MAX 10 – NIOS ADC Example

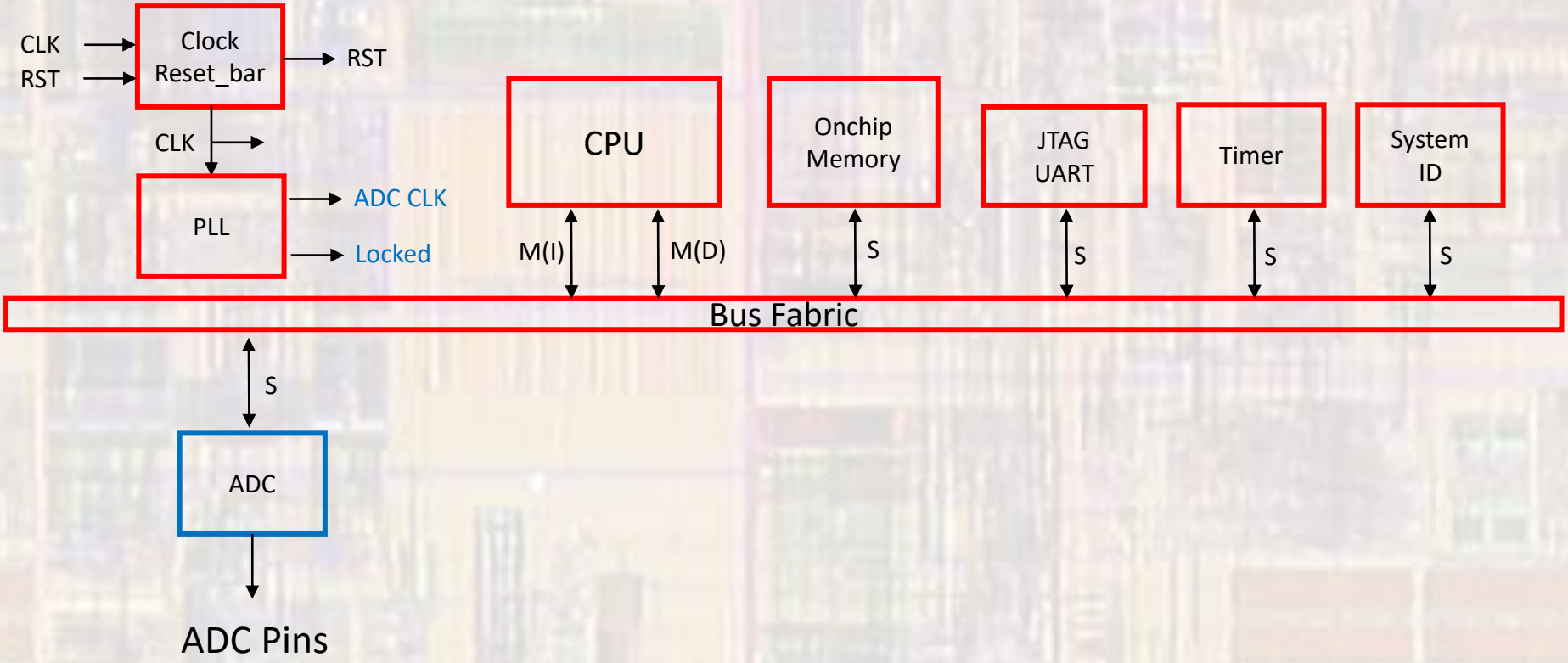
Last updated 7/20/23

Max10 ADC Example - NIOS

- ADC Configuration
  - 3 approaches to using the ADCs
    - Used as part of a NIOS system
      - Avalon interface built in by Platform Designer
    - Used with a hand built interface
      - Emulate the Avalon interface
    - Used with the Quartus ToolKit (Inside System Console) to verify operation
      - Avalon interface built into the toolkit

