AN3352

How to Use SAMA5D2 IRQs Under Linux®

Introduction

This application note describes how to handle SAMA5D2 GPIO-based IRQs under Linux.

The Arm® processor includes only two types of externally triggered interrupts: FIQs and IRQs. In SAMA5D2, FIQs and IRQs are exported to the external pins, and IRQs are shared internally by all peripherals.

Since IRQs from the Arm processor are also shared by the SAMA5D2 PIO controller, every GPIO can be used as an external interrupt in SAMA5D2. In this type of application, the GPIO can be configured so as to be monitored when it is subject to an input change. The IRQ interrupt is then asserted by the PIO controller.

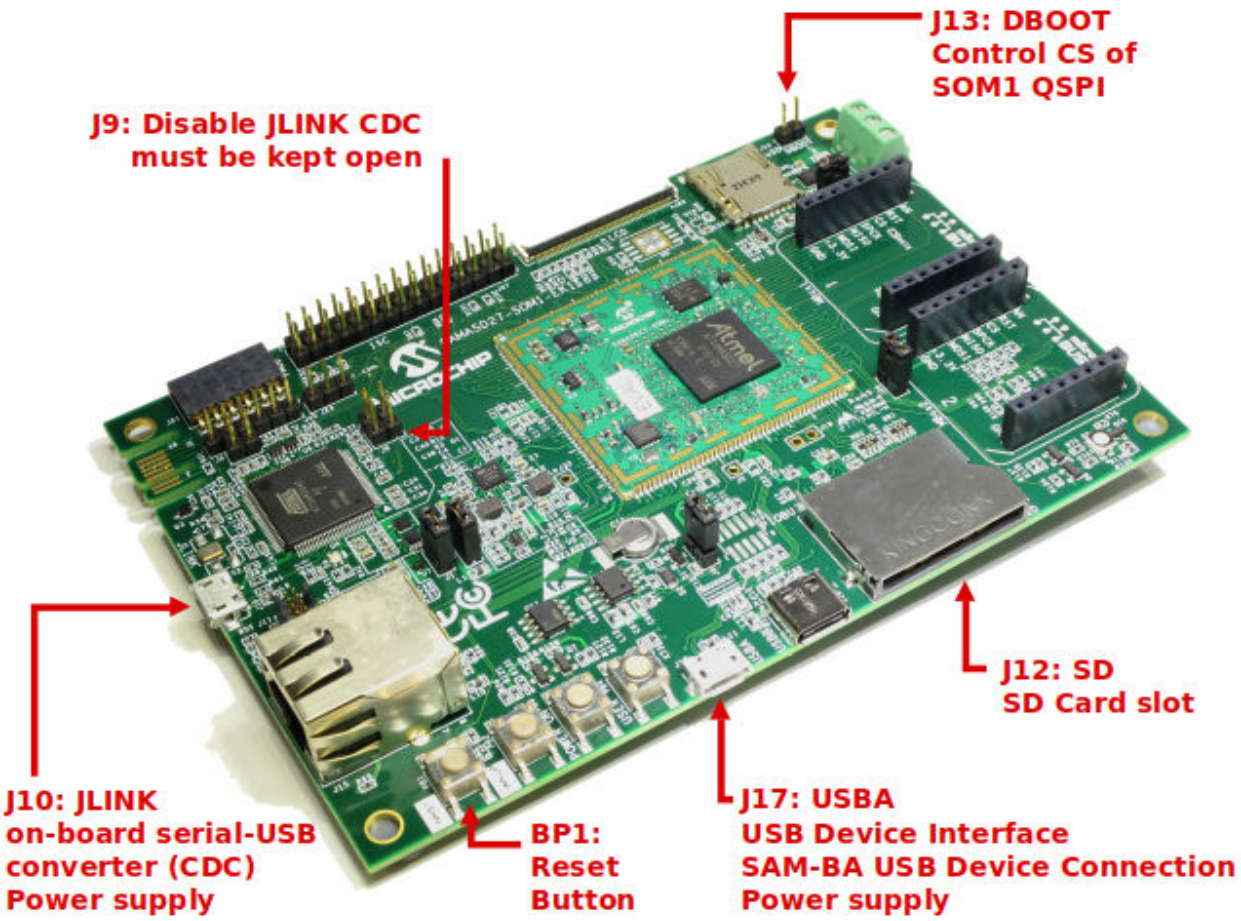
The GPIO chip model has been introduced into the kernel, so GPIO-based IRQs can be requested and handled in user space. See Application for the application source codes. The demo shows another way to request and handle IRQs than the standard kernel API request_irq().

