EE2401 ANALOG LAB

DIGITAL SIGNAL PROCESSOR

DATA ACQUISITION AND PROCESSING

Teammates

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OVERVIEW

01 What is DSP?	02 IC- DSPIC30F2020	03 Electrical Characteristics
04 DSP Evaluation Board-DM300014	05 Checklist & UART	06 MPLAB IDE

WHAT IS A DSP?

A digital signal processor (DSP) is a specialized microprocessor chip, with its architecture optimized for the operational needs of digital signal processing, which is generally used to process real time data. DSP is the application of the mathematical operations to digitally represent signals.

In a digital oscilloscope, a Digital Signal Processor (DSP) plays a crucial role in processing and analyzing the signals.

FUNCTIONS OF DSP

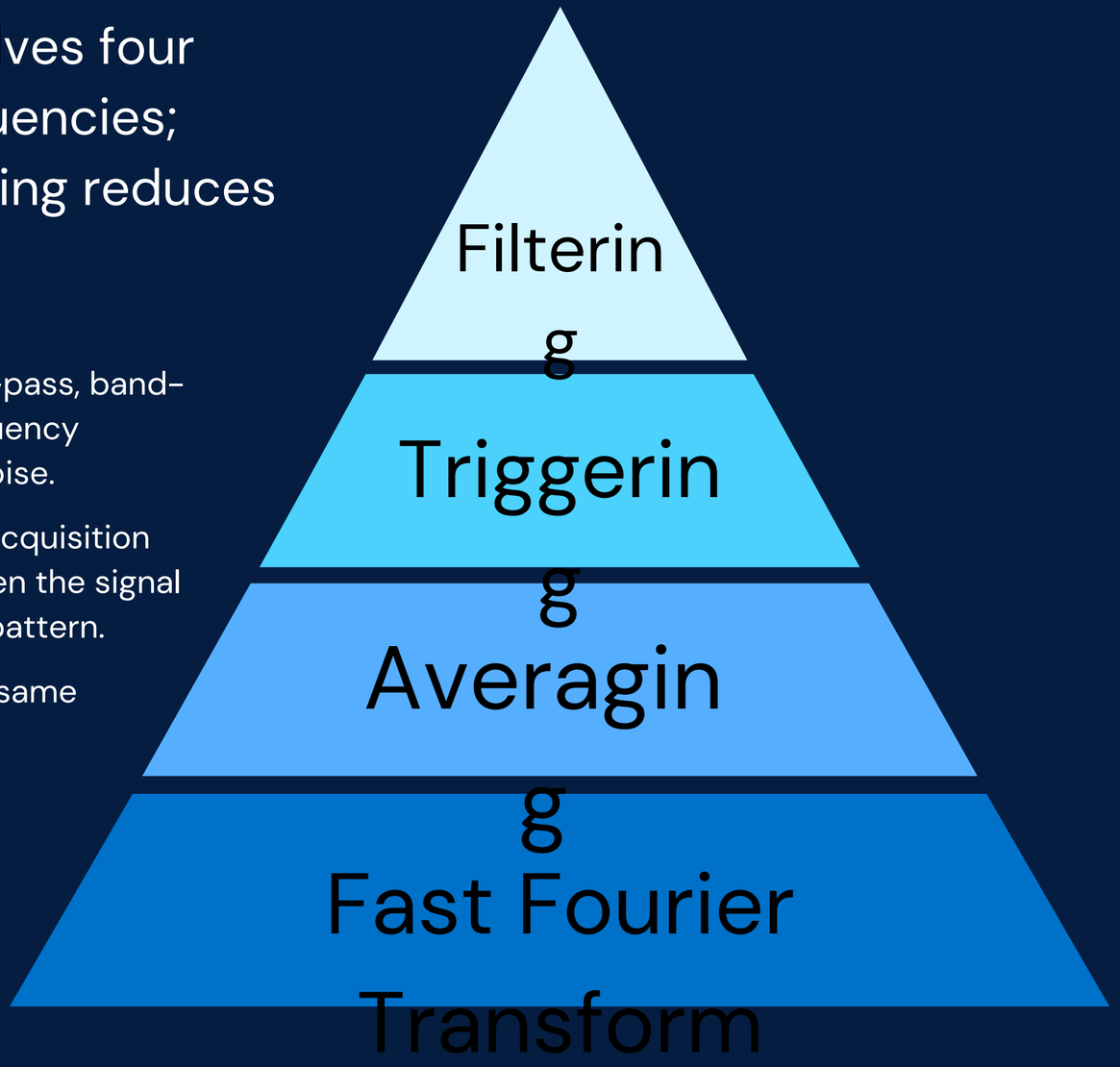
Digital signal processing in oscilloscopes involves four main functions: Filtering isolates desired frequencies; triggering synchronizes signal capture; averaging reduces noise; FFT analyzes signal frequency content.

