Redus Engineering Devine, Tx	

Project Title - Evaluation of ONWA KA-GC9A	Proj. Ref. **OP Valve**	Page **1 of 37**	File Ref. **TR-21-04**

Evaluation of ONWA KA-GC9A

9-Axis Magnetic compass with built-in GPS module for Manned Submersibles

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1. EXECUTIVE SUMMARY

This document covers the potting and testing of the ONWA Marine Electronics, KA-GC9A combination magnetic compass, GPS receiver and boat attitude transducer conducted on June 24-25, 2021 in Devine, Tx. The objective of the project was to pot the device with a two-part marine epoxy and then test the customized unit to determine if the unit could continue to transmit NMEA 0183 sentences at a simulated depth of 1,200 fsw. The test was conducted in a test chamber capable of achieving a pressure up to 2,500 psig or 5,600 fsw. Chamber pressure and temperature were logged on a PLC. The simulated depth in the chamber was increase in 100 ft increments until the 1,200 fsw target depth was achieved. At each of these depth increments, the transponder was held at this pressure for approximately 5 minutes. The transponder continued to operate throughout the test. On disassembly of the test chamber and removal of the transponder, no obvious damage had occurred to the transponder.

As a test of the system, the KA-GC9A was plugged into a laptop with OpenCPN installed. OpenCPN is an open source Chartplotter and GPS Navigation Software that can be installed on a laptop computer to let it act as a chart plotter. The KA-GC9A correctly showed the boat on the display and the heading based on the magnetic compass correctly changed direction as the unit was rotated. The GPS coordinates were correctly displayed.

2. INTRODUCTION

Small private manned submersibles like those built by PSub.org members can utilize inexpensive marine GPS receivers and boat attitude transducers if they can be marinized for underwater use.

The goal of this project was to document the performance of the ONWA Marine Electronics, model KA-GC9A 9-Axis Electronic compass with built-in High Accuracy GPS module shown in Figure 1. Specifically, the ability of the unit to continue to transmit NMEA 0183 sentences at a target depth of 1,200 fsw was to be determined. Prior to the test the unit was modified by adding water blocks to the wire conductors in the cable and potted with a two-part marine epoxy. This report describes the steps to make the water blocks and pot the ABS plastic enclosure and the pressure test.

To conduct the depth test, a test chamber was utilized shown in Figures 2 and 3. A positive displacement, triplex plunger pump was used to generate the pressure for the test with fresh water as the media. The adjustable pressure relief valve for the pump was set at 600 psig which sets the maximum pressure the chamber can achieve.

