PWM

Welcome back to Cypress Academy, PSoC 6 101. In this video, I will show you how to setup the PWMs to control the servos in the robotic arm for our BLE-controlled robotic arm project. Let’s get started.

Let’s make a new project to understand how the TCPWM component works.

Make a new project, let’s call it “BasicTCPWM”. This project will vary the brightness of a LED with a very simple delay scheme.

I will add the TCPWM component by dragging and dropping it in to the schematic. Let’s rename it to PWM and set the period to 100 and compare to 0.

I will now drag in the pin component. Again, we’ll rename it to RED.

Now for the clock, drag and drop that component and we can keep the default configuration of the clock alone.

Make sure you wire the clock to the PWM and the pin to the PWM as I did when I dragged the components into the design.

Now to assign the pin component to the physical pin on the PSoC 6 device. Again P0[3].

Time to generate the application.

Now let’s go the CM4 main application file.

I will add a local variable to main function called compareValue and set the default value to 50.

Start the PWM using the simple start API command.

In the infinite for loop, I will change the compare value of the PWM using the “CY\_TCPWM\_PWM\_SetCompare0” API call and the PWM\_HW macro. There are multiple counters in the PWM, so the setcompare function needs to know which one I want to change. In this case, I’ll use the macro PWM\_CNT\_NUM. Now the last argument is used to set the compare value, I’ll set it to the local variable we created, compareValue.

Now I want to increment the local variable, compareValue, by 1 and mod it by 100 so it counts up to 100, the maximum period we set before, and resets to 0.

Finally we need a delay so we can actually see the change, so let’s use the CyDelay API and 20 milliseconds. This will make the LED slowly dim and back to maximum brightness.

Now, build, program and test.

Awesome! I love blinky LEDs!

Now let’s add the PWM functions to our BLE-controlled robotic arm project, “MainController”.

The servo motor in my robotic arm requires a 20hz pulse and the pulse width needs to be between one and two milliseconds. At one millisecond it’s turned all the way to the left and at two, it’s all the way to the right and half a millisecond, right in the middle.

So, to make all the math work, we’ll choose a 4MHz clock, pre divide it by 4 and then set the period to 20,000. What that means is each tick of the PWM clock will represent 1uS. In order to get a 1 ms wide pulse also known as a 1000 microsecond wide pulse Ill need a compare value of 1000. This also means that 1% will be 10 PWM clock ticks. Now I can set the compare value with software between 1,000 and 2,000 to give us full range control on the motors.

So, I’ll start by dragging and dropping one PWM from the catalog on to the schematic. Let’s setup the period and compare to 20,000 and 1,000 respectively; turn on the divide by 4 pre-divider. And click okay.

We want to control two motors to start, so let’s copy that component and paste a second one into our design. It will be named PWM\_2 and that’s convenient since PWM\_1 I’ll use to control motor 1 and PWM\_2 for motor 2. The copy paste function is also nice in that all of the settings from PWM\_1 were also copied over to PWM\_2 saving us some time.

Now let’s add two digital output pins to our design…I like the copy-paste function, so I’ll pull in one and rename it “M\_1” for motor 1. A quick copy/paste and I now have “M\_2” as well.

Let’s connect those pins to the PWMs’ PWM output line on the component.

Next, we need a clock. I’ll drag and drop a clock in and set it to 4MHz. Then wire it to both of the PWMs.

One of the most forgotten steps in a design, is to assign the pins; so let’s do that now before we forget. Go to the pins settings and we’ll set M\_1 to P0[2] and M\_2 to P5[5] which matches up to the H-bridge pins on my Arduino shield I’m using.

Let’s generate the application and start working on some firmware.

Create and edit the file pwmTask.h. Add the #prama once, and includes for FreeRTOS and Semaphores. Next I will create two enumerated types, one for motors called motors\_t and one for position called motor\_pos\_t. These enums will be used in the structure called PWM\_Message\_t that the other tasks will use to communicate with our PWM controller. All right, lets define the structure to send messages to the PWM. This structure will allow me to tell the PWM task, that we’ll create next, what motor we want to change, whether we want a relative or absolute change, and a percent change we want to make. I’ll call this structure “PWM\_Message\_t”. Finally, I will define the function prototypes for the motor task and a helper function called getMotorPercent that the other tasks can use to find out the current state of the motors.