Reference Documents

Title	Reference	Available
SAMA5D2 Series Datasheet	DS60001476	https://www.microchip.com/design-centers/32-bit-mpus
SAMA5D27 SOM1 Kit1 User Guide	DS50002667	https://www.microchip.com/DevelopmentTools/ProductDetails/PartNO/ATSAMA5D27-SOM1-EK1

Prerequisites

- Hardware
  - PC
  - SAMA5D27 SOM1 Evaluation Kit (Part Number: ATSAMA5D27-SOM1-EK1)
  - SDCard
- Software
  This demo runs on the AT91 Linux platform built by Buildroot. The first step is to set up the AT91 Buildroot development environment. Refer to the web site: http://www.at91.com/linux4sam/bin/view/Linux4SAM/BuildRoot


J13: DBOOT
Control CS of
SOM1 QSPI
J9: Disable JLINK CDC
must be kept open
J12: SD
SD Card slot
J10: JLINK
on-board serial-USB
converter (CDC)
Power supply
BP1:
Reset
Button
J17: USBA
USB Device Interface
SAM-BA USB Device Connection
Power supply

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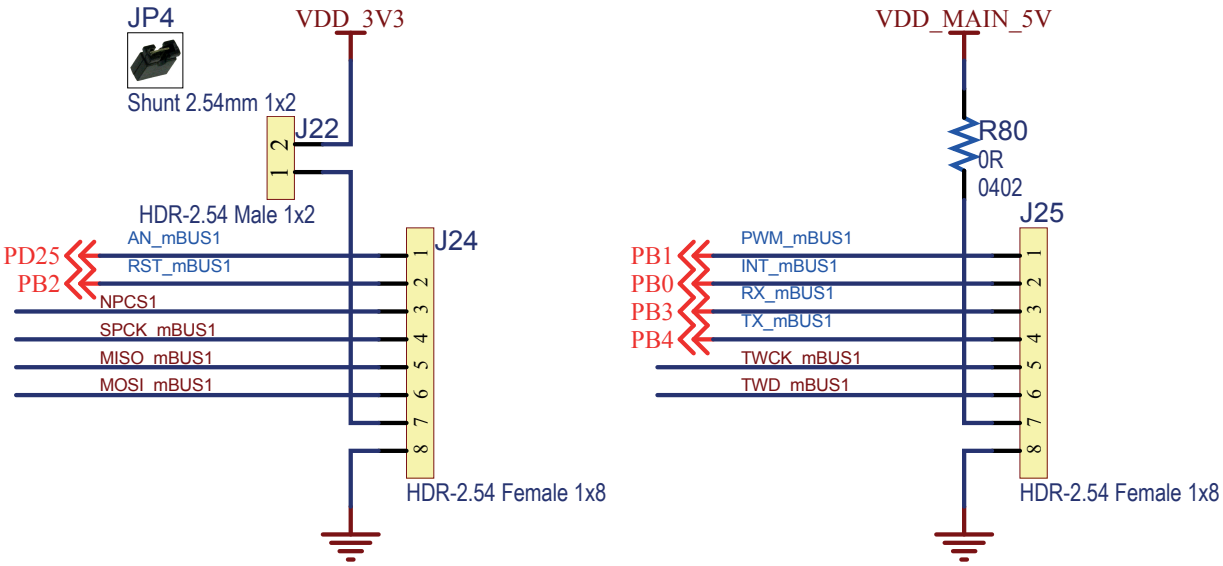
1. Hardware Design

1.1 Interface



“mikroBUS 1” was used for testing and monitoring.

This document shows how to request and handle mikroBUS1 IRQs on Linux.

PB0 is a GPIO-based IRQ numbered 83. This number is assigned by software during IRQ registering.