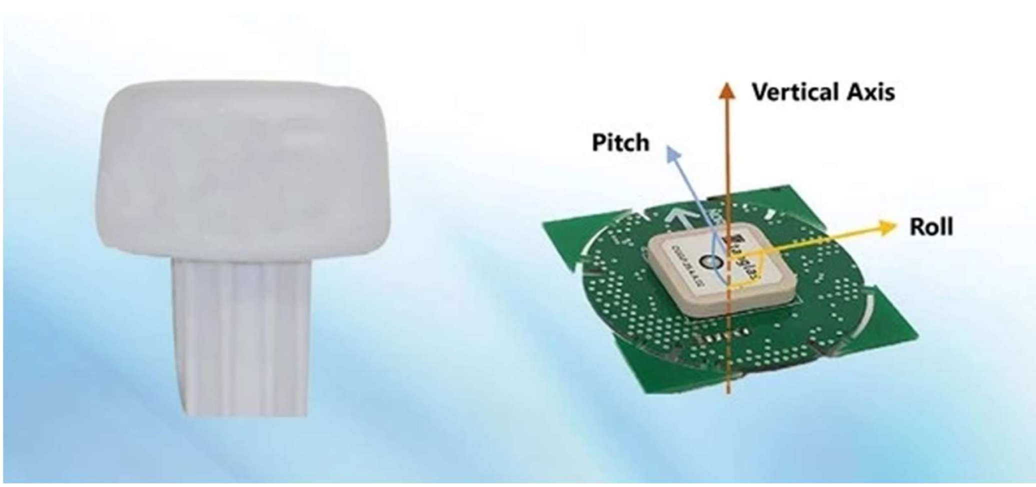


Figure 1 ONWA Marine Electronics, model KA-GC9A

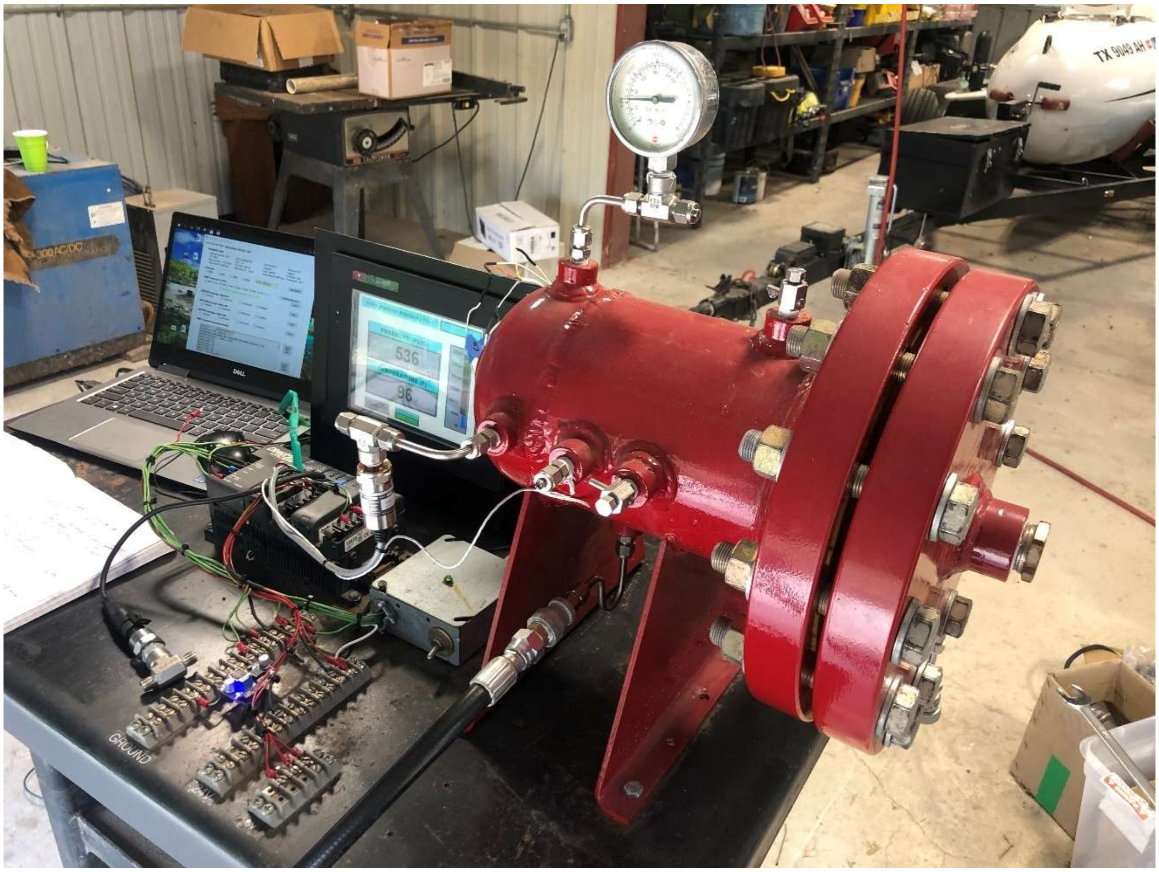


Figure 2 Test Chamber with KA-GC9A installed

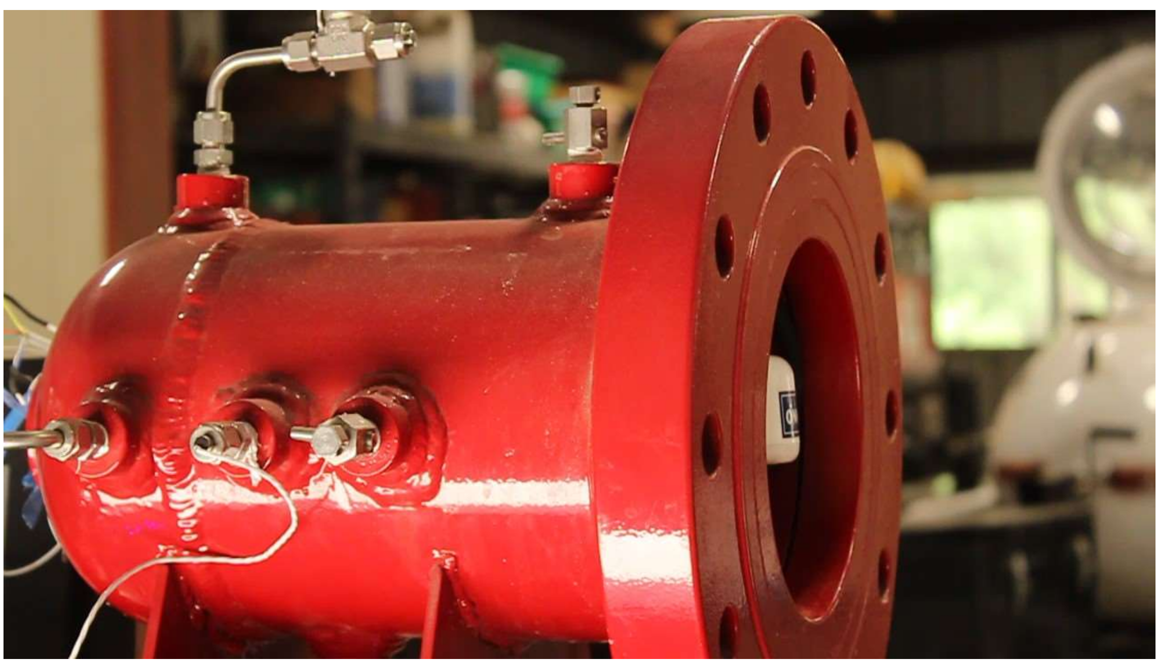


Figure 3 - KA-GC9A orientation during test

3. RESULTS & CONCLUSIONS

1) The maximum recorded pressure was 539 psig. This pressure corrosponds to 1,213 fsw assuming a 64 lbm/ft^3 salt water density.
2) The KA-GC9A continued to operate for 1 hour at 1,200 fsw.
3) Based on this test, the recommended maximum operating depth is 1,200 fsw with the epoxy potting and water blocks for conductors.
4) Because of the solid potting of the enclosure, a much deeper maximum depth is possible but needs to be confirmed with an experiment.
5) A step by step procedure was used to encapsulate the KA-GC9A electronics in epoxy.
6) By using the ONWA 9 Axis E-Compass manager, the NMEA 0183 output was modified to send boat attitude data of roll and pitch.

4. DISCUSSION

4.1 Description of KA-GC9A

The ONWA Marine Electronics, model KA-GC9A 9-Axis Electronic compass with built-in High Accuracy GPS module outputs NMEA 0183 serial data including GPS coordinates, COG, speed, roll, pitch and temperature. The KA-GC9A does not require a separate black box driver device, it has all the driving electronics included in a single compact transducer/receiver case.

To wire the device, connect 12VDC to unit and connect the NMEA 0183 data wire to any NMEA compatible instrument, computer or NMEA data repeater. See Appendix E for a drawing that shows how the KA-GC9A is wired. The ASCII NMEA 0183 sentences are used to transmit data.

4.2 Specifications of KA-GC9A

Interface (NMEA 0183 version 2.0):

- Baud rate: 4800
- Output sentences: GPRMC, GPGSA, GPGGA, GPGLL, GPVTG, GPHDT(5Hz), GPGMS

Note: All output sentences are in intervals of 1 Hz unless specified.

Electrical:

- RS-232, 18KV ESD

Power Supply:

- 5V-15.5V, Over-voltage and reverse polarity protected
- Power consumption: 450 mW

User Interface:

- Uses 9-Axis E-Compass Manager
- Any device that can display NMEA 0183 sentences

IMU (Inertial Measurement Unit):

- 9-Axis (Features a GPS/Glonass receiver coupled with a 9-axis AHRS unit providing 3D orientation by integrating gyroscopes and data fusing with accelerometers and magnetometers)

Maximum Operating Depth:

- Maximum tested to date is 1,200 fsw after potting.

4.3 Test Chamber Setup

As seen in Figure 2, to setup the pressure test of the KA-GC9A unit, a 3,000 psig pressure transmitter was calibrated and wired into the Automation Direct 205 series PLC analog input card. A bourdon pressure gauge was also installed as a backup. The PLC hardware as well as the I/O for the test is shown in Appendices A and B. A positive displacement pump in the pressure washer was used to develop the pressure. An RTD was installed in the test chamber to measure the temperature. The KA-GC9A was wired to a USB connector that was plugged into the USB port of a laptop. ONWA supplied 9-axis E-compass manager, was used to display data as well as the NMEA 0183 output sentences as shown in Figure 4. Note that this software can be used to modify what is outputted by the device from its default state. As an example, to turn on pitch and roll, the box next to GMS needs to be checked.

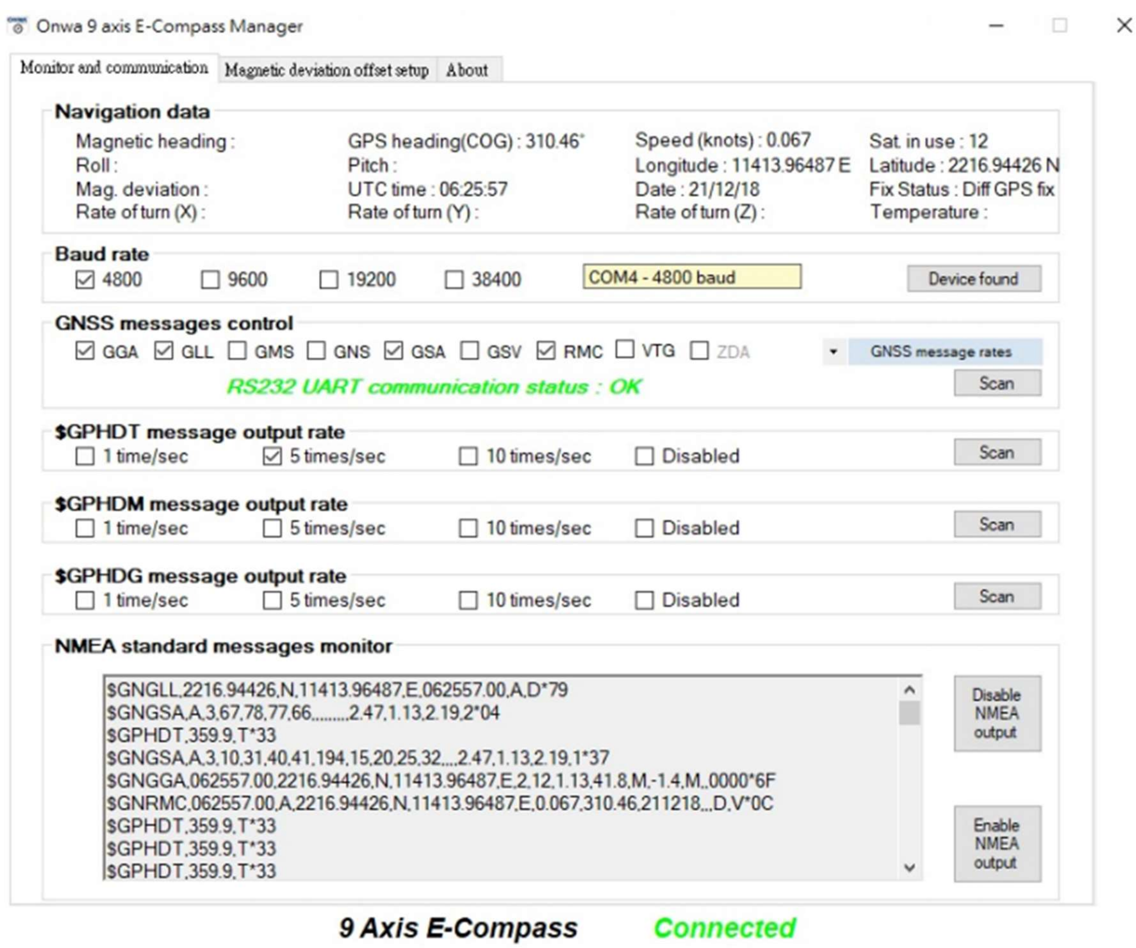


Figure 4 9 Axis E-Compass manager display

The cold-water supply to the test-stand supplied pressure at approximately 76 psig. This corresponds to 171 fsw which is the minimum depth test conducted. For higher pressures, a bypass vernier valve was used. By closing off more and more of the bypass flowrate, the pressure in the chamber is increased. For the 1,200 fsw test (533 psig), the external pressure relief valve was set to 600 psig.