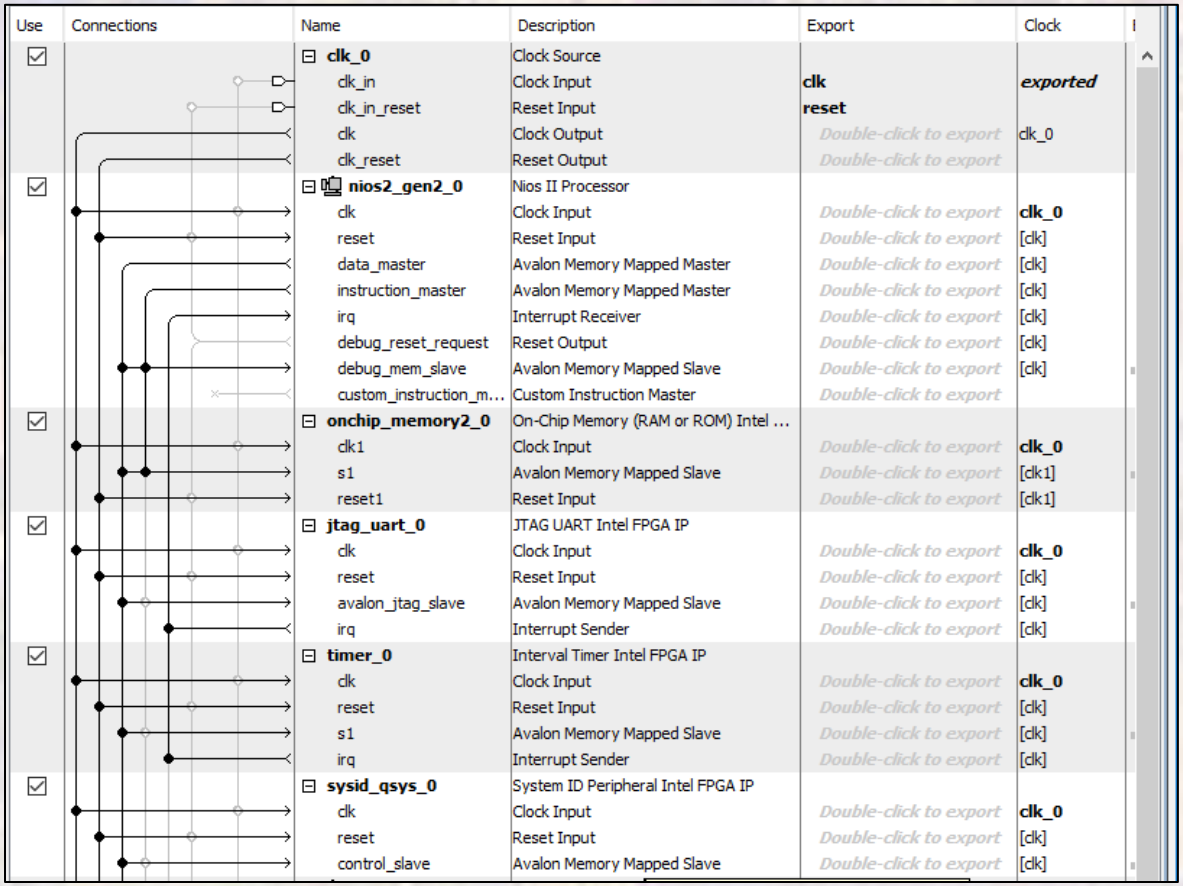
Max10 ADC Example - NIOS

- Nios ADC
  - Create a processor system to use the ADC



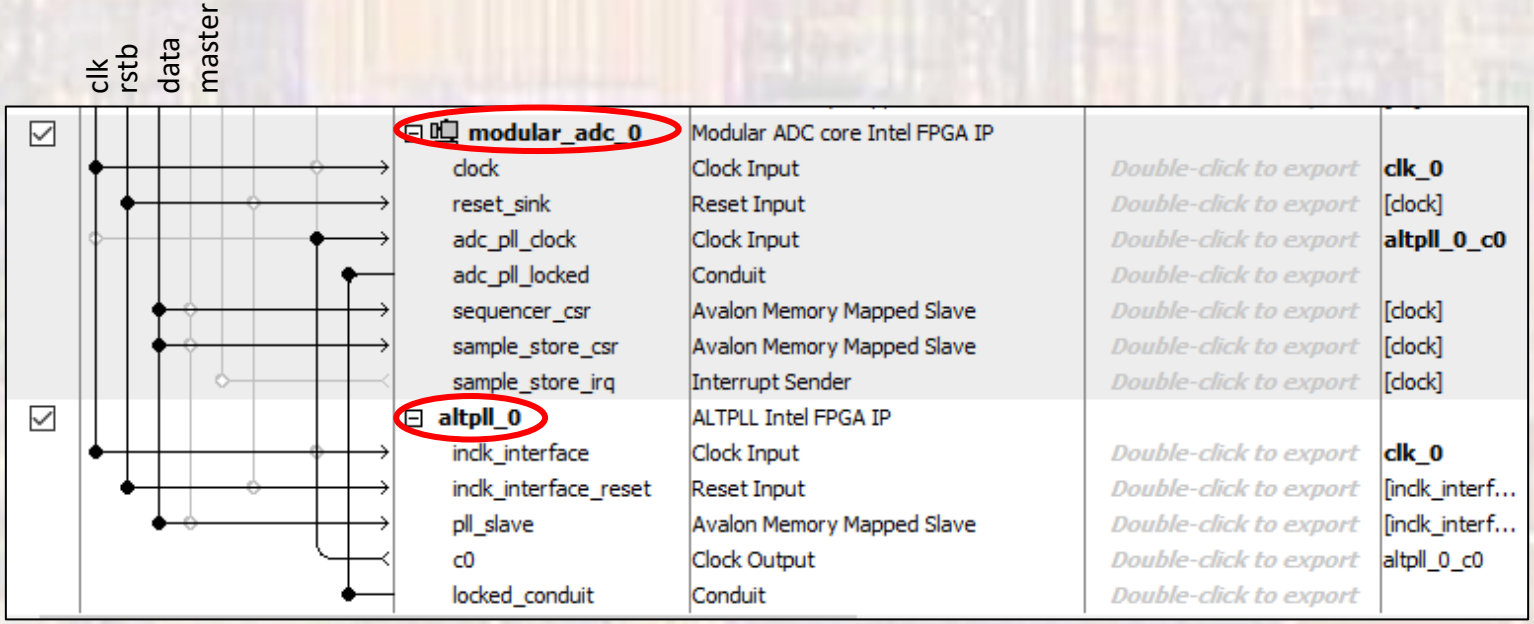
Max10 ADC Example - NIOS

- Nios ADC
  - Create a processor system to use the ADC
    - Basic Processor system



Max10 ADC Example - NIOS

- Nios ADC
  - Create a processor system to use the ADC
    - Modular ADC (see next slide)
      - Requires a locked output from the PLL
    - PLL
      - 10MHz max clk frequency



