# BeagleBone Black project

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# Tasks

- **Compile embedded Linux for BeagleBone Black**
- **Develop C application which uses**
  - **TCS34725 RGB colour sensor**
  - **L3GD20H 3-axis gyroscope**

# Compiling Linux

- Buildroot
  - custom Linux kernel 3.12 with patches for Texas Instruments SoCs
  - U-Boot 2016.03
  - gdbserver for remote debugging
  - openssh for remote connection
  - set of elementary programs BusyBox

# Files

- FAT32 boot partition
  - X-Loader - MLO
  - U-boot binary - u-boot.bin
  - Linux kernel - zImage
- Linux partition
  - filesystem - rootfs.ext2

# Configuration

- Allowed remote login for root user using password
  - /etc/ssh/sshd_config
  - PermitRootLogin yes
  - otherwise turn off!!!
- Set static IP address
  - /etc/network/interfaces
  - iface eth0 inet static
    address 192.168.1.2
    netmask 255.255.255.0

# Development

- IDE Eclipse Oxygen from October 2017
- remote debugging
- both devices in 192.168.1.0 subnet
- root user

# Cross-Compilation Configuration

- Adding a line for cross-compiling tools to the PATH variable in the file ".profile":
  PATH=" /home/jaroslav/buildroot-2016-05/buildroot/output/host/usr/bin:$PATH"
- Creation of C/C++ project: gyroRGB
- Set the toolchain: Cross GCC
- Configuration: Debug [Activate]
- Prefix: arm-buildroot-linux-uclibcgnueabihf-
- Path: /home/jaroslav/buildroot-2016.05/output/host/usr/bin

**The compiling process is made in Linux x86 machine and the execution in ARM architecture (BBB)!**

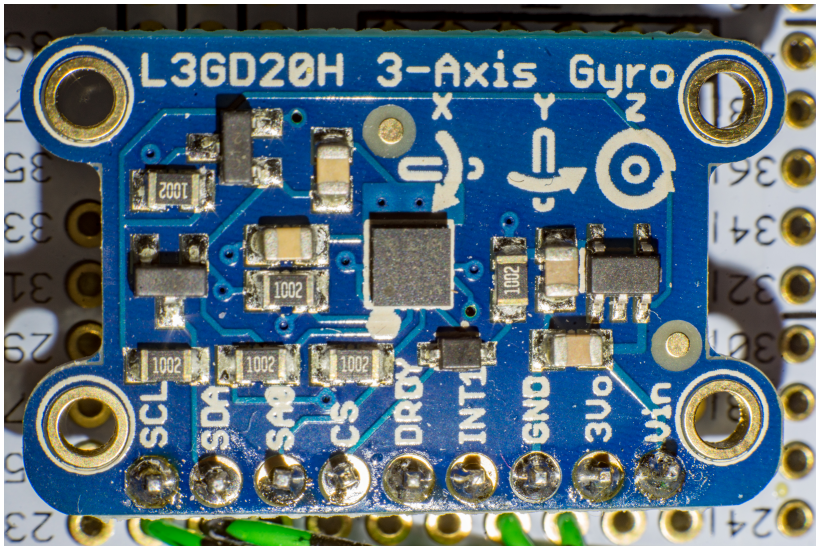
# Development III

Run **Debug Configuration**
Open a new **C/C++ Remote Application** and the code of the program to be debugged

- Project name
- Build Configuration: Use Active
- C/C++ Application: browse executable
- Remote Absolute File Path for C/C++ Application
- Commands to execute before application: chmod +x location path of the application
- **GDB Debugger:** Location path of the **gdb**
- **GDB Command:** Location path of the **.gdbinit** file
- **Debugger Options:** Gdbserver Settings / Port number

