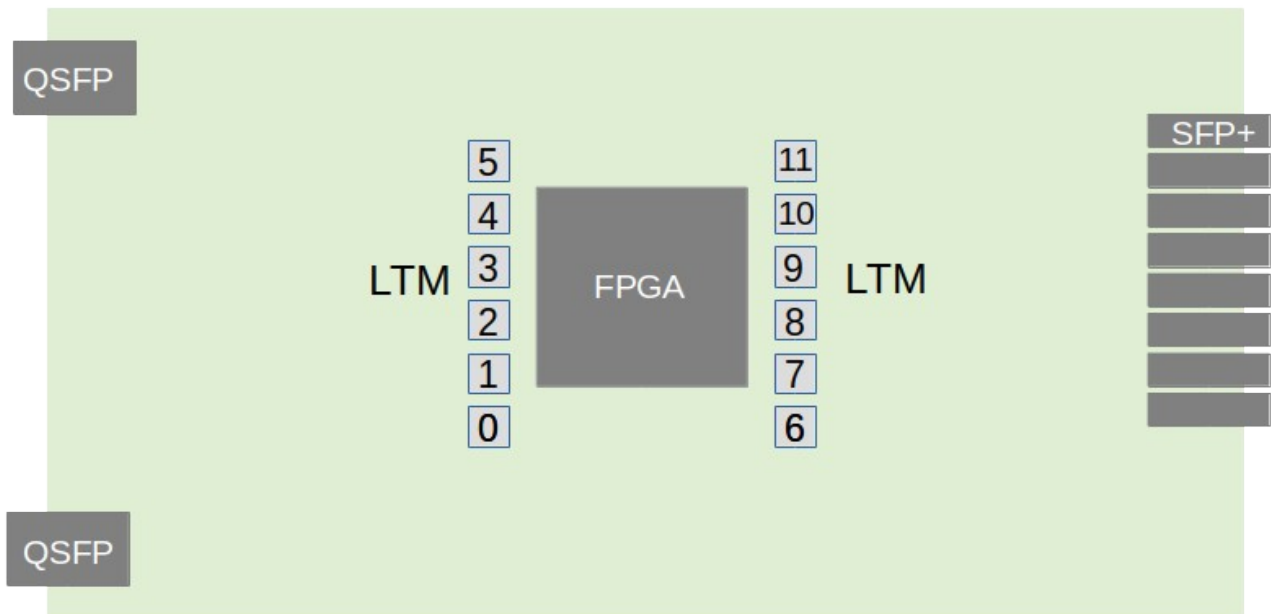**LTM/PMBus Monitor**

The Talon-DX on-board power distribution is accomplished by 12 x
Linear Technology LTM4677 Dual 18A uModule Regulators with Digital
Power System Management devices.

The physical layout of these devices on the Talon-DX board is
described in the following diagram.

The QSFP, FPGA and SFP+ modules are included in the diagram to
provide a reference to the physical orientation of the Talon-DX board
with respect to the LTM modules (light gray). The LTM module
enumerations in the diagram represent indexing internal to the TANGO
device server infrastructure. One device server process will be
instantiated on the Talon-DX HPS processor, and 12 instances of TANGO
devices will be defined within the TANGO database. Each device in the
TANGO database is enumerated with this LTM index.

The I2C mapping for these devices are as follows:

> busID = 1 (or internal FPGA – see table below)
> i2cAddress = (see table below)
> mod = **i2c**
> compat = **pmbus**
> name = **pmbus**
> hw = **hwmon/hwmon#**

The device tree file for the fan controller contains the following
information for each of the ltm modules:

```
ltm@40 {
compatible = "pmbus";
reg = <0x40>;
#address-cells = <1>;
#size-cells = <0>;
};
```

The properties of each LTM on the physical Talon-DX board is indicated in the following table.

