecting the 1.5-kΩ pull up and enabling

the 15-kΩ pull down. As the lines are now in SE0 state, the A-device takes up the peripheral role and establishes a connect by enabling its internal 1.5-kΩ pull up resistor. The bus now reflects a J-state which gets detected as a peripheral connect by the initial B-device, which now assumes the host state. The 5-V VBUS is sourced by A-device, irrespective of the roles determined by HNP.

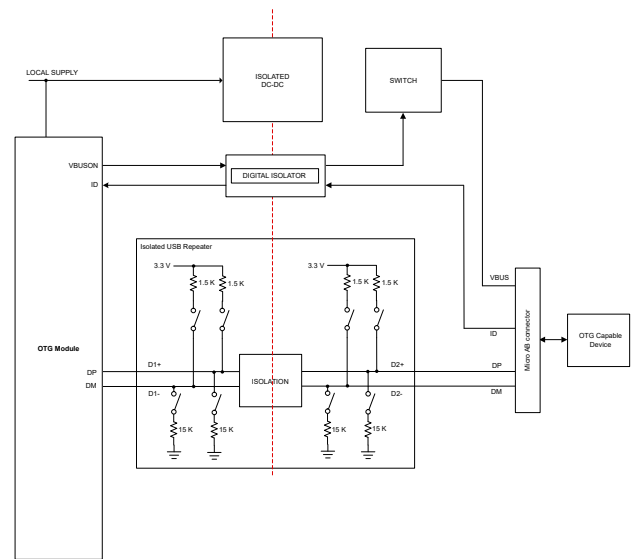


Figure 3. Block diagram of a self-powered Isolated on-the-go module.

Demonstration of OTG with ISOUSB211 EVM

Figure 4 demonstrates the isolated USB-OTG implementation using on-board components. The circuit includes **ISOUSB211** isolated high-speed USB repeater, **SN6505** 5-W push pull transformer driver and **ISO6721** dual-channel digital isolator to implement the isolated USB-OTG operation. As highlighted in the previous section, it is necessary for the isolated USB solution to allow any side to be upstream- or downstream-facing for USB-OTG application. This flexibility is allowed by ISOUSB211 which has automatic role-detection making it straightforward for any side to assume the upstream or downstream role based on which side detects a 1.5-kΩ pull-up first. ISO6721 transfers ID information across the isolation barrier from the connector to the OTG module. V2OK signal from ISOUSB211, which indicates if VBUS2 is available, is fed to USB_DET pin of the OTG module. USB2.0 standard mandates that a device should not

introduce pull-up on the DP/DM lines unless VBUS is present. The OTG module controls the internal pull-ups based on the USB_DET status. The switch in the power path between the secondary side’s low-dropout regulator (LDO) output to the connector’s VBUS for controlling power delivery is based on the type of device connected to the module. The OTG Module drives the VBUSON signal, in case an off-chip source needs to power up the connected device. This controls the switch between the secondary side LDO’s output to connector’s VBUS.

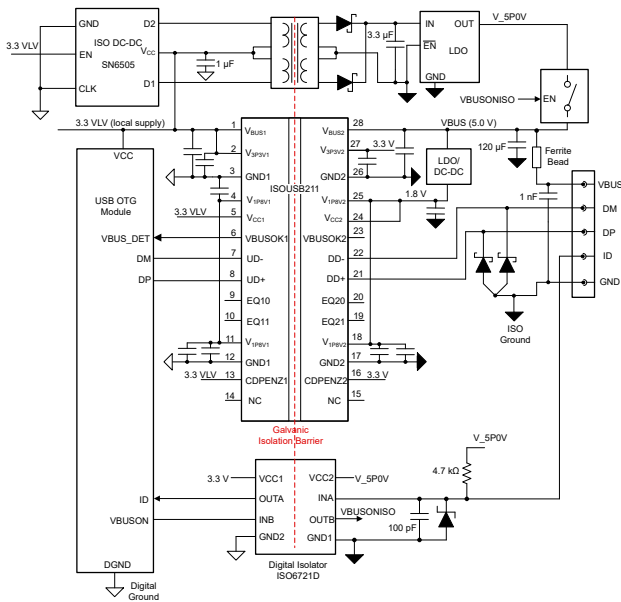


Figure 4. Isolated USB OTG port implementation with ISOUSB211 and ISO6721D.