On SAMA5D27-SOM-EK1, PB0 is connected to INT_mBUS1:

IRQ83 → PB0 → INT_mBUS1

2. Software Design

The Microchip Linux platform was built using Buildroot with the following configuration:

```
atmel_sama5d27_som1_ek_mmc_dev_defconfig
```

SAM MPU chips include two types of external interrupt:

- External IRQs:
  - come from the product lines and have the same IRQ handle level than peripheral internal interrupts,
  - are driven by AIC,
  - must be requested and handled in kernel space through a standard kernel API (request_irq()).
- GPIO-based IRQs:
  - use lower IRQ handle levels than external IRQs, so their response time is slower (but sufficient for most applications),
  - are driven by the GPIO controller and AIC,
  - can be requested and handled in user space through the gpiochip device node.

In SAM MPU chips, all GPIO pins can be used as external interrupts.

This document shows how to request and handle GPIO-based IRQs in user space via the /dev/gpiochip0 device node.

2.1 Device Tree

- Action: no need to change
- Location: buildroot-at91/output/build/linux-linux4sam_6.0/arch/arm/boot/dts
- Sources: sama5d2.dtsi

The IRQ user space demo is based on the GPIO chip driver.

GPIO chip device tree:

```
pioA: pinctrl@fc038000 {
    compatible = "atmel,sama5d2-pinctrl";
 // specify which driver will be used for this pioA device

    reg = <0xfc038000 0x600>;
 // pioA base address is 0xfc038000, size is 0x600

    interrupts = <18 IRQ_TYPE_LEVEL_HIGH 7>,
 // 128 gpios were divided into four banks

           <68 IRQ_TYPE_LEVEL_HIGH 7>,
 // each gpio bank has its own irq line


 //check buildroot-at91/output/build/linux-linux4sam_6.0/include/dt-bindings/interrupt-
 controller/irq.h


 // for the definitions of TRQ_TYPE….

           <69 IRQ_TYPE_LEVEL_HIGH 7>,
           <70 IRQ_TYPE_LEVEL_HIGH 7>;
    interrupt-controller;
```

```
    #interrupt-cells = <2>;
    gpio-controller;
    #gpio-cells = <2>;
    clocks = <&pioA_clk>;

 // definition for pioA clock source


};

pioA_clk: pioA_clk {
    #clock-cells = <0>;
    reg = <18>;

 // PID of pioA is 18, this definition of offset will be used to enable pioA clock in PMC


    atmel,clk-output-range = <0 83000000>;

 // pioA input clock, max frequency is 83MHz


};
```

2.2 Kernel

- Action: no need to change
- Location: buildroot-at91/output/build/linux-linux4sam_6.0/
- Defconfig: sama5_defconfig
- Driver files: drivers/pinctrl/pinctrl-at91-pio4.c

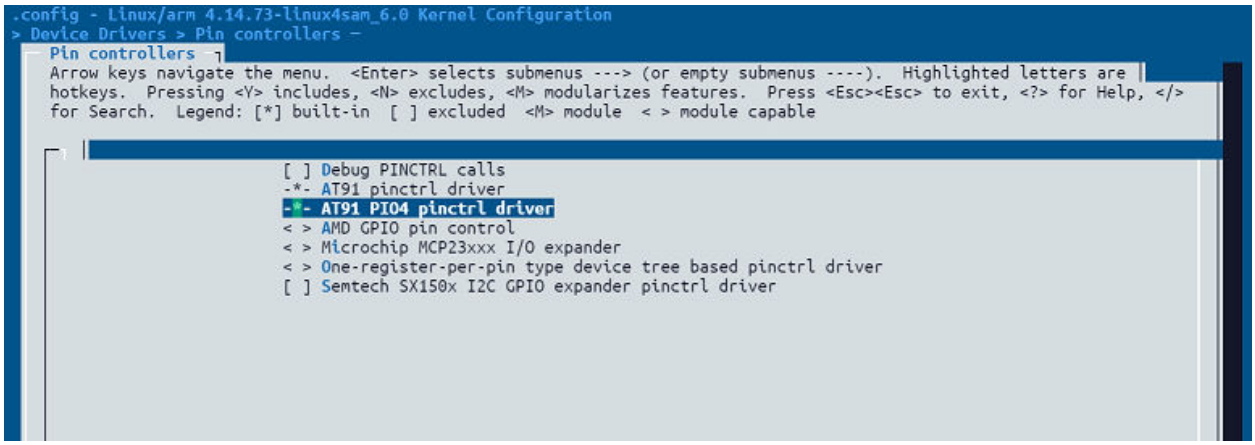
A GPIO-based IRQ function has been exported to user space by the GPIO chip driver, so IRQ applications can be developed in user space.

