2016

Project I: Signal Pulse Period Determination

EE663: REAL TIME AND EMBEDDED SYSTEMS

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Project Requirement

The project requirement specifies the design and implementation of a program that measures the period of one thousand pulses and displays the distribution of the measured pulse periods of the signals. The inter-arrival time between the edges is expected to average around 1000 µs, but the inter-arrival times could be distributed between 950 µs and 1050 µs. When the program is invoked, the user would have to be prompted to start measurement. Once the user enters an input, the inter-arrival times between 1000 edges is measured and the values starting from the lowest measured time period is displayed with the number of occurrences of the period within the 1000 pulses. Time periods which do not occur in the measurements should not be displayed. The project also specifies the below additional requirements:

- At least one relevant POST (**P**ower **O**n **S**elf-**T**est) routine must be present at the start of the program. It should perform the necessary diagnosis of at least some the used hardware and software systems.

- The program should operate in an infinite loop in this fashion until interrupted or killed by the user. The User would have to be ideally prompted to start measurement of new data. The user can be given the option to terminate the program once necessary measurements are completed.

Overview

The project requires the understanding and usage of timers, interrupt controllers, IO port configuration and general coding guidelines to successfully implement the project. The execution of the project can be sub-divided into major phases:

1. Identifying the registers controlling the DIO port configuration, and providing the necessary values to configure the selected port as a Positive Edge detecting Digital Input Port.

2. The functionality which is executed, when an edge is detected (Interrupt Service Routine) has to be designed and implemented and mapped in the vector table to the address indicated for the corresponding interrupt.

3. A Timer is used to determine the physical time period between two events in real time. The timer function should be configured and initialized with suitable values so that the difference between its values at different times can be directly related to physical time elapsed between the events.

4. The system is assumed to be always connected to the signal source. Hence absence of the signal would indicate an error in the interfacing between the signal source and the system. The implemented POST routine, would monitor the occurrence of an interrupt for a given time from the start of program.

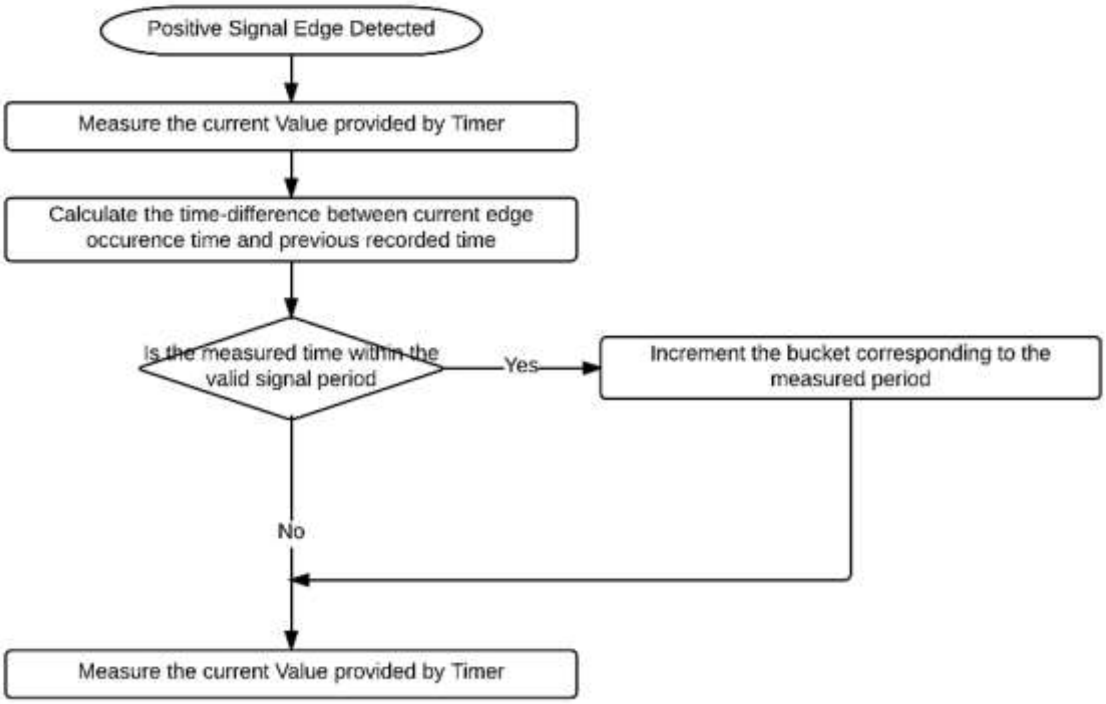
5. The user is prompted, to confirm if he would like to repeat the measurements, once a set of measurements are performed. As long as the user responds affirmatively the system measures the received signal infinite number of times. The only way to terminate the system would be by user prompt or by program termination through the hardware control interface.