01 Filtering: Different types of filters (low-pass, high-pass, band-pass, etc.) can be applied to isolate specific frequency components of the signal or remove unwanted noise.

02 Triggering: It allows the oscilloscope to start the acquisition process when certain conditions are met, like when the signal crosses a voltage threshold or follows a specific pattern.

03 Averaging: Averaging multiple acquisitions of the same signal helps reduce noise and provide a clearer representation of the signal.

04 FFT: Fast Fourier Transform converts the time-domain signal into its frequency-domain representation, which allows analysis of the signal's frequency components.



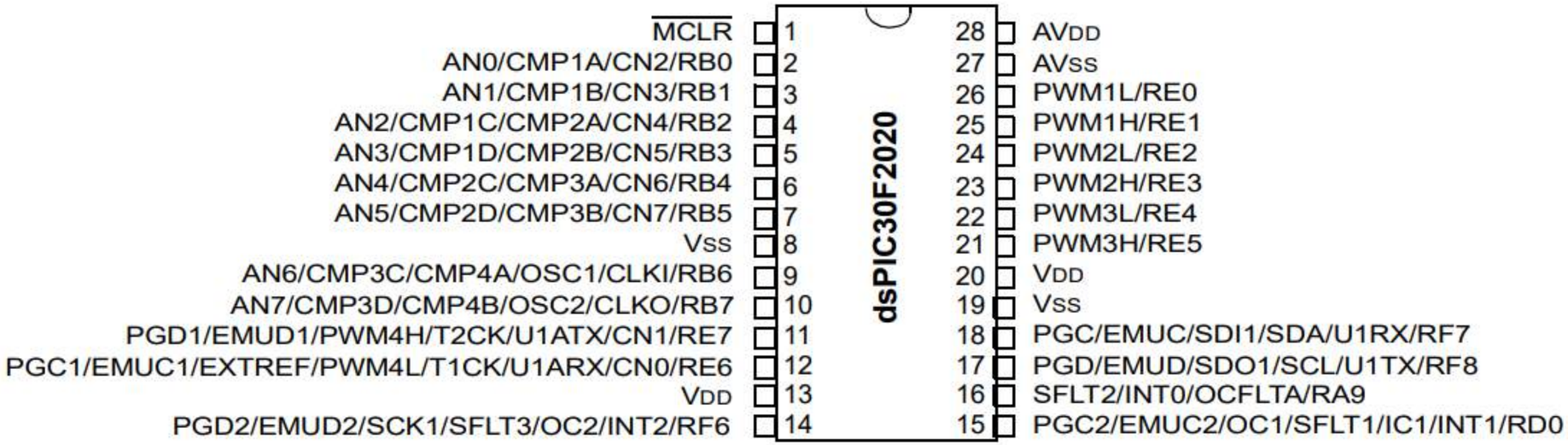
IC - DSPIC30F2020

It is a 16-bit Digital Signal Controller (DSC) from Microchip Technology. It has a set of peripherals, including analog-to-digital converters (ADC), digital I/O, timers, UART, SPI, I2C, high performance CPU, PWM (Pulse-Width Modulation), etc. Microchip provides peripheral libraries that simplify the process of configuring and using the various peripherals of the dsPIC30F2020. These libraries can help us write code more efficiently. The microcontroller allows to implement most of it without external circuitry - controller, memory, sample logic, ADC, trigger and trigger level control all reside within a single chip. This makes the design very compact, inexpensive, and easy to build. It has program memory of 12 KBytes, 512 Bytes Data SRAM.

