CprE 288 – Introduction to Embedded Systems
Exam 2 Review

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Announcements

EXAM

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- Exam 2: Thursday 11/9, in class
  - Open textbook/datasheet, 1 page of paper notes, and calculator allowed
  - 75 minutes
  - Electronic textbook/datasheet is fine. But nothing else on your electronic device can be used or you will receive an **F** for CPRE 288

Exam Topics

Programming TMC4123 I/O modules and functions

- USART
- ADC
- Input capture (Timer/Counter)
- Output compare (Timer/Counter)
  - Generating waves (PWM mode, Periodic Mode)
- General Timer Modes
- GPIO Configuration

On each subject, be familiar with

- Application background, working principles, and related concepts
- Programming interface
- Writing C functions for common purposes
- Typical application scenarios

Exam Questions

Some common question styles

- Short questions
  - Conceptual
  - Analysis
  - Calculation
- Programming: for a given application
  - Initialize an I/O module
  - Access I/O data
  - Interrupt programming

And others

Exam Questions: Data Sheet, Read it & ask questions

- Flavors of some potential Exam 2 questions
  - Program configuration registers to meet given requirements
    - UART, ADC, Input Capture, Output Compare, Timers, Interrupts
    - There is a section for each device mentioned above in the data sheet
  - Based on a given configuration, answer questions about how a program will behave
    - E.g. How long will something take to occur?
    - E.g. How many times a second will something occur?
  - Explain why a given configuration is incorrect for implementing a specified behavior
  - Assuming a given configuration, write a short program to implement a specific behavior
  - ADC calculation problems

Exam Preparation

How to prepare

- Review Labs
- Review the lecture slides
  - Read datasheet when needed
- Review/redo homework
  - Proficiency and efficiency are importance
- Ask questions
  - Emails

USART

USART: Serial Communication

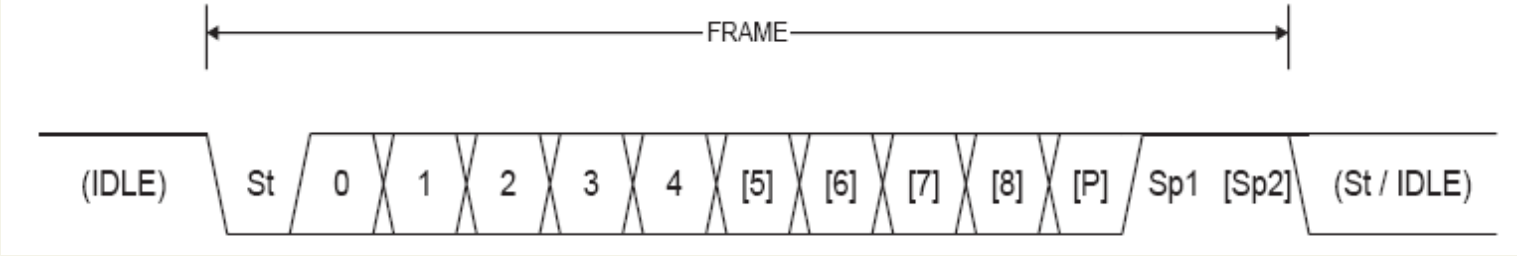
- USART = Universal Synchronous & Asynchronous Serial Receiver & Transmitter
  - We only studied the Asynchronous part (UART)
- Serial communication: Data is transmitted bit by bit at the physical layer of network
  - Can transmit over long link distances
  - Uses *start* and *stop* to sandwich data bits
  - *parity bit* can be used for error detection

Baud Rate and Frame Format

Important concepts

- **Baud rate**: Number of symbols transmitted per second from the transmitter to the receiver
  - It's also the rate of symbol changes to the transmission media
- **Frame format**: The format of a single data packet
  - USART transmits one data packet per request
  - One data packet contains a single data character, plus start bit, stop bit(s), and optional parity bit