Areas of Focus

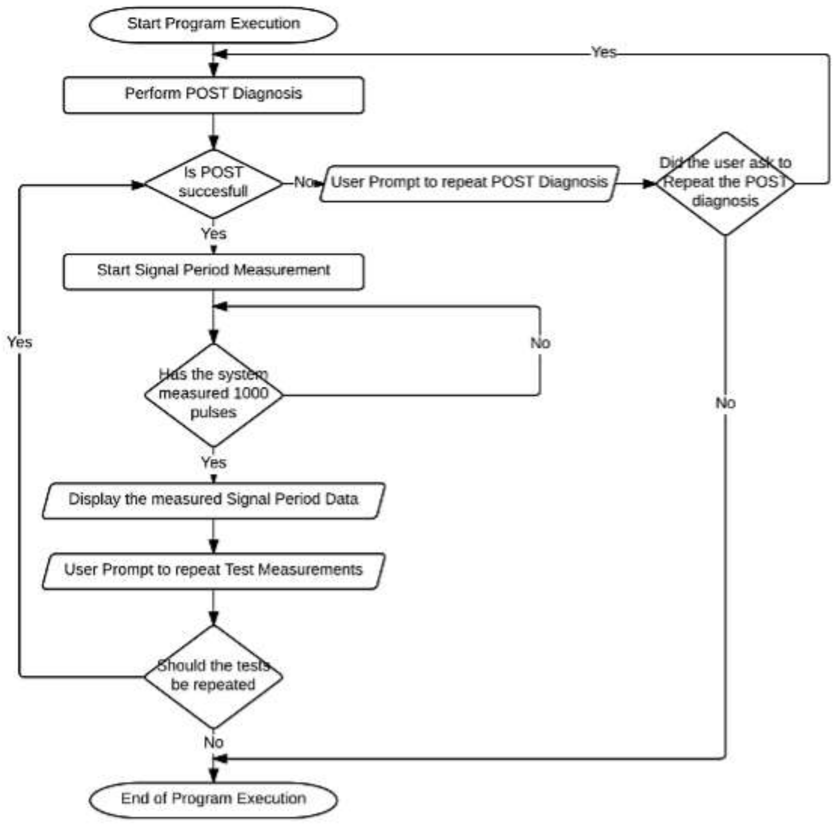
1. Hardware : Vyoma Sharma
    - Timer
    - Interrupts (Assisted by Siddharth Ramkrishnan)
    - IO Port configuration
2. Software : Siddharth Ramkrishnan
    - ISR configuration and mapping
    - Program logic determination
    - Software coding and control flow analysis (assisted by Vyoma Sharma)