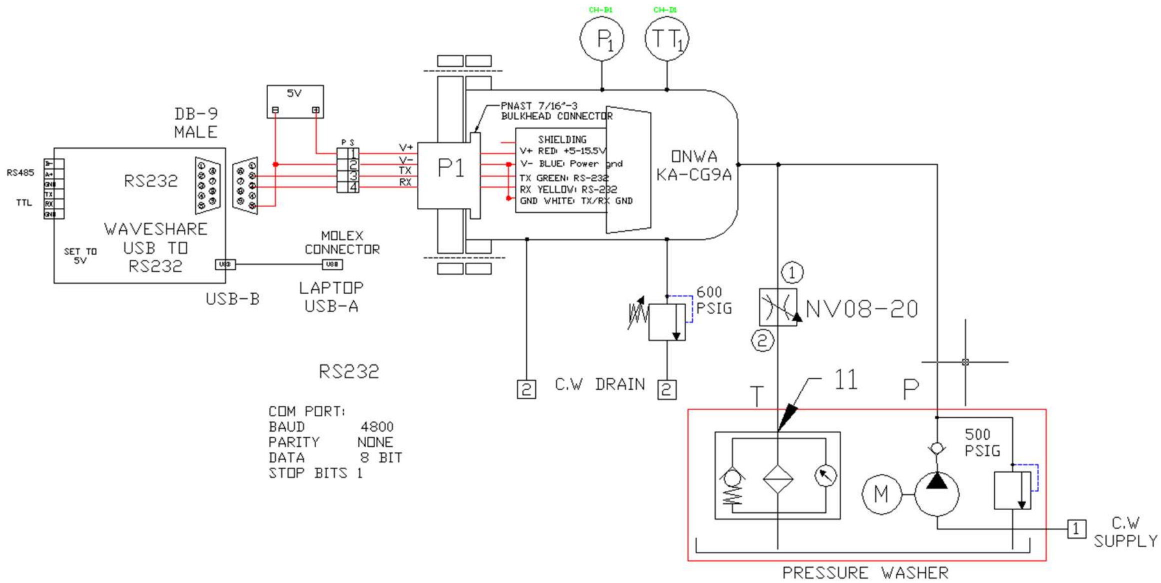


Figure 5 - Setup for Pressure Test

4.4 Depth Test Results

The target test pressures are shown in Table 1.

Table 1 Test Depths and Hydrostatic Pressures

Depth (fsw)	Pressure*(psig)
171	76.0
300	133.3
400	177.8
500	222.2
600	266.7
700	311.1
800	355.6
900	400.0
1,000	444.4
1,200	533.3

At each of these test points, the pressure was held steady for approximately 5 minutes until the target depth of 1,200 fsw was reached. The pressure was held steady at this depth approximately 1 hour. The intention of the test was to determine if the housing could withstand the pressure without cracking or flooding. As such the pass/fail criteria for the test was the KA-GC9A's ability to transmit data.

The test was done on June 24 starting at 1:43 pm. Figure 5 shows the depth and temperature over the test period.

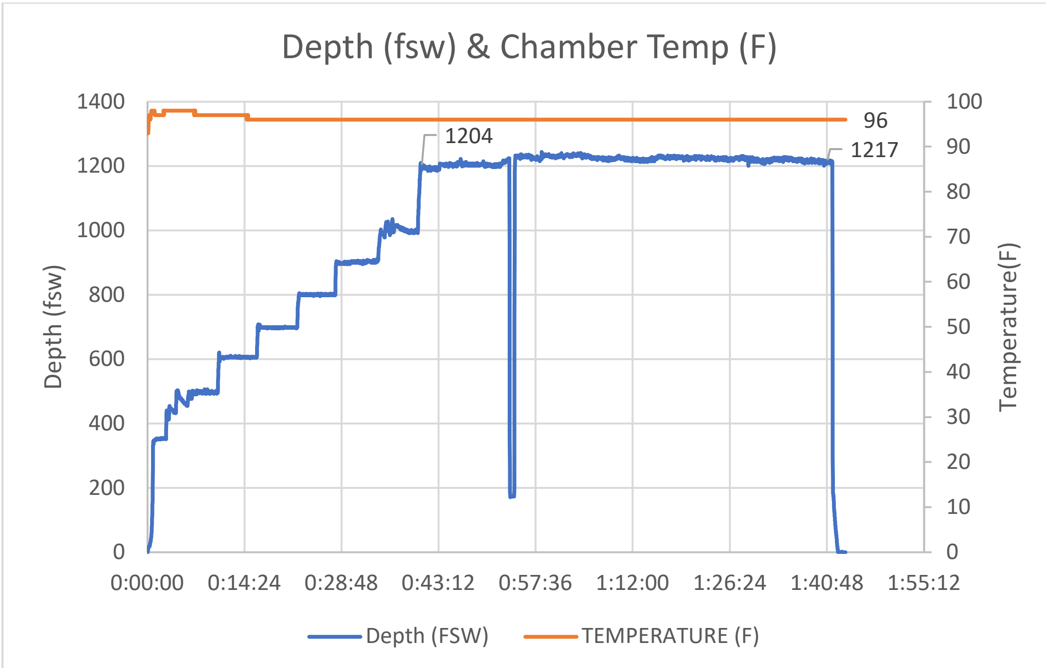


Figure 6 - Plot of depth (fsw) and chamber temperature

At 53 minutes into the test the 4-stroke gas engine that was powering the positive displacement pump ran out gas which caused the pressure to drop. After refueling, the test resumed.

The maximum pressure that occurred during the test of 539 psig which corresponds to 1,213 fsw.

5. POTTING

5.1 Overview

On June 24, 2021, the KA-GC9A was potted with a two-part marine epoxy for the purpose of enabling the unit to be submerged to depths of at least 1,200 ft. Customization was required because the enclosure is made of ABS plastic and the void space in the unit, not occupied by the PCB, was filled with air. Also, the water egress protection of the OTS unit is designed for surface marine applications. To reduce the price of this DIY conversion, the existing cable pigtail was used. To keep water from migrating between the soft flexible cable shielding and the potting epoxy, each of the multistrand conductors were modified by adding a ¾ inch section of bare copper wire. This is referred to as a water block.

See Figure 7 showing the KA-GC9A after the cap is unscrewed. There is an o-ring that is used to seal the cap to the base. Even though this o-ring is not required after potting, it will be left in place to keep the water from migrating into the threaded area.

Figure 7 – Units opened up to show PCB

The PCB is held to the base stand offs with some white adhesive that can be removed with a pick. Figure 8 shows the PCB after being lifted off the base. A small flat head screwdriver was used to separate the PCB from the base.

Figure 8 – KA-GC9A showing bottom of PCB and connection cable

The metal retaining plate shown in the base is used to compress a cylindrical silicon like plug into a recessed hole in the base. This compresses the cable to prevent water from egress in the OTS unit. This plug will be discarded to enable epoxy to encapsulated the cable and to centralize the cable in the recessed hole.

