

Migration of AFE5808A and DAC AD5327 drivers from Daphne v1-v2.A to v3 using PetaLinux

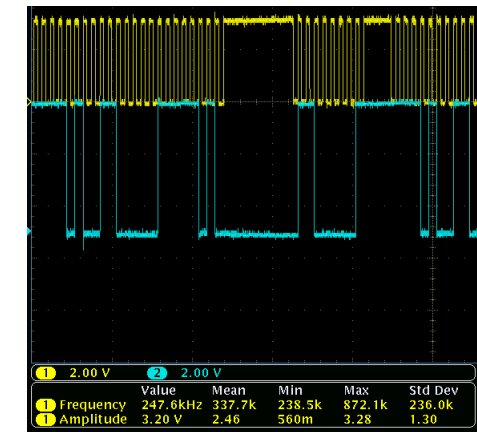
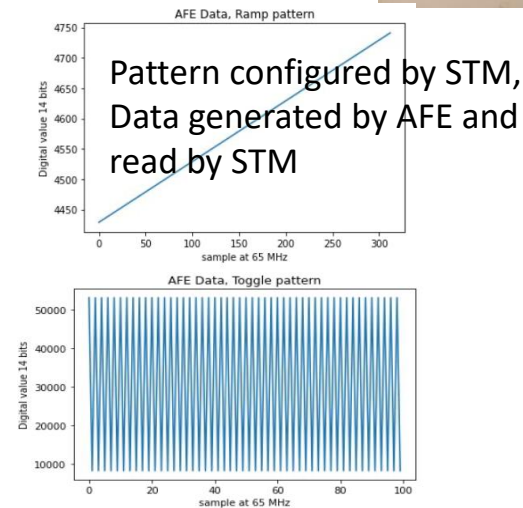
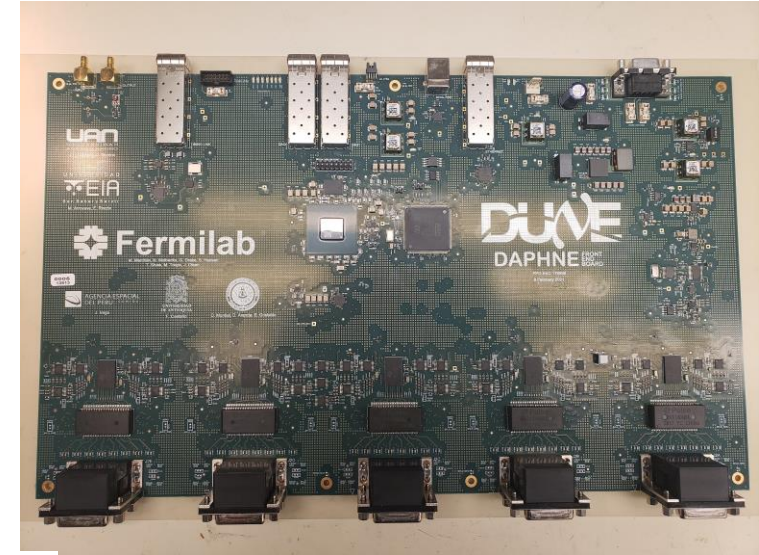
Fabian Castaño (On behalf of the PDS members)