Frame Format



Start bit: logic low, 1 bit

Data bits: 5, 6, 7, 8, or 9 bits

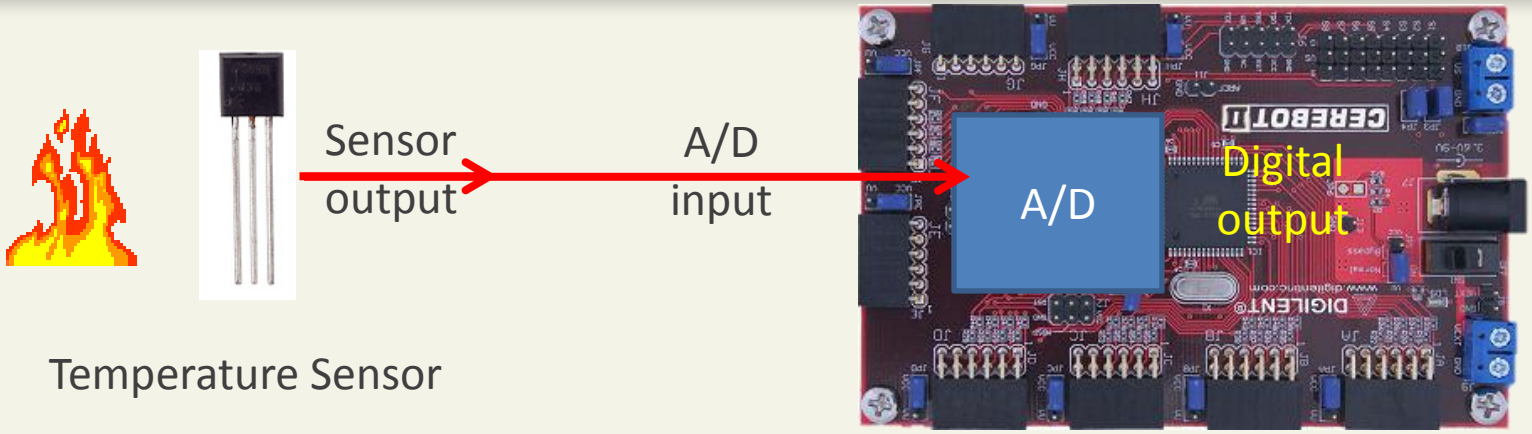
Parity bit: Optional 1 bit, Odd, Even or none