# Sensors

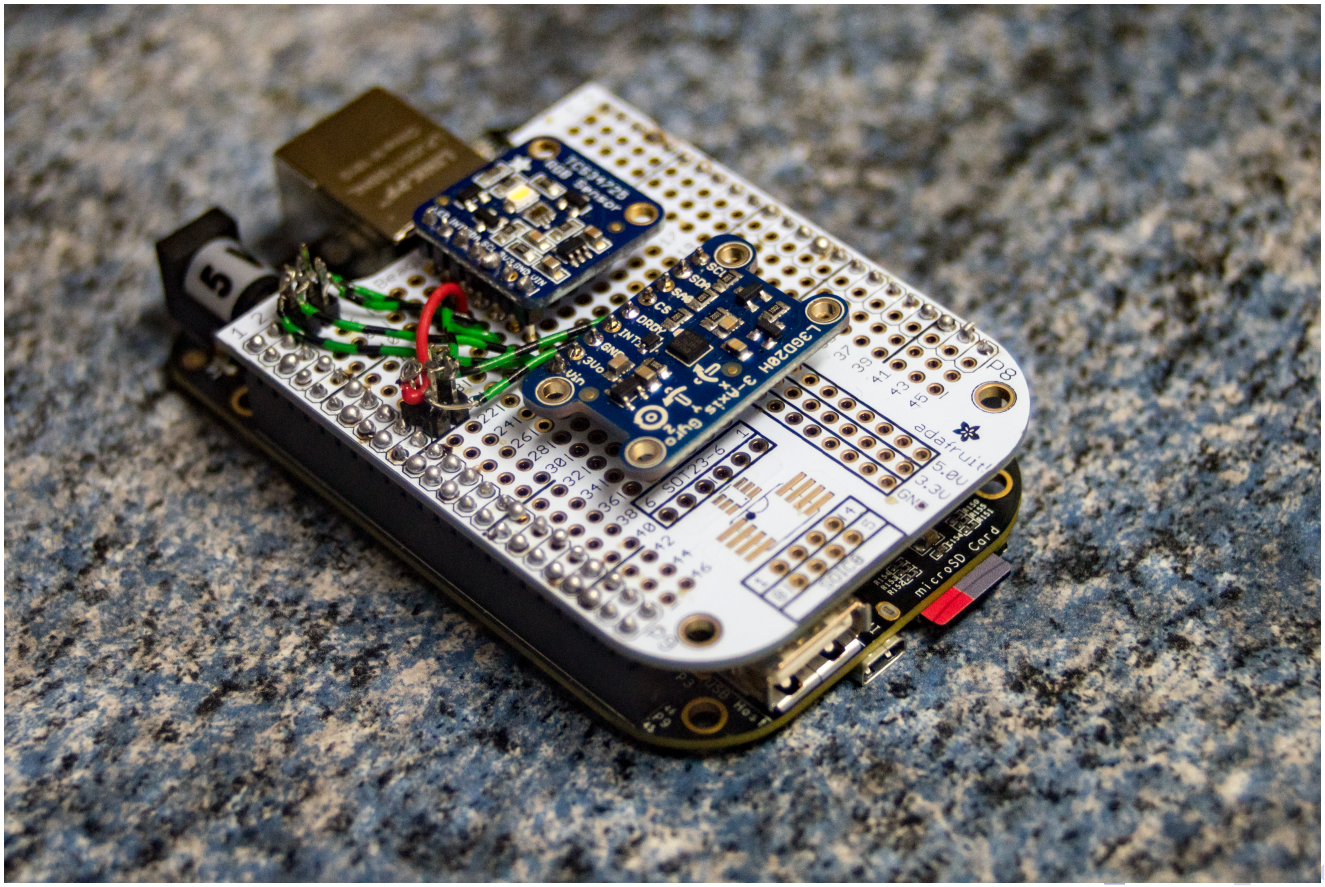

(a) TCS34725 RGB colour sensor




(b) L3GD20H 3-axis gyroscope

# Soldering

Figure: BeagleBone Black with HAT with sensors



# Implementation - RGB sensor

- First check in the datasheet of the sensor for address of the I2C device.