LTM ID	Physical Board ID (Locator Ref)	I2C Bus	I2C Address	Voltage Output 1	Voltage Output 2
0	U54	FPGA	0x47 (71)	0.85V	0.85V
1	U58	FPGA	0x49 (73)	0.85V	0.85V
2	U15	FPGA	0x45 (69)	0.85V	0.85V
3	U9	1	0x4B (75)	1.12V	1.12V
4	U12	FPGA	0x42 (66)	0.85V	0.85V
5	U30	1	0x40 (64)	3.3V	3.3V
6	U8	1	0x4A (74)	0.9V	1.2V
7	U53	FPGA	0x46 (70)	0.85V	0.85V
8	U58	1	0x41 (65)	1.12V	1.8V
9	U13	FPGA	0x43 (67)	0.85V	0.85V
10	U55	FPGA	0x48 (72)	0.85V	0.85V
11	U14	FPGA	0x44 (68)	0.85V	0.85V

As identified by the devicetree entry, a compatible linux driver is provided via the generic **pmbus.c** driver. This driver exposes all relevant and required attributes for control of the module via the sysfs mechanism. The driver is located within the linux kernel source code at

~/drivers/hwmon/pmbus/pmbus.c

Upon linux boot, the sysfs mount point for each individual module becomes:

/sys/bus/i2c/devices/0-0040

with the last portion of the path corresponding to the i2c address (hex) for the specific device.

Below this directory, the device attributes are organized under a

directory entitled **hwmon/hwmon#**, where **#** is the enumeration for the specific device. Because many device drivers may share this enumeration construct (hwmon) it should be noted that this prefix is appended at mount time (linux boot time) with an enumeration. The enumeration (and subsequently the mount point for the device attributes) may differ from one boot to the next. As a result, the TalonDXBSMCBase class contains a function called **get_hw_path** which given the appropriate filter (in this case, hwmon) detects the enumeration, and returns the correct path for access to attributes for the current boot configuration. There is no indication that the enumeration of the device path will change after boot time.

The generic pmbus driver provides access to all available attributes present in the LTM4677 device. This includes voltage, current, power and temperature monitor points on each individual device for both available channels. All attributes for each LTM module are treated as individual scalar attributes within the TANGO device server.

Attributes related to warning and alarm thresholds are included in the TANGO device server, however these attributes are not polled at this time. Instead, the TANGO warning and alarm infrastructure is employed to provide warning and alarm thresholds for all monitor point attributes. These thresholds may be modified by the user via the GUI for this device.

TANGO DEVICE SERVER

Base Class

The TANGO device server is built upon the TalonDXBSMCBase class. This class provides basic information for the device under control, which is stored in the TANGO database as device properties. The list of device properties in the base class are as follows:

- **busID** – the I2C bus address for the HW device
- **i2cAddress** – the I2C device address for the HW device
- **mod** – the device module name (as referenced in the device tree file)
- **compat** – the device compatibility string as detected by the Linux driver (if available)
- **name** – the device name (not required)
- **deviceID** – internal index for device (if multiple devices)
- **hwFilter** – a string used to construct the *hwPath* variable within the TANGO device server.
- **HwPrefix** – a string used to construct the *hwPath* variable within the TANGO device server.

In addition, the **ltmID** device property is included within the TalonDXBSMCPmBus class, in order to provide a reference to the

physical LTM device on the Talon-DX board. This device property contains the LTM ID value noted in the table above.

One additional device property in the base class is *hwPath*. This property is constructed within the *init* method of the TANGO device server. This is the path where device attributes are exposed to the user space within the HPS Linux distribution.

A suite of TANGO device commands accompany these attributes within the base class, providing access to the values to any software able to access the device.

<u>Device Class</u>

The TANGO device server class responsible for monitoring the LTM/PmBus devices is named **TalonDXBSMCPmBus**. The class provides monitoring of the following attributes for each LTM device. Note that attributes not used by the TANGO device server are not listed here (notably warning and alarm threshold values, labels etc...).