IC - dsPIC30F2020

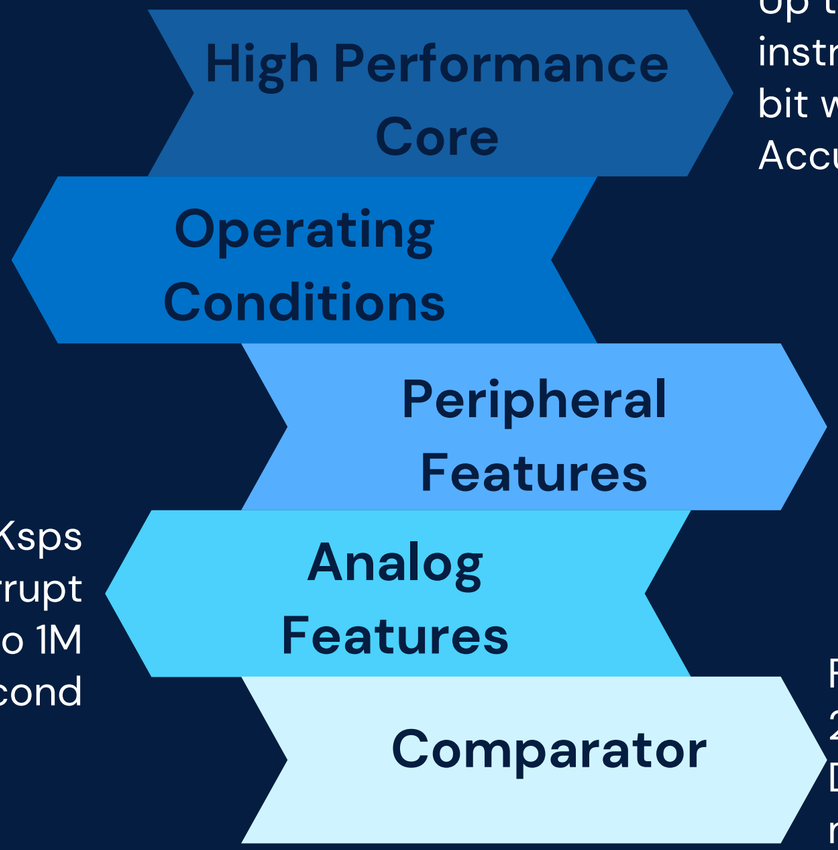
Datasheet: Link

28-Pin SDIP and SOIC



A brief description of device I/O pinouts for the dsPIC30F2020 and the block diagram: Link

Features of dsPIC30F2020



Up to 30 MIPS operation, 24-bit wide instructions, 16-bit wide data path, Two 40-bit wide accumulators, Single-cycle Multiply-Accumulate (MAC) operation

Low-power, high-speed Flash (DC to 30MIPS) technology, 3.3V and 5.0V operation (±10%), Industrial and Extended temperature ranges of -40°C to 125°C

High-current sink/source I/O pins: 25 mA/25 mA, Three 16-bit timers, Four 16-bit Capture input functions, Two 16-bit Compare/PWM output functions

10- bit ADC with 2000 Ksps conversion rate, Interrupt hardware supports up to 1M interrupts per second

Four Analog Comparators with 20 ns response time and 10-bit DAC reference generator, PWM module interface with Duty Cycle Control, Period Control and Fault Detect

ELECTRICAL CHARACTERISTICS OF DSPIC30F2020

Absolute Maximum Ratings

Ambient Temperature under bias: -40°C to +125°C
Storage Temperature: -65°C to +150°C
Voltage on any pin wrt VSS (except VDD): -0.3V to (VDD+0.3V)
Voltage on VDD wrt VSS: -0.3V to +5.5V
Maximum Current out of VSS: 300 mA
Maximum current out of VDD: 300 mA
I/O clamp current: +/- 20 mA
Maximum output current sunk or sourced by any I/O: 25 mA
Maximum current sunk or sourced by all ports: 200 mA

Standard Operating Conidtion:

Voltage: 3.3V and 5.0V (+/-10%)
Industrial Temperature: -40° C to +85° C
Extended Temperature: -40° C to +125 °C

Pin-wise Max Operating Current

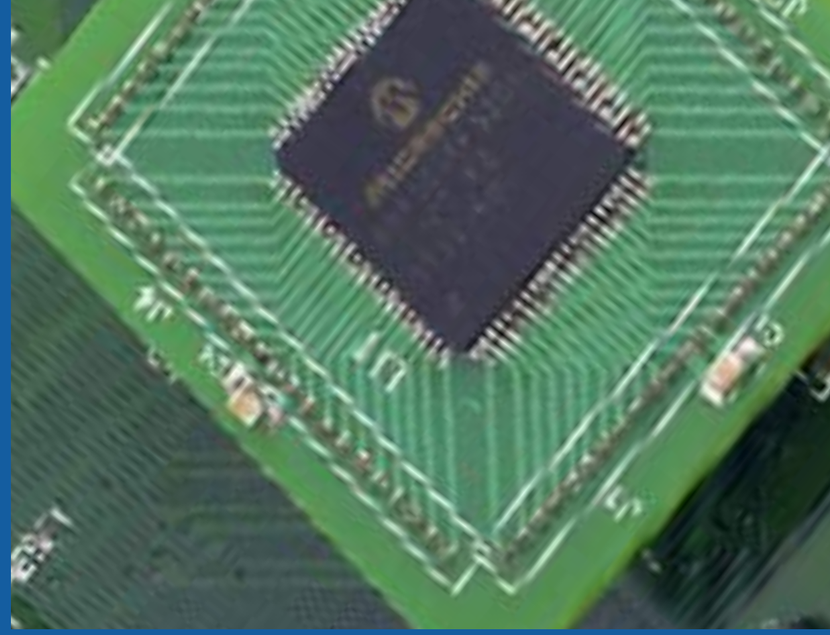
DC CHARACTERISTICS			Standard Operating Conditions: 3.3V and 5.0V (±10%) (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended			
Parameter No.	Typical(1)	Max	Units	Conditions		
Operating Current (IDD)(2)						
DC20a	13	16	mA	+25°C	3.3V	FRC 3.2 MIPS, PLL disabled
DC20b	14	16	mA	+85°C		
DC20c	14	17	mA	+125°C		
DC20d	22	26	mA	+25°C	5V	
DC20e	22	26	mA	+85°C		
DC20f	22	27	mA	+125°C		
DC22a	19	22	mA	+25°C	3.3V	FRC, 4.9 MIPS, PLL disabled
DC22b	19	23	mA	+85°C		
DC22c	19	23	mA	+125°C		
DC22d	30	36	mA	+25°C	5V	
DC22e	30	37	mA	+85°C		
DC22f	31	37	mA	+125°C		
DC23a	27	33	mA	+25°C	3.3V	FRC, 7.3 MIPS, PLL disabled
DC23b	28	33	mA	+85°C		
DC23c	28	34	mA	+125°C		
DC23d	44	53	mA	+25°C	5V	
DC23e	45	53	mA	+85°C		
DC23f	45	54	mA	+125°C		
DC24a	66	79	mA	+25°C	3.3V	FRC 13 MIPS, PLL enabled
DC24b	67	80	mA	+85°C		
DC24c	68	81	mA	+125°C		
DC24d	108	129	mA	+25°C	5V	
DC24e	109	130	mA	+85°C		
DC24f	110	131	mA	+125°C		
DC26a	98	118	mA	+25°C	3.3V	FRC 20 MIPS, PLL enabled
DC26b	99	118	mA	+85°C		
DC26d	159	191	mA	+25°C	5V	
DC26e	160	192	mA	+85°C		
DC26f	161	193	mA	+125°C		
DC27d	222	267	mA	+25°C	5V	FRC, 30 MIPS, PLL enabled
DC27e	223	267	mA	+85°C		