Max10 ADC Example - NIOS

- Nios ADC
  - ADC Module

Configuration

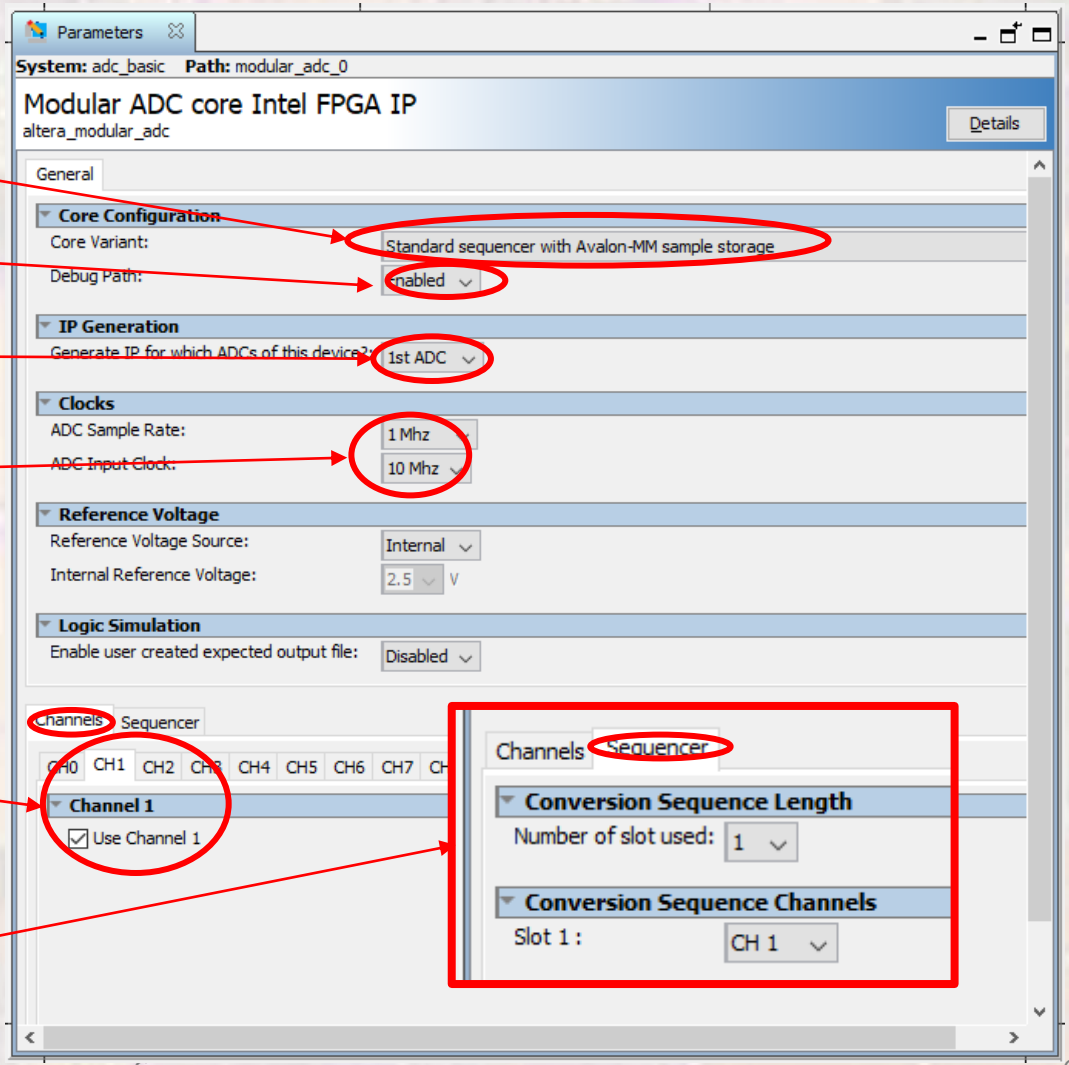
Select Disable

Only ADC1 available on DE10-Lite

Max Sample Rate
Required Clock

Channel 1
Arduino A0 pin

Sequencer Setup



Max10 ADC Example - NIOS

- Nios ADC

```
-------------------------------------
--
-- nios_adc_de10.vhdl
--
-- Created  9/18/18
-- by:      johnsontimoj
-- rev:     0
--
-------------------------------------
--
-- Basic Nios system - with adc
--
-------------------------------------

library ieee;
use ieee.std_logic_1164.all;
use ieee.numeric_std.all;


entity nios_adc_de10 is
   port(
      CLOCK_50 :     in std_logic
   );
end entity;
```

```
architecture behavioral of nios_adc_de10 is

   component nios_adc is
        port (
            clk_clk       : in std_logic := 'X'; -- clk
            reset_reset_n : in std_logic := 'X'  -- reset_n
        );
    end component nios_adc;

 begin

   u0 : component nios_adc
        port map (
            clk_clk       => CLOCK_50,        --   clk.clk
            reset_reset_n => '1'              -- reset.reset_n
        );
end architecture;
```

