TSEP Technical Software Engineering Plazotta

Our work is inspired by science, not fiction!

Front Panel Microcontroller FPC4

Individual Front Panels for Measuring Instruments

Modern measuring instruments today have an elaborate human-machine interface with which the instrument software can be operated. Not only simple keys can be found on the front panels of the devices, but also rotary controls, monochrome and multicoloured LEDs, displays (LCDs, LEDs, OLEDs, ePaper), touch screens and much more. TSEP has started to combine all this functionality in one µC already 10 years ago. Today the fourth generation of front panel controllers, the FPC4, is in use. The FPC series is based on the Cypress PSoC microcontroller family. These are especially suitable for such applications due to their programmable hardware (similar to an FPGA). The FPC4 is also compatible with Windows or Linux as operating system on the device.

Highlights

- Rich Functionality
- Numerous Softwaretools
- Easy Adaptation to new Device Features
- Compatibel with Windows and Linux

Hardware Options

PSoC

Currently, various PSoC models (PSoC 3, 4, 5) are supported. Depending on the requirements, cost-effective and less performant PSoC 4 up to high performant PSoC 5 can be used for corresponding tasks. The software connection to the measuring instrument is made via USB, although other communication buses are also conceivable.

The Cypress PSoC microcontrollers used have a supply voltage range of 0.5V/1.71V/3V to 5.5V and the temperature range is suitable for industrial applications. The microcontrollers are available in compact packages such as QNF56, VFBGA, TQFP 100 and many more.

Depending on the configuration of the FPC4, the following functionalities are available.

Keys

The smallest FPC4 supports the evaluation of 64 keys. The keys to be evaluated must be connected to the FPC4 in a keyboard matrix. Each row of the matrix must be connected via a 47kΩ pull-down resistor and each column via a 10kΩ pull-up resistor. A hardware debouncing of the keys is not necessary, since this is realized by the FPC4 firmware. The evaluation of multiple keystrokes is not part of the FPC4 firmware by default, but can be implemented on customer request.

Rotary Control

The FPC4 supports many different electronic and mechanical rotary controls, e.g. from the manufacturers EBE, ALPS, Elma. The direction of rotation is detected by the time shift of the two channels. A sampling rate of 1ms has proven to be sufficient for mechanical rotary controls. In contrast to mechanical rotary controls, the evaluation of electronic models is very time-critical. Depending on the model, only a few microseconds remain to detect the direction of rotation. The channels and the push button of the rotary control must be connected via 10kΩ pull-up resistors. If the encoder signals are very noisy, the use of Schmitt triggers is recommended.

LED

Individual LEDs can be connected either directly to the GPIOs on the FPC4 via series resistors or via appropriate amplifiers, depending on the power consumption. If RGB LEDs are required, they must be connected via LED driver modules (e.g. TLC5941). Single RGB LEDs can be controlled without LED driver on request. To make controlling the RGB LEDs easy for the device firmware, TSEP has developed FPC4 access interface software that encapsulates access to the FPC4's RGB LEDs so that the parent application does not require any knowledge of the hardware design and connection of the RGB LEDs. Each individual RGB LED can be addressed via an ID and the corresponding color values. With the above mentioned LED driver module, each individual LED has a resolution of 4096, which means that almost any color can be generated.

Control and Regulation

Simple fans are usually connected via an amplifier to the GPIO pins of the PSoC. If the FPC4 has access to a temperature sensor, the complete control is performed in the FPC4. The PWM signal used to control the fan can be configured. In order to operate the fan at the quietest frequency, the period duration is set via command interface. The minimum temperature at which the fan should run, the temperature at which it is controlled without PWM and the hysteresis in (prevents the fan from constantly switching on and off in the threshold temperature range) can also be changed via the command interface. With the more powerful microcontrollers, more complex control tasks can also be performed. A precise control of four rotors simultaneously is quite feasible for a PSoC5 in addition to the tasks of an FPC4. The control parameters are configurable, so the customer can decide how the control curve should run. Even rotors with relative position information, such as rotors from Pro.Sis.Tel, can be provided with absolute paths internally in the microcontroller and can be exactly positioned again and again, provided the appropriate hardware circuitry is in place.