DSP EVALUATION BOARD

The evaluation board typically provides a platform for prototyping and testing applications using the dsPIC30F2020. It includes the microcontroller, necessary support components like voltage regulators, crystal oscillator, connectors for peripherals and I/O, and often additional features like analog signal conditioning circuits.

The evaluation board being used is DM300014.
Datasheet for DM300014: Link

More on Evaluation Board..



The Development Board Contains

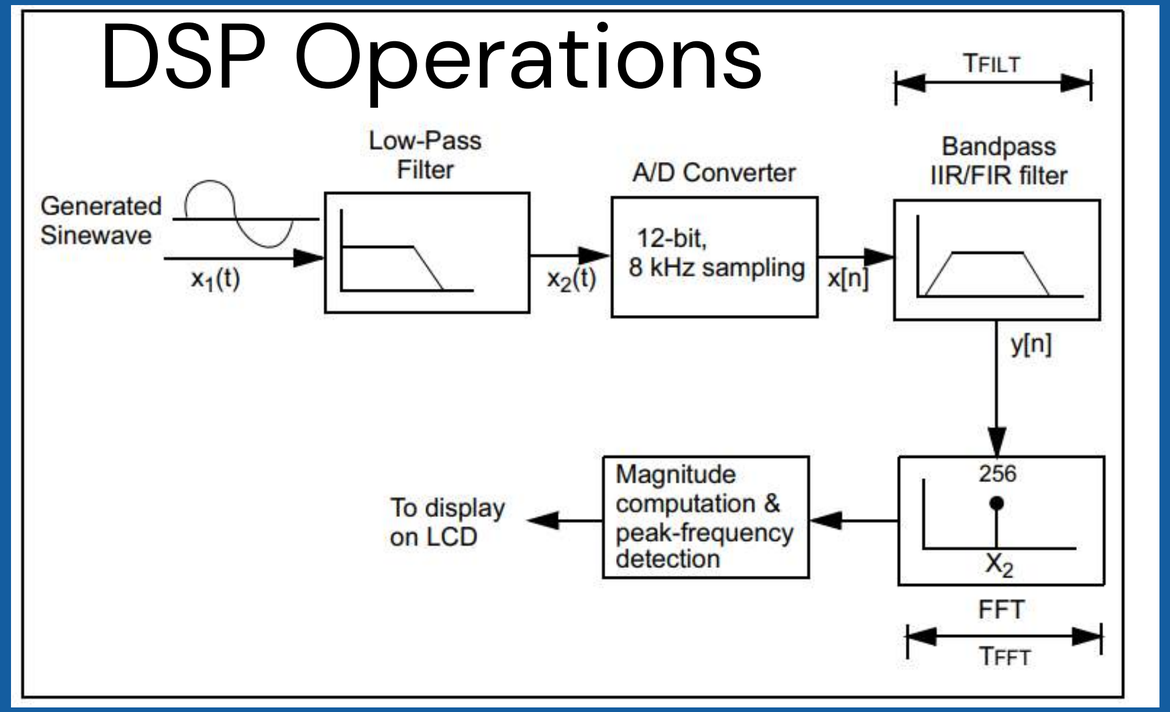
- The dsPICDEM 1.1 Printed Circuit Board
- Preprogrammed dsPIC30F6014 Plug-in Module
- 9V DC Power Supply
- RS-232 Interface Cable
- dsPICDEM 1.1 Development Board Kit CD containing demonstration programs

