Isolated USB Programmer for LpGBT (UPL) for the ATLAS-HGTD upgrade

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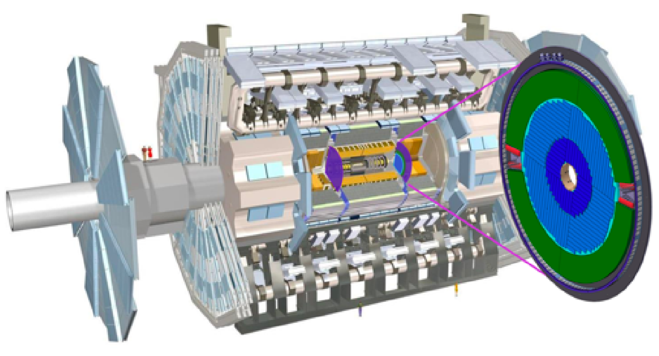
Introduction

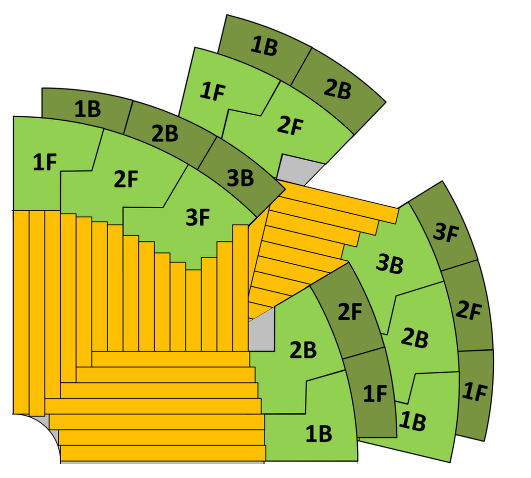
The increase of pileup will be one of the main challenges in the High-Luminosity LHC. Therefore, a High-Granularity Timing Detector (HGTD) has been proposed for the ATLAS Phase-II upgrade to mitigate the pileup effects caused by the increasing luminosity of proton-proton collision.

The Peripheral Electronics Boards (PEB) are located at the peripheral area of HGTD, and serve as a data transmission bridge between the front-end detector modules and DAQ system, the luminosity system as well as the detector control system. The CERN developed radiation-tolerant data transmission ASIC lpGBT plays a very important role in the data transmission of the PEB.



The 2 existing lpGBT configuration tools, piGBT and CERN USB-I2C dongle, are not suitable for the configuration of the lpGBT on PEB. For example, the piGBT has large size while the CERN USB-I2C dongle is platform-dependent and no GPIOs available. Moreover, neither of them considered electrical isolation, which is required for PEBs configuration at the debugging stage to keep the independence of different PEB power channels.

