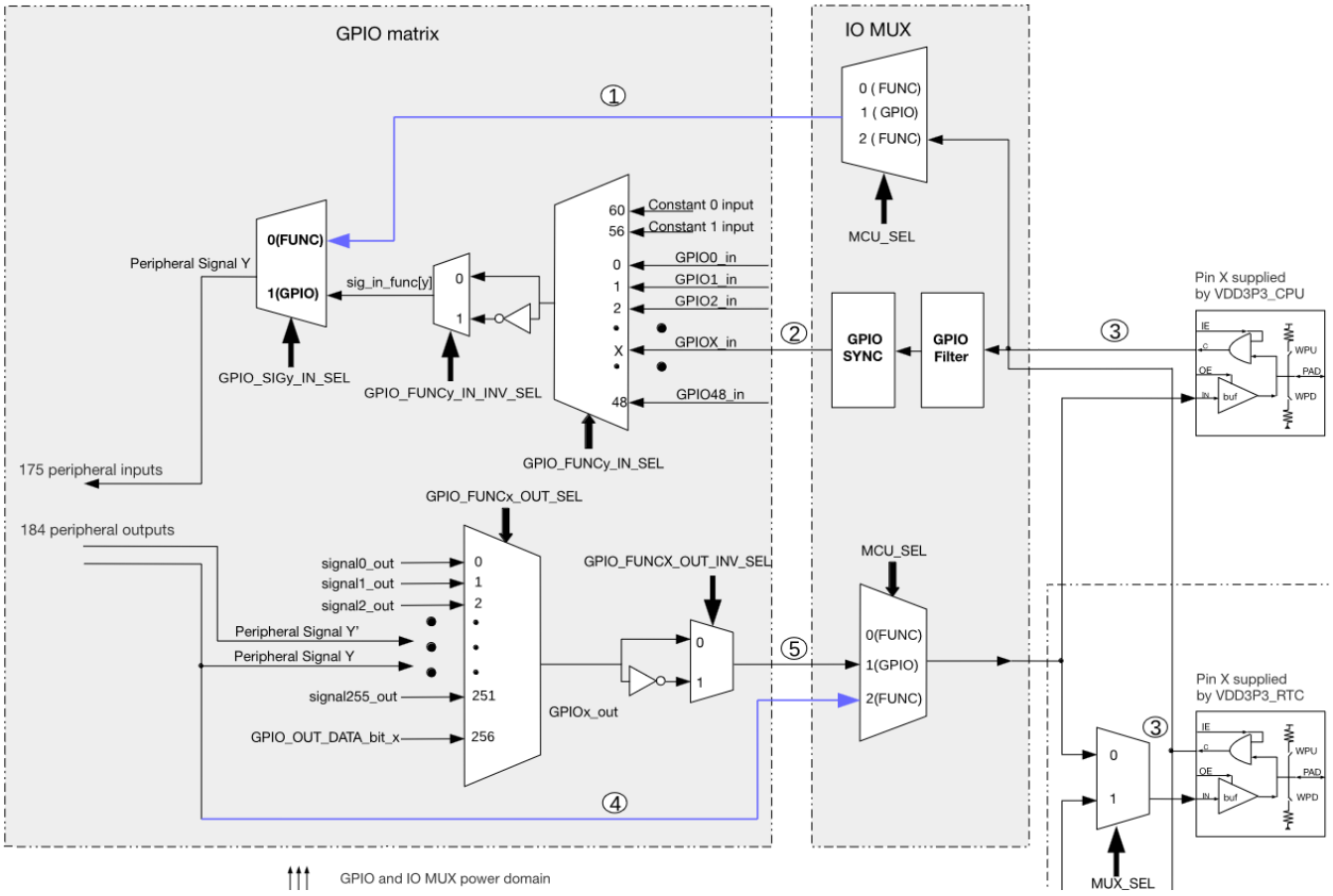
# GPIO and pin muxing

Take a look at the esp32s3 TRM chapter 6.3, table 6.2 and table 6.3 to understand relation between the peripheral signals, IO MUX and the GPIO matrix. Teaser picture:




IO MUX pin settings (selected function, drive strength, pull-up, pull-down, input enable) are controlled by the children of the `iomux: pinctrl@60009000` node, like this:

```
&iomux {
    spi2_pins: spi2_pins {
        pinctrl-single,pins = <
            PIN(9)  (FUN0_20MA)             /* CS1 */
            PIN(10) (FUN_SEL(4) | FUN_DRV_20MA)    /* CS0 */
            PIN(11) (FUN_SEL(4) | FUN_DRV_40MA)    /* MOSI */
            PIN(12) (FUN_SEL(4) | FUN_DRV_40MA)    /* SCK */
            PIN(13) (FUN_SEL(4) | FUN0_20MA_IE_WPU)>;/* MISO */
    };
};
```

These properties cannot be changed at runtime (short of writing directly to IO_MUX_n_REG registers).

When there's no direct connection for the function in the IO MUX (e.g. UART2 signals are not there) or the pin with direct connection cannot be used, a function may be routed through the GPIO matrix to a different GPIO and connected to a different pin. These settings are controlled by the children of the nodes `gpio_out_mux: gpio_out_mux@60004554` and `gpio_in_mux:`

gpio_in_mux@60004154. Numbering schemes are different for output and input muxes. E.g. for the ouput mux a GPIO index is mapped to a peripheral signal (table 6.2):

```
&gpio_out_mux {
    spi2_gpio_out: spi2_gpio_out {
        pinctrl-single,pins = <
            GPIO_FUNC_OUT_SEL(9) 111>;        /* SPI2 CS1: GPIO9, signal 111
*/
    };
};
```

For the input mux a peripheral signal is mapped to a GPIO index:

```
&gpio_in_mux {

    uart2_gpio_in: uart2_gpio_in {
        pinctrl-single,pins = <
            GPIO_FUNC_IN_SEL(18) 5>;        /* U2RXD: signal 18, GPIO5 */
    };
};
```

All used pinctrl phandles are then mentioned in the device's pinctrl property:

```
&spi2 {
    pinctrl-0 = <&spi2_pins &spi2_gpio_out>;
    pinctrl-names = "default";
};
```

Other properties of a GPIO pin (input/output, normal/open drain, interrupt type) can be controlled through the GPIO API or through the device tree connection for the pin, like the pins 6, 7 and 8 here:

```
i2c0 {
    #address-cells = <1>;
    #size-cells = <0>;
    compatible = "i2c-gpio";

    sda-gpios = <&gpio0 6 (GPIO_ACTIVE_HIGH | GPIO_OPEN_DRAIN)>;
    scl-gpios = <&gpio0 7 (GPIO_ACTIVE_HIGH | GPIO_OPEN_DRAIN)>;

    pinctrl-0 = <&i2c0_pins>;
    pinctrl-names = "default";

    mpu6050@68 {
        compatible = "invensense,mpu6050";
        reg = <0x68>;
        interrupt-parent = <&gpio0>;
        interrupts = <8 IRQ_TYPE_EDGE_RISING>;

        pinctrl-0 = <&accelerometer0_pins>;
```

```
        pinctrl-names = "default";
    };
};
```

GPIO pins that need to be in a specific state can be brought there by adding gpio-hog nodes under the gpio controller node, see Documentation/devicetree/bindings/gpio/gpio.txt for the details.

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