Note: No pin assignments required for ADC pins

Max10 AD

- Nios ADC
  - system.h

```
/*
 * modular_adc_0_sample_store_csr configuration
 *
 */

#define ALT_MODULE_CLASS_modular_adc_0_sample_store_csr altera_modular_adc
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_BASE 0x11000
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CORE_VARIANT 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_LENGTH 1
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_SLOT_0 "CH1"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_SLOT_1 "CH0"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_SLOT_10 "CH0"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_SLOT_11 "CH0"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_SLOT_12 "CH0"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_SLOT_13 "CH0"
```

```
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_SLOT_62 "CH0"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_SLOT_63 "CH0"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_SLOT_7 "CH0"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_SLOT_8 "CH0"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_SLOT_9 "CH0"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_DUAL_ADC_MODE 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_IRQ -1
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_IRQ_INTERRUPT_CONTROLLER_ID -1
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_IS_THIS_FIRST_OR_SECOND_ADC 1
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_NAME "/dev/modular_adc_0_sample_store_c
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_PRESCALER_CH16 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_PRESCALER_CH8 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_REFSEL "Internal VREF"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_SPAN 512
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_TYPE "altera_modular_adc"
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH0 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH1 1
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH10 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH11 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH12 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH13 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH14 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH15 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH16 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH2 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH3 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH4 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH5 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH6 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH7 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH8 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_CH9 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_USE_TSD 0
#define MODULAR_ADC_0_SAMPLE_STORE_CSR_VREF 2.5
```

Max10 AD

- Nios ADC
  - system.h

```
/*
 * modular_adc_0_sequencer_csr configuration
 *
 */

#define ALT_MODULE_CLASS_modular_adc_0_sequencer_csr altera_modular_adc
#define MODULAR_ADC_0_SEQUENCER_CSR_BASE 0x11230
#define MODULAR_ADC_0_SEQUENCER_CSR_CORE_VARIANT 0
#define MODULAR_ADC_0_SEQUENCER_CSR_CSD_LENGTH 1
#define MODULAR_ADC_0_SEQUENCER_CSR_CSD_SLOT_0 "CH1"
#define MODULAR_ADC_0_SEQUENCER_CSR_CSD_SLOT_1 "CH0"
#define MODULAR_ADC_0_SEQUENCER_CSR_CSD_SLOT_10 "CH0"
#define MODULAR_ADC_0_SEQUENCER_CSR_CSD_SLOT_11 "CH0"
#define MODULAR_ADC_0_SEQUENCER_CSR_CSD_SLOT_12 "CH0"
```

```
#define MODULAR_ADC_0_SEQUENCER_CSR_CSD_SLOT_63 "CH0"
#define MODULAR_ADC_0_SEQUENCER_CSR_CSD_SLOT_7 "CH0"
#define MODULAR_ADC_0_SEQUENCER_CSR_CSD_SLOT_8 "CH0"
#define MODULAR_ADC_0_SEQUENCER_CSR_CSD_SLOT_9 "CH0"
#define MODULAR_ADC_0_SEQUENCER_CSR_DUAL_ADC_MODE 0
#define MODULAR_ADC_0_SEQUENCER_CSR_IRQ -1
#define MODULAR_ADC_0_SEQUENCER_CSR_IRQ_INTERRUPT_CONTROLLER_ID -1
#define MODULAR_ADC_0_SEQUENCER_CSR_IS_THIS_FIRST_OR_SECOND_ADC 1
#define MODULAR_ADC_0_SEQUENCER_CSR_NAME "/dev/modular_adc_0_sequencer_csr"
#define MODULAR_ADC_0_SEQUENCER_CSR_PRESCALER_CH16 0
#define MODULAR_ADC_0_SEQUENCER_CSR_PRESCALER_CH8 0
#define MODULAR_ADC_0_SEQUENCER_CSR_REFSEL "Internal VREF"
#define MODULAR_ADC_0_SEQUENCER_CSR_SPAN 8
#define MODULAR_ADC_0_SEQUENCER_CSR_TYPE "altera_modular_adc"
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH0 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH1 1
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH10 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH11 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH12 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH13 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH14 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH15 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH16 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH2 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH3 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH4 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH5 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH6 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH7 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH8 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_CH9 0
#define MODULAR_ADC_0_SEQUENCER_CSR_USE_TSD 0
#define MODULAR_ADC_0_SEQUENCER_CSR_VREF 2.5
```