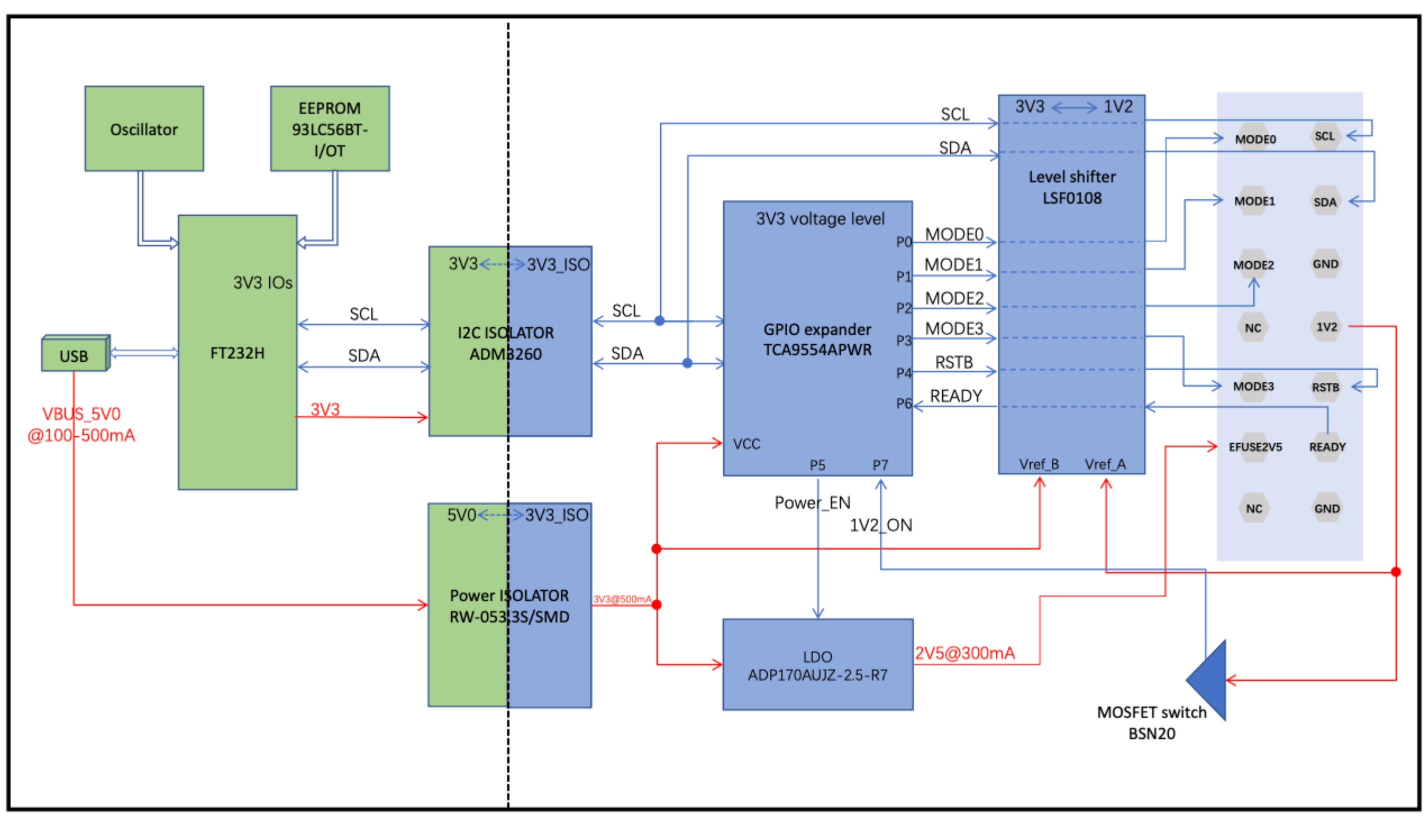
Therefore, we developed a dedicated and isolated USB Programmer for LpGBT (UPL), which can be used in some lpGBT-related tests and PEB configuration in the future.



Hardware

PCB design

- Use the USB-I2C ASIC FT232H, where the USB & I2C protocols are both implemented. The configuration information from host computer can be converted to I2C signals through the UPL

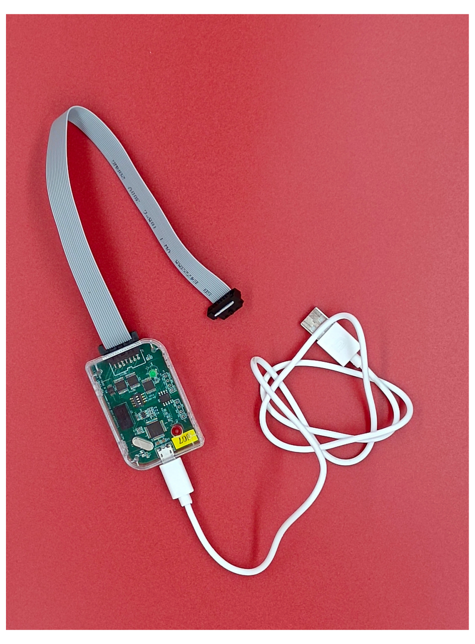


- The I2C isolator and power isolator can make both the I2C signals and power supply isolated between host side and detector side.

  The GPIO expander is used to extend more GPIOs. And the level shifter can shift the voltage level between 3.3V and 1.2V.

Board description

- The UPL has a very compact size of 5.6 cm X 3.6 cm
- The micro-USB connector on one side is used to connected with host computer
- The 14-pin Header connector on the other side is used to connected with lpGBT or other I2C slave devices. And it is assigned with 2 I2C bus ports and 8 GPIO ports.



- The board is embedded in a transparent plastic box, which can make it more easy to handle
- In addition, the green and red LEDs can respectively indicate power-good of the lpGBT and ongoing communication.