Demonstration Modes

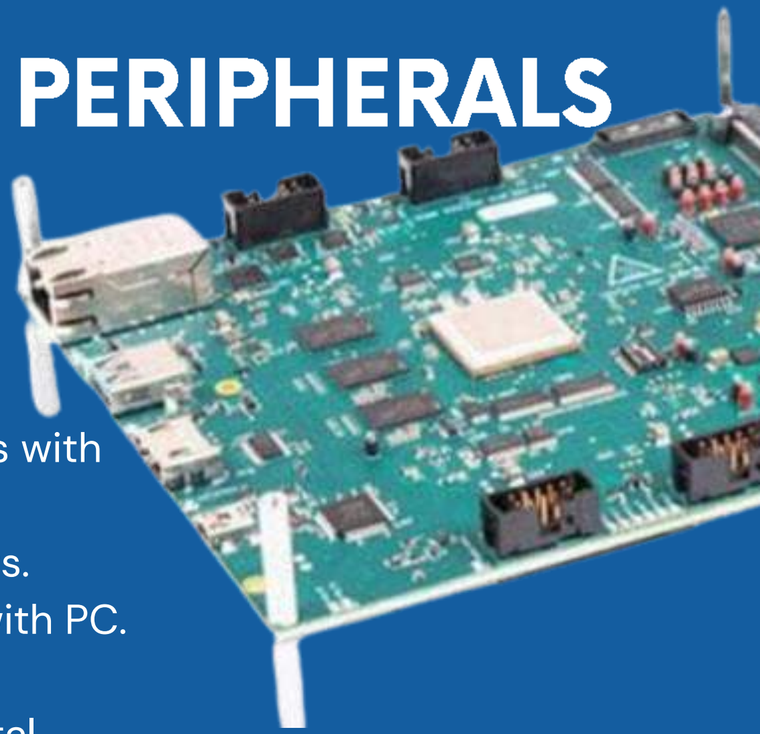
- Data Acquisition Display mode
- Digital Signal Processing (DSP) Operations mode
- Dual Tone Multi-Frequency (DTMF) Generation mode

Digital Filtering Options

- None
- Infinite Impulse Response (IIR)
- Finite Impulse Response (FIR)



DSPIC30F MCU/DSP FEATURES AND PERIPHERALS



MCU/DSP Features

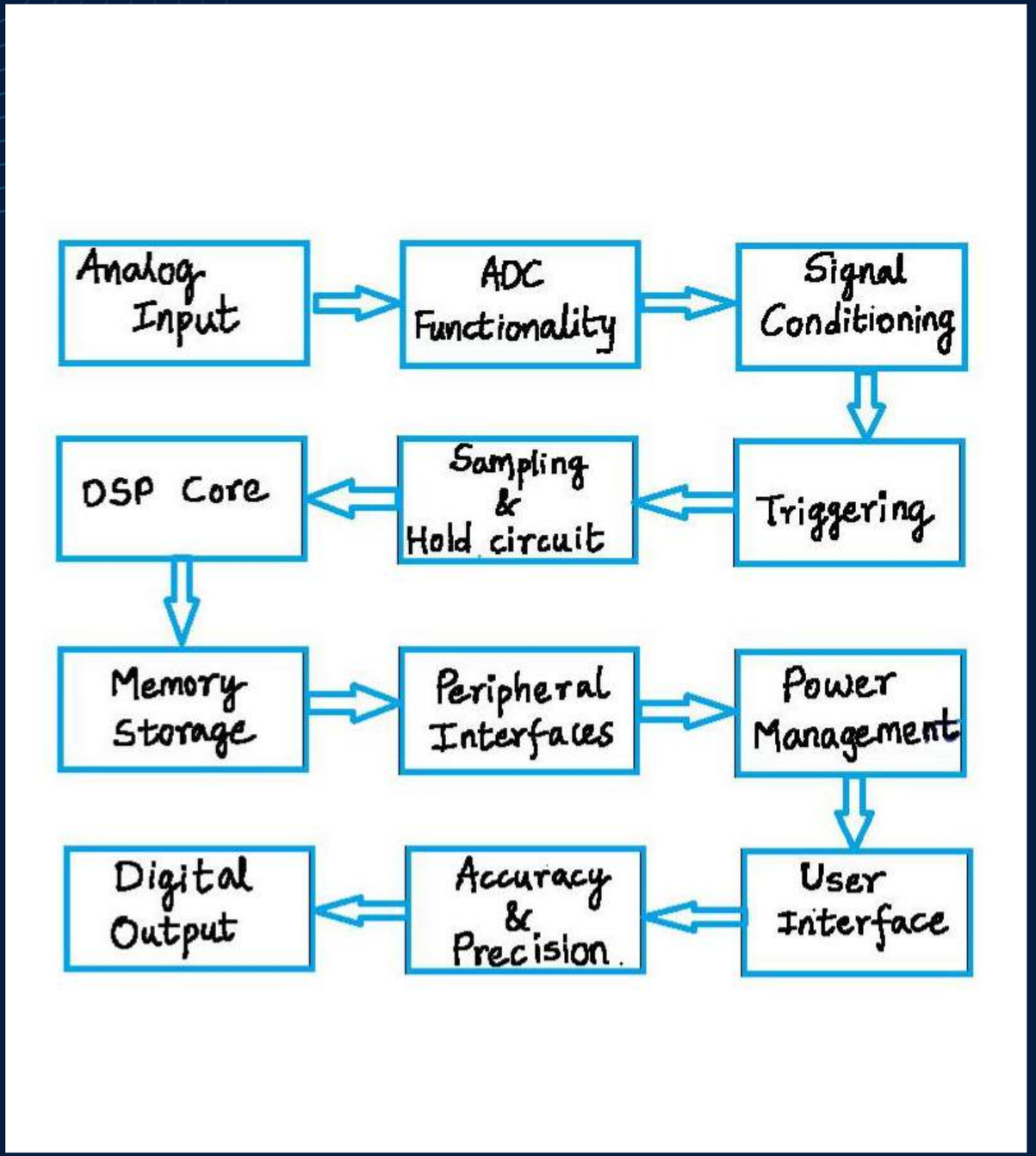
- DSP Engine:
  - 40-bit accumulators with Saturation, Overflow, and Rounding modes.
  - Multiply-and-Accumulate (MAC) instructions.
- Bit-Reversed Addressing for 256-point FFT input data.
- Modulo Addressing for circular array access.
- Hardware Loop instructions for efficient repetitive execution.
- Program Space Visibility (PSV) for accessing large tables from program memory.