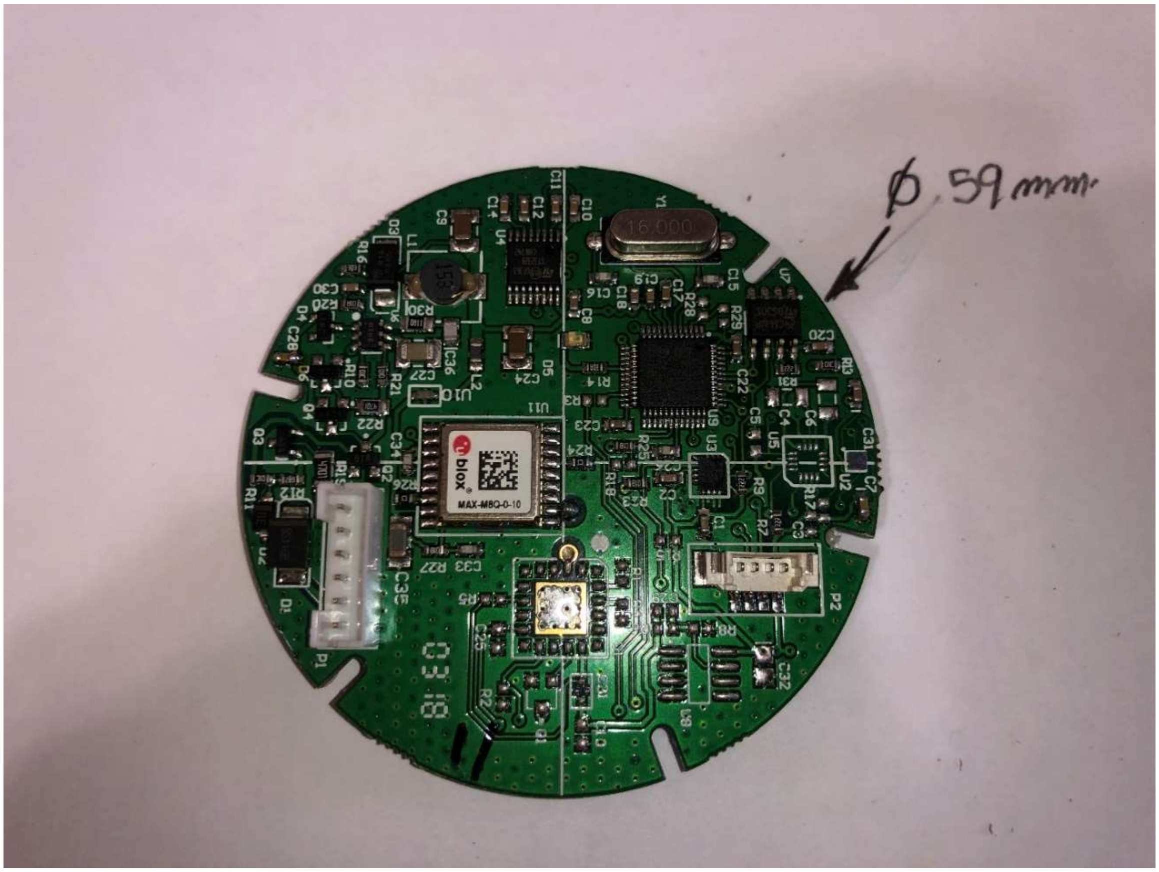


Figure 9 - KA-GC9A showing bottom of PCB

Figure 9 shows the bottom of the PCB. Note that most of the parts are surface mounted.

The top of the PCB is shown in Figure 9. Which shows the GPS antenna.

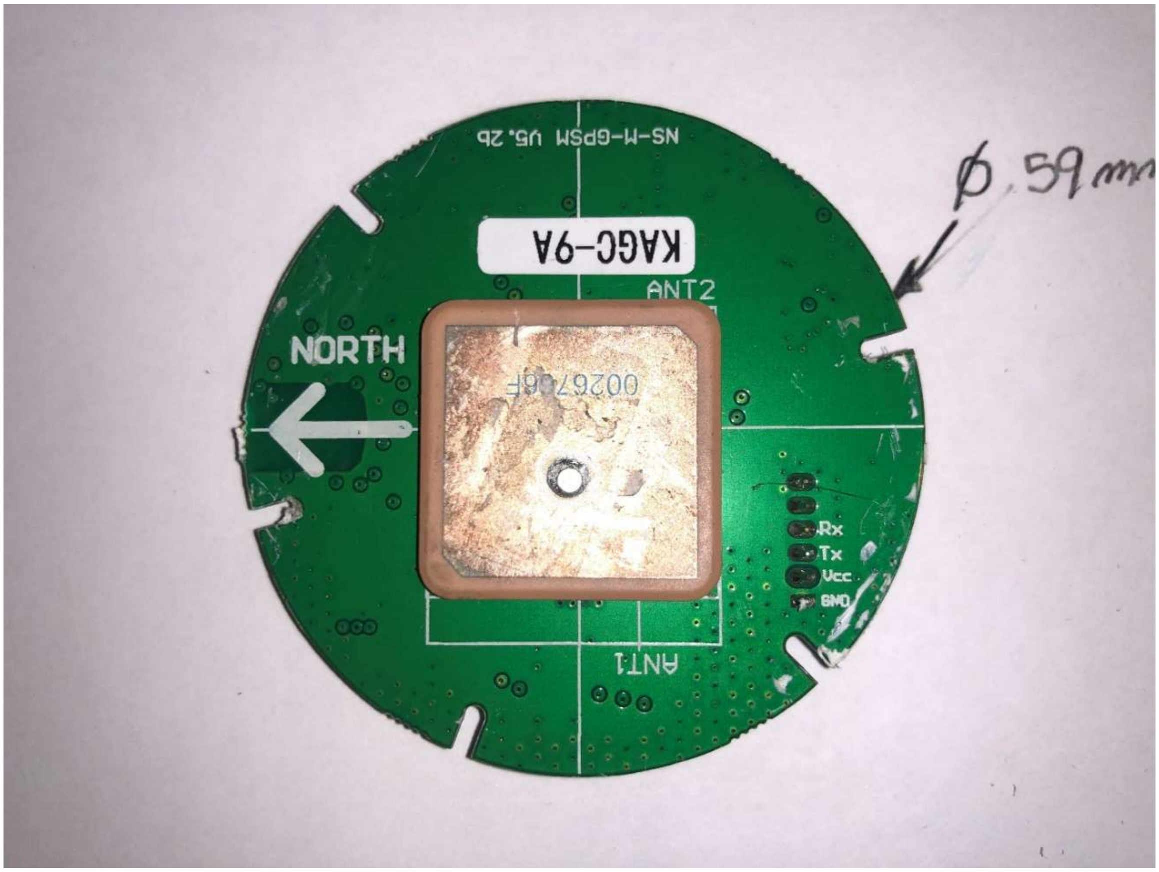


Figure 10 - KA-GC9A showing GPS antenna on top of PCB

5.2 Potting Procedure

The steps used for potting the KA-GC9A are shown below:

1) Wire KA-GC9A as described in drawing in Appendix E to computer USB and confirm unit is working.
2) Put base in vice and rotate cap counterclockwise to remove cap.
3) Use pick to remove the flexible white adhesive holding PCB to base.
4) With a small flathead screw driver lift the PCB away from the base.
5) Clean off remaining flexible white adhesive from PCB.
6) Disconnect the 6 pin connector from PCB.
7) Unscrew the cross head screws holding the metal plate that compresses plug.
8) Drill a 3/8” hole through the centerline of the base along the long axis of the base. This will be used to fill the assembled unit with catalyzed epoxy.
9) Use a fine grit sandpaper to roughen up the inside surface of base and cap. This will promote good adherence of the epoxy to the walls.
10) Cut the 5 conductor cable approximately 6 inches from the connector end.

11) Remove the flexible compression plug but keep both the plastic and metal hold downs.
12) On the part of the cable that has the connector, strip back the outer insulation to approximately 2-7/8 inch from the end of the connector. This should leave about ¾ inch of outer insulation from the edge of the shrink tube.
13) Solder a ¾ inch section of solid core wire (like found on resistors, 0.025" diameter) in each of the 5 conductors. These sections are water blocks to prevent water from migrating along the flexible insulation when under pressure.

Figure 11 – Cable harness with water block on one conductor

14) Secure the small cross head screws to the plate to hold the wire to the center of the entrance hole. Note the compressible plug has been removed so that catalyzed epoxy can surround the 5 wire conductor cable.
15) Secure the plastic hold down with small cross head screw.
16) Spread the 5 uninsulated wires apart so that they do not touch and are held off the base by approximately ¼". These will be completely encapsulated with the potting is complete.
17) Secure the cable to the base mounting tube with a tie.
18) The base should look like Figure 17 below prior to potting.