18 January 2024



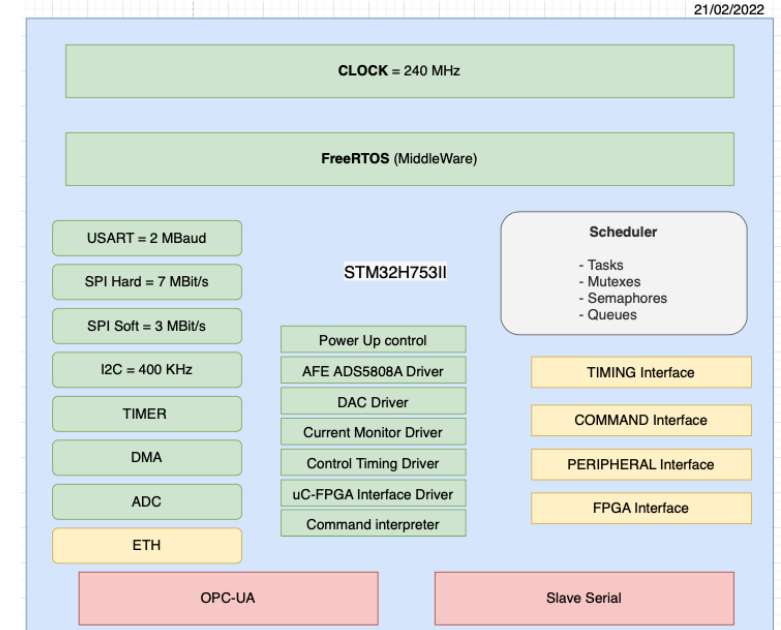
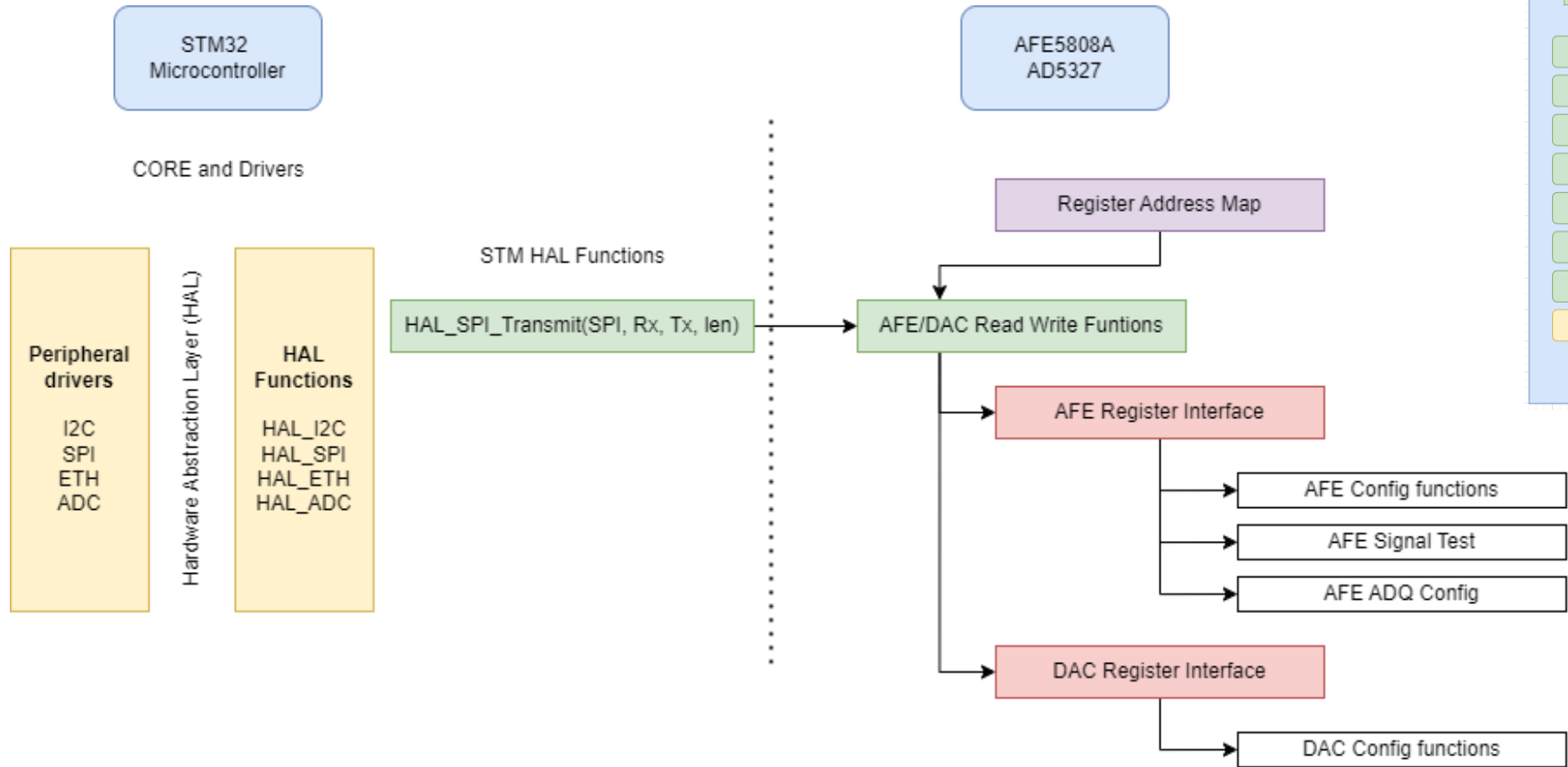
AFE5808A driver for DAPHNE v1-v2a

- AFEs and DAC driver implementation
 - Full access AFE driver developed (full memory R/W capability)
 - Full access DAC driver developed



AFE5808A driver for DAPHNE v1-v2a

- DAPHNE v1-v2a Slow Control Firmware architecture



AFE5808A driver for DAPHNE v3

- Change to KRIA K26 SoM

- Platform config

<https://www.hackster.io/fabioc9675/empowering-dune-setting-up-vivado-vitis-and-petalinux-b879ee>

- Project initialization

<https://www.hackster.io/fabioc9675/empowering-dune-a-guide-to-starting-with-kria-kr260-vivado-fe39c5>

- PetaLinux image compile

<https://www.hackster.io/fabioc9675/empowering-dune-creating-petalinux-2022-2-os-image-for-kria-2fbca1>

- Hardware support

<https://www.hackster.io/fabioc9675/empowering-dune-support-for-hard-peripherals-rpi-pmod-kria-505ded>

- AXI UARTLite

<https://www.hackster.io/fabioc9675/empowering-dune-axi-uartlite-using-petalinux-2022-2-in-kria-7e11cf>