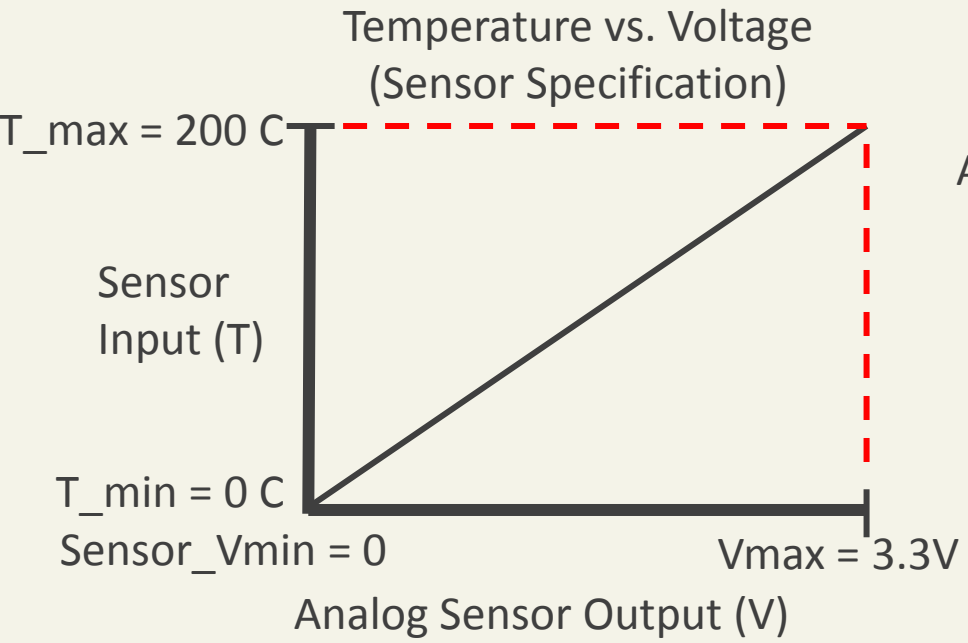
Stop bit: logic high, 1 bit or 2 bits

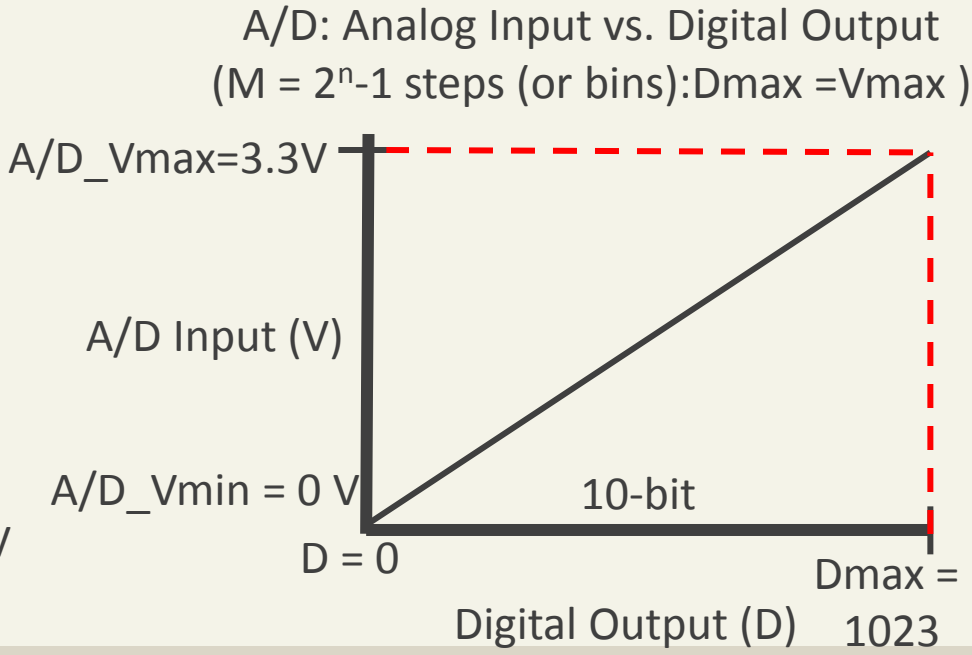
*Both sides of communication should use the same **frame format** and **baud rate***

