TB3134

16-Bit Multiplication and Addition by using the Math Accelerator Peripheral on PIC16(L)F161X

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INTRODUCTION

Several products in the PIC® device family have a Math Accelerator module to do a 16-bit multiplication and addition in hardware. This technical brief describes briefly how the module works, how to use this module in users' applications, and what is important to observe.

BASIC PRINCIPLE

The PID module in some of the PIC16(L)F161X family devices is also known as the Math Accelerator module. When the MODE<2:0> bits of the PIDxCON register are equal to '000', '001', '010', or '011', the module is in Add and Multiply mode. The data flow for the multiply and add operation is shown in Figure 1.

Since the Math Accelerator shares the registers with the PID module, all the names are related to PID control. As shown in Figure 1, PIDxIN and PIDxSET are the two inputs to the adder. The result of the adder and PIDxK1 are the inputs of the multiplier. There is an adder which adds up to itself to do the accumulation of the output. The result of the calculation is stored in PIDxOUT.

The output equation is shown below:

$$OUTPUT = (A + B) \bullet C$$

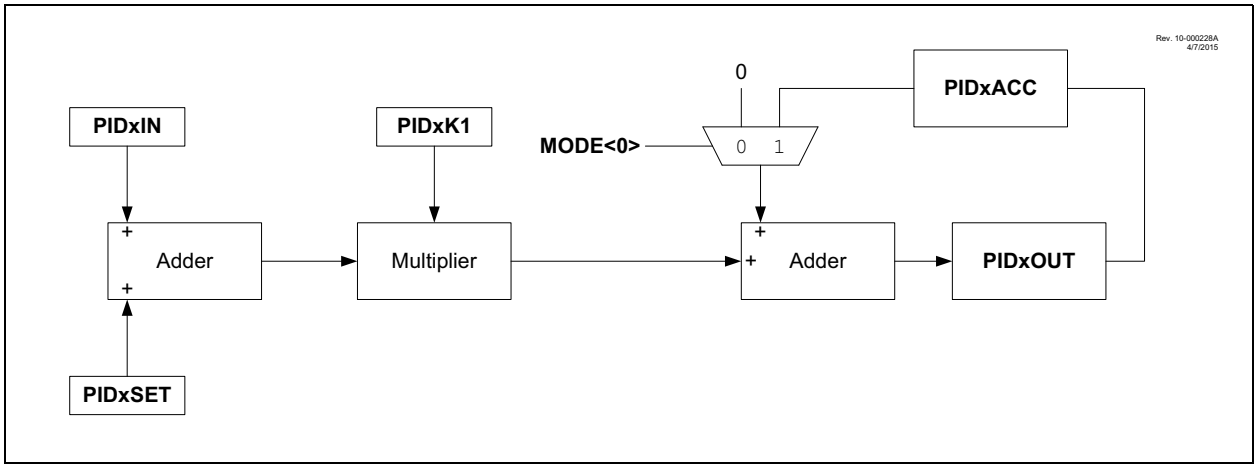
Note: A = PIDxIN, B = PIDxSET, and C = PIDxK1.

To apply an add computation, simply set C (PIDxK1) to '1'. To apply a multiply computation, it is better to set B (PIDxSET) to '0' and use A and C, since the module uses PIDxINL to trigger the computation.

There are four modes that give different options based on the user's needs:

- MODE<2:0> = 000: Inputs are unsigned, and the output does not accumulate
- MODE<2:0> = 001: Inputs are unsigned, and the output accumulates with previous outputs
- MODE<2:0> = 010: Inputs are signed, and the output does not accumulate
- MODE<2:0> = 011: Inputs are signed, and the output accumulates with previous outputs

FIGURE 1: SIMPLIFIED BLOCK DIAGRAM OF THE ANGULAR TIMER MODULE



IMPLEMENTATION

Initialization

To initialize this module, set the MODE<2:0> bits of the PIDxCON register to one of the four Add/Multiply modes, depending on which form of the calculation is desired. Then set the EN bit of the PIDxCON register to enable the module. It is recommended that the user clear all the registers that are related to the calculation, especially the PIDxACC, to make sure the values of the last computation would not affect this one.

Operation

After setting up the module, the Math Accelerator is ready to compute.

Write the value of C to the PIDxK1H/L register pair and the value of B to the PIDxSETH/L register pair, as well as the higher byte of A to the PIDxINH register.

Finally, write the lower byte of A to the PIDxINL register. This will begin the mathematical operation and set the BUSY bit of the PIDxCON register.

During the computation, either poll the BUSY bit of the PIDxCON register to check for it clearing or wait for the PIDxDIF interrupt to trigger, indicating that the operation has completed.

After the computation is completed, read the PIDxOUT registers for the result of the calculation. In accumulation modes, the PIDxOUT register will hold any previous values added to the current calculation's value. In non-accumulation modes, the PIDxOUT register will hold just the current calculation's value.

