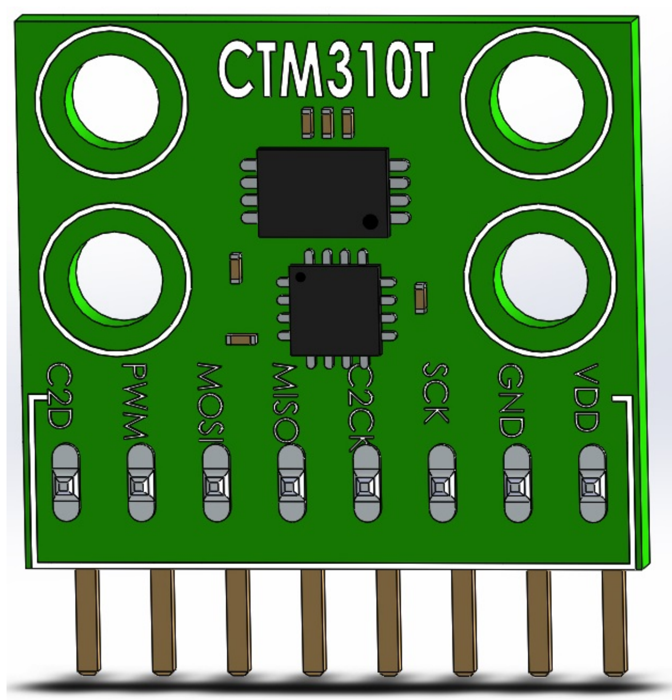
CTM310T USER MANUAL



This module contains Crocus Technology's CT310 TMR-based 2D magnetic sensor, and an onboard microcontroller unit which processes analog output signals from the sensor. Highly accurate magnetic angular results can be read from the SPI interface, or the pulse width modulation (PWM) digital output.

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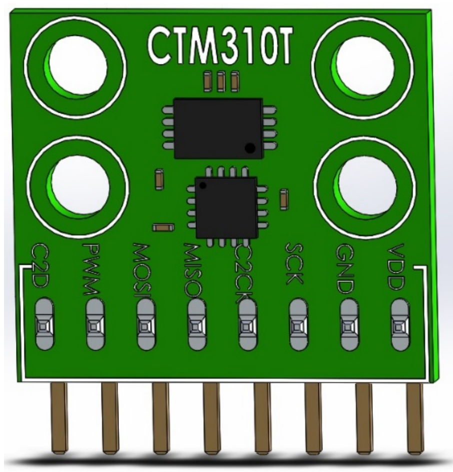
1. Module Overview

Referenced Device(s): CM310LS-HT8



1.1 Introduction

The CTM310T evaluation/demo board features the Crocus CT310 2D angular sensor and an integrated microcontroller (MCU) which processes the analog outputs from the sensor and provides a digital angle output. The angular result is provided to a host via the SPI interface, or as a PWM output.

The CT310 is based on Crocus Technology's XtremeSense™ TMR 2D technology. It features a dual full-bridge configuration, each bridge incorporates four (4) TMR elements. This user guide describes how to connect and use the CTM310T demo board. It also provides a description of the circuit implemented and expected test results.

2.2 Features

- 0.60° maximum angular error
- SPI digital output
- 12-bit PWM output
- Magnetic Field Range 25 mT to 90 mT
- +2.2 V to +3.6 V power supply
- -40°C to +125°C temperature range

2.3 General Description

The CTM310T demo board is shown below and features:

- 8-pin male header
- 18.5 mm × 21.0 mm

The 8-pin male header on the right of the board are connected as follows. VDD, GND, are used to connect the power supply, ranging from 2.2 V to 3.6 V. The three wire SPI interface signals are the SCK, MISO, and MOSI. The PWM output is output on pin 7. Signals C2CK, and C2D are reserved and should left disconnected.