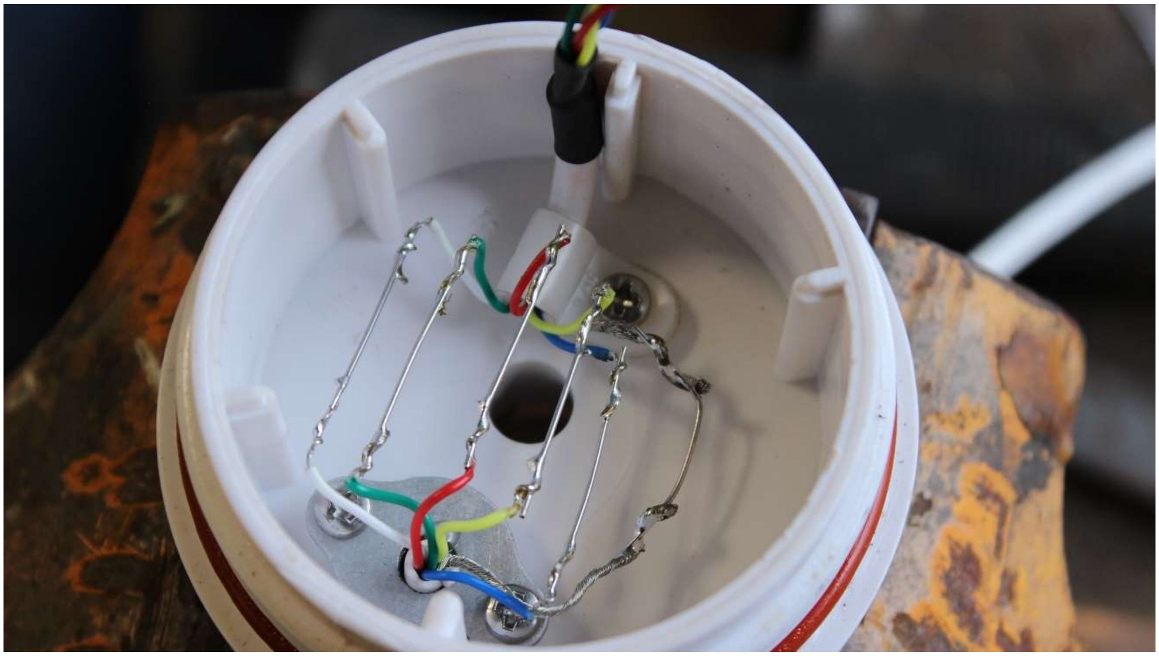


Figure 12 - Water blocks on each conductor secured at both ends

19) Test KA-GC9A still broadcasting NMEA 0183 sentences. If not check wiring.
20) Mix up 8 ounces of resin and harder. Mixing ratio by volume is 3 parts West System 105 Epoxy Resin (Part 1) with 1 part of West Systems 209 Extra Slow hardener (Part 2). Therefore, to get 8 ounces of catalyzed resin, mix 6 ounces of Part 1 and 2 ounces of Part 2. At 70°F the pot life is 40-50 minutes with working time of 3-4 hours with cure to solid in 20-24 hours. Follow manufacture's mixing instructions.
21) Place the catalyzed epoxy in a vacuum chamber for about 5 minutes to remove air bubble caused by mixing the two parts. Note that if you do not have a vacuum pump and chamber, this step can be omitted with the understanding that small air bubbles entrained during mixing will be present in the final casting. While this will weaken the casting to some degree, it is probably not significant at the depths anticipated.

Figure 13 – West System 105 epoxy resin and 209 extra slow hardener

22) Only approximately 30 ounces will be used.
23) Wearing latex gloves, apply a thin coat of catalyzed resin to the area around the bare wires.
24) Apply thin coat of catalyzed resin to the underside of PCB.
25) Position the PCB so that the North Arrow on PCB corresponds with the bow direction arrow on the bottom of the case.
26) Apply a drop of UV light Glue to each of the support tabs and harden with UV light. Note that if UV light glue is not available, other quick drying adhesives will work.
27) Fill the cap with catalyzed resin until the level reaches the bottom of the threaded section. The inner support ring should be just covered.
28) Holding the cap so that the resin does not spill, screw the base to the cap until snug.
29) Pour catalyzed resin into 3/8 inch hole until the level of the resin reaches the base of the M25-1.5 threads.
30) Place the potted KA-GC9A assembly back into a vacuum chamber for 5 minutes to pull out any remaining air pockets.
31) Top off resin to base of threads if necessary.
32) Set aside for curing for 24 hours.
33) Test KA-GC9A still broadcasting NMEA 0183 sentences.

6. OpenCPN

As a test of the system, the KA-GC9A was plugged into a laptop with OpenCPN installed. OpenCPN is an open source Chartplotter and GPS Navigation Software that can be installed on a laptop computer to let it act as a chart plotter.

The KA-GC9A correctly showed the boat on the display and the heading based on the magnetic compass correctly changed direction as the unit was rotated. The GPS coordinates were correctly displayed.

7. FUTURE WORK

This work has confirmed the ONWA KAGC-9A will continue to output NMEA sentences when exposed to pressures associated with 1,200 fsw if potted with epoxy and water blocks are applied to connectors.

The cable to the unit is adequate for topside marine environment but could be heavier for psub applications. One future change would be to use a SubConn Micro Circular series inline connector, model MCILM5 with an 18” pigtail as a replacement for the factory cable. The pigtail would be connected to the water blocks conductors. The material for these 5, 6 and 8 conductor inline cable (2 ft, 60 cm): 20 AWG, 0.52 mm^2 is chloroprene rubber. They are 20AWG with an OD of 0.312” (8mm).

The maximum test depth for this work corresponded with the design for my next submersible. It is likely that this potted unit could operate at much deeper depths. A future test might be at a much deeper depth.

Appendix A – PLC I/O and Hardware

Programmable Logic Controller I/O

1/26/2021

I/O	Description	Type	Slot	Address	Status	Alarm Associated
Alarms						
1	High pressure in test chamber, > 3000 psig					
2						
3						
4						
5						
6						
Inputs	Description	Type	Slot	Address	Status	Alarm Associated
CH-B1	HP TEST CHAMBER PRESSURE (0-3000 PSIG)	Analog	0	V2000	Installed	Alarm-1, High pressure in test chamber, > 3000 psig
CH-B2	LP TEST CHAMBER PRESSURE (0-5PSIG)	Analog	0	V2001	Installed	
CH-B3	CURRENTLY NOT USED	Analog	0	V2002		
CH-B4	CURRENTLY NOT USED	Analog	0	V2003		
CH-B5	CURRENTLY NOT USED	Analog	0	V2004		
CH-B6	CURRENTLY NOT USED	Analog	0	V2005		
CH-B7	CURRENTLY NOT USED	Analog	0	V2006		
CH-B8	CURRENTLY NOT USED	Analog	0	V2007		
CH-B9	CURRENTLY NOT USED	Analog	0	V2020-V2021		
CH-B10	CURRENTLY NOT USED	Analog	0	V2022-V2023		
CH-B11	CURRENTLY NOT USED	Analog	0	V2024-V2025		
CH-B12	CURRENTLY NOT USED	Analog	0	V2026-V2027		
CH-C1	CURRENTLY NOT USED	Digital	1	X40		
CH-C2	CURRENTLY NOT USED	Digital	1	X41		
CH-C3	CURRENTLY NOT USED	Digital	1	X42		
CH-C4	CURRENTLY NOT USED	Digital	1	X43		
CH-C5	CURRENTLY NOT USED	Digital	1	Y40		
CH-C6	CURRENTLY NOT USED	Digital	1	Y41		
CH-C7	CURRENTLY NOT USED	Digital	1	Y42		
CH-C8	CURRENTLY NOT USED	Digital	1	Y43		
CH-D1	TEST CHAMBER TEMPERATURE (F)	Analog	2	V2040	Installed	
CH-D2	CURRENTLY NOT USED	Analog	2	V2044		
CH-D3	CURRENTLY NOT USED	Analog	2	V2042		
CH-D4	CURRENTLY NOT USED	Analog	2	V2046		

PLC Modules

Slot	Name	Module	Points	Address	Description
-1	A	D2-260-1	NA	NA	CPU 30.4K WORDS W/1 RS232 & 1 RS232/422/485 PORT
0	B	F2-08AD-2	16	X0-X17	8 Channel Analog Input Voltage 12-Bit Res.
1	C	D2-08CDR	8	X20-X27	Combo 4 PT 24VDC Input and 4 PT Relay Output
2	D	F2-04RTD	32	X30-X47	4 Channel RTD, 0.1 Deg C Resolution

D2-04B-1 DL205 BASE 4-SLOT REQ 110/220VAC PWR W/300mA 24VDC AUX P/S

HMI EA9-T8CL

Appendix B – Transmitter Specifications

Item	Description
Application	High Pressure Transmitter
Manufacturer	TE Connectivity Measurement Specialties
Mfg. Model No.	M5231-000005-03KPG
Digi-Key Part Number	223-1726-ND
Description	TRANSDUCER 0.5-4.5VDC 3000PSI
Pressure Type	Vented Gauge
Operating Pressure	3000 PSI (20684.27kPa)
Type	Analog Voltage
Output	0.5 V ~ 4.5 V
Accuracy	±0.25%
Voltage - Supply	4.75V ~ 5.25V
Port Size	Male - 1/4" (6.35mm) NPT
Features	Temperature Compensated
Termination Style	Cable
Maximum Pressure	6000PSI (41368.54kPa)
Operating Temperature	-40°C ~ 125°C
Package / Case	Cylinder
Datasheet	M5200 Industrial Pressure Transducer (te.com)