Check the kernel configuration for the GPIO function:

```
user@at91:~/buildroot-at91$ make linux-menuconfig
```

Device Drivers > Pin controllers > AT91 PIO4 pinctrl driver

With this setting, the “pinctrl” and “gpio” drivers for AT91 will be built into the kernel. The GPIO driver is then accessible via the device node in rootfs (/dev/gpiochip0).



2.3 Rootfs

- Action: no need to change
- Location: buildroot-at91/output/images/rootfs.tar

The following device node is used to access the GPIO chip driver:

- /dev/gpiochip0

2.4 Application

This section provides a C language demo for GPIO-based IRQ in user space.

How to compile

```
user@at91:~$ buildroot-at91/output/host/bin/arm-buildroot-linux-uclibcgnueabihf-gcc
gpio_irq.c -o irq_test
```

Source code

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <fcntl.h>
#include <poll.h>
#include <string.h>
#include <linux/gpio.h>
#include <sys/ioctl.h>

#define DEV_GPIO  "/dev/gpiochip0"

#define POLL_TIMEOUT -1 /* No timeout */

int main(int argc, char *argv[])
{
    int fd, fd_in;
    int ret;
    int flags;

    struct gpioevent_request req;
    struct gpioevent_data evdata;
    struct pollfd fdset;

    /* open gpio */
    fd = open(DEV_GPIO, O_RDWR);
    if (fd < 0) {
        printf("ERROR: open %s ret=%d\n", DEV_GPIO, fd);
        return -1;
    }

    /* Request gpio_pb0 interrupt */
    // 128 gpio in gpiochip0
    // 0  ~ 31    PA0 -> PA31
    // 32 ~ 63  PB0 -> PB31
    // 33 ~ 95  PC0 -> PC31
    // 96 ~ 127 PD0 -> PD31
    req.lineoffset = 32;
    req.handleflags = GPIOHANDLE_REQUEST_INPUT;
    req.eventflags  = GPIOEVENT_REQUEST_BOTH_EDGES;
    strncpy(req.consumer_label, "gpio_irq", sizeof(req.consumer_label) - 1);

    /* requrest line event handle */
    ret = ioctl(fd, GPIO_GET_LINEEVENT_IOCTL, &req);
    if (ret) {
        printf("ERROR: ioctl get line event ret=%d\n", ret);
        return -1;
    }

    /* set event fd nonbloack read */
    fd_in = req.fd;
    flags = fcntl(fd_in, F_GETFL);
    flags |= O_NONBLOCK;
    ret = fcntl(fd_in, F_SETFL, flags);
    if (ret) {
        printf("ERROR: fcntl set nonblock read\n");
    }

    for (;;) {
        fdset.fd      = fd_in;
```

```
        fdset.events  = POLLIN;
        fdset.revents = 0;

        /* poll gpio line event */
        ret = poll(&fdset, 1, POLL_TIMEOUT);
        if (ret <= 0)
            continue;

        if (fdset.revents & POLLIN) {
            printf("irq received.\n");
            /* read event data */
            ret = read(fd_in, &evdata, sizeof(evdata));
            if (ret == sizeof(evdata))
                printf("id: %d, timestamp: %lld\n", evdata.id, evdata.timestamp);
        }
    }

    /* close gpio */
    close(fd);

    return 0;
}
```

3. Hands-On

Copy the irq_test app to target and execute it, then trigger this IRQ with either the falling or the rising edge.

```
# chmod +x irq_test
# ./irq_test
irq received.
id: 2, timestamp: 1326702743513717054
irq received.
id: 1, timestamp: 1326702744536525542
irq received.
id: 2, timestamp: 1326702745118564762
irq received.
id: 1, timestamp: 1326702745694055688
```

4. Revision History

4.1 Rev. A - 12/2019

First issue.

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