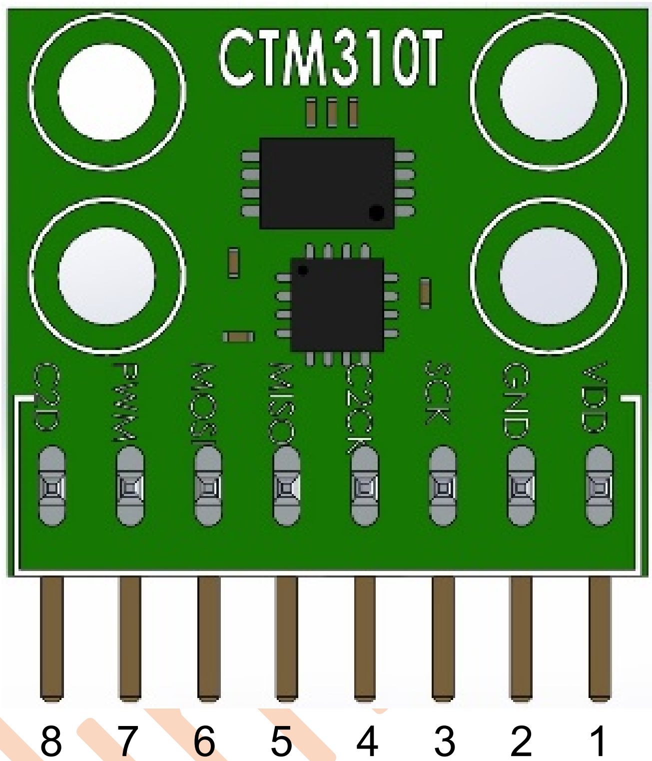


FIGURE 1. CTM310T DEMO BOARD

2.4 Electrical Connections

CTM310T Pin #	*Pin Name*	*Pin Description*
1	*VDD*	*Module supply voltage*
2	*GND*	*Supply return*
3	*SCK*	*SPI clock*
4	*C2CK*	*Reserved*
5	*MISO*	*SPI Master in, Slave out*
6	*MOSI*	*SPI Master out, Slave in*
7	*PWM*	*Pulse width modulation output*
8	*C2D*	*Reserved*

2. Mechanical Dimensions

2.1 Board Dimensions and Mounting Hole Template

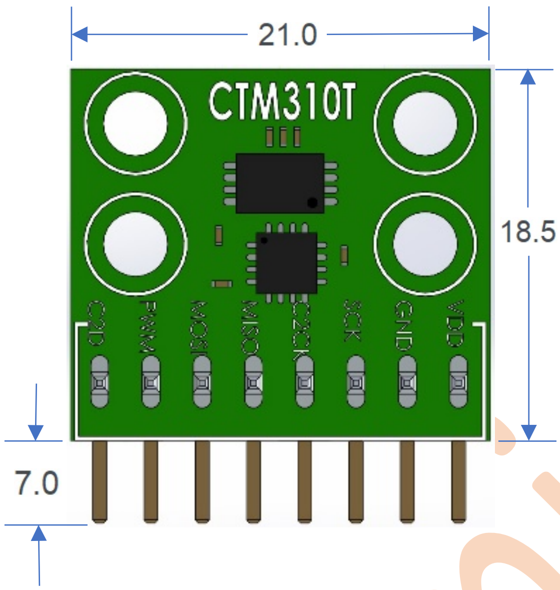


FIGURE 2. CTM310T DEMO BOARD

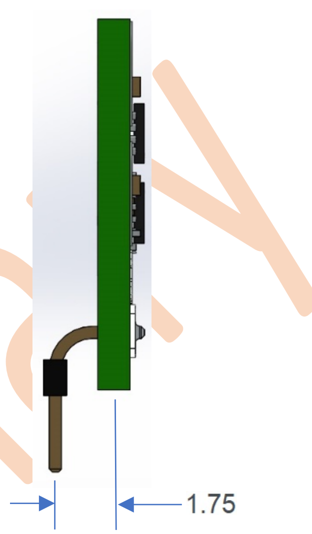
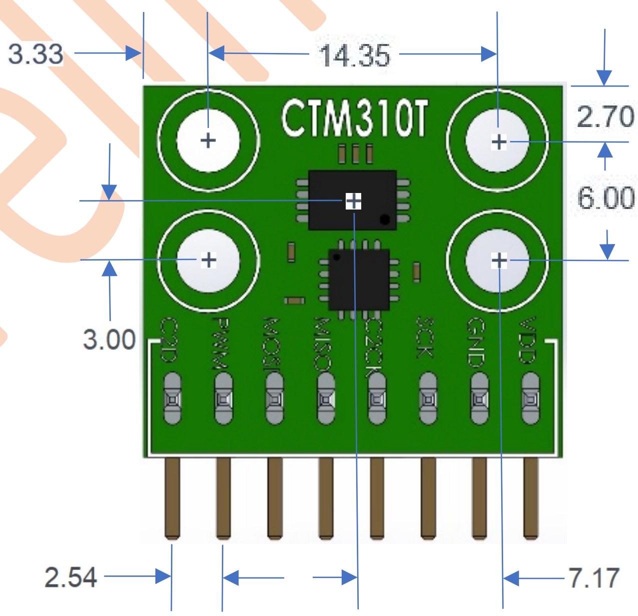


FIGURE 3. MODULE SIDE VIEW



note: all dim in mm

FIGURE 4. MODULE HOLE PATTERN

3. Axis of Sensitivity

CT310 features dual full-bridge networks. The direction of sensitivity are shown below in Figure 4 which identifies the sine, and cosine axis of the sensor. Figure 5 illustrates the direction of field rotation vs the calculated angular result. When the magnetic field is rotated clockwise in front of the CT310 sensor, the calculated angle increases. Counter-clockwise rotation will decrease the angular result. For best performance, the center of the magnetic field should be carefully aligned with the center of the sensor package. The centerline between mounting holes are aligned with the exact center of the CT310 sensor. The magnetic field can be produced by a single diametrically polarized magnet, or two symmetrically placed permanent magnets mounted on a rotating disk. One magnet mounted with the north polarity facing the sensor, the other magnet with the south pole facing the sensor.