- **current_input** : the current input value at the LTM device, measured in mA. This attribute is polled at 3s intervals. The corresponding driver attribute in the sysfs system is **curr1_input**.
- **voltage_input** : the voltage input value at the LTM device, measured in mV. This attribute is polled at 3s intervals. The corresponding driver attribute in the sysfs system is **in1_input.**
- **current_output_1** : the current output value for channel 1 at the LTM device, measured in mA. This attribute is polled at 3s intervals. The corresponding driver attribute in the sysfs system is **curr2_input.**
- **current_output_2** : the current output value for channel 2 at the LTM device, measured in mA. This attribute is polled at 3s intervals. The corresponding driver attribute in the sysfs system is **curr3_input.**
- **voltage_output_1** : the voltage output value for channel 1 at the LTM device, measured in mV. This attribute is polled at 3s intervals. The corresponding driver attribute in the sysfs system is **in2_input.**
- **voltage_output_2** : the voltage output value for channel 2 at the LTM device, measured in mV. This attribute is polled at 3s intervals. The corresponding driver attribute in the sysfs system is **in3_input.**
- **power_output_1** : the power output value for channel 1 at the LTM device, measured in uW (micro Watts). This attribute is polled at 3s intervals. The corresponding driver attribute in the sysfs system is **power1_input.**
- **power_output_2** : the power output value for channel 2 at the LTM device, measured in uW (micro Watts). This attribute is polled

at 3s intervals. The corresponding driver attribute in the sysfs system is **power2_input.**

- **Temperature_1** : the temperature value from temperature monitor point 1 on the device, measured in thousands of a degree Celsius. This attribute is polled at 3s intervals. The corresponding driver attribute in the sysfs system is **temp1_input.**
- **Temperature_2** : the temperature value from temperature monitor point 2 on the device, measurd in thousands of a degree Celsius. This attribute is polled at 3s intervals. The corresponding driver attribute in the sysfs system is **temp2_input.**

Commands

Commands have been included within the TANGO device to facilitate external software accessing the alarm state of any monitor point. However, these commands pertain to the alarm state as tracked by the hardware device itself. As noted previously in this document, this feature of the hardware device is not utilized, in favour of the substantially more flexible TANGO warning and alerting parameters. These parameters can be set a priori, as well as being able to be configured from the GUI during operation.

The **getLtmID** command returns the value of the LTM ID for the specified LTM module being queried.

GUI

The GUI provides the user with the ability to see at a glance, all monitored parameter values, with an indication as to a warning or alarm level. Upon instantiation, the user must select an LTM device to which the GUI will connect.
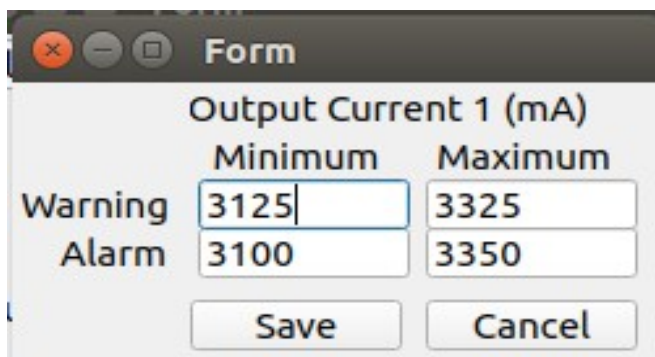
Once the connection is made to a specific LTM device, the GUI
subscribes to all TANGO periodic events generated by the polled
attributes. Attribute values are update upon receipt of polled
values.

In addition, the LEDs associated with each value display the warning/
alarm status of the attribute, corresponding to the attribute
configuration values for alarm. TANGO provides the capacity to store
a min and max value for warning and alarm thresholds. The recorded
attribute value is compared to these thresholds at each polling
interval, and the GUI LED colour is updated accordingly.

The user has the capability to update or change the warning and alarm
thresholds for each attribute individually by selecting the ...
button just below the LED. This opens a dialog which allows the user
to provide new threshold values in the appropriately indicated units
for the attribute. Once validated and saved, the threshold values are
stored in the TANGO database entry associated with the specific LTM
module. This ensures that thresholds can be set for each individual
LTM module in the final system.

The user is provided with a 'Select' button at the top of the GUI.
When operated in standalone mode, this button is present, and allows
the user to select the LTM module to view via a graphical
representation of the Talon-DX board.

Note that only valid selections for LTM modules (ie. Modules that are registered and present on the Talon-DX board) are available to be selected. By simply clicking on the desired LTM module graphical representation, the GUI for the LTM display is switched to the display of attributes related to that specific module.