Item	Description
Application	Test Chamber Temperature RTD
Manufacturer	DC Direct
Mfg. Model No.	314-140 Small Budget RTD Sensor
Description	100 ohm RTD element, Alpha = 0.00385, Class B
Temperature Range	-58ºF to +390ºF (-50°C to +200°C)
Probe Diameter	1/4″
Probe Length	1.18” long
Termination Style	3 wire configurations
Sheath	316 Stainless Steel
Extension Leads:	72” long, 24 AWG stranded PFA insulated cores with silicone rubber
Wire Color Code	3 wire - 2 colored red and 1 colored white
Datasheet	TC Direct for Temperature Sensing, Measurement and Control

NEMA 0183 sentences (GPRMC, GPGSA, GPGLL, GPZDA, GPVTG, GPHDT)

$GPGLL - Geographic position, latitude / longitude
$GPGSA - GPS DOP and active satellites
$GPHDT - Heading, True
$GPVTG - Track made good and ground speed
$GPZDA - Date & Time
$GPGMS – Roll and Pitch

$GPRMC

Recommended minimum specific GPS/Transit data

```
eg1. $GPRMC,081836,A,3751.65,S,14507.36,E,000.0,360.0,130998,011.3,E*62
eg2. $GPRMC,225446,A,4916.45,N,12311.12,W,000.5,054.7,191194,020.3,E*68


           225446        Time of fix 22:54:46 UTC
           A             Navigation receiver warning A = OK, V = warning
           4916.45,N     Latitude 49 deg. 16.45 min North
           12311.12,W    Longitude 123 deg. 11.12 min West
           000.5         Speed over ground, Knots
           054.7         Course Made Good, True
           191194        Date of fix  19 November 1994
           020.3,E       Magnetic variation 20.3 deg East
           *68           mandatory checksum


eg3. $GPRMC,220516,A,5133.82,N,00042.24,W,173.8,231.8,130694,004.2,W*70
              1    2    3    4    5     6    7    8      9     10  11
12


      1   220516     Time Stamp
      2   A          validity - A-ok, V-invalid
      3   5133.82    current Latitude
      4   N          North/South
      5   00042.24   current Longitude
      6   W          East/West
      7   173.8      Speed in knots
      8   231.8      True course
      9   130694     Date Stamp
      10  004.2      Variation
      11  W          East/West
      12  *70        checksum


eg4. $GPRMC,hhmmss.ss,A,llll.ll,a,yyyyy.yy,a,x.x,x.x,ddmmyy,x.x,a*hh
1    = UTC of position fix
2    = Data status (V=navigation receiver warning)
3    = Latitude of fix
4    = N or S
```

```
5    = Longitude of fix
6    = E or W
7    = Speed over ground in knots
8    = Track made good in degrees True
9    = UT date
10   = Magnetic variation degrees (Easterly var. subtracts from true
course)
11   = E or W
12   = Checksum
```

$GPGSA

GPS DOP and active satellites

```
eg1. $GPGSA,A,3,,,,,,16,18,,22,24,,,3.6,2.1,2.2*3C
eg2. $GPGSA,A,3,19,28,14,18,27,22,31,39,,,,,1.7,1.0,1.3*35


1    = Mode:
       M=Manual, forced to operate in 2D or 3D
       A=Automatic, 3D/2D
2    = Mode:
       1=Fix not available
       2=2D
       3=3D
3-14 = IDs of SVs used in position fix (null for unused fields)
15   = PDOP
16   = HDOP
17   = VDOP
```

$GPGLL

Geographic Position, Latitude / Longitude and time.

```
eg1. $GPGLL,3751.65,S,14507.36,E*77
eg2. $GPGLL,4916.45,N,12311.12,W,225444,A


           4916.46,N    Latitude 49 deg. 16.45 min. North
           12311.12,W   Longitude 123 deg. 11.12 min. West
           225444       Fix taken at 22:54:44 UTC
           A            Data valid


eg3. $GPGLL,5133.81,N,00042.25,W*75
               1    2     3    4 5

      1    5133.81   Current latitude
      2    N         North/South
      3    00042.25  Current longitude
      4    W         East/West
      5    *75       checksum
```

$--GLL,lll.ll,a,yyyyy.yy,a,hhmmss.ss,A llll.ll = Latitude of position

a = N or S
yyyyy.yy = Longitude of position

a = E or W
hhmmss.ss = UTC of position
A = status: A = valid data

$GPZDA

Date & Time

UTC, day, month, year, and local time zone.

$--ZDA,hhmmss.ss,xx,xx,xxxx,xx,xx
hhmmss.ss = UTC
xx = Day, 01 to 31
xx = Month, 01 to 12
xxxx = Year
xx = Local zone description, 00 to +/- 13 hours
xx = Local zone minutes description (same sign as hours)

$GPVTG

Track Made Good and Ground Speed.

```
eg1. $GPVTG,360.0,T,348.7,M,000.0,N,000.0,K*43
eg2. $GPVTG,054.7,T,034.4,M,005.5,N,010.2,K


           054.7,T      True track made good
           034.4,M      Magnetic track made good
           005.5,N      Ground speed, knots
           010.2,K      Ground speed, Kilometers per hour


eg3. $GPVTG,t,T,,,s.ss,N,s.ss,K*hh
1    = Track made good
2    = Fixed text 'T' indicates that track made good is relative to
true north
3    = not used
4    = not used
5    = Speed over ground in knots
6    = Fixed text 'N' indicates that speed over ground in in knots
7    = Speed over ground in kilometers/hour
8    = Fixed text 'K' indicates that speed over ground is in
kilometers/hour
9    = Checksum
```

The actual track made good and speed relative to the ground.

$--VTG,x.x,T,x.x,M,x.x,N,x.x,K
x.x,T = Track, degrees True
x.x,M = Track, degrees Magnetic

x.x,N = Speed, knots
x.x,K = Speed, Km/hr

$GPHDT

Heading, True.

Actual vessel heading in degrees Ture produced by any device or system producing true heading.

$--HDT,x.x,T
x.x = Heading, degrees True

$GPGMS

Boat roll, pitch, magnetic compass heading, and temperature

```
eg1. $GPGMS,0002.5,-003.0,-012.4,-001.9,-232.7,-334.8,000345.9,-
00431.4,000155.8,0033.3,1,0*57

$GPGMS   = E-Compass Protocol header
0002.5   = E-Compass heading course
-003.0   = Angle offset between E_Comp & GPS heading courses
-012.4   = Pitch angle of X axis (range -45.0 to 45.0)
-001.9   = Roll angle of Y axis (range -45.0 to 45.0)
-231.7   = X_MAG_value, E-compass X axis mag. value
-334.8   = Y_MAG_value, E-compass Y axis mag. value
000345.9 = Reserved for debug
-00431.4 = Reserved for debug
000155.8 = Reserved for debug
0033.3   = Temperature °C
1        = mag, sensor ready or not, (1=ready, 0=not ready)
0        = Reserved for testing
57       = Checksum
<CR><LF> = End of message termination

1        =     E-Compass Protocol header
2        =     E-Compass heading course
3        =     Angle offset between E_Comp & GPS heading courses
4        =     Pitch angle of X axis (range -45.0 to 45.0)
5        =     Roll angle of Y axis (range -45.0 to 45.0)
6        =     X_MAG_value, E-compass X axis mag. value
7        =     Y_MAG_value, E-compass Y axis mag. Value
8        =     Reserved for debug
9        =     Reserved for debug
10       =     Reserved for debug
11       =     Temperature °C
12       =     mag, sensor ready or not, (1=ready, 0=not ready)
13       =     Reserved for testing
14       =     Checksum
<CR><LF> = End of message termination
```

Appendix D – PLC Ladder Logic

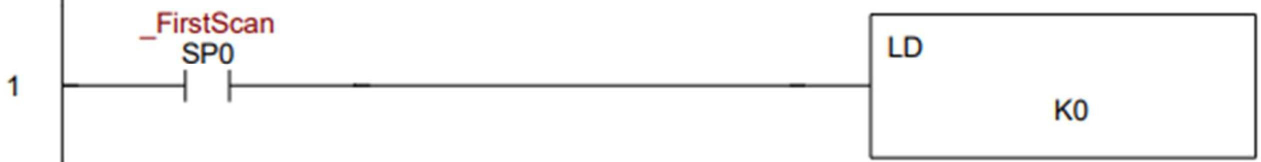
Path: c:\users\public\documents\directsoft6\projects\onwa ka-gc9a.prj
Save Date: 06/25/21 13:06:30
Creation Date: 06/25/21 11:59:52
PLC Type: 260
Class ID: DirectLogic 205 Series
Link Name: 260 new