Demo Peripherals

- Timer1: 16-bit timer.
- Timer2 and Timer3: 16-bit timers with 256:1 prescaler.
- Timer4 and Timer5: 32-bit timers.
- UART2 TX/RX: Communication with PC.
- SPI 2: Communication with Addressable-Pixel LCD and digital potentiometer.
- 12-bit ADC: Conversion of analog signals.
- Data Converter Interface: Interface with Si3000 voice-band Codec.
- INTx pins: Switch inputs detection.
- Hierarchical/Prioritized Interrupt Control with nesting enabled.

Checklist for Evaluating DSP Board Functionality

- **Analog Input:** Verify the ability to take analog input signals from external sources through appropriate interfaces.
- **ADC functionality:** Ensure proper operation of the Analog-to-Digital Converter (ADC) for digitizing analog signals with adequate resolution and sampling rate.
- **Signal Conditioning:** Test various circuits like amplifiers, filters to prepare analog signals for digitization.
- **Triggering:** Verify the triggering mechanism to capture signals at specific instances based on user-defined trigger conditions.
- **Sampling and Hold Circuit:** Check the functionality of the sampling and hold circuit to accurately sample analog signals and maintain the sampled value during conversion.
- **DSP Core:** Evaluate the DSP core's ability to execute signal processing algorithms such as filtering (e.g., low-pass, high-pass), averaging, and Fast Fourier Transform (FFT) for spectral analysis.
- **Digital Output:** Verify the ability to display processed signals on an LCD screen or output them via USB for further analysis using PC software.
- **Accuracy & Precision:** Validate the accuracy and precision of signal acquisition, processing, and display to ensure reliable operation in various measurement scenarios.



Send/Receive Data From UART in dsPIC30F

UART(Universal Asynchronous Receiver Transmitter) is the most commonly used communication protocol in micro-controllers due to its simplicity, easy implementation, and minimum hardware requirements.

We provide +9V power supply to DsPIC30F4011 Development Board; the serial cable is connected between the DsPIC30F4011 Development Board and PC. Then, we open the Hyper Terminal screen, select the required port and set the default settings.
If the UART is working properly, the screen should show some text messages.