Main features

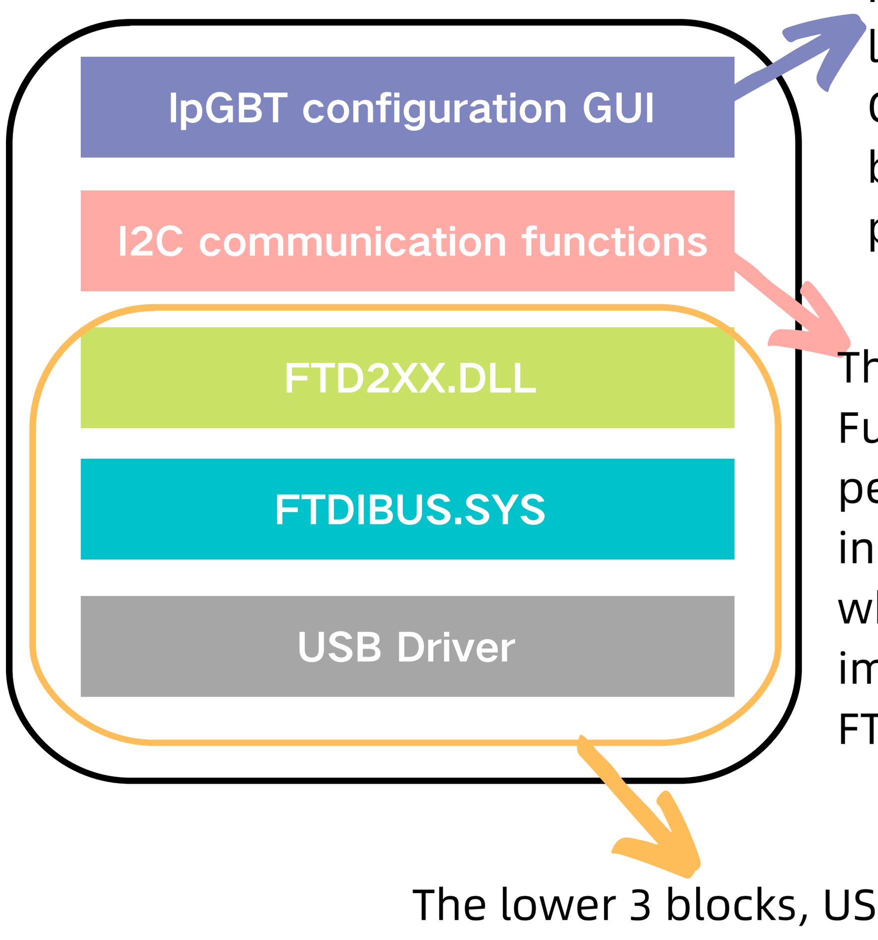
- Excellent cross-platform compatibility

  Royalty free D2XX *Direct* Drivers (USB Drivers + DLL S/W Interface)
  - Windows 10 and Windows 10 64-bit
  - Windows 8 and Windows 8 64-bit
  - Windows 7 and Windows 7 64-bit
  - Windows Vista and Vista 64-bit
  - Windows XP and XP 64-bit
  - Windows XP Embedded
  - Windows 2000, Server 2003, Server 2008
  - Windows CE 4.2, 5.0, 5.2 and 6.0
  - Mac OS-X
  - Linux (2.6.32 or later)

  - Instead of using the platform-dependent MCU, a USB-I2C ASIC called FT232H is used on the UPL to do the conversion between USB and I2C protocols. The supplier of the ASIC provides the specific USB driver that can allow you to talk to the chip from your computer.
  - The specific USB driver can work on a variety of operating systems as the picture lists. The users can download the corresponding one according to the OS they are using.
- Electrical isolation
  - The isolators are used to electrically isolate the host side and the detector side for both signals and power supply.
  - The device under configuration would not be interfered by the host side, which can protect the device from being upset or even damaged.
- Easy to setup and use
  - No complicated environmental setting, just the USB driver installation
  - One can easily develop its own dedicated control software based on the USB driver with the supported programming languages including python, C++, C# and so on.
  - A control GUI dedicated for lpGBT configuration was already developed with TKinter, a python built-in GUI development package, which means no additional GUI package installation.