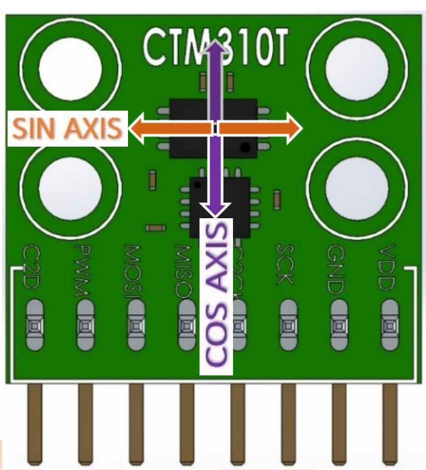


FIGURE 5. SINE AND COSINE AXIS

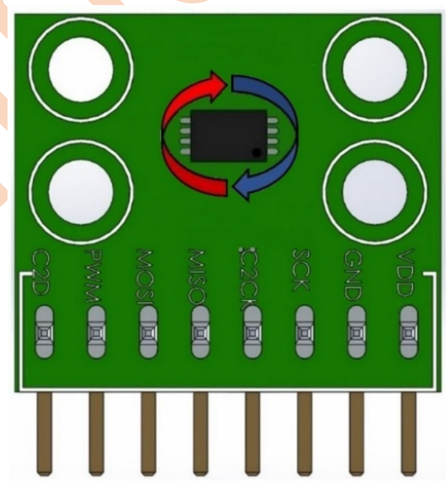


FIGURE 6. MAGNET ROTATION INCREASING RESULT

4. Electrical Specifications

5.1 Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the CTM310T. The module may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. Crocus Technology does not recommend exceeding or designing to absolute maximum ratings.

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{DDMAX}	Voltage on any Supply Pin	-0.3		3.8	V
I_{DDMAX}	Maximum Current into VDD Pin			200	mA
T_{STG}	Storage Temperature	-50		150	°C
$I_{I/OMAX}$	Current per I/O pin			50	mA

5.2 Recommended Operating Conditions

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{DD}	Voltage on any Supply Pin	2.2	3.3	3.8	V
I_{DD}	Current into VDD pin	20			mA
T_A	Operating Ambient Temperature	-40	+25	125	°C

5.3 General Electrical Characteristics

The numbers below refer to the maximum performance achieved by CTM310T due to peripheral limitation. The firmware or user configuration might reduce the max performance figures.

Symbol	Parameter		Min.	Typ.	Max.	Unit
f_{CLK}	Internal Clock Frequency		0		25	MHz
SR_{ADC}	ADC Sampling Rate		-		200	ksps
f_{RATE}	Output Refresh Rate	SPI	0.5		2.0	MHz
DC_{PWM}	PWM Duty Cycle		0		100	%

5. Magnetic Sensor Specifications

Unless otherwise specified: V_{DD} = 1.0 V to 5.5 V, C_{BYP} = 0.1 µF, $B_{OPERATING}$ = 25 mT to 90 mT and T_A = -40°C to +125°C. Typical values are V_{DD} = 3.0 V and T_A = +25°C.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
Magnetic						
$B_{OPERATING}$	Operating Magnetic Field		25	60	90	mT
Electrical						
R_{BRIDGE}	Bridge Resistance	T_A = +25°C	3.0	4.5	6.0	kΩ
TCR	Temperature Coefficient of Resistance (1)			500		ppm/°C
Differential Outputs						
θ_{ERR}	Angular Error (2)	After Compensation		0.25	0.60	°
θ_{ERR_HYST}	Angle Error due to Hysteresis			No Hysteresis		°
V_{SIN_D}, V_{COS_D}	SIN, COS Differential Output Voltage Peak-to-Peak		0.35	0.45	0.50	V/V
TCV_{OUT}	Temperature Coefficient of Differential Output (1)			-1200		ppm/°C
V_{OFF_SIN}, V_{OFF_COS}	SIN, COS Voltage Offset			±1	±5	mV/V
k	SIN, COS Amplitude Synchronism Ratio		97	100	103	%
TCk	Temperature Coefficient of Amplitude Synchronism (1)			3.0		ppm/°C
OE_{SIN}, OE_{COS}	SIN, COS Orthogonality Error	$B_{OPERATING}$ = 25 mT to 80 mT	88	90	92	°
$t_{RESPONSE}$	SIN, COS Response Time (1)	C_L = 22 pF		1.0		µs
e_N	Noise (1)	f_{BW} = 1 Hz to 10 kHz, V_{DD} = 3.0 V		2.4		$\mu V_{RMS}/V$