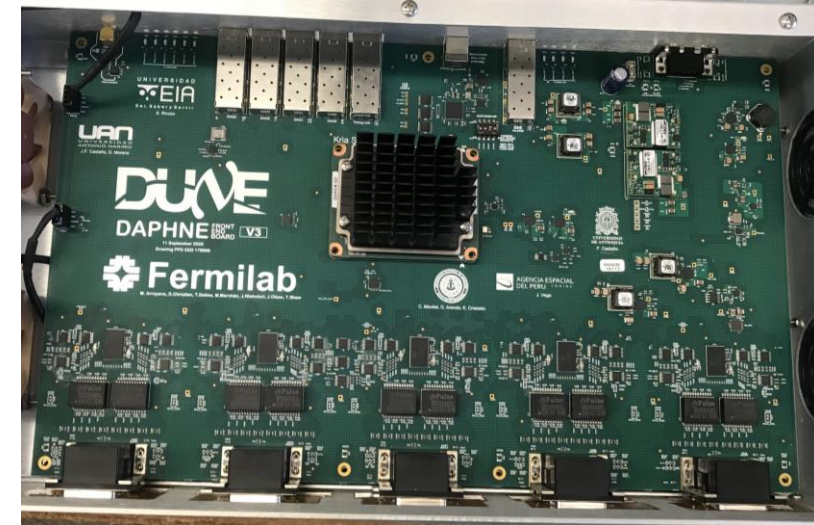
- AXI IIC

<https://www.hackster.io/fabioc9675/empowering-dune-axi-iic-using-petalinux-2022-2-in-kria-a71f25>

- AXI Quad SPI

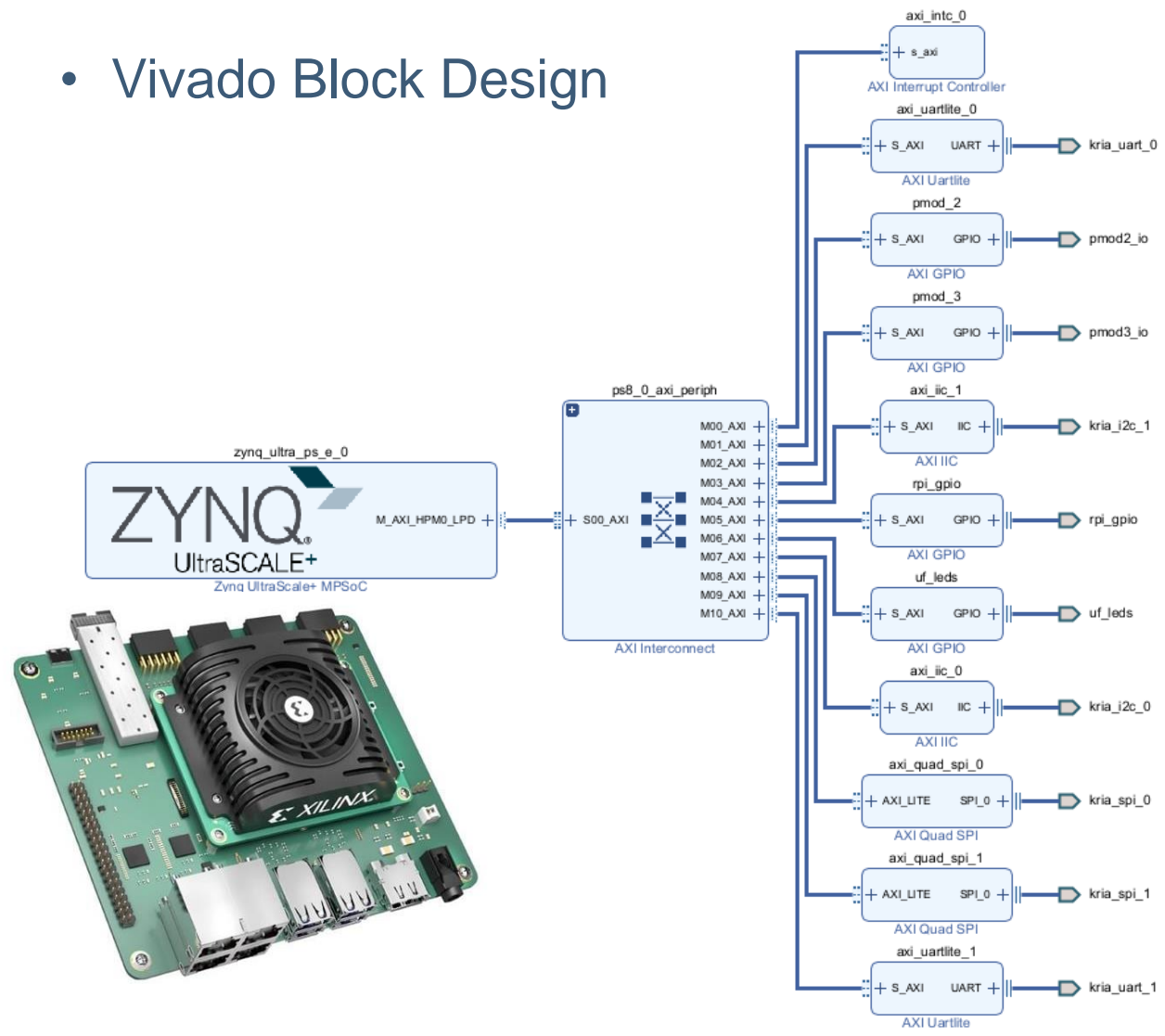
<https://www.hackster.io/fabioc9675/empowering-dune-axi-quad-spi-using-petalinux-2022-2-in-kria-ad6d72>