Max10 ADC Example - NIOS

- Nios ADC
  - drivers/inc/altera_modular_adc.h

```
typedef struct alt_modular_adc_dev
{
    alt_dev              dev;
    /* Callback routine pointer */
    alt_adc_callback     callback;
    /* Callback context pointer */
    void                 *callback_context;
    /* Base address of the sample store micro core */
    alt_u32              sample_store_base;
   /* Base address of the sequencer micro core */
    alt_u32          sequencer_csr_base;
   /* Dual ADC mode enable status */
    alt_u8               DUAL_ADC_MODE;
} alt_modular_adc_dev;

/*
 * Public APIs
 */
void adc_stop(int sequencer_base);
void adc_start(int sequencer_base);
void adc_set_mode_run_once(int sequencer_base);
void adc_set_mode_run_continuously(int sequencer_base);
void adc_recalibrate(int sequencer_base);
void adc_interrupt_enable(int sample_store_base);
void adc_interrupt_disable(int sample_store_base);
void adc_clear_interrupt_status(int sample_store_base);
void adc_wait_for_interrupt(int sample_store_base);
int adc_interrupt_asserted(int sample_store_base);
alt_modular_adc_dev* altera_modular_adc_open (const char *name);
void alt_adc_register_callback(
    alt_modular_adc_dev *dev,
    alt_adc_callback callback,
    void *context,
    alt_u32 sample_store_base);
int alt_adc_word_read (alt_u32 sample_store_base, alt_u32* source_ptr, alt_u32 len);

void altera_modular_adc_init(alt_modular_adc_dev* dev, alt_32 ic_id, alt_32 irq);
```

sequencer and sample/store bases

start, stop, mode Functions

word_read function

Max10 ADC Example - NIOS

- Nios ADC
  - User program

ADC operates independently – no pointer to structure or 'open' required

```
/*
 * adc1.c
 */
//////////////////////////////////
//
// ADC with NIOS example
//
//////////////////////////////////

#include "alt_types.h"              // to support adc expected types
#include "altera_modular_adc.h"
#include "system.h"
#include <stdio.h>
#include <unistd.h>                 // usleep

//
// Note no Device open required - built into the
// controller ???

int main(void){
    printf("Entered Main\n");
    alt_u32 adc_val;
    float adc_volt;
    int adc_plot_index;
    const char * adc_graph[10] = {"|",
                                  " |",
                                  "  |",
                                  "   |",
                                  "    |",
                                  "     |",
                                  "      |",
                                  "       |",
                                  "        |",
                                  "         |",
                                  };

    // Configure the ADC for single measurements
    // must stop the ADC to change values
    //
    adc_stop(MODULAR_ADC_0_SEQUENCER_CSR_BASE);
    adc_set_mode_run_once(MODULAR_ADC_0_SEQUENCER_CSR_BASE);
```