ADC

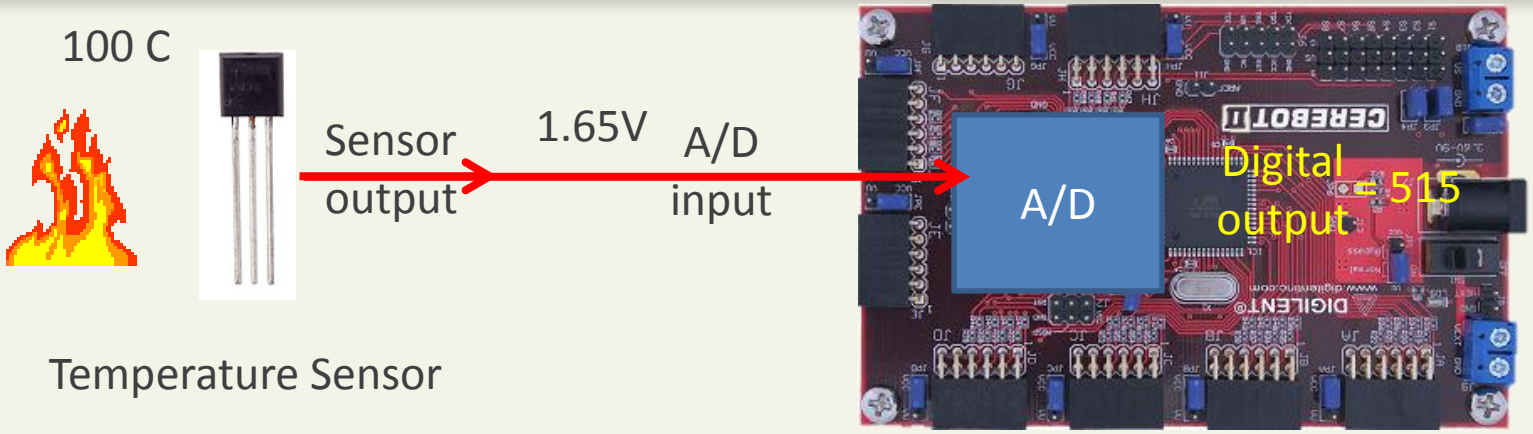
Sensor and ADC

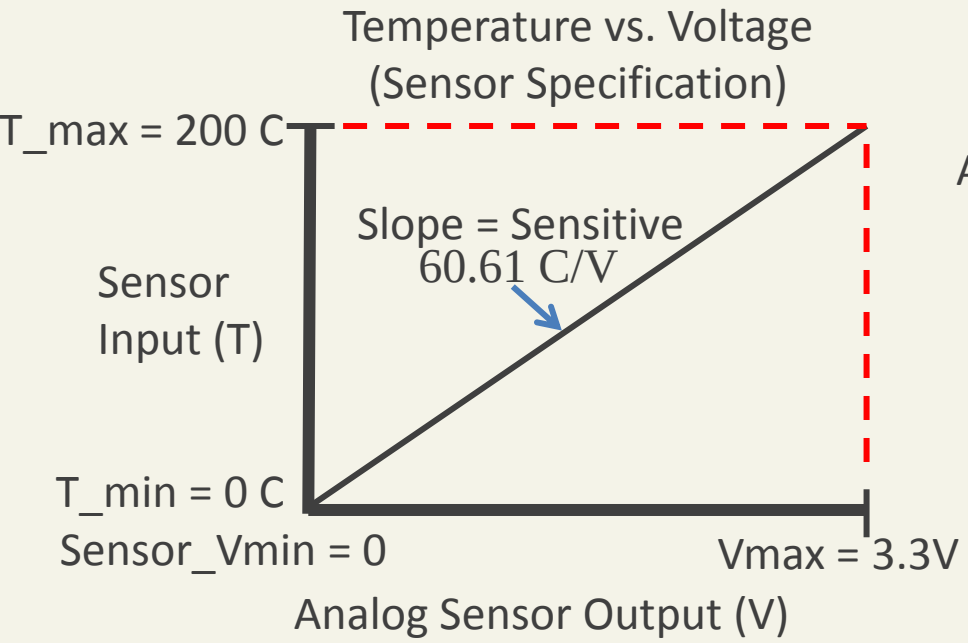


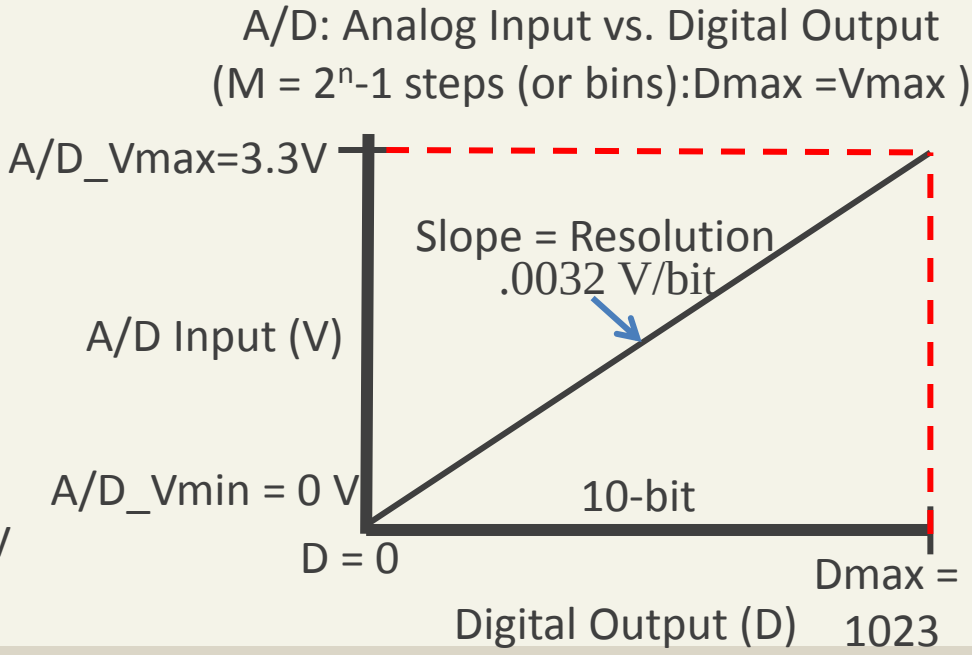




Sensor and ADC

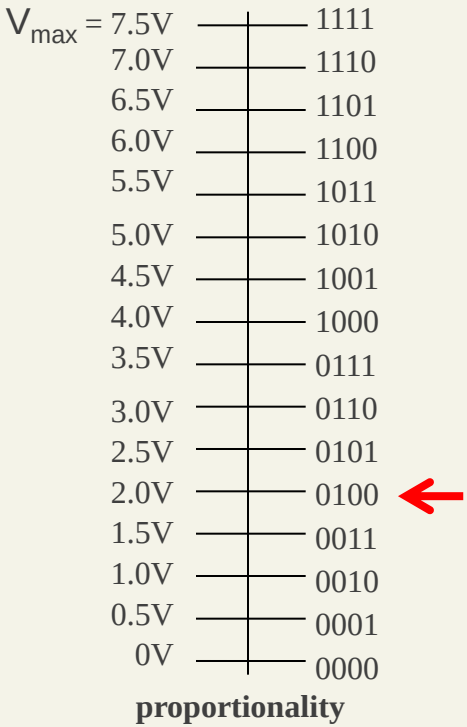


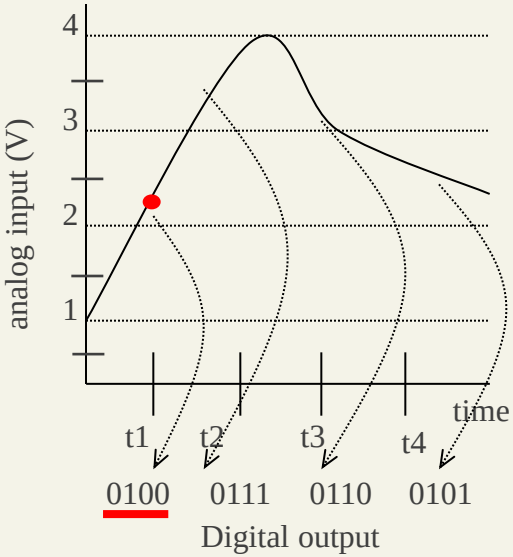




Sampling and Conversion

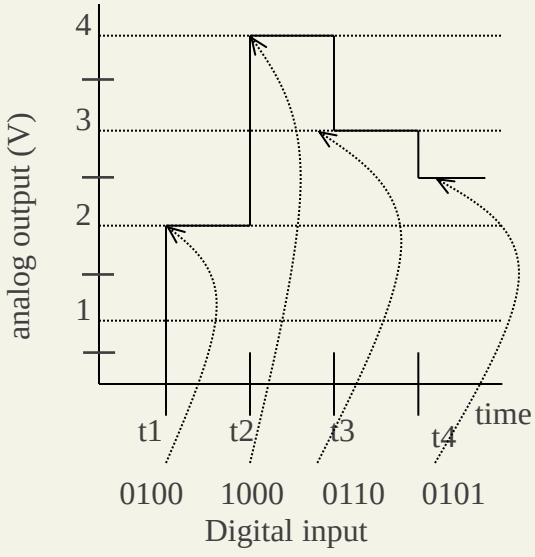
Mapping between
Analog and Digital





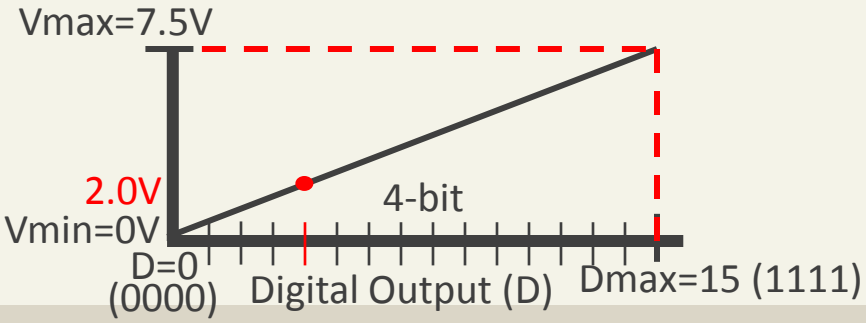
Digital sampling of
an analog signal

analog to digital



Digital generation of
an analog signal

digital to analog



Embedded Systems Design: A Unified Hardware/Software Introduction, (c) 2000 Vahid/Givargis