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AFE5808A driver for DAPHNE v3

- Vivado Block Design



Network 0

Masters	Slaves
/zynq_ultra_ps_e_0	0x8000_0000 /axi_intc_0/s_axi 64K
M_AXI_HPM0_LPD	0x8001_0000 /axi_iic_0/S_AXI 64K
	0x8002_0000 /axi_iic_1/S_AXI 64K
	0x8003_0000 /axi_quad_spi_0/AXI_LITE 64K
	0x8004_0000 /axi_quad_spi_1/AXI_LITE 64K
	0x8005_0000 /axi_uartlite_0/S_AXI 64K
	0x8006_0000 /axi_uartlite_1/S_AXI 64K
	0x8007_0000 /pmod_2/S_AXI 64K
	0x8008_0000 /pmod_3/S_AXI 64K
	0x8009_0000 /rpi_gpio/S_AXI 64K
	0x800a_0000 /uf_leds/S_AXI 64K
	0x800b_0000



AFE5808A driver for DAPHNE v3

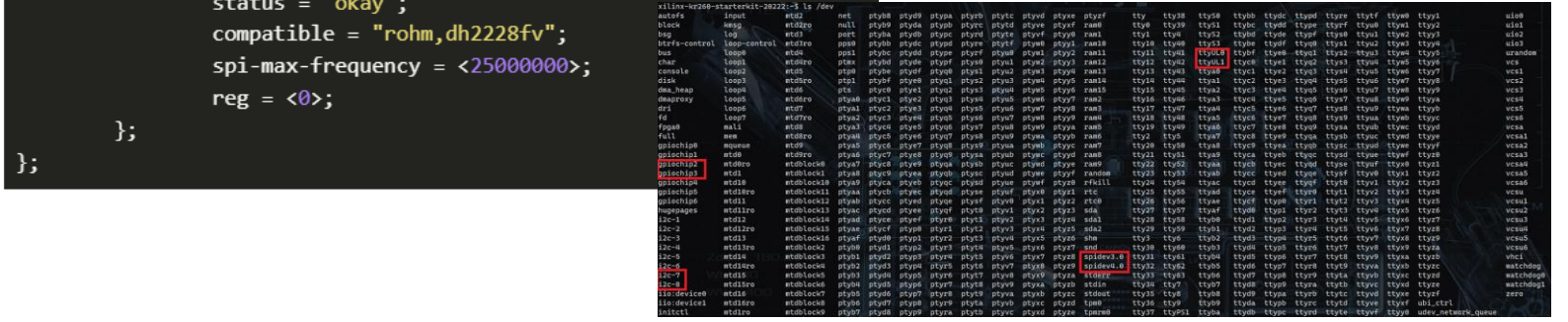
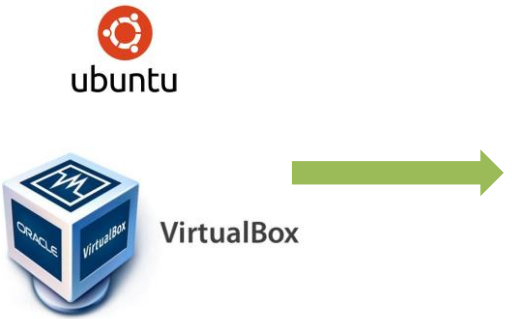
• Device Tree Overlay

```
axi_quad_spi_0: axi_quad_spi@80080000 {
    bits-per-word = <8>;
    clock-names = "ext_spi_clk", "s_axi_aclk";
    clocks = <&zynqmp_clk 71>, <&misc_clk 0>;
    compatible = "xlnx,axi-quad-spi-3.2", "xlnx,xps-spi-2.00.a";
    fifo-size = <16>;
    interrupt-names = "ip2intc_irqt";
    interrupt-parent = <&axi_intc_0>;
    interrupts = <0 0>;
    num-cs = <0x1>;
    reg = <0x0 0x80080000 0x0 0x10000>;
    xlnx,num-ss-bits = <0x1>;
    xlnx,spi-mode = <0>;
};
```

```
axi_quad_spi_0: axi_quad_spi@80080000 {
    bits-per-word = <8>;
    clock-names = "ext_spi_clk", "s_axi_aclk";
    clocks = <&zynqmp_clk 71>, <&misc_clk 0>;
    compatible = "xlnx,axi-quad-spi-3.2", "xlnx,xps-spi-2.00.a";
    fifo-size = <16>;
    interrupt-names = "ip2intc_irqt";
    interrupt-parent = <&axi_intc_0>;
    interrupts = <0 0>;
    num-cs = <0x1>;
    reg = <0x0 0x80080000 0x0 0x10000>;
    xlnx,num-ss-bits = <0x1>;
    xlnx,spi-mode = <0>;
    spidev@0x00 {
        status = "okay";
        compatible = "rohm,dh2228fv";
        spi-max-frequency = <25000000>;
        reg = <0>;
    };
};
```