After the pwmTask.h header file is built, we can go ahead and update the main\_cm4.c file. Four things need to happen

1. Add the include for the pwmTask.h
2. Create a variable for the pwmQueue
3. Initialize the pwmQueue
4. Start the PWM Task

When you have different tasks communicating with each other via an RTOS queue, there is always a question of where you define and initialize the queue. I like the main function to “own” these and then tell the other files about it in a global.h.

So, create a global.h, add the guards, put in a include for freertos and semaphores, and define the extern for the pwmQueue. Now other files can get access to the queue just by including global.h

Now create and edit the file pwmTask.c.

The only purpose of this whole pwmTask is to take message from the other tasks in the form of percent … meaning a number between 0 and 100 and then turn the percent into a pulse width between 1ms and 2ms. And finally turn the pulse width into a compare value which can be written PWM compare value register so that you get output pulses of the correct frequency and width.

I am going to want 3 pairs of functions,

percent to pulse width and pulse width to percent

then I need

PWM compare value to pulse width and pulse width to pwm compare value

And finally percent to compare value and compare value to percent.

So, how do I do that? Well… the math is simple. Look at this graph. On the x-axis I have pulse width in micro seconds and on the y-axis I have percent. When you have a pulse width of 1000 us you should have a percent of 0…here is the first point of the line. Then when you have a pulse width of 2000us you will have 100%, that is the next point on the line.

From algebra one we remember y=mx + b… OK.. so the formula that turns pulse widths into percent is percent = slope times the pulse width minus 100 percent. The slope of the line is rise over run, or 100 percent minus 0 percent over 2000 microseconds minus 1000 microseconds.

And that can be rearranged to get percent into pulse width like this

Pulse width = percent times the slope or 2000us minus 1000us divided by 100 minus 0 plus 1000us

So, lets start this thing by creating the helper functions. First define the ranges of pulses… MIN\_US and MAX\_US. Then define the the PWM parameters PWM clock, pwm divider. These could be read from the schematic… but I wanted to make this simpler to understand so I am hard coding them. Next derive the number of PWM ticks per microsecond.

Now I can build the helper functions

Percent to pulse just takes a percent and turns it into a pulse width with the formula I derived earlier… then pulse to percent does the inverse.

Then two helper functions to turn compare values into pulse widths and pulse widths into compare values. These two functions use the settings on our schematic to figure this out.

And finally two functions to turn compare values into percent and percent into compare values.

Now in my program I can use these help functions to set the PWMs using percent or findout what percent by reading the current compare value of the PWMs.

The next function I build will be used by other tasks to look at the current state of the PWM in percent. Ill call the function get motor percent. The getMotorPercent function takes as input either M1 or M2, then it looks at the PWM and figures out what the compare value is for that PWM, and uses the helper function compare to percent return the current percent value.

Now I’ll create the PWMTask. When the task starts I’ll start the two PWMs using the start API command; then in an infinite loop I’ll wait to receive an RTOS command from the queue. When I get a command from the queue, I’ll figure out what the hardware and counter numbers are so I can use the appropriate macros.

Then what I’ll do is, if the message coming in wants to make a relative change in percent, I’ll get the current compare value, convert it to percent, make the change. If the message calls for an absolute value change, I’ll make the change. Then I’ll update compare value of the appropriate PWM.

That’s it for the UART Task.

Now, I need a way to test this, so I’m going to add it to the UART command set we defined earlier. In the UARTTask.c I need to add includes for global.h and pwmTask.h. And down in the UART Task I’m going to use the commands “o” and “p” to change the relative percent value of motor one by negative 10% and positive 10%, respectively. And I’ll use commands “k” and “l” to do the same for motor 2. So, in the case statement for the command ‘p’, I’ll set the message to one, to control motor one, absolute percent to minus one since we’re doing a relative change, and relative percent change to 10. Then queue the message and break. Now I’ll do the same for the other commands.

In order to make the debugging easier I am going to add a command to printout the current status of the motors. So, add to the case statement a case for ‘s’ that printfs the getMotor percent for M1 and M2.

Are we done? No! We can’t forget to add the messages to the help command, “?”. So, I’ll do that real quick.

And that’s it…that’s the beauty of an RTOS. Simplifying complex designs.

Let’s build, program and test…

Now we have a functioning UART-controlled robotic arm…but we’re not done yet, this is supposed to be a BLE-controlled robotic arm. So, we have a little more work still to go. In the next video, I will walk you through setting up an I2C control interface.

You can post your comments and questions in our PSoC 6 community or as always you are welcome to email me at alan\_hawse@cypress.com or tweet me at @askioexpert with your comments, suggestions, criticisms and questions.