Formula for Conversion

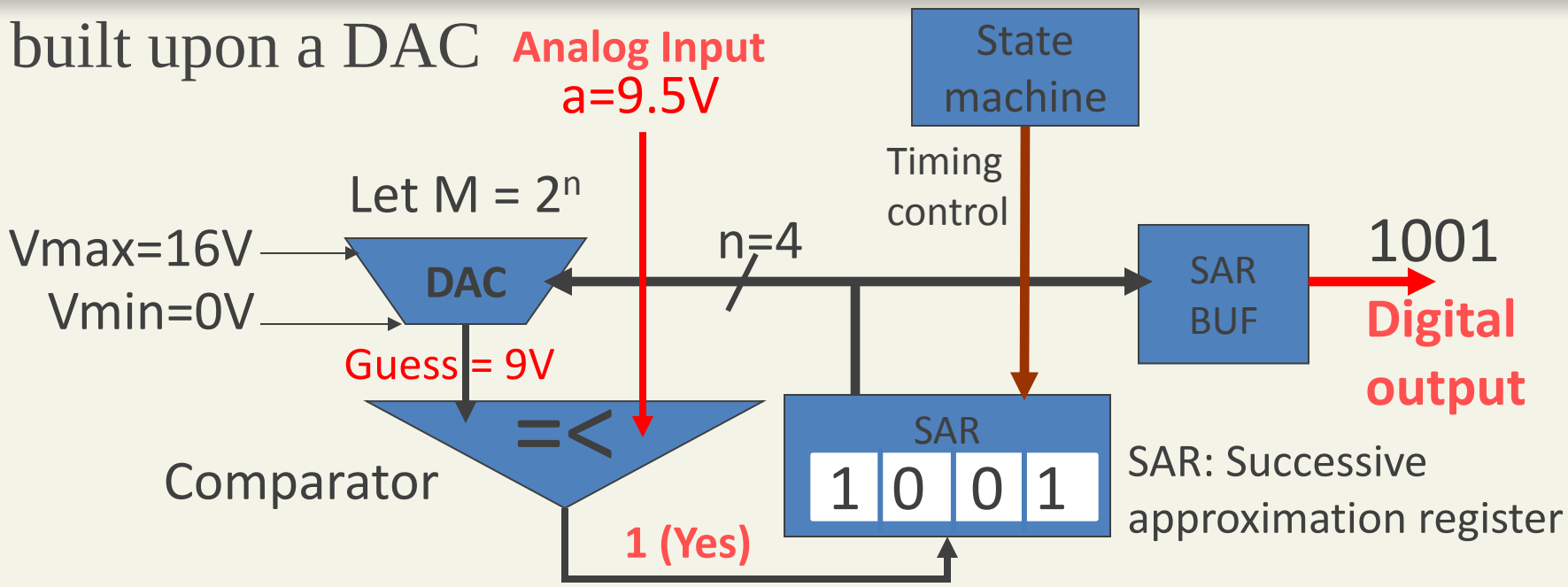
Assume linear sensor, ADC is always linear

$$\frac{a - A_{\min}}{A_{\max} - A_{\min}} = \frac{v - V_{\min}}{V_{\max} - V_{\min}} = \frac{d}{M}$$

- Sensor converts analog signal to electrical signal (voltage)
- ADC converts an electrical signal (voltage) to a digital number

Constructing the ADC (Successive Approximation)

It's built upon a DAC



Step	Range	Mid (digital)	Mid (voltage)	Is a >= Guess (voltage)?
0	0bxxxx	0b1000	8 Volts	Yes
1	0b1xxx	0b1100	12 Volts	No
2	0b10xx	0b1010	10 Volts	No
3	0b100x	0b1001	9 Volts	Yes
4	0b1001			

INPUT CAPTURE AND OUTPUT COMPARE

Input Capture and Output Compare

Input capture and output compare work with digital waveforms

IC: Recognize waveforms by capturing the time of events

OC: Generate waveforms by setting the time of events

TMC4123 has several Timer modes