Triggers

Since the writing to the PIDxINL register triggers the computation, PIDxINL should be loaded last among all the input registers. If the user is using C language to program, it's not safe to load the PIDxIN register pair together, since when loading PIDxIN, the compiler may load PIDxINL first and the module will disregard the higher byte of the input and start the operation. Therefore, please make sure the PIDxINL register is loaded last.

CONCLUSION

The Math Accelerator module does 16-bit addition and multiplication in hardware. It saves the user a lot of time comparing to software calculation. It takes only four instruction cycles for the module to do a calculation, while it takes around 200 to 300 instruction cycles by using software to do the same calculation. Therefore, there is a huge efficiency improvement by using the Math Accelerator.

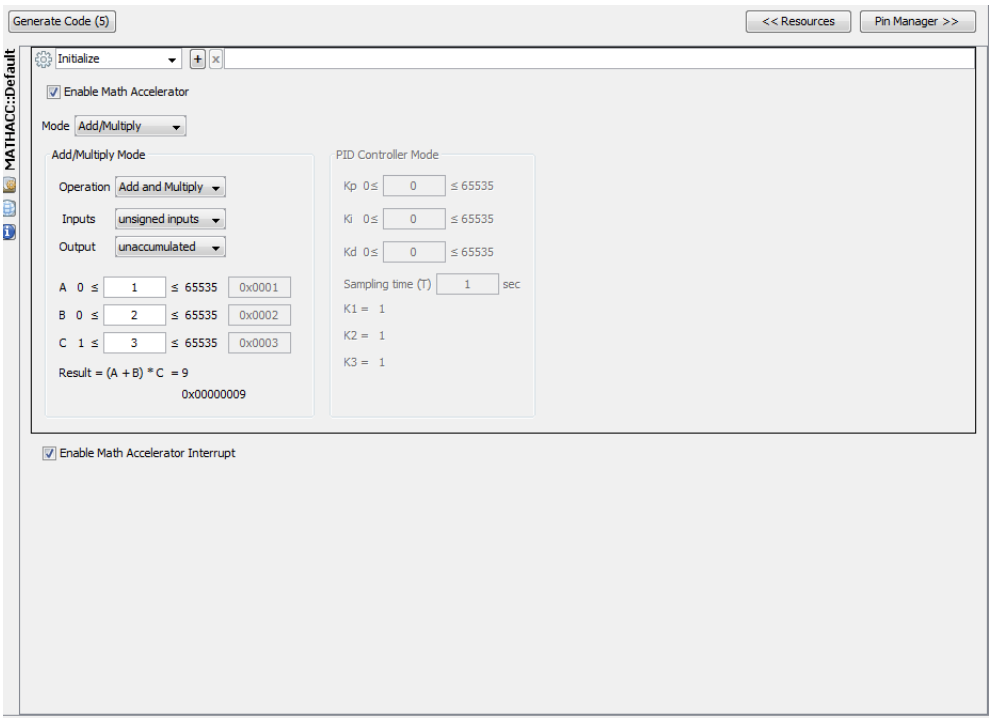
APPENDIX A: CODE FOR IMPLEMENTING THE MATH ACCELERATOR


```
    /**
     * Setup the Math Accelerator to do some simple 16-bit multiplication,
     *  addition, and accumulation
     */
    ////////////////////////////////////////////////////////////////////
    PID1ACCU = 0;                   // Clear the Accumulator (PID1ACCU)
    PID1ACCHH = 0;                  // Clear the Accumulator (PID1ACCHH)
    PID1ACCHL = 0;                  // Clear the Accumulator (PID1ACCHL)
    PID1ACCLH = 0;                  // Clear the Accumulator (PID1ACCLH)
    PID1ACCLL = 0;                  // Clear the Accumulator (PID1ACCLL)
    PID1CON1bits.MODE = 0b010;      // Signed inputs, without accumulation (PIDxCON1)
    PID1CON1bits.EN = 1;            // PID module is enabled (PID1CON1)
    ////////////////////////////////////////////////////////////////////

    /**
     * Load in values corresponding to the table in the lab manual
     * Output = (A + B) * C
     */
    ////////////////////////////////////////////////////////////////////
    PID1K1 = 1;                 // (PID1K1)  C
    PID1SET = 1;                // (PID1SET) B
    PID1INH = 0;                // (PID1INH) A (high)
    PID1INL = 0;                // (PID1INH) A (low) This starts the math execution (PIDxINL)
    ////////////////////////////////////////////////////////////////////


while(PID1CON1bits.BUSY);           // Wait for the module to complete
volatile int32_t result = PID1OUT;  // Load the result
```

APPENDIX B: SCREEN SHOT OF HOW TO INITIALIZE THE MATH ACCELERATOR MODULE BY USING MPLAB® CODE CONFIGURATOR



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