Analysis / Design

Interrupt Service Routine



Main Program Execution



Hardware Connection Overview

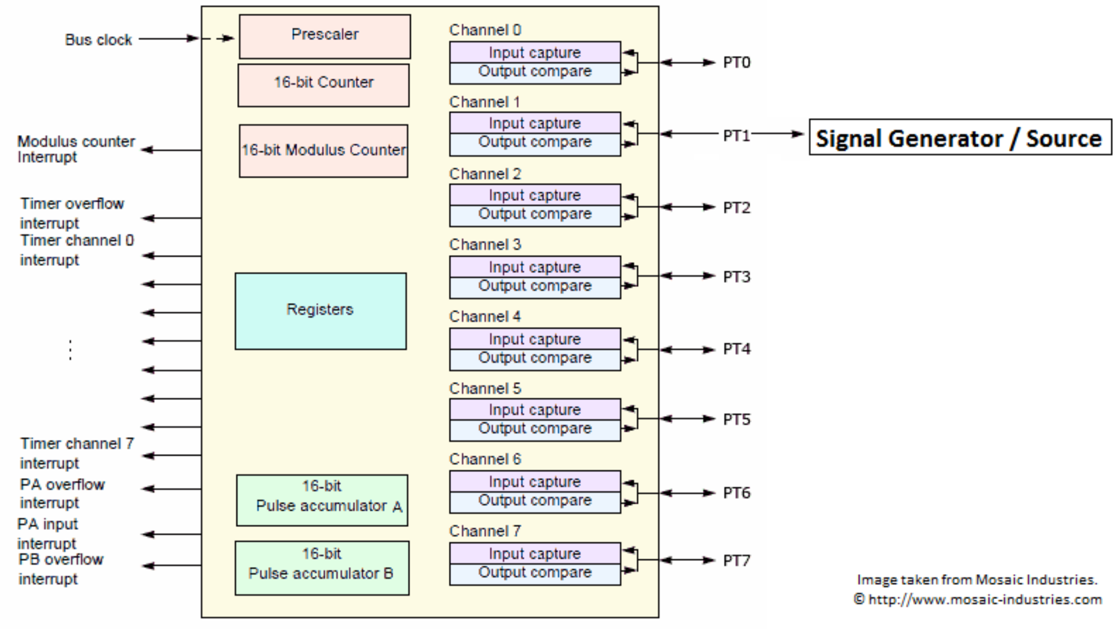


Figure 3. Overview of Hardware Architecture [1]

J1- Pin 15 (PT1/IOC1) on the Freescale board is configured for input capture mode and trigger its interrupt at the positive edge of the signal at the DIO port.

The Interrupt then reads the current timer value and determines the inter-arrival time since the last detected edge. If the detected time period is valid, then the corresponding bucket is updated.

The MAIN () program performs the POST diagnosis and initializes the system to capture signal timing data and monitors if sufficient signal pulses have been captured. Once sufficient pulses have been received the data is displayed and prompts the user to check if measurement has to be repeated.

Test Plan

Power On Self-Test:

