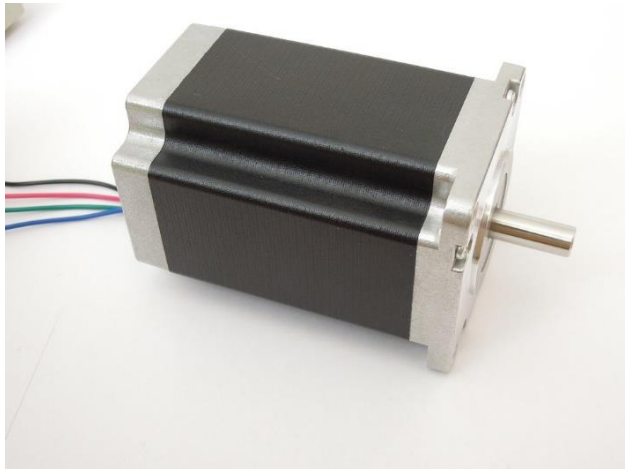
AHRS-M2/AHRS-M1 Compass Integration

Conquering Complexity™

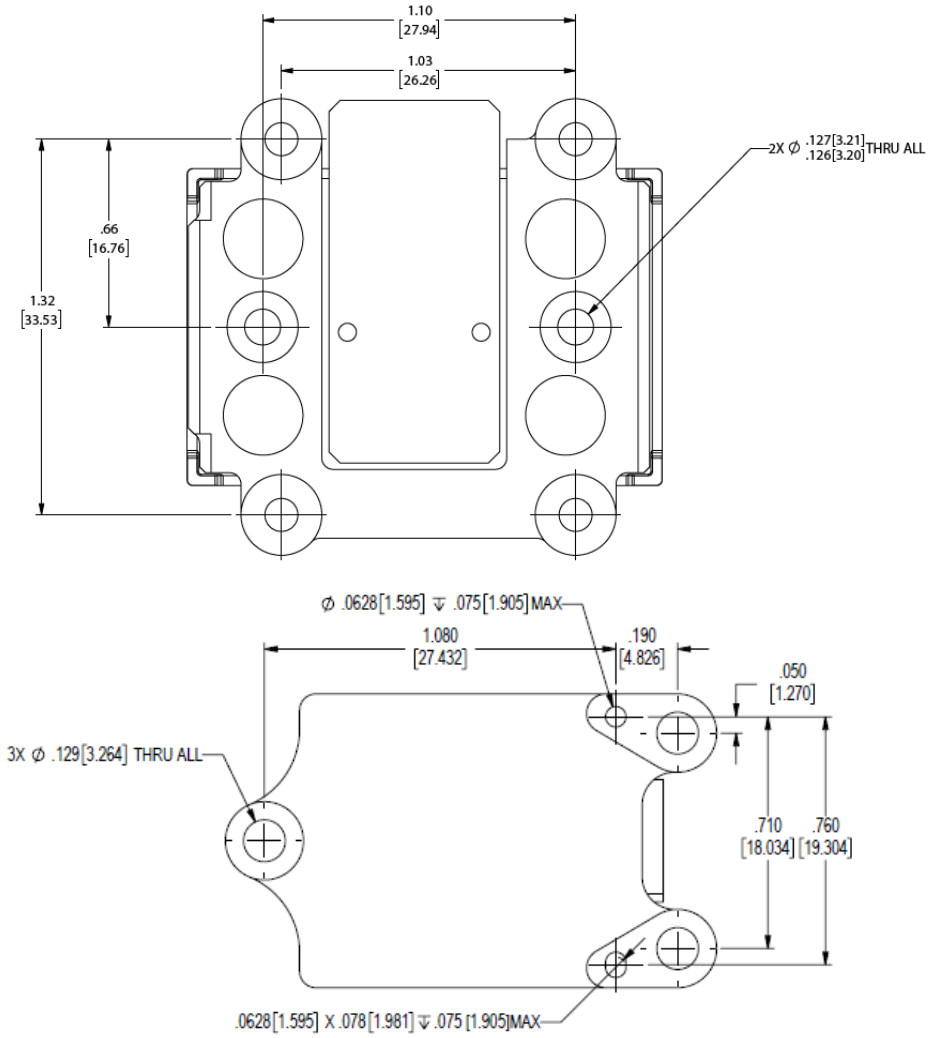
Placement

- Compasses should be placed well away from magnetic disturbances
  - “Hard disturbances” (e.g. magnets) produce a magnetic field
  - “Soft disturbances” (e.g. nickel, iron, ferrous alloys) conduct magnetic fields away from the compass
- Large magnetic fields (>1 Gauss) will prevent successful in-field calibration
  - Very large fields can magnetize compass sensors
- The compass cannot be calibrated to changing fields
  - Motors, batteries, and power cables are common sources of these fields
  - Accuracy can be severely degraded



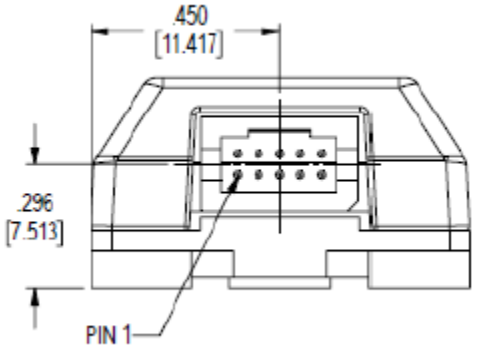
Alignment

- Alignment pins on M-series and P-series compasses allow compasses to be fixed to within 0.037 degrees
- Compasses can be installed in any orientation, and sensor measurements can be rotated with the `boresightMatrix` rotation matrix