(1) Guaranteed by design and characterization.
(2) Hysteresis error and output noise are included in the Angular Error specification

6. Block Diagram

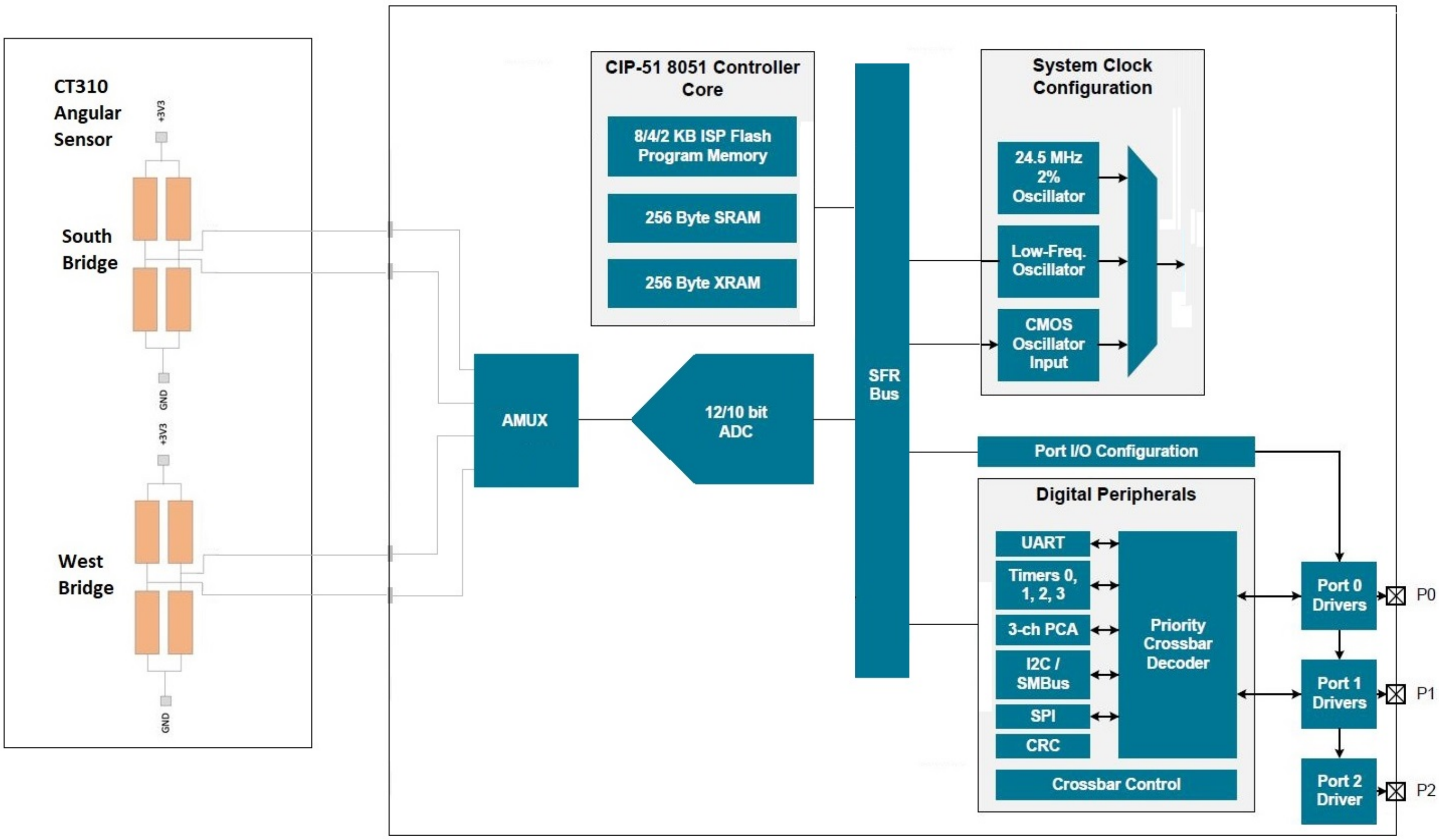


Figure 7. CTM310T Functional Block Diagram

6.1 Block Overview

The purpose of the CTM310T module is to demonstrate the functionality of Crocus Technology's CTM310 TMR-based 2D angular sensor which integrates two full-bridge networks. Four analog signals are output from the sensor, sine positive output (SINP), sine negative output (SINN), cosine positive output (COSP) and cosine negative output (COSN). These signals are used by the microcontroller to determine the angular position of a magnetic field in relation to the sensor. Sine, and cosine signals are connected to a multiplexer internal to the MCU, then converted into 12-bit results which are buffered, and averaged. The MCU compensates for offset, amplitude, and orthogonality characteristics of the sensor. An arctan2 math function converts the corrected sine and cosine values to a precise angle which can be externally read via the SPI port, or as a PWM digital waveform.