Example Code to Send Data Through UART

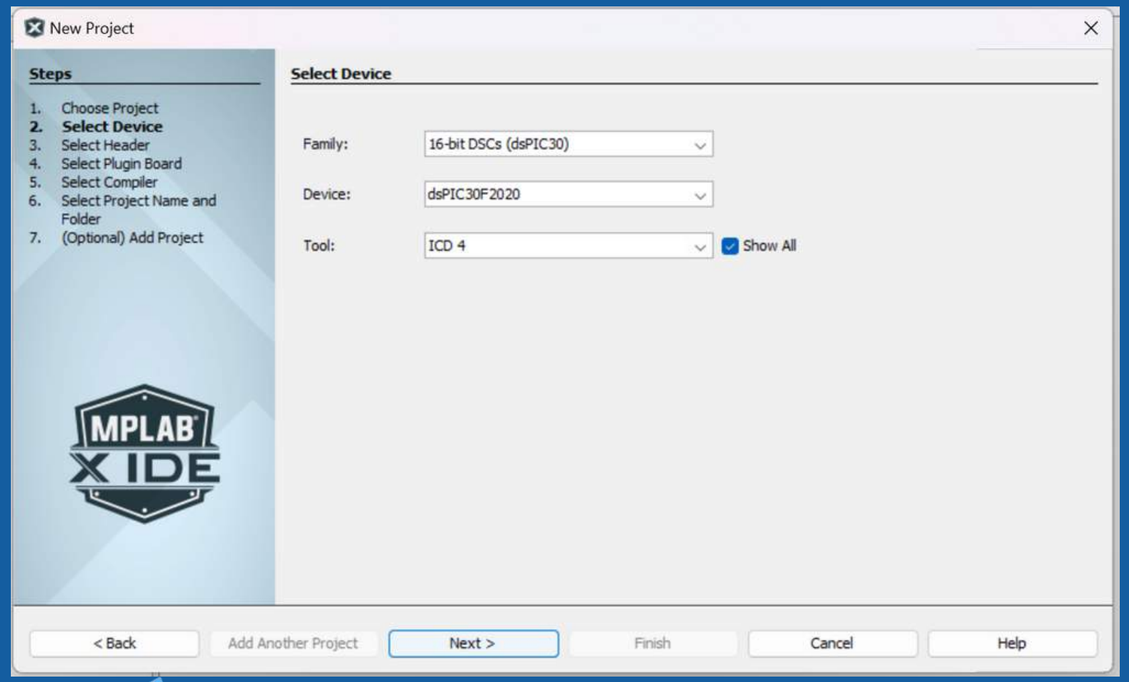
```
#define FCY 30000000

#include <xc.h>
#include <stdio.h>
#include <delay.h>
#include <libpic30.h>
#include <math.h>
#include <p30F4011.h>



_FOSC(CSW_FSCM_OFF & FRC_PLL16);  // Fosc=16x7.5MHz, i.e. 30 MIPS
_FWDT(WDT_OFF);                   // Watchdog timer off
_FBORPOR(MCLR_DIS);
```

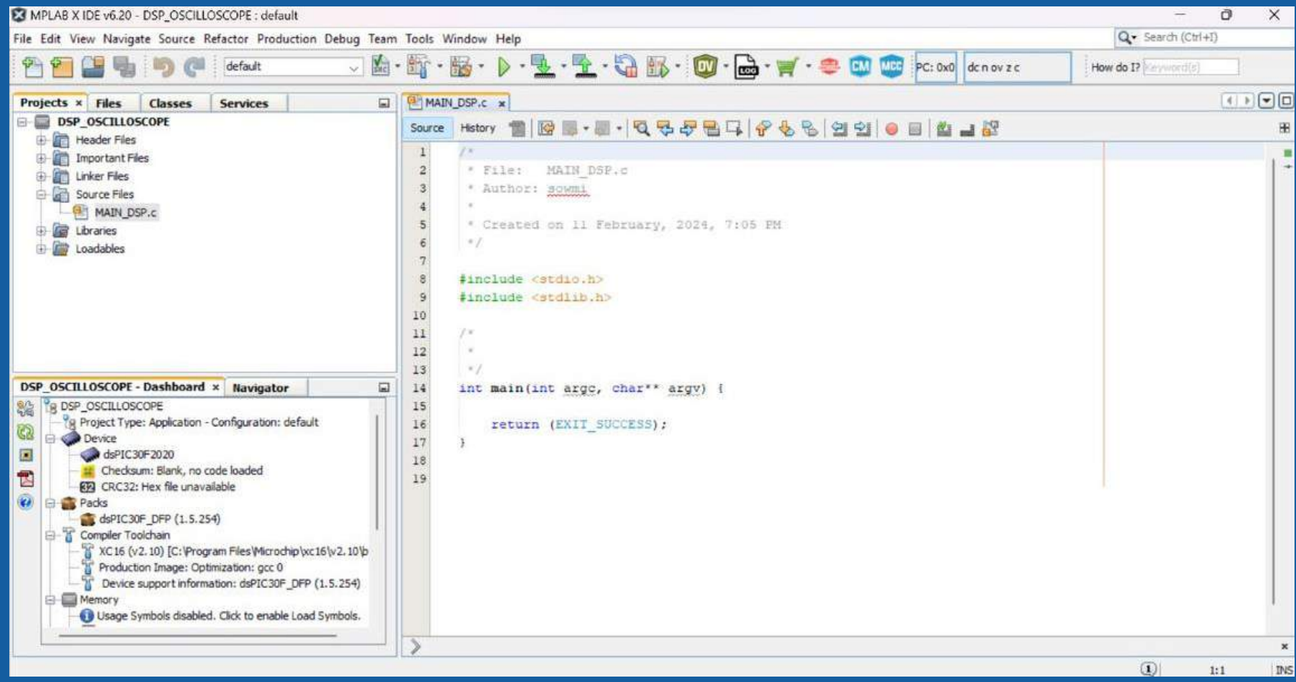
```
_FOSC(CSW_FSCM_OFF & FRC_PLL16);  // Fosc=16x7.5MHz, i.e. 30 MIPS
_FWDT(WDT_OFF);                   // Watchdog timer off
_FBORPOR(MCLR_DIS);

void UART_Init ( void )
{
    _TRISF3 = 0;            //Look for the exact TX/RX pins of your pic device
    _TRISF2 = 1;            //TX pin must be set as output port and RX input


    U1BRG = 7;              // 115000 baud rate @ 30 MIPS
    U1MODEbits.UARTEN = 1; // Enable UART
}
```

```
int main( void )
{
    UART_Init();

    while( 1 )
    {
        //To print a variable
        sprintf(array,"%d",variable);
        printf(array);
        printf("\r\n");

        //To print text
        printf("Greetings from Pakistan\r\n");

        __delay_ms(1000);
    }
}
```