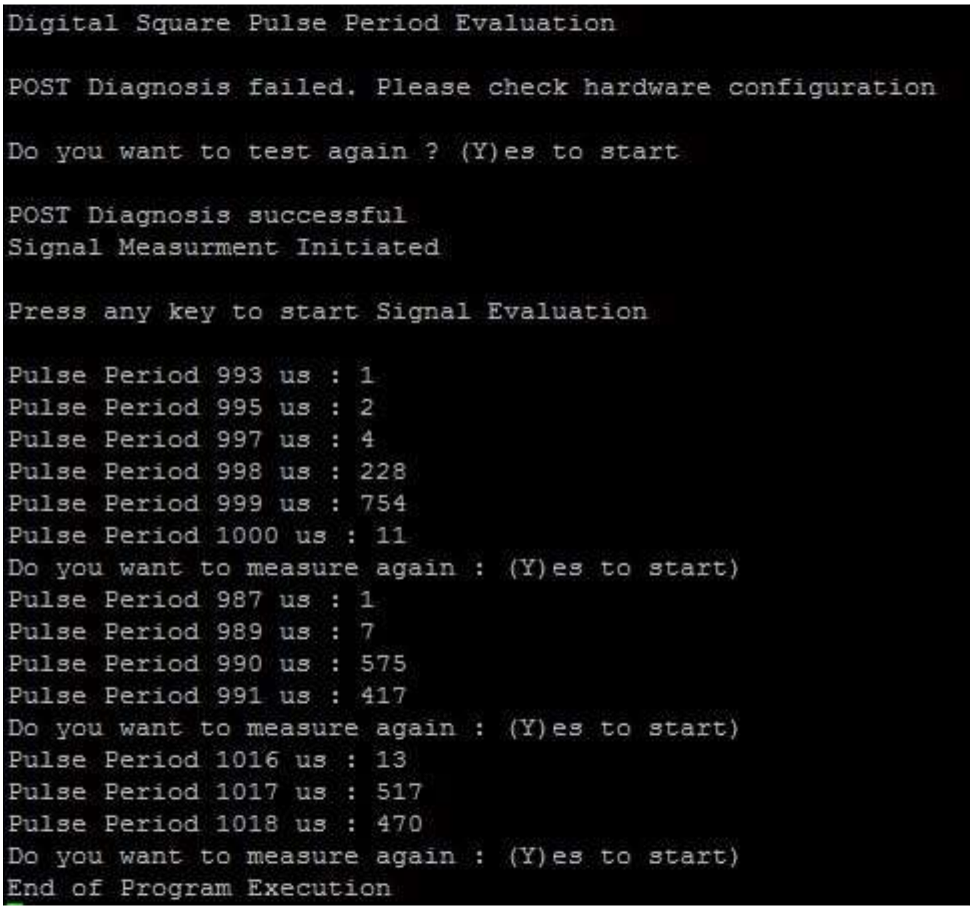
POST is used to diagnose the system at the start of program. The system waits for a calibrated time period; to detect if an interrupt occurs. If no interrupt is detected with the calibrated time the POST status is determined to be successful. If no interrupt is detected within the time, POST determines an error is present in that hardware configuration. The user is prompted to repeat the POST diagnosis in case of failure.

Signal pulse period test:

The tests are performed, by starting the program without a working signal source. The software detects that no signal is present and displays system Error and prompts the user to repeat the tests repeatedly until a successful POST is obtained. Signal measurement is not permitted until a valid POST diagnosis is performed.

Once the POST Diagnosis has been successfully performed, the user is prompted to start signal measurement. For the purpose of tests, a signal generator of known frequency is connected to the system and measured period distribution is compared to the expected signal period determined from signal frequency. The test is repeated for different frequencies and the change in the mode signal period is noted.

Project Results:



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Digital Square Pulse Period Evaluation

POST Diagnosis failed. Please check hardware configuration

Do you want to test again ? (Y)es to start

POST Diagnosis successful
Signal Measurment Initiated

Press any key to start Signal Evaluation

Pulse Period 993 us : 1
Pulse Period 995 us : 2
Pulse Period 997 us : 4
Pulse Period 998 us : 228
Pulse Period 999 us : 754
Pulse Period 1000 us : 11
Do you want to measure again : (Y)es to start)
Pulse Period 987 us : 1
Pulse Period 989 us : 7
Pulse Period 990 us : 575
Pulse Period 991 us : 417
Do you want to measure again : (Y)es to start)
Pulse Period 1016 us : 13
Pulse Period 1017 us : 517
Pulse Period 1018 us : 470
Do you want to measure again : (Y)es to start)
End of Program Execution
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- The program execution is initiated without an active signal generation source. Hence no interrupt is detected. The system detects this as a POST error and prompts the user to repeat the POST tests. The failed POST tests are depicted to indicate the need of a passed test to initiate signal period measurement.

- The valid signal measurement is performed with the signal generator frequency centred at 1 kHz. It is evident that the measured signal period corresponds to the expected time period determined from the signal frequency.

- The test is repeated for different signal frequencies and the shift in the mode signal period is noted.

Lessons Learned:

- The first tutorial provided us, all the necessary basics to successfully implement project 1. There were significant learnings from the tutorial regarding the use of timers, serial communication and interfacing between PC and the embedded system board.

- One of the major learnings of this project was the interfacing between the hardware and the software. There was very little reference available online for the specific code warrior package for HCS12 hardware setup. We finally learnt that most of the interrupt mapping is done by the software suite, with the user only having to specify an index corresponding to the configured interrupt.