7. SPI Bus Communication

The CTM310T sensor module is configured as a SPI slave, and does not currently require, or accept any SPI commands from the master.

8.1 Magnetic Angle Reads

The CTM310T microcontroller calculates the magnetic angle and writes the result to the SPI output buffer. The master device initiates a 16-bit serial clock stream on the CLK pin. Angular data is presented to the master on the MISO pin, data is valid on the rising edge of each clock cycle.

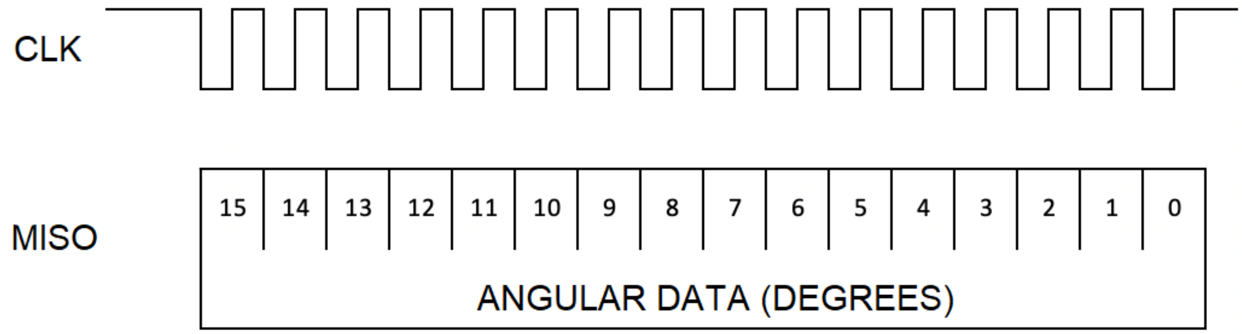


Figure 8. SPI Magnetic Angle Read

8.2 SPI Data Output

The angular data will be output on the SPI MISO pin which returns a numeric value from 0 to 3599 in bits 0 to 11. Bits 12 to 15 are unused and set to zero. The numeric value is the angle from 0° to 359° plus a tenths digit. For example, if the numeric value returned from the CTM310T module is 2247 (0x08C7), the magnetic field's orientation is rotated 224.7° from the sensor.

8. PULSE WIDTH MODULATION

9.1 PWM Operation

CTM310T module features a Pulse-Width-Modulation output that converts the 12-bit angular result into a variable duty-cycle, fixed frequency output signal.

PWM signals can be used as a single pin transmission protocol. The master device using a Timer measures both the duty cycle and frequency of the incoming PWM signal to determine the 12-bit value. The three figures below show how the frequency stays constant while the duty cycle changes. The duty cycle shown in Figure 9 reflects a 50% duty cycle. The magnetic field angle can be calculated by: Duty Cycle × 360.0° = Angular Result. In the following examples: 0.5 × 360.0° = 180.0°. The angular result in Figure 10 is 0.1460 × 360° = 52.6°. The angular result of Figure 11 is 332.3°.