**Available Options**

| DEVICE | ADDRESS | PACKAGE – LEADS | INTERFACE DESCRIPTION | ORDERING NUMBER |
|---|---|---|---|---|
| TCS34721† | 0x39 | FN–6 | $I^2C$ Vbus = $V_{DD}$ Interface | TCS34721FN |
| TCS34723† | 0x39 | FN–6 | $I^2C$ Vbus = 1.8 V Interface | TCS34723FN |
| TCS34725 | 0x29 | FN–6 | $I^2C$ Vbus = $V_{DD}$ Interface | TCS34725FN |
| TCS34727 | 0x29 | FN–6 | $I^2C$ Vbus = 1.8 V Interface | TCS34727FN |

† Contact TAOS for availability.

# Implementation - RGB sensor

- Example of configuration used in the code

```
// Select enable register(0x80)
// Power ON, RGBC enable, wait time disable(0x03)
char config[2] = {0};
config[0] = 0x80;
config[1] = 0x03;
write(file, config, 2);
```

# Implementation - RGB sensor

- Command Register

**Table 4. Command Register**

| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| COMMAND | CMD | TYPE | | ADDR/SF | | | | |

```
config[0] = 0x80;
```

# Implementation - RGB sensor

- Time Register

**Wait Time Register (0x03)**

Wait time is set 2.4 ms increments unless the WLONG bit is asserted, in which case the wait times are 12× longer. WTIME is programmed as a 2's complement number.

**Table 7. Wait Time Register**

| FIELD | BITS | DESCRIPTION | | | |
|---|---|---|---|---|---|
| WTIME | 7:0 | REGISTER VALUE | WAIT TIME | TIME (WLONG = 0) | TIME (WLONG = 1) |
| | | 0xFF | 1 | 2.4 ms | 0.029 sec |
| | | 0xAB | 85 | 204 ms | 2.45 sec |
| | | 0x00 | 256 | 614 ms | 7.4 sec |

```
config[1] = 0x03;
```

# Implementation - Gyroscope

- First check in the datasheet of the sensor for address of the I2C device.

The Slave ADdress (SAD) associated to the L3GD20H is 110101xb. SDO/SA0 pin can be used to modify less significant bit of the device address. If SDO/SA0 pin is connected to voltage supply LSb is '1' (address 1101011b) else if SDO/SA0 pin is connected to ground LSb value is '0' (address 1101010b). This solution permits to connect and address two different gyroscopes to the same $I^2C$ bus.

# Implementation - Gyroscope

- Example of configuration used in the code

```
// Enable X, Y, Z-Axis and disable Power down mode(0x0F)
char config[2] = {0};
config[0] = 0x20;
config[1] = 0x0F;
```

# Implementation - Gyroscope

- Axis control register

**Table 19. CTRL1 register(1)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DR1 | DR0 | BW1 | BW0 | PD | Zen | Xen | Yen |

1. Xen, Yen, Zen enable X, Yor Z register in level sensitive trigger mode. Once LVLen bit = 1, DEN level replaces the LSB of X, Y or Z axes and all axis are available for reading.

# Implementation - Gyroscope

- Axis control register possible combination of value

**Table 20. CTRL1 description**

| | |
|---|---|
| DR1-DR0 | Output data rate selection. Refer to *Table 21* |
| BW1-BW0 | Bandwidth selection. Refer to *Table 21* |
| PD | Power mode. Default value: 0. Refer to *Table*<br>0= Power Down<br>1= Normal Mode<br>(For Sleep Mode set {PD:Zen:Yen:Xen} to {1000}) |
| Zen | Z axis enable. Default value: 1<br>(0: Z axis disabled; 1: Z axis enabled) |
| Yen | Y axis enable. Default value: 1<br>(0: Y axis disabled; 1: Y axis enabled) |
| Xen | X axis enable. Default value: 1<br>(0: X axis disabled; 1: X axis enabled) |

**DR<1:0>** is used to set ODR selection. **BW <1:0>** is used to set bandwidth selection.