- `boresightMatrix` can be set to several preset values with the `orientation` variable



M2 Electrical Interface

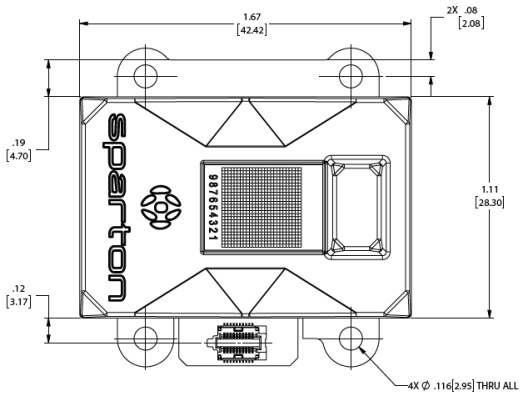
- Default baud rate: 115200
- Logic level: 3.3V TTL
- V+ voltage: 4V to 10V
- Mating Connector: SAMTEC -ISDF-05-D-L (TIGER EYE™ 0.50 pitch)
- Cable: Samtec ASD-191102-03 (Sparton PN 130-9789-003)



Pin #	Pin Name	I/O	Function
P1	GND	O	System Ground
P2	GPIO1	I/O	RESERVED
P3	USER_TXD	O	3.3V logic TXD output from User Com Port
P4	GPIO2	I/O	RESERVED
P5	USER_RXD	I	3.3V logic RXD input to User Com Port
P6	#RESET	I	3.3V logic, active-low reset input (the pin has a weak pull-up)
P7	V+	I	+4 to +10 DC power supply input
P8	UART1_TXD	O	RESERVED
P9	#EINT0	I	3.3V logic, active-low interrupt input (the pin has a weak pull-up) Used for programming purposes
P10	UART1_RXD	I	RESERVED

P-series Electrical Interface

- Default baud rate: 115200
- Logic level: 3.3V TTL
- V+ voltage: 4V to 10V
- Cable: Flexible circuit board (Sparton PN 130-9793-001)