Touch Panel Evaluation

With the FPC4 it is possible to evaluate capacitive and resistive touch panels. The evaluation of resistive touch panels is based on the evaluation of the resistance values of a voltage divider, which are generated by touching the touch panel. The FPC4 captures these voltage values via an internal analog-digital converter and calculates the current position of the print. For capacitive touchpads, the FPC4s have integrated CapSense components that can be used to evaluate the touchpad. The calibration of the touch panel is permanently stored in the FPC4. The FPC4 transmits the touch events to the operating system via the HID protocol, e.g. as mouse events.

Display

The FPC4 can control text LCDs (e.g. HD44780), graphic LCDs (e.g. RA8822). With graphic LCDs, the texts, images and font can be stored, so that there is no need for constant communication between the application and the FPC4. On customer request, the FPC4 can take over the evaluation and checking of the inputs (rotary controls or keys) and independently change the corresponding menus or carry out the corresponding actions. If the FPC4 takes over the evaluation of the inputs, the device firmware is only notified when an event occurs and one does not have to worry about the structure of the display and the evaluation of the user inputs.

Power-on Mimic of Computer Boards

The FPC4 takes over the power-on mimic for computer boards. This is not relevant for devices connected to power supply of PCs, but for battery powered devices or devices operating in extreme environments this is an important feature. For battery powered devices it is possible to prevent the device from being switched on if the voltage is too low. If the FPC4 has access to the batteries or the charge controller, it is possible that the device can only be switched on again when a certain charge status is reached. For devices that have to operate at a defined temperature range, it is possible that the device can only be switched on in this temperature range.

Device Watchdog

For FPC4s that control the power-on mimic, we offer a device watchdog. This is a two-stage watchdog, the software watchdog (SWDT) runs on the computer board and the hardware watchdog (HWDT) on the FPC4. The SWDT can be started, stopped and triggered via an interface, the trigger time is adjustable. This SWDT takes over the whole handling with the HWDT connected via USB. If an application registered with the SWDT does not trigger the watchdog, the SWDT first triggers a proper restart, if this is not successful (e.g. blue screen) the HWDT restarts the device.

Software

Firmware

Independent of the type of microcontroller used, a cooperative operating system developed by TSEP runs as basic software on the FPC4s, which was designed for systems with very low resources. It performs the following tasks: Control of the program flow via messages; static memory management; time-controlled processes; standardized communication via USB bulk transfer; hardware access layer for encapsulation of the hardware and register access. Due to this structure of the microcontroller software it is possible to change the type without much effort, because most of the firmware remains identical, only the encapsulated access to the registers and components of the microcontroller have to be adapted.

Firmware Updates

The bootloader code is located in a read-only area of the FPC4 program memory. Depending on the model, the FPC4 bootloader logs on to the operating system via USB as a HID device or as a bootloader device. Before each start of the microcontroller firmware, a checksum is calculated over the program memory. If this checksum does not match the checksum stored in the memory, the FPC4 does not start its normal firmware, but starts the bootloader mode. This mechanism ensures that the FPC4 does not become a service case after a power failure during the update process. The FPC4 starts in the bootloader mode and can perform a firmware update again. Each FPC4 supports a USB command for firmware update. TSEP provides the appropriate tooling for this. The FPC4 firmware update can also be executed during the device firmware installation.

Software Tools

The FPC4 does not only consist of a µC firmware, but also contains a larger number of software tools like: Firmware update tooling during the device software installation; software interface for the control interface of the FPC4; drivers for the control interface of the FPC4 (tracing features, update feature, configuration, touch panel configuration); filter drivers for a free configuration of the key and rotary control events in the device software; tools for visualizing the control interface. The FPC4 can be customized with different features and thus be optimally adapted to the measuring device. Due to the possibility of a firmware update via USB, new device features of the FPC4 can easily be added with the device installation. To connect the FPC4 to the device software running on either windows or linux, we offer drivers and interface software for easy access to the microcontroller.