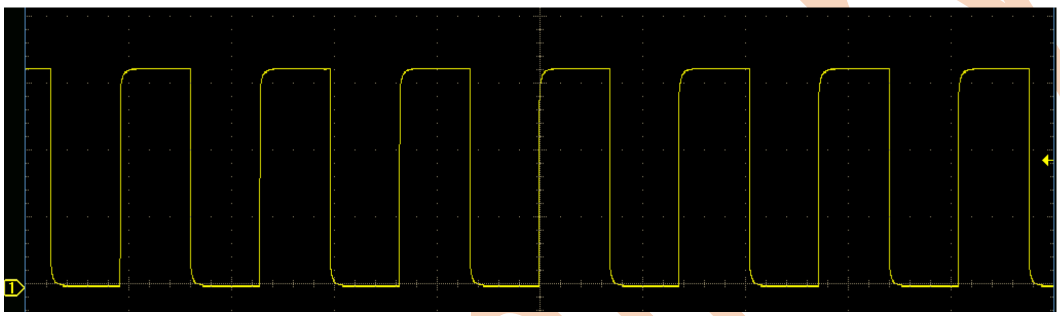


FIGURE 9. PWM 50% DUTY CYCLE

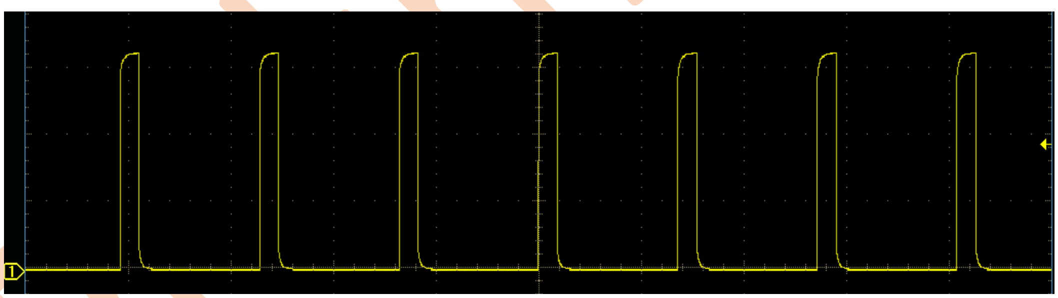


Figure 10. PWM 14.6% Duty Cycle

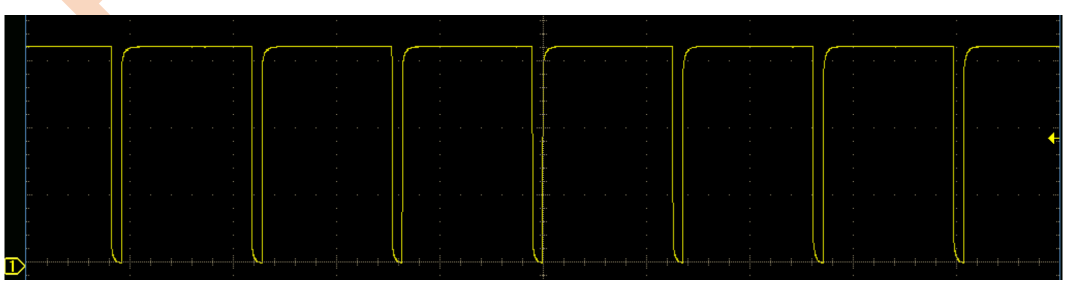


Figure 11. PWM 92.3% Duty Cycle

9. Board Schematic

Listed below is the schematic diagram of the CTM310T sensor module.