Bash code to load overlay

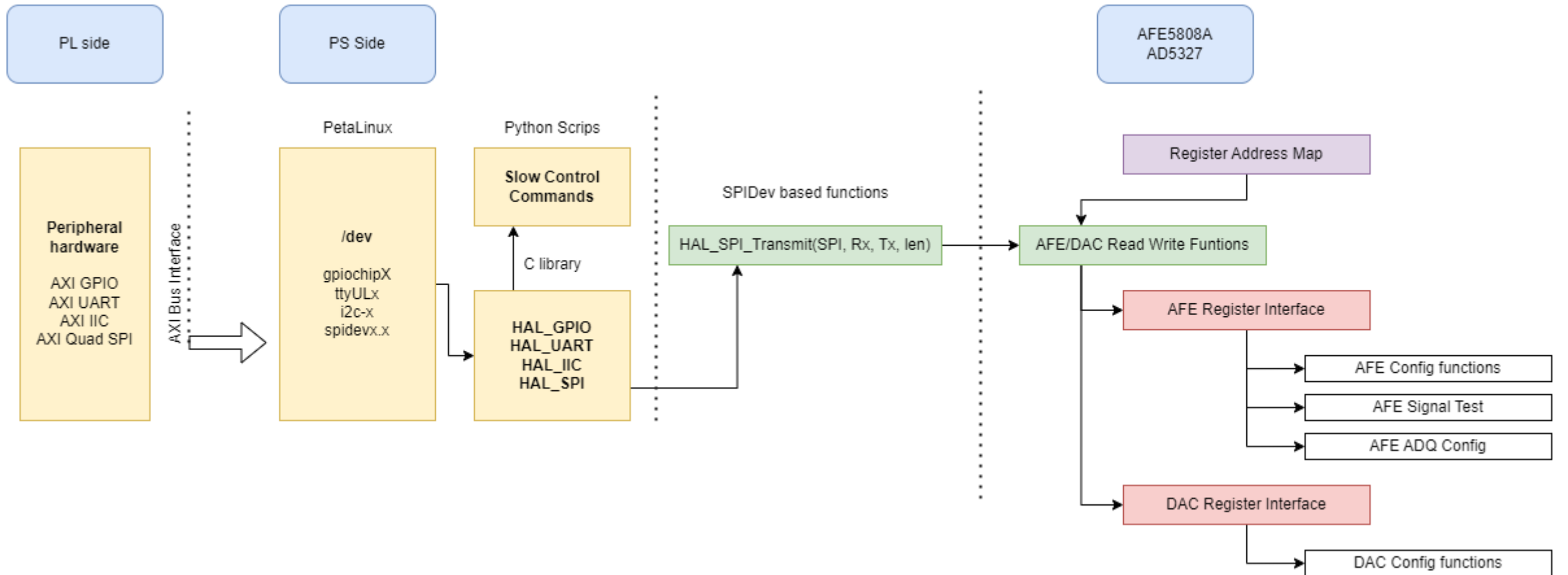
```
xmutil unloadapp
xmutil loadapp kr260_slow
chown petalinux:petalinux /dev/spidev3.0
chown petalinux:petalinux /dev/spidev4.0
chown petalinux:petalinux /dev/i2c-7
chown petalinux:petalinux /dev/i2c-8
chown petalinux:petalinux /dev/ttyUL0
chown petalinux:petalinux /dev/ttyUL1
chown petalinux:petalinux /dev/gpiochip2
chown petalinux:petalinux /dev/gpiochip3
```



<https://www.hackster.io/fabioc9675/empowering-dune-axi-quad-spi-using-petalinux-2022-2-in-kria-ad6d72>