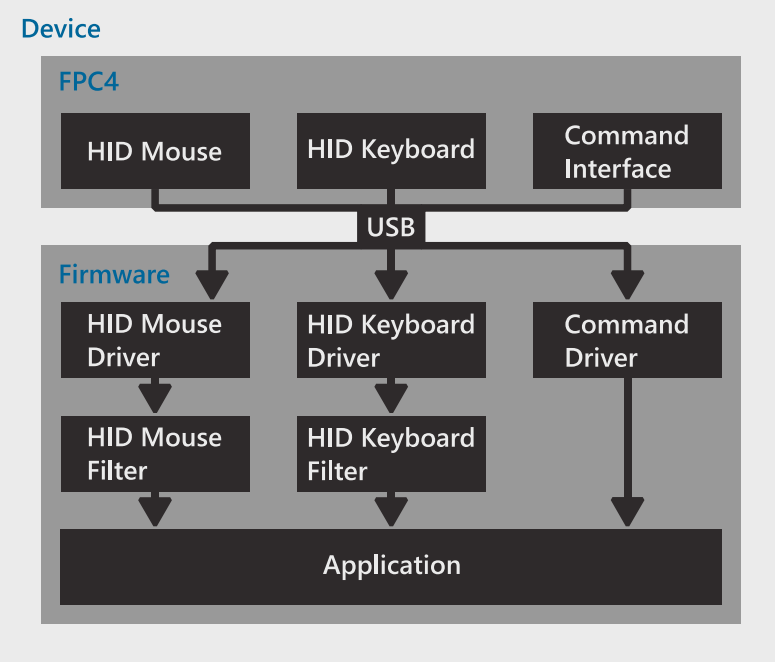
FPC4-Device Firmware Interface

In most cases USB is the easiest way to connect the front panel to the device. The FPC4 logs on to the operating system as a full-speed USB device with three different interfaces, i.e. a USB connection is required in hardware terms, but a composite device with three devices is recognized by the operating system. If there is no USB interface available, the transmission of events to the rest of the measuring device can also take place via SPI, I2C, UART, analog signals, ... on the front panel.

The key events are sent via the HID key driver, the rotary control events via the HID mouse driver and commands for controlling and reading out external peripheral devices are sent via the command driver. A filter driver is used to differentiate between the rotary control or to modify the key events. The filter driver used for the Windows world converts the FPC4 HID messages into the desired keyboard and mouse events. Mouse events can also be sent as keyboard messages. The configuration values are located in the registry. TSEP provides the necessary tooling to configure the values.

Using the individual filter drivers, all events can be configured from the operating system without the FPC4 requiring a firmware update. Another advantage of using the filter driver is that the keyboard events can be configured language independent.

Fig.1: Structure of the FPC4 device firmware interface.



Selection of FPC4 Microcontrollers

Mikrokontroller	min/max. Temp	min/max VCC	Bauform	I_gpoOut in mA	Type
CY8C3xxx	-40°C/85°	0.5V to 5,5V	TQFP 100	10 sink, 4 source	PSocC3
CY8C42xxxx	-40°C/85°	1.71V to 5,5V	TQFP 100	10 sink, 4 source	PSocC4
CY8C5xxxxLP	-40°C/85°	1.71V to 5,5V	TQFP 100	10 sink, 4 source	PSocC5

Feature Overview oft he FPC4s

Type	PSocC3	PSocC4	PSocC5
Keys	144[1]	144[1]	144[1]
Mechanical Rotary Control	8[1]	8[1]	8[1]
Electronical Rotary Control (e.g. BGE25)	2	2	2
EEprom Access, SPI, I2C	✓	✓	✓
Fan Control	✓	✓	✓
Flash Access (e.g. M25P80)	✓	✓	✓
Firmware Update During Runtime	✓	✓	✓
RGB LEDs via Driver Module	✓[2]	✓[2]	✓[2]
Device Watchdog	✓	✓	✓
Freely Configurable GPIOs	✓	✓	✓
Resistive Touch Panel	✓[2]	✓[2]	✓[2]
Capacitive Touchpad	×	×	✓
Text LCD	✓[2]	✓[2]	✓[2]
Monochrome Graphic LCD	×	×	✓
Voltage Sensors, Temperature Sensors, ...	✓[2]	✓[2]	✓[2]
Power-On Mimic for Computer Board	✓	✓	✓
Extended Power-On Mimic (Peltier,...)	✓	✓	✓
Extended Rotor Control (Number of Rotors)	2[2]	2[2]	2[2]

[1] No technical restriction, other configurations available on request
[2] Not part of the standard FPC4 firmware, available on request

Order Information

Development Services

Order Ref.	Description
FPC-DEV	Development of custom FPC4

Unit Pricing

Order Ref.	Description
FPC-UNIT	Units

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