Scenario A: Isolated OTG module connected to a USB-drive (bus-powered)

ID pin connected to the isolated OTG module (A-device) is shorted to ground. This information is sent across the isolation barrier through the reverse channel of ISO6721. The OTG module then signals VBUSON to go high, which in turn controls the switch to turn on, providing power to the flash drive (B-device). Until this stage V2OK is held low, and the OTG module does not initiate D+/D- pull-up control. Once the device side is powered up, the V2OK goes high, allowing the OTG module to control the pull-ups as per the USB2.0 standard.

Scenario B: Isolated OTG module connected to a laptop (host)

ID pin connected to the isolated OTG module (B-device) is floating, and is transmitted through the reverse channel of ISO6721 as a high. OTG module retains the status of the VBUSON to low, which retains the turned off state of switch as the host connected is self-powered. V2OK goes high as soon as the connect is established given that the host is self-powered and the pull-ups are initiated as per the USB2.0 standard.

Demonstration

The following segment demonstrates the implementation of OTG with ISOUSB211EVM evaluation module.

To demonstrate the power delivery from A-type device to B-type device in either direction, an additional SN6505EVM was introduced.

Connect phone to laptop

In Figure 5, an OTG capable phone (with a female micro-B connector, dual role port) is connected to a laptop (with a type A female port) through a Type-A male to micro-B male through the ISOUSB211EVM. The experiment is for copying the files from the phone to the laptop.

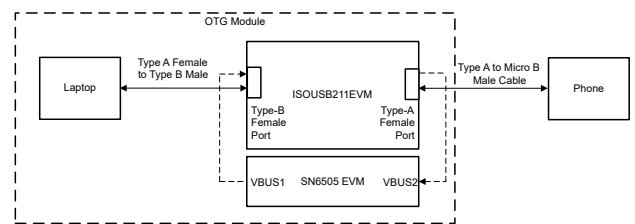


Figure 5. ISOUSB211+Pendrive (OTG Module) connected to a Host.

During the first connect, the cable end connected to phone has ID connected set to high-Z (B-type device). Once the phone recognizes the ID pin set to high-Z, it assumes the B-type role. Power transfer is done through SN6505 path on ISOUSB211EVM from laptop to phone. The phone asserts a pull up on DP line (indicating the B-type role) and ISOUSB211 introduces its internal 1.5kΩ pull-up on side 1. After this, the communication

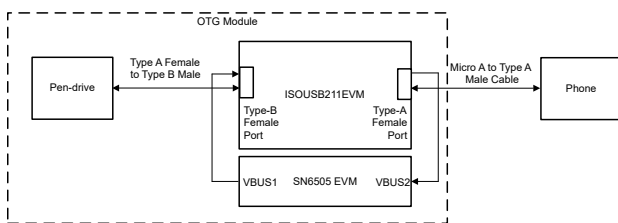
between the A-type and B-type device happens as per the USB2.0 standard.

The peripheral is able to communicate and data transfer was successful.

Connect phone to USB-drive

In **Figure 6**, an OTG capable phone (with a female micro-B connector, dual role port) is connected to a flash-drive (with a type-A port) through a type-A female to micro-A male connector (use a type-A male to type-A male connector to connect to EVM). The experiment is for copying the files from the flash-drive to phone.

Figure 6. ISOUSB211+Pendrive (OTG Module) connected to a Host.



During the connect, the cable end connected to phone has ID pin shorted to ground (A-type device). The phone recognizes the ID pin set to low, it assumes the A-type role. The reverse power path established from the SN6505 is active, and powers up the flash-drive. The flash-drive asserts a pull up on DP line (indicating the B-type role) and ISOUSB211 introduces its internal 1.5k Ω pull-up on side 2. After this, the communication between the A-type and B-type device happens as per the USB2.0 standard.

The peripheral is able to communicate and data transfer was successful.

Summary

Isolated USB OTG applications can be easily established using isolators that have flexible host and peripheral sides which gets configured during operation based on which side the 1.5-k Ω pull up is first observed externally on DP/DM lines. Such configurations can ensure smaller footprints, reduced connectors, and completely switchable roles without changes in hardware.

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