ABU120BT PROJECT TEST CHAMBER

Ladder logic for the ONWA KA-GC9A Pressure Test
Date 6/25/21
CLR

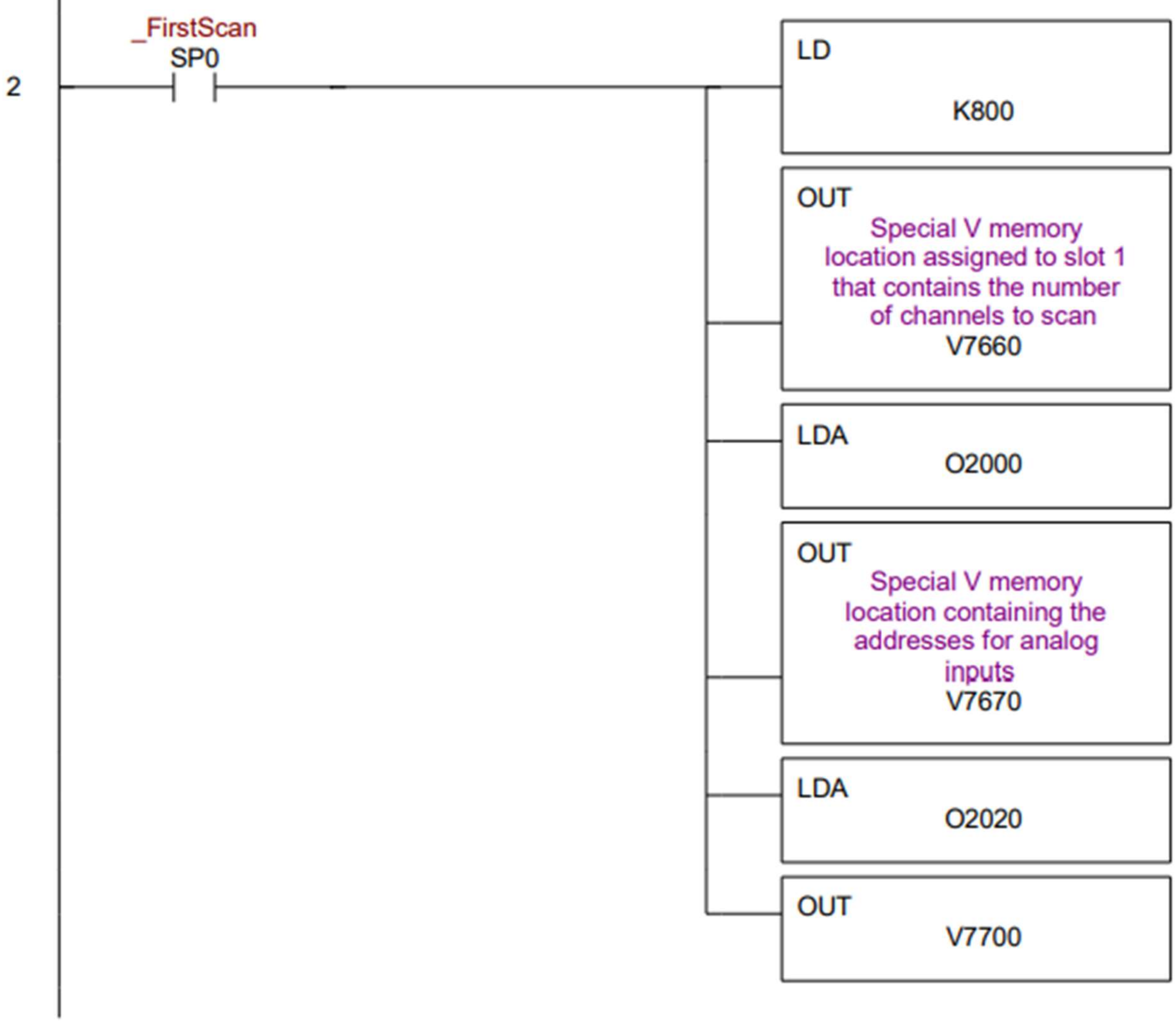
REVISION HISTORY:

6-25-21 Initial setup for ONWA KA-GC9A



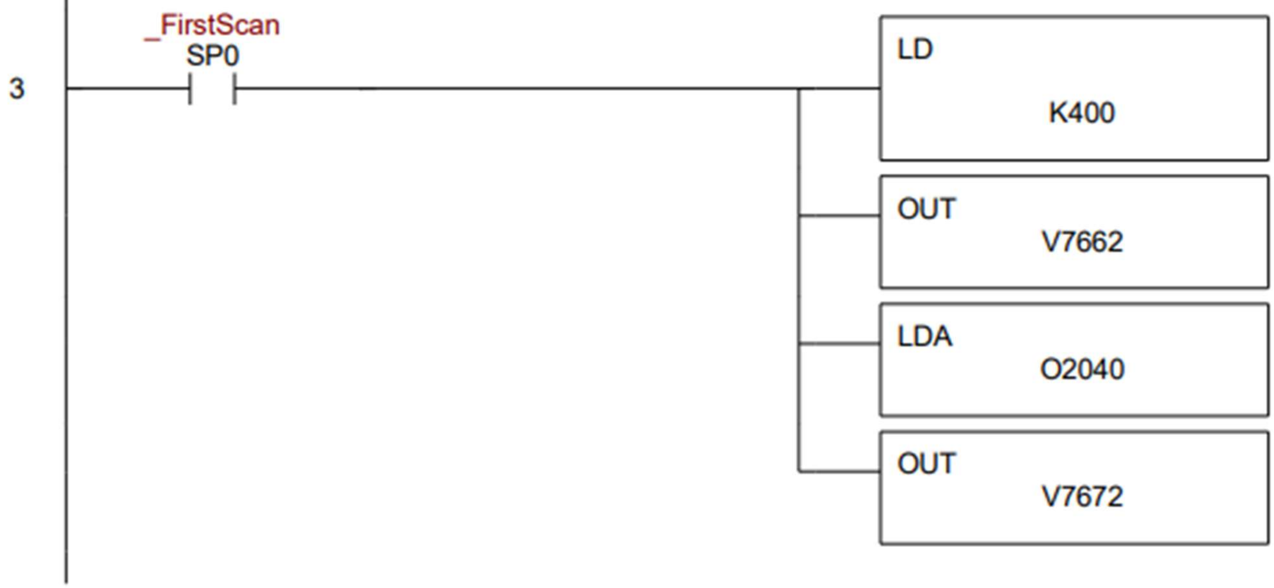
This rung specifies the number and location of V memory addresses into which the analog input signal from F2-08AD-2 module in slot 0, just to eft of CPU, will be stored. Channels are:

CHB1 V2000 Chamber HP Pressure, psig (0-3000 psig)
CHB2 V2001 Chamber LP Pressure, psig (0-5 psig)
CHB3 V2002 Currently not used
CHB4 V2003 Currently not used
CHB5 V2004 Currently not used
CHB6 V2005 Currently not used
CHB7 V2006 Currently not used
CHB8 V2007 Currently not used