AFE5808A driver for DAPHNE v3

- DAPHNE v3 Slow Control Firmware architecture



AFE5808A driver for DAPHNE v3

- C Library structure “afe5808a_lib.so”

```
xilinx-kr260-starterkit-20222:~/SPI_prj$ nm -D afe5808a_lib.so
00000000000283c T HAL_AFEReadRegister
000000000002578 T HAL_AFEReadWriteRegister
00000000000278c T HAL_AFEWriteRegister
0000000000053b0 T HAL_AFE_All0sTest
0000000000052e0 T HAL_AFE_All1sTest
000000000005278 T HAL_AFE_CustomTest
0000000000046b0 T HAL_AFE_InitialConfig
000000000005144 T HAL_AFE_RampTest
000000000004f88 T HAL_AFE_ResetConfig
000000000005210 T HAL_AFE_SkewTest
0000000000051a8 T HAL_AFE_SyncTest
000000000004694 T HAL_AFE_TestConfig
000000000005348 T HAL_AFE_ToggleTest
000000000003bc0 T HAL_DAC1BiasSet_ModifyParam
0000000000042ac T HAL_DAC1BiasSet_SetValue
000000000003878 T HAL_DAC1TrimOffset_ModifyParam
0000000000040c4 T HAL_DAC1TrimOffset_SetValue
000000000003d6c T HAL_DAC2BiasSet_ModifyParam
0000000000043a0 T HAL_DAC2BiasSet_SetValue
000000000003a1c T HAL_DAC2TrimOffset_ModifyParam
0000000000041b8 T HAL_DAC2TrimOffset_SetValue
000000000003f18 T HAL_DAC3BiasSet_ModifyParam
000000000004494 T HAL_DAC3BiasSet_SetValue
0000000000035ec T HAL_DAC_BiasSetWriteRegister
000000000003384 T HAL_DAC_TrimOffsetWriteRegister
000000000001e50 T HAL_GPIO_PinOut_Init
000000000001eb8 T HAL_GPIO_WritePin
000000000001d1c T HAL_SPI_CLOSE
000000000001af0 T HAL_SPI_OPEN
000000000001a68 T HAL_SPI_TransmitReceive
000000000002b28 T MX_AD_DAC_AFE0_Init
000000000002cd4 T MX_AD_DAC_AFE1_Init
000000000002e80 T MX_AD_DAC_AFE2_Init
00000000000302c T MX_AD_DAC_AFE3_Init
0000000000031d8 T MX_AD_DAC_AFE4_Init
000000000002a44 T MX_AD_DAC_BIASSET_Init
000000000001f4c T MX_AFE0_Init
000000000002088 T MX_AFE1_Init
0000000000021c4 T MX_AFE2_Init
000000000002300 T MX_AFE3_Init
00000000000243c T MX_AFE4_Init
000000000001d4c T MX_GPIO_Init
000000000001a08 T MX_SPI3_Deinit
000000000001928 T MX_SPI3_Init
000000000001a38 T MX_SPI4_Deinit
000000000001998 T MX_SPI4_Init
00000000000293c T MX_SPI_AFE_OP_Config
000000000004588 T MX_SPI_DAC_OP_Config
```

```

▼ SPI_prj
  > image
  ▼ include
    C ad5327.h
    C afe5808a.h
    C hal_ad5327.h
    C hal_afe_cfg.h
    C hal_afe5808a.h
    C hal_gpio.h
    C hal_spi.h
  ▼ src
    C hal_ad5327.c
    C hal_afe_cfg.c
    C hal_afe5808a.c
    C hal_gpio.c
    C hal_spi.c
    afe5808a.py
    Makefile
    README.md
    test.py

```

```

/* Transmit and SPI Receive function */
HAL_SPIStatusTypeDef HAL_SPI_TransmitReceive(SPI_HandleTypeDef *hspi, uint8_t *dataW, uint8_t *dataR,
                                              uint8_t dataSize, uint16_t Timeout)
{
    HAL_SPIStatusTypeDef errorcode = HAL_SPI_OK;

    hspi->spi_trx.tx_buf = (unsigned long)dataW;
    hspi->spi_trx.rx_buf = (unsigned long)dataR;
    hspi->spi_trx.len = dataSize;

    // Transmit and receive data from buffer
    hspi->fileReturn = ioctl(hspi->fileDevice, SPI_IOC_MESSAGE(1), &(hspi->spi_trx));
    if (hspi->fileReturn != 0)
    {
        // printf("SPI transfer returned %d...\r\n", hspi->fileReturn);
    }

    return (errorcode);
}