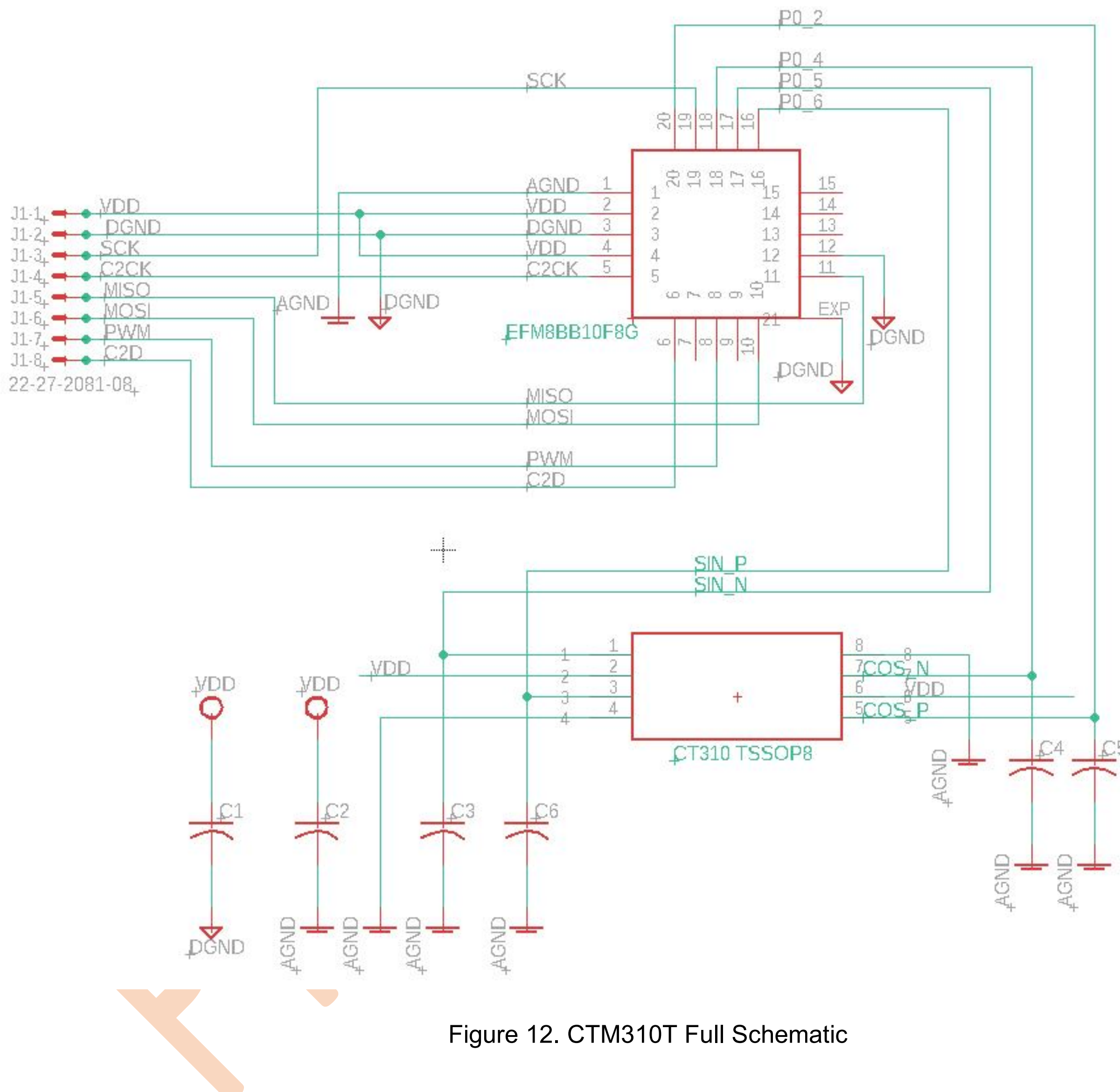


Figure 12. CTM310T Full Schematic

10. PCB Layout

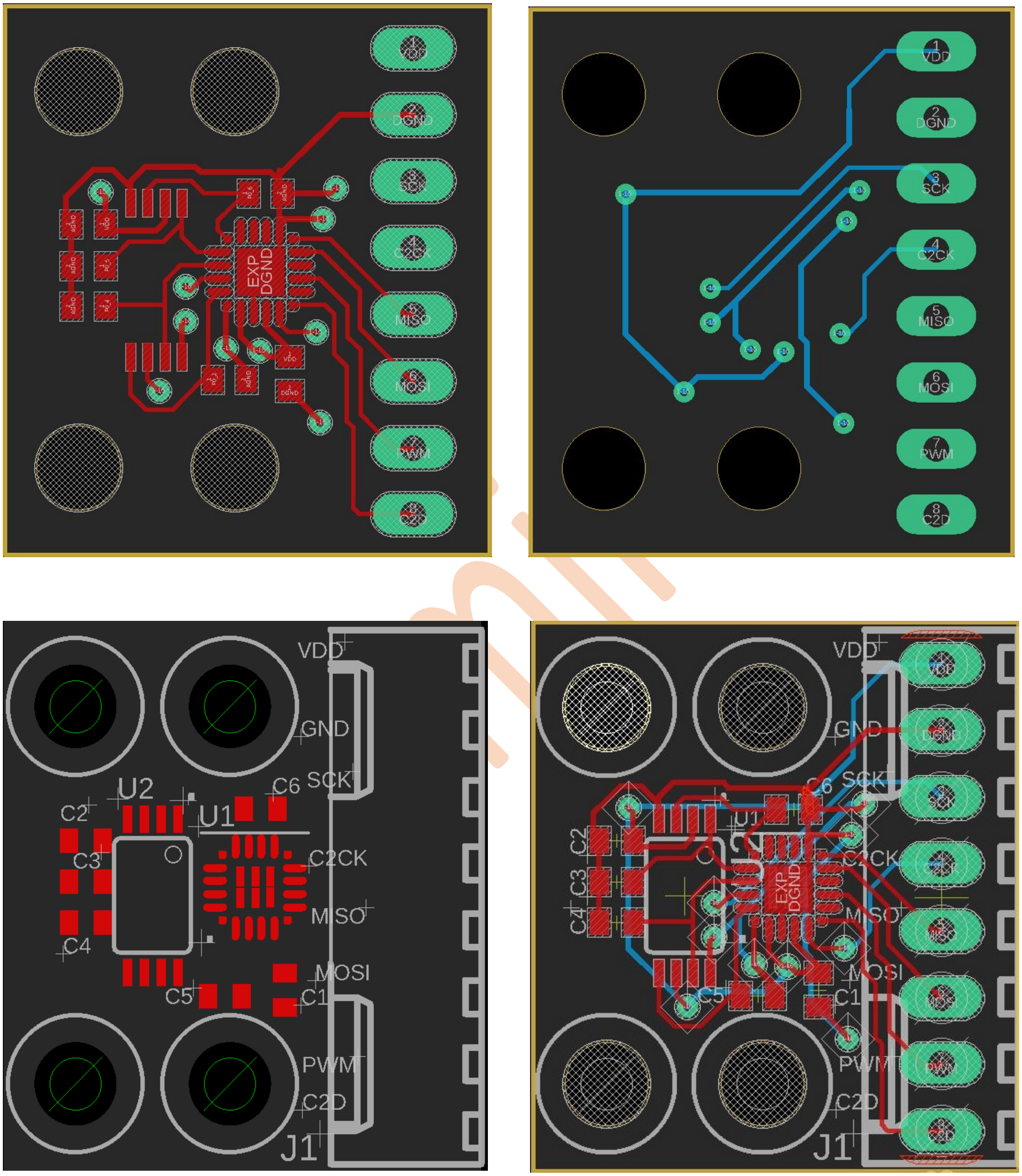


FIGURE 13. Printed Circuit Board Layout

11. Bill of Materials

Part	Description	Value	Qty
C1-6	Murata Capacitor, 0.1 µF X7R	GRM033Z71A104KE14	6
U1	Silicon Labs Microcontroller	EFM8BB10F8G-A-QFN20	1
U2	Crocus Technology 2D TMR sensor	CT310LS-HT8	1
J1	Sullins, 0.1° right angle header	PRPC008SBAN-M71RC	1