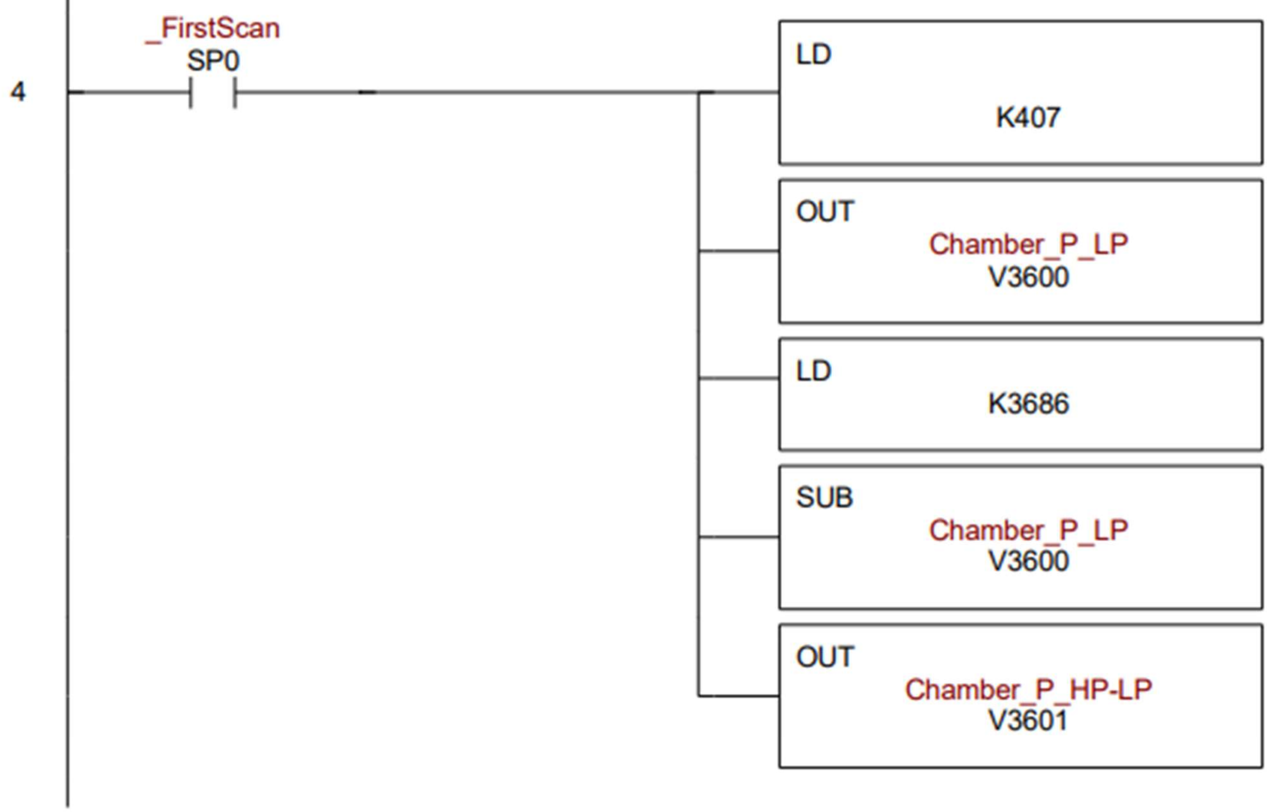
This rung specifies the number and location of V memory addresses into which the analog input signal from F2-04RTD module in slot 2 will be stored. Channels are:

CHD1 V2040 Chamber Temperature, F *10
CHD2 V2042 Currently Not Used
CHD3 V2044 Currently Not Used
CHD4 V2046 Currently Not Used



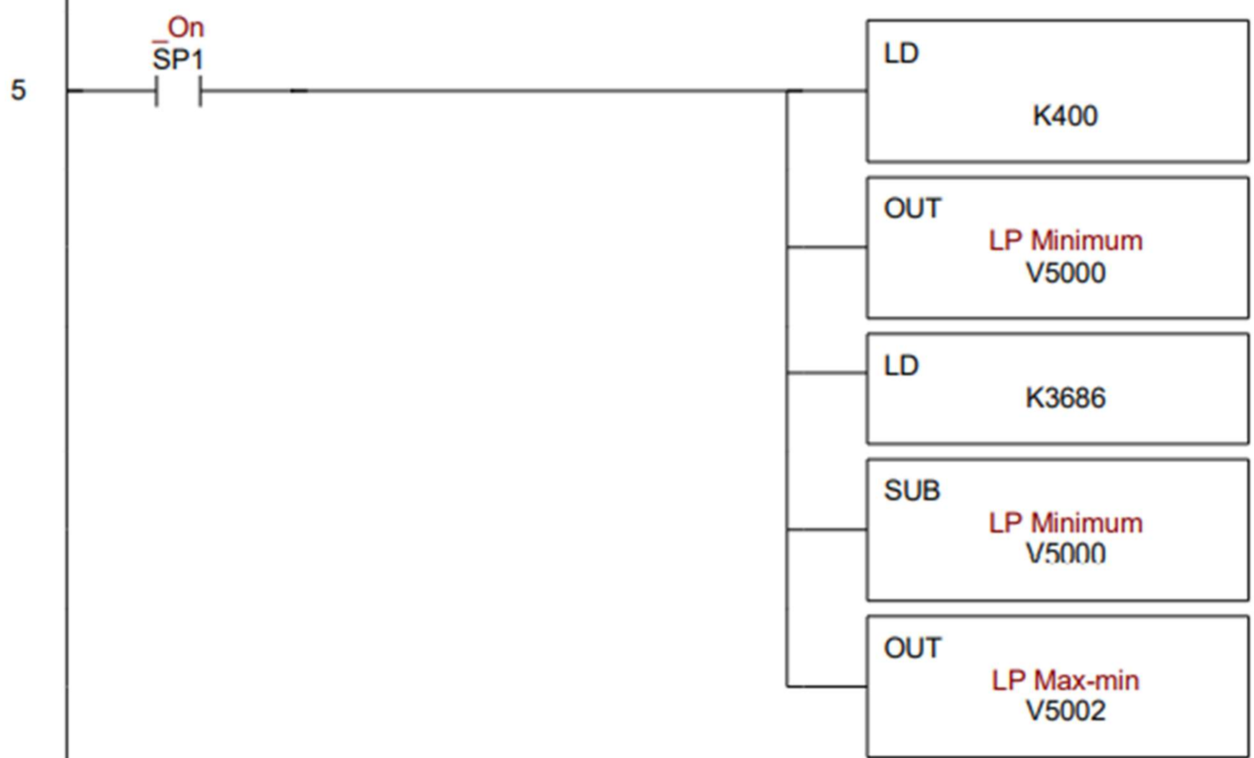
The rung sets up chamber HP pressure sensor processing. This sets the low pressure value and the difference in pressure between the LP and HP readings.

V2000 = Chamber pressure signal (0-4095)
V3600 = Pressure signal minimum value (0-4095)
V3601 = Pressure signal maximum - Pressure signal minimum (0-4095)
V3000 = Chamber pressure psig

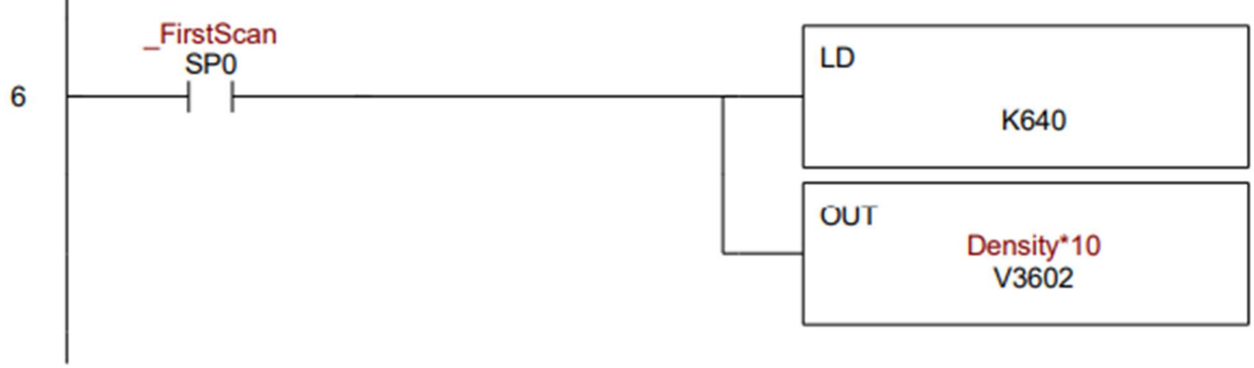


The rung sets up chamber LP pressure sensor processing. This sets the low pressure value and the difference in pressure between the LP and HP readings.

V2001 = LP Chamber pressure signal (0-4095)
V5000 = LP Pressure signal minimum value (0-4095)
V5002 = LP Pressure signal maximum - Pressure signal minimum (0-4095)
V5004 = LP Chamber pressure psig*100



This rung sets water density for water depth calculation during startup.



This rung sets a trigger discreet bit that is used to dispay the time and date on the touch scr... display as a dynamic text. When C21 is set, the System time and date are displayed on ea... screen.

_On
SP1

7

TIME/DATE_Trig
C21
(OUT)

A

_On
SP1

Chamber Pressure
V2000

8

≥

K4095

A

LD

K3600

OUT
Chamber Pressure
V2000

This rung converts the signal for chamber pressure, rangeing from 0-4095, into psig.
Sensor range is 0 to 3000 psig.