Software

Software architecture

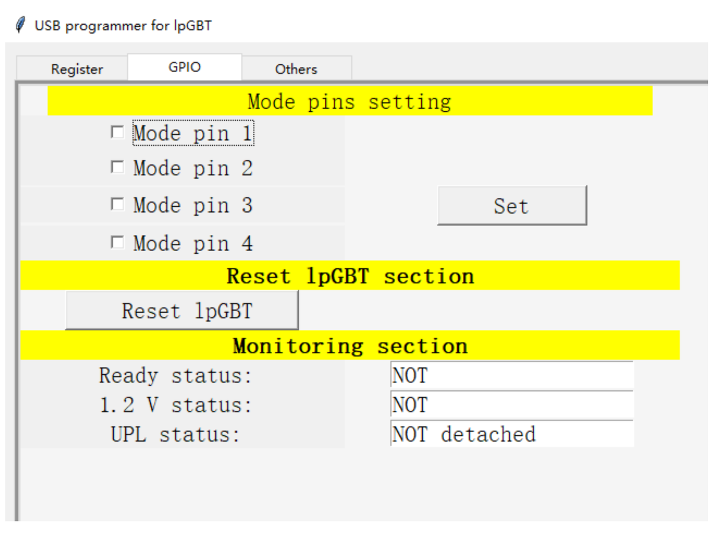


In order to facilitate the lpGBT configuration, The GUI is performed in this block with a python package called TKinter.

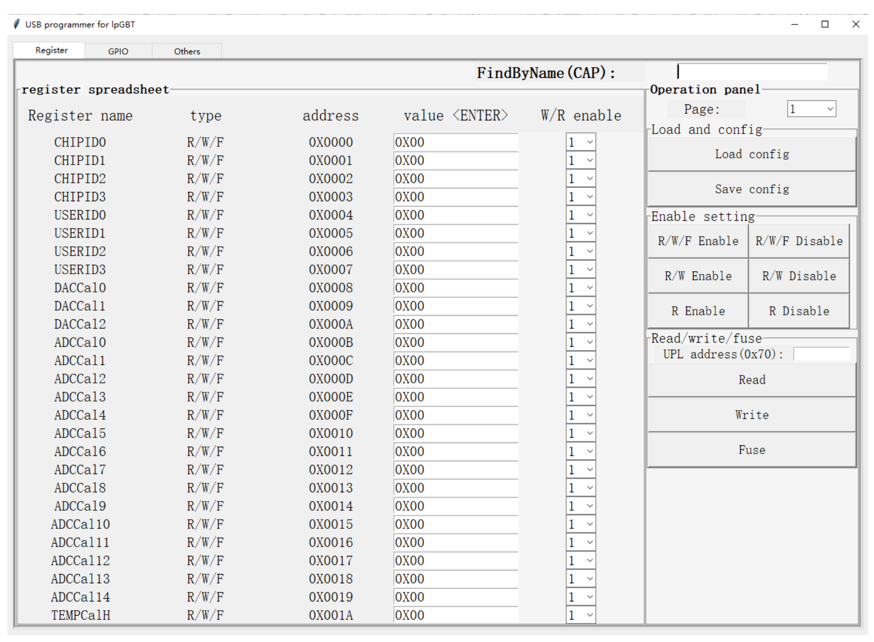
The I2C communication Function block aims to perform the I2C protocol in the software level, which will be finally implemented by the FT232H ASIC.

The lower 3 blocks, USB driver, FTDIBUS.SYS and FTD2XX.DLL, are the lowest level interface that can directly interact with the hardware.