```

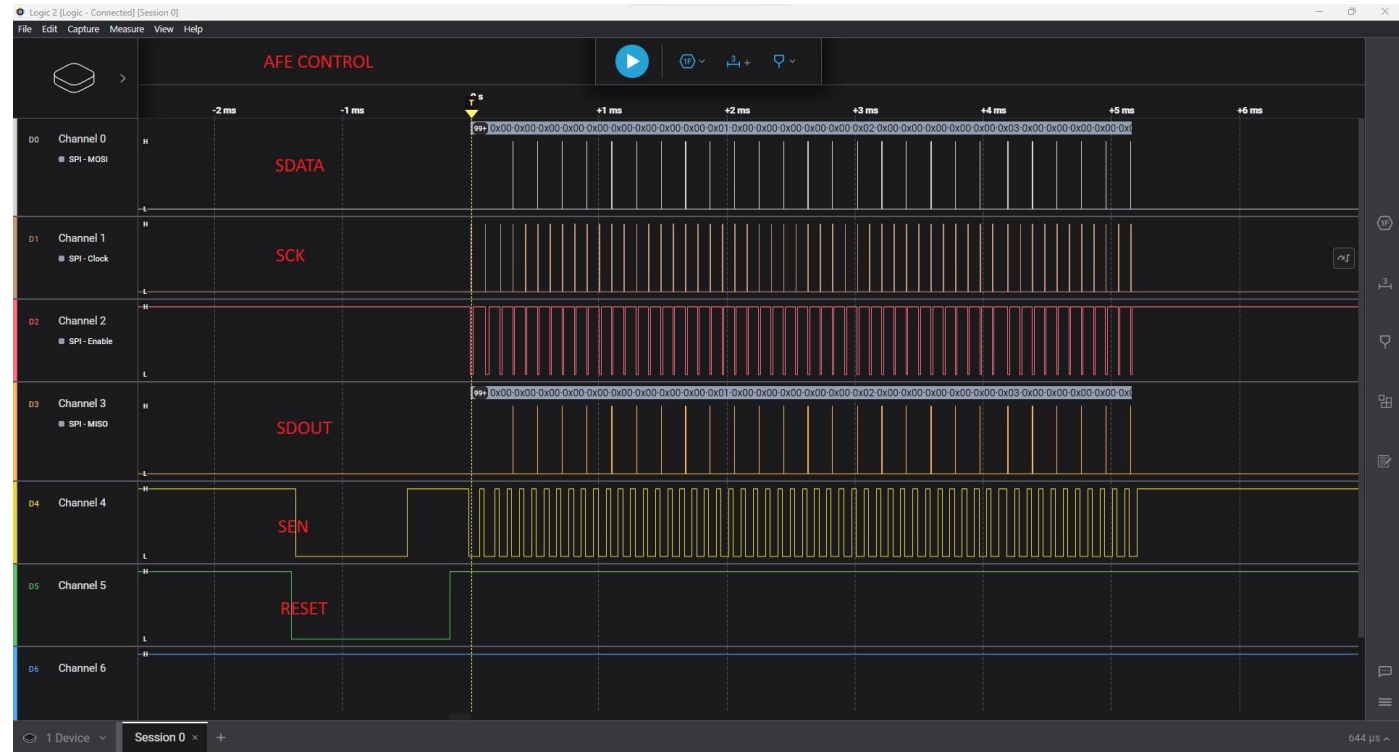
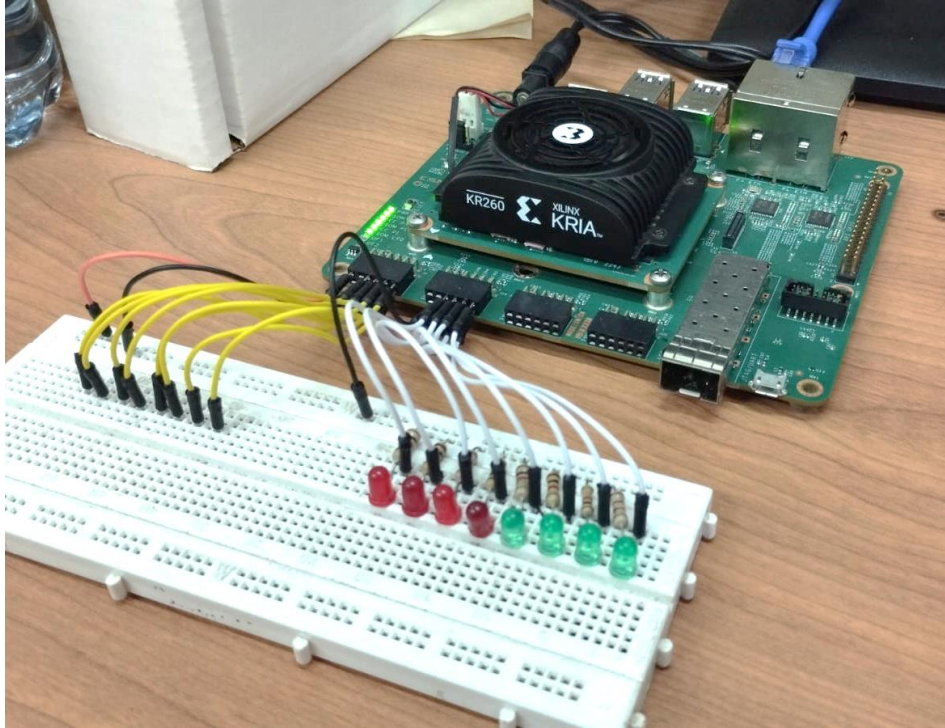
Repository available on

https://github.com/fabioc9675/DUNE_Daphne_v3_AFE/tree/devFabian



AFE5808A driver for DAPHNE v3

- C Library structure “afe5808a_lib.so”



