Homework V **Benjamin Streit**
Professor Gary J. Minden EECS 388
Date Assigned: 10/30/18 Date Due: 11/06/18

1. When generating a Pulse Width Modulator (PWM), what are the two key parameters used to set the period or pulse width?

Two time durations are needed as parameters for a PWM, the period and the pulse width. For a system clock frequency of 120 MHz, which has a period of 8.33 nanoseconds, the basic time duration function is as follows:

$$T_p = (8.33\text{ns} \cdot K) \cdot M$$

Where T_p is the time duration, or period, K is the scaling factor, and M is the reload value.

2. Explain a timer pre-scaler and its purpose.

A timer pre-scaler is a counting circuit that reduces a high frequency electrical signal to a lower frequency through integer division. The purpose of the timer pre-scaler is to allow the timer to be clocked at the rate a user specifies.

3. Suppose a general-purpose timer is configured for A/B mode, i.e. two 16-bit timers (**TIMER_CFG_SPLIT_PAIR | TIMER_CFG_A_PERIODIC** in **TimerConfigure**). The timer generates a periodic signal with a period of 80 ms. What values of K (scale factor) and M (load value) will generate this signal. The System Clock is 120 MHz.

For a system clock of 120 MHz, the period is 8.33 nanoseconds. T_t is 80ms. K will be the scaling factor, M will be the reload value. Given the problem description, K and M are defined as follows:

$$0 < M < 2^{16}$$
$$1 \leq K \leq 256$$

Computations are as follows:

$$T_T = 8.33 \cdot 10^{-9} \cdot M$$

$$80 \cdot 10^{-3} = 8.33 \cdot 10^{-9} \cdot M$$

$$M = \frac{80 \cdot 10^{-3}}{8.33 \cdot 10^{-9}}$$

$$M = 9603841.53661465$$

M is greater than 2^{16} , so the system clock must be scaled by K. M will be set to $60,000$. Now, solve for K:

$$T_T = (8.33 \cdot 10^{-9} \cdot K) \cdot M$$

$$K = \frac{80 \cdot 10^{-3}}{60000 \cdot 8.33 \cdot 10^{-9}}$$

$$K = 160.0640256102$$

K must be an integer, so $K = 160$. All computed values are as follows:

$$M = 60,000,\ K = 160, \text{ and } T_T = 80\text{ms}$$

4. For an ADC, the input signal (Vin) can change while the conversion is taking place. What circuit is used to prevent the changing Vin signal from affecting the measurement?

The ADC module on the Tiva TM4C1294 uses a Successive Approximation Register (SAR) to perform conversions. This successive approximation uses a switched capacitor array to sample, hold the signal during conversion, as well as providing conversion result.

5. If a general-purpose timer is configured to run in 32-bit mode, what is the longest possible interval between "zero flags"? Assume the System Clock is 120 MHz.

On the Tiva TM4C1294 micro-controller a general-purpose timer configured to run in 32-bit mode does not have access to the pre-scaler. Consequently, the formula from question 3 can be re-purposed with slight modifications:

$$T_T = (8.33 \cdot 10^{-9}) \cdot M$$

With 32-bits, M is defined as follows:

$$0 < M < 2^{32}$$

Computations for greatest value of T_T are as follows:

$$T_T = (8.33 \cdot 10^{-9}) \cdot 4294967295$$

$$T_T = 35.77707756735\text{s}$$

It is clear that given a general purpose timer on the Tiva TM4C1294 micro-controller configured for 32-bit mode, and a system clock of 120 MHz, the longest possible interval between "zero flags" is 35.77707756735 seconds.

6. For the TM4C1294 ADCs, how many sequencers are there for each ADC? What is the FIFO size for each sequencer in ADC1?

The ADCs on-board the Tiva TM4C1294 micro-controller have four sample sequencers, each with FIFO entry size of 32-bits, with the lower 12-bits containing the conversion result.

7. What is the base address of the PWM peripheral?

The base address of the PWM peripheral is as follows: `0x4002.8000`.

8. How many analog inputs are available to ADC1 on the TM4C1294 micro-controller?

ADC1 on the TM4C1294 micro-controller has 20 analog input channels available, these are shared with ADC0.

9. The TM4C1294 ADCs can oversample in hardware. Explain oversampling and why one would use it.

Oversampling, in signal processing, is the process of sampling a signal at a higher frequency than twice the highest frequency component in the signal, and averaged. For example, a signal is said to be oversampled by a factor of `x` if it is sampled at `x` time twice the highest frequency component in the signal. Oversampling can be beneficial when attempting to increase resolution and reduce cost and noise during analog-to-digital and digital-to-analog

conversion. For example, say the goal is to implement a 24-bit ADC. Using oversampling, it would be possible to deploy a 20-bit ADC sampling at 256 times the target sampling rate. This would increase the signal to noise ratio by 16 times. As a result, 4-bits would be effectively added to the resolution of the ADC, meaning the 20-bit ADC now has 24-bit resolution.

10. Name three capabilities (functions, ways to use) a general-purpose timer.

Three capabilities of a general-purpose timer are as follows:

(i) Measure motion of motor

(ii) Measure position of sensor

(iii) Trigger ADC events