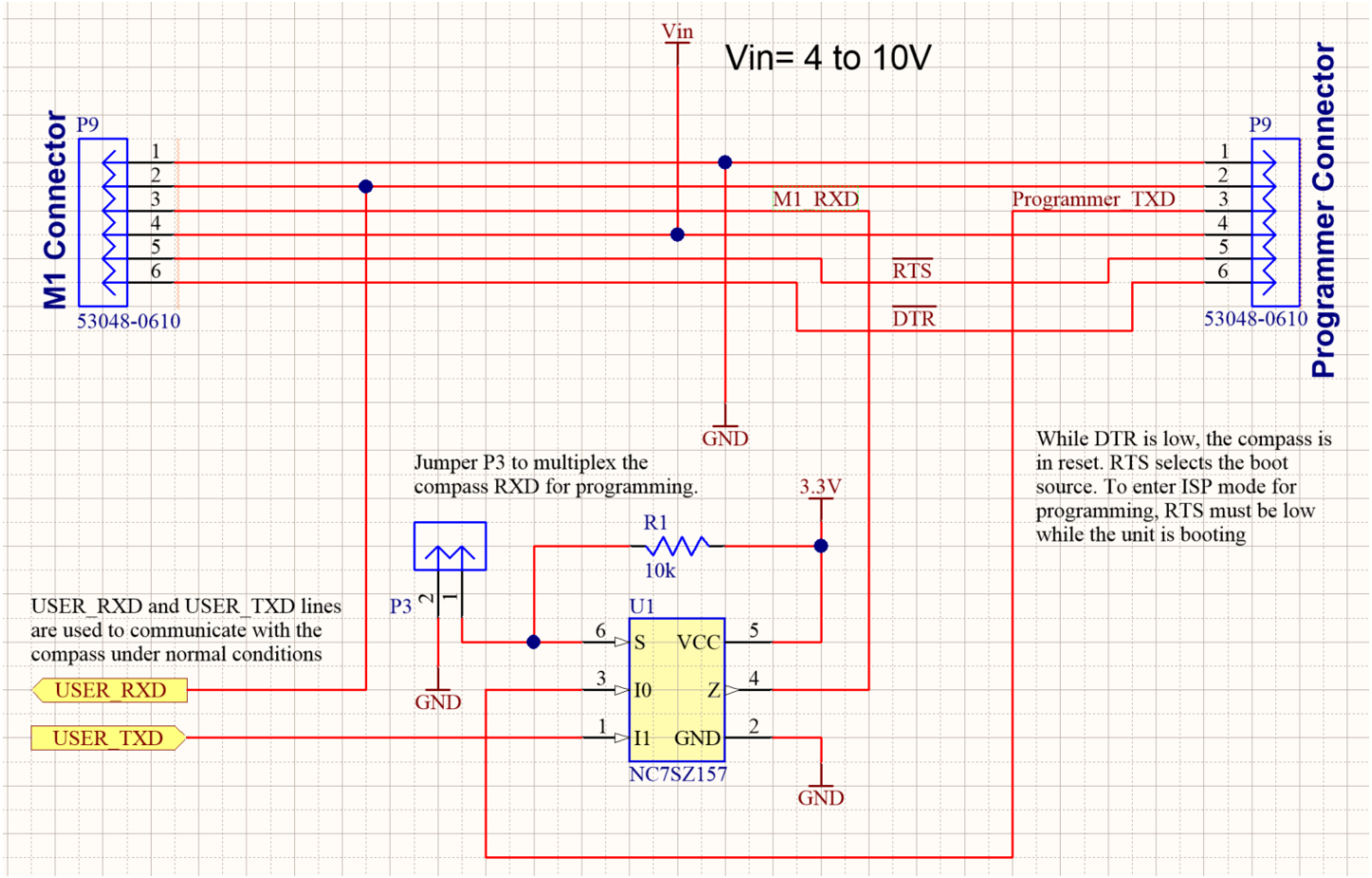


Connector (Connector Type: Samtec SS4-10-3.00-L-D-K-TR; Mating connector: ST4-10-1.00-L-D-P-TR):