Repository available on

https://github.com/fabio9675/DUNE_Daphne_v3_AFE/tree/devFabian



AFE5808A driver for DAPHNE v3

- Python script to use the “afe5808a_lib.so” library

```
# test.py
import ctypes
import time
from afe5808a import *

# Cargar la biblioteca compartida
my_library = ctypes.CDLL('./afe5808a_lib.so')

# Perophysical config
my_library.MX_GPIO_Init() # Initialize the GPIO driver
my_library.MX_SPI3_Init() # Initialize the SPI driver
my_library.MX_SPI4_Init() # Initialize the SPI driver

# AFE Initialization
my_library.MX_AFE0_Init() # Initialize the AFE0

# DACs Initialization
my_library.MX_AD_DAC_BIASSET_Init()
my_library.MX_AD_DAC_AFE0_Init()

# Send the configuration sequence for AFE 0
my_library.HAL_AFE_InitialConfig(my_library.hafe0)

time.sleep(0.01)
```

```
# Send config for DACs
my_library.HAL_DAC1TrimOffset_SetValue(my_library.hdac_trimAfe0, 0, 20)
time.sleep(0.01)

# Accede a la instancia de la estructura (en este caso, hafe0)
hafe0 = my_library.hafe0

# Convierte la instancia a la estructura definida en Python
hafe0_py = ctypes.cast(hafe0, ctypes.POINTER(AFE_HandleTypeDef)).contents

# Cambia el valor del registro
hafe0_py.ADCRegisterMap.REG03bits.DIGITAL_GAIN_ENABLE = 1
my_library.HAL_AFEWriteRegister(hafe0, 3,
ctypes.byref(hafe0_py.ADCRegisterMap.REG03bits))

readData = (ctypes.c_uint16)(0)
my_library.HAL_AFEReadRegister(hafe0, 3, ctypes.byref(readData))
print("REG03bits = ", readData)

# Cerrar el SPI device
my_library.MX_SPI3_Deinit() # Initialize the SPI driver

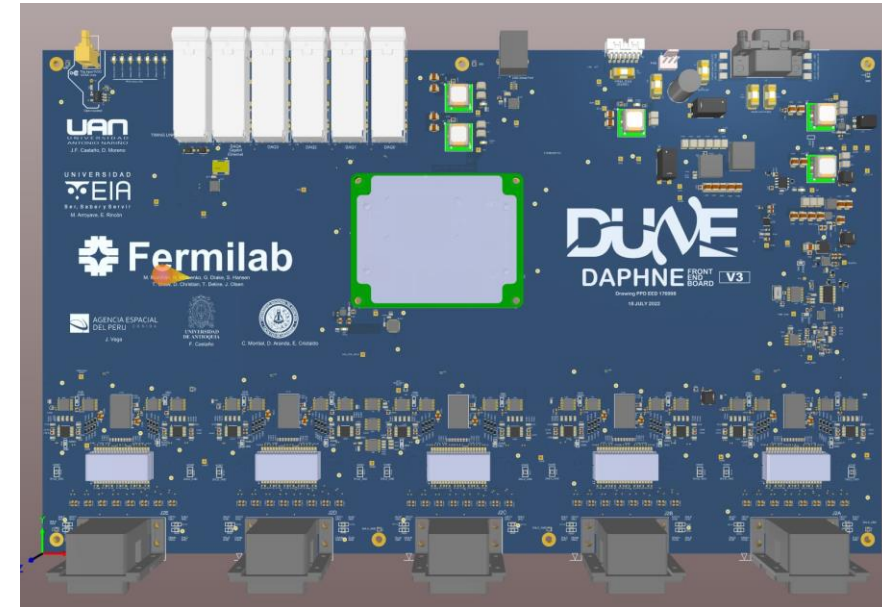
# Accede a los campos de la estructura
# print("CS Pin:", hafe0_py.SPI_handle.SPI_Device.decode("utf-8"))
# Accede a más campos según sea necesario...
```



AFE5808A driver for DAPHNE v3

- Next Steps

- Create Device Tree Overlay for 5 AFEs and DACs (In process)
- Modify Pinout mapping in the constrain files (In process)
- Make a test using DAPHNE v3.0



Names	AFE 0		AFE 1		AFE 2		AFE 3		AFE 4	
	Kria Conn	BGA Name	Kria Conn	BGA Name	Kria Conn	BGA Name	Kria Conn	BGA Name	Kria Conn	BGA Name
AFE_PDN	C59-2	AE13								
AFE_RST	C54-2	AG13								
SDOUT_miso	A55-2	Y13	B21-1	E12	B21-1	E12	D58-2	AH14	D58-2	AH14
SDATA_mosi	B56-2	W13	A16-1	J12	A16-1	J12	C58-2	AC13	C58-2	AC13
SCLK_sck	B57-2	AB15	C20-1	F12	C20-1	F12	C50-2	AD12	C50-2	AD12
AFE_SEn_cs	A60-2	AA12	D20-1	E10	B20-1	B10	D49-2	AF11	D57-2	AG14
TRM_SYNCn	B58-2	AB14	C22-1	B11	B17-1	K13	D46-2	AG10	D54-2	AE15
TRM_LDACn	A59-2	Y12	C23-1	A10	B16-1	J10	C47-2	AH11	C55-2	AH13
OFF_SYNCn	A56-2	W12	D21-1	D10	B18-1	K12	C48-2	AC12	C56-2	AC14
OFF_LDACn	A58-2	W11	D22-1	C11	A17-1	H12	D48-2	AH10	D56-2	AE14
DAC_LDACn	C51-2	AE10								
DAC_SYNCn	C52-2	AF10								
DAC_SCLK	D53-2	AD14								
DAC_DIN	D52-2	AD15								

Development of Testing Hardware

7-channel multi-tester



- This simple device features an Ohm-meter, a diode-meter and a voltmeter with the (+) and (-) leads switched to several pin positions of a built-in DB-15 and HIROSE HR10A-10R-12P(73) connectors. The switching is done automatically by implementing seven internal relays controlled by a ESP32 device.
- The device is working on CERN in the installation of Proto DUNE.