12. Conclusion

The CTM310T demonstrates the capabilities of the CT310, a 2D TMR angular sensor, combined with a low-cost microcontroller that performs the data acquisition from the sensor, compensates for offset, amplitude, and orthogonality factors. The digital angular result is provided on the SPI bus, and over a PWM output signal. Crocus Technology's high performance CT310, TMR 2D sensor, offers high accuracy, very low power consumption, and excellent stability over a wide temperature range.

Contacts

For samples or questions:
support@crocus-technology.com

Appendix: Full Schematic

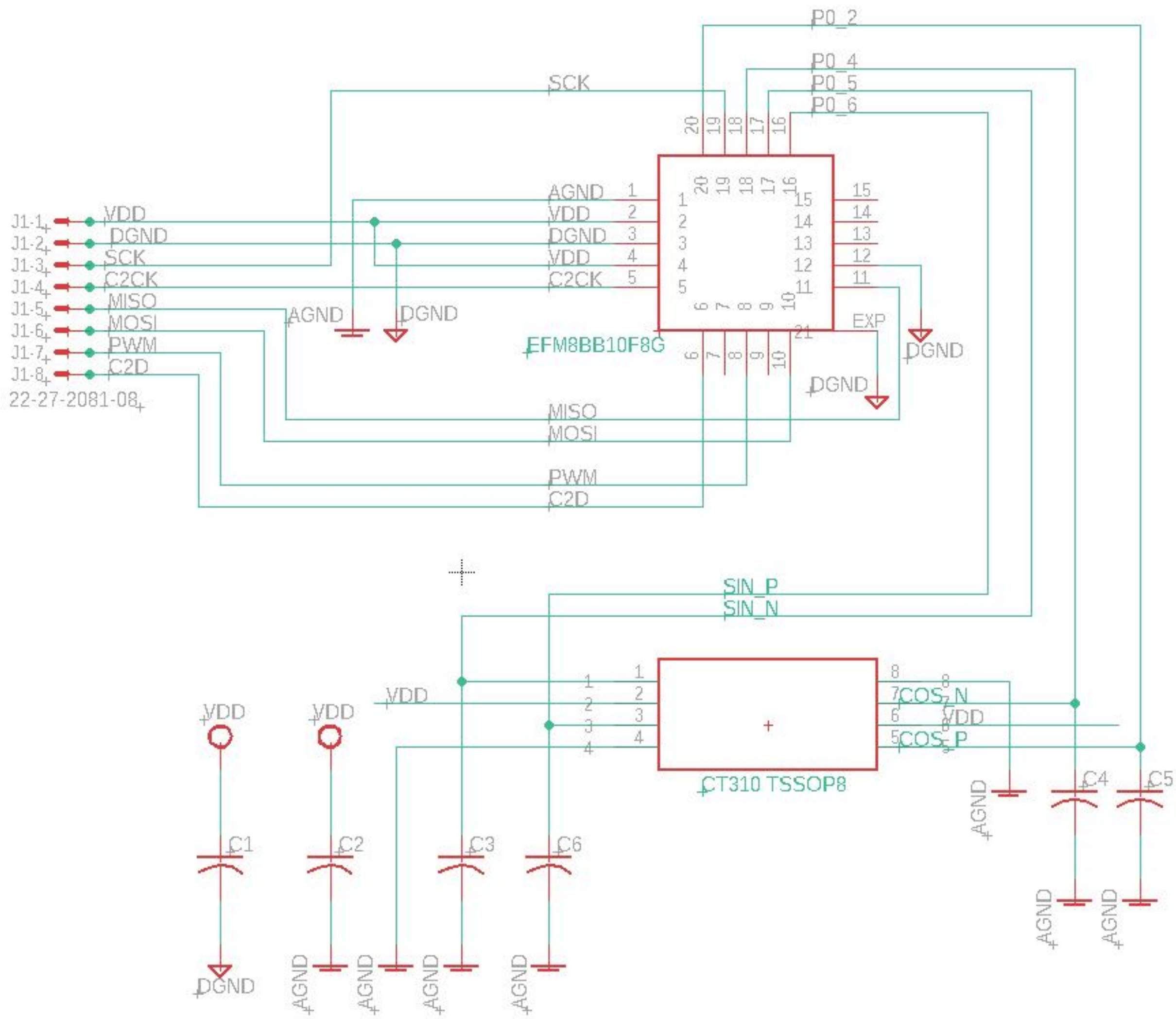


FIGURE 14. SCHEMATIC DIAGRAM