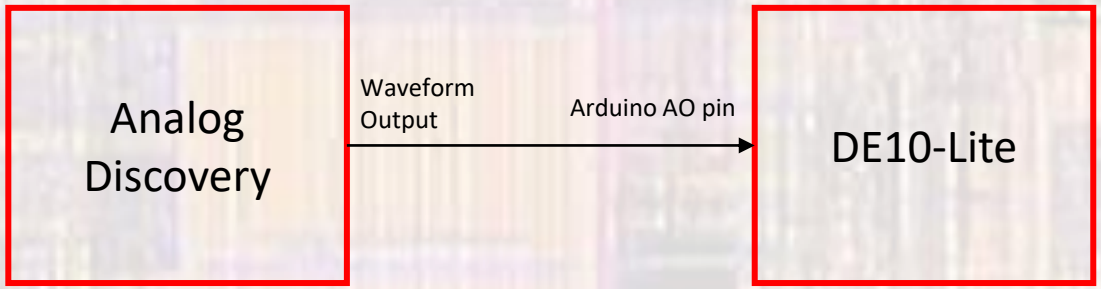
```
    while(1){
        adc_start(MODULAR_ADC_0_SEQUENCER_CSR_BASE);
        usleep(100000);
        alt_adc_word_read(MODULAR_ADC_0_SAMPLE_STORE_CSR_BASE, &adc_val, MODULAR_ADC_0_SAMPLE_STORE_CSR_CSD_LENGTH);

        adc_volt = (float)adc_val * 5.0 / 4096.0;
        adc_plot_index = (int)(adc_volt/0.34);
        printf("adc value = %lu\t adc voltage = %f\t %s\n", adc_val, adc_volt, adc_graph[adc_plot_index]);
    } // end while

  return 0;
} // end main
```

Max10 ADC Example - NIOS

- NIOS ADC
  - Setup



Max10 ADC

- Nios ADC
  - 0.5Hz input

nios_adc_sw Nios II Hardware configuration - cable: USB-Blaster on localhost [USB-0] device ID: 1 insta

```
adc value = 1116      adc voltage = 1.362305
adc value = 572       adc voltage = 0.698242
adc value = 285       adc voltage = 0.347900
adc value = 58        adc voltage = 0.070801
adc value = 49        adc voltage = 0.059814
adc value = 255       adc voltage = 0.311279
adc value = 531       adc voltage = 0.648193
adc value = 1066      adc voltage = 1.301270
adc value = 1478      adc voltage = 1.804199
adc value = 2050      adc voltage = 2.502441
adc value = 2384      adc voltage = 2.910156
adc value = 2698      adc voltage = 3.293457
adc value = 2777      adc voltage = 3.389893
adc value = 2666      adc voltage = 3.254395
adc value = 2445      adc voltage = 2.984619
adc value = 1966      adc voltage = 2.399902
adc value = 1564      adc voltage = 1.909180
adc value = 970       adc voltage = 1.184082
adc value = 599       adc voltage = 0.731201
adc value = 207       adc voltage = 0.252686
adc value = 62        adc voltage = 0.075684
adc value = 76        adc voltage = 0.092773
adc value = 234       adc voltage = 0.285645
adc value = 647       adc voltage = 0.789795
adc value = 1028      adc voltage = 1.254883
adc value = 1621      adc voltage = 1.978760
adc value = 2021      adc voltage = 2.467041
adc value = 2480      adc voltage = 3.027344
adc value = 2685      adc voltage = 3.277588
adc value = 2772      adc voltage = 3.383789
adc value = 2681      adc voltage = 3.272705
adc value = 2346      adc voltage = 2.863770
adc value = 2004      adc voltage = 2.446289
adc value = 1424      adc voltage = 1.738281
adc value = 1015      adc voltage = 1.239014
adc value = 493       adc voltage = 0.601807
adc value = 229       adc voltage = 0.279541
```

Max10 ADC Example - NIOS

- DE10-Lite – ADC WARNINGS
  - Only ADC1 is brought out to pins
    - No access to ADC2 inputs from the FPGA pins
  - The pin #s are shifted
    - Arduino A0 is mapped to ADC1_in1

      …
    - Arduino A5 is mapped to ADC1_in6
  - No other ADC inputs are pinned out