Connector – Pin Number	Pin Name	I/O	Function
1	V+	I	+4 to +10V DC power supply input. Max load = (80mA (AHRS-8), 80mA, (GEDC-6EP), 33mA (DC-4EP))
2	V+	I	+4 to +10V DC power supply input. Max load = (80mA (AHRS-8), 80mA, (GEDC-6EP), 33mA (DC-4EP))
3	USER_RXD	I	3.3V logic RXD input to User Com Port
4	USER_RXD	I	3.3V logic RXD input to User Com Port
5	USER_TXD	O	3.3V logic TXD output from User Com Port
6	USER_TXD	O	3.3V logic TXD output from User Com Port
7	/RESET	I	3.3V logic, active-low reset input (the pin has a weak pull-up)
8	/RESET	I	3.3V logic, active-low reset input (the pin has a weak pull-up)
9	/EINT0	I	3.3V logic, active-low interrupt input (the pin has a weak pull-up). Used for programming purposes
10	/EINT0	I	3.3V logic, active-low interrupt input (the pin has a weak pull-up). Used for programming purposes
11	GND	N/A	System Ground
12	GND	N/A	System Ground
13	V_TEST	O	3.3V regulator output for test purposes (factory use only)
14	V_TEST	O	3.3V regulator output for test purposes (factory use only)
15	DEBUG_RXD	I	3.3V logic RXD Input to Debug Port (factory use only)
16	DEBUG_RXD	I	3.3V logic RXD Input to Debug Port (factory use only)
17	DEBUG_TXD	O	3.3V logic TXD Output from Debug Port (factory use only)
18	DEBUG_TXD	O	3.3V logic TXD Output from Debug Port (factory use only)
19	#WP_EEPROM	I	3.3V logic, active-low EEPROM write protect (the pin has 10kΩ pull-down)
20			Reserved

Compass Pass-through

- Troubleshooting, as well as firmware and World Magnetic Model (WWM) updates require direct communication with the compass. Compass Rxd should be multiplexed.



Protocols

- NorthTek
  - Northtek is a Forth environment. NorthTek scripts can be stored and run on boot. Because it is interpreted and runs at low priority, a small amount of time (~5 ms) will pass before Northtek runs on low priority, so bitstreaming is preferred for most applications.
  - NorthTek scripts can perform calculations and output data in arbitrary formats.
- RFS
  - Binary packet format
- NMEA
  - Compasses can output data in NMEA sentences
- Bitstreaming
  - Data can be streamed on various triggers
  - Data can be checksummed for error checking.
  - The enabled data is output in a specific format
  - Multiple channels are available

Bitstream example

chan0Enables array[0 15 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]array set drop // clear any streams
chan0Format 3 set drop // set ASCII output

// Enable variables
chan0EnableBit roll dvid@ set drop
chan0EnableBit pitch dvid@ set drop
chan0EnableBit yaw dvid@ set drop
chan0EnableBit cputime dvid@ set drop

chan0Enable. // Print enabled variable information

chan0Trigger 6 set drop // set trigger to timer
chanTimerX100us 1000 set drop // set 100us timer multiplier (set to trigger on 100ms interval)
chan0TriggerDivisor 1 set drop // set trigger divisor and start stream (set to divide by 1)

Things to Avoid

- Ultrasonics
  - The MEMS gyroscopes used in Sparton compasses resonate at 20-30 kHz. Avoid exposure to vibrations at these frequencies.
  - Ultrasonic cleaning will irreversibly damage MEMs sensors in the compass. Ultrasonic cleaners are powerful enough that frequency is not critical
- Helium Leak Testing
  - MEMS Gyroscopes are resonant structures sealed in a near vacuum package. Helium will infiltrate the package through the compass potting and interfere with gyroscope operation. Low levels of exposure introduce a bias on the gyroscope; High levels completely stop gyroscope operation. Recovery can take months.
  - Helium leak tests should always check for leakage into the enclosure, in order to minimize exposure.
- Acetone Cleaning
  - Acetone will rapidly eat away at ABS plastic housings

Troubleshooting

- Problem: Compass does not communicate/compass locks up
  - Causes: Baud is wrong, Rx and Tx are reversed, Insufficient power, memory leak in Northtek script, incorrect jumpers on NDS-1E devkit
- Problem: Drifting yaw/high yaw error
  - Cause: Poor infield calibration, incorrect boresightMatrix
    - Differences in predicted and actual magnetic measurements cause the yaw to drift over time (up to ~10s) until they converge
    - Some amount of drift is expected during calibration, as new calibration coefficients are calculated
- Problem: High pitch/roll error
  - Cause: High accelerometer bias, incorrect boresightMatrix
    - High accelerometer bias indicates physical damage
- Problem: Compass thinks it is spinning
  - Cause: High gyro bias
    - Can be fixed (M-series only) by setting `gyroBiasEstVarianceInit` to a larger value. Can be caused by helium exposure