lpGBT configuration GUI description



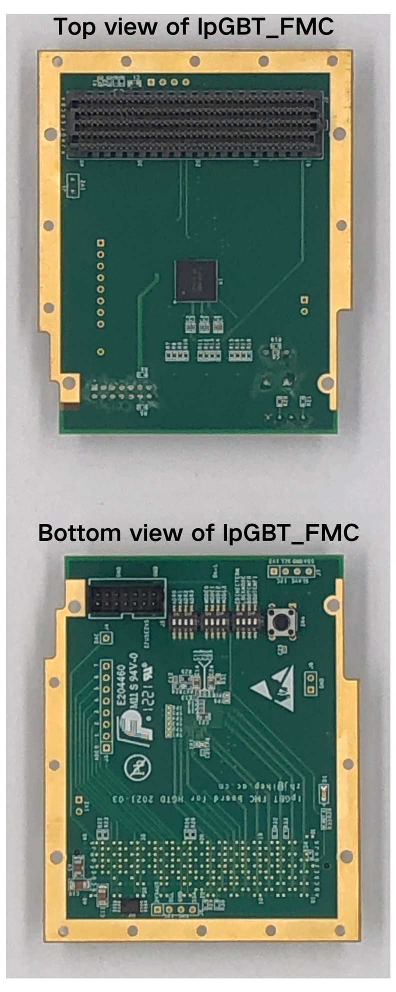
Concerning the mode setting, reseting, e-fusing, READY signal and power supply monitoring of lpGBT, the 8 GPIOs of UPL are used and they can also be handled from the GUI.



All the lpGBT registers are mapped into the GUI, where you can directly manipulate those registers, such as reading, writing, batch-reading, batch-writing, and etc

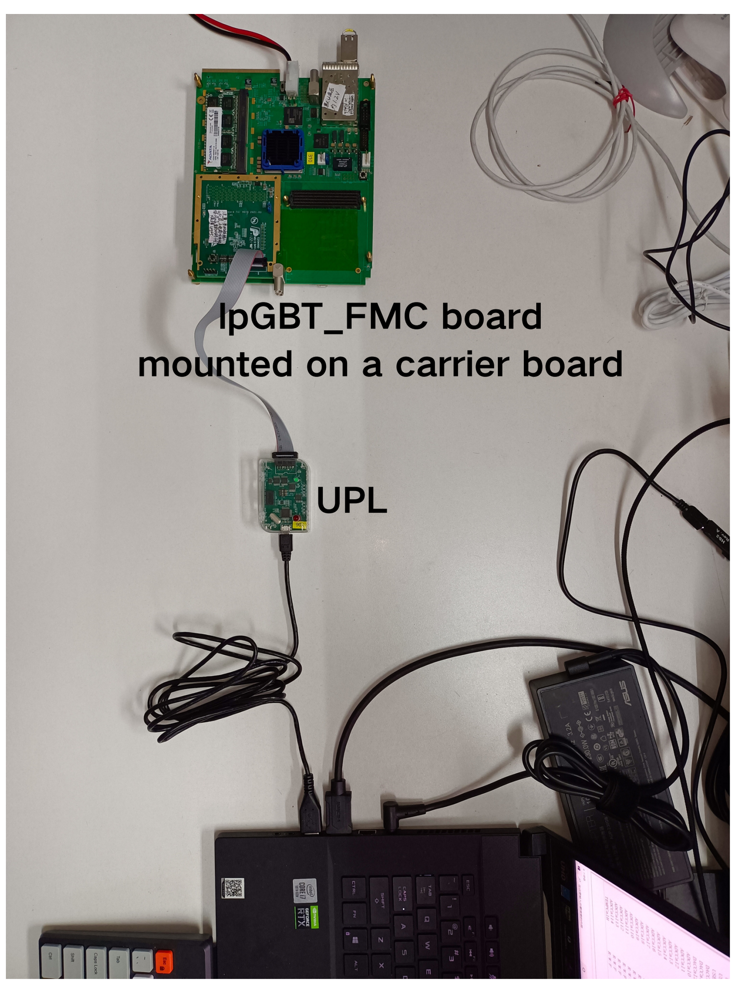
Test with lpGBT_FMC board

lpGBT_FMC board description



- The lpGBT_FMC board is a dedicated board that can simply integrate the lpGBT into a demonstration system with its FMC connector.
- Basically, all the lpGBT signals/pins are routed to the FMC connector, including clocks, up e-link, down e-link, high-speed links and I2C signals.
- It uses a 14-pin connector, which is compatible with the one used on the CERN EMCI board. This connector can be used to configure the lpGBT chip with UPL.

Configure lpGBT_FMC board with UPL



- The picture shows a setup of configuring the lpGBT_FMC board with UPL.
  The connectivity is:
  Host computer + UPL + lpGBT_FMC board.
- From the test results of this setup, the UPL and its control GUI are quite robust and reliable.
- The power dissipation of the UPL is also measured, it's about 0.3W