MPLAB IDE COMPILER

The evaluation board DM300014 is compatible with MPLAB IDE

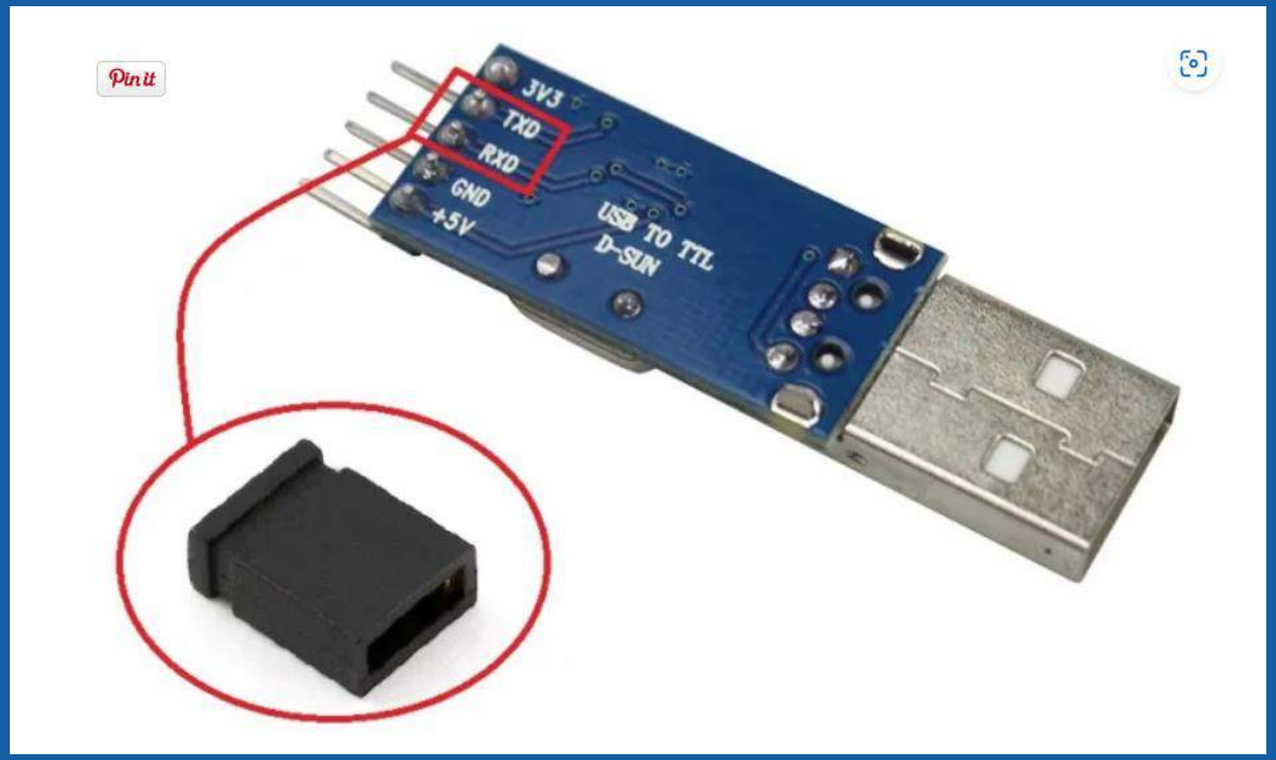




There are 4 steps in this:

1) Create a project in MP LAB IDE
2) Assemble and link the code
3) Program the chip with MPLAB ICD
4) Debug the code with MPLAB ICD

MPLAB ICD need to be powered and connected to your PC



ICD (Incircuit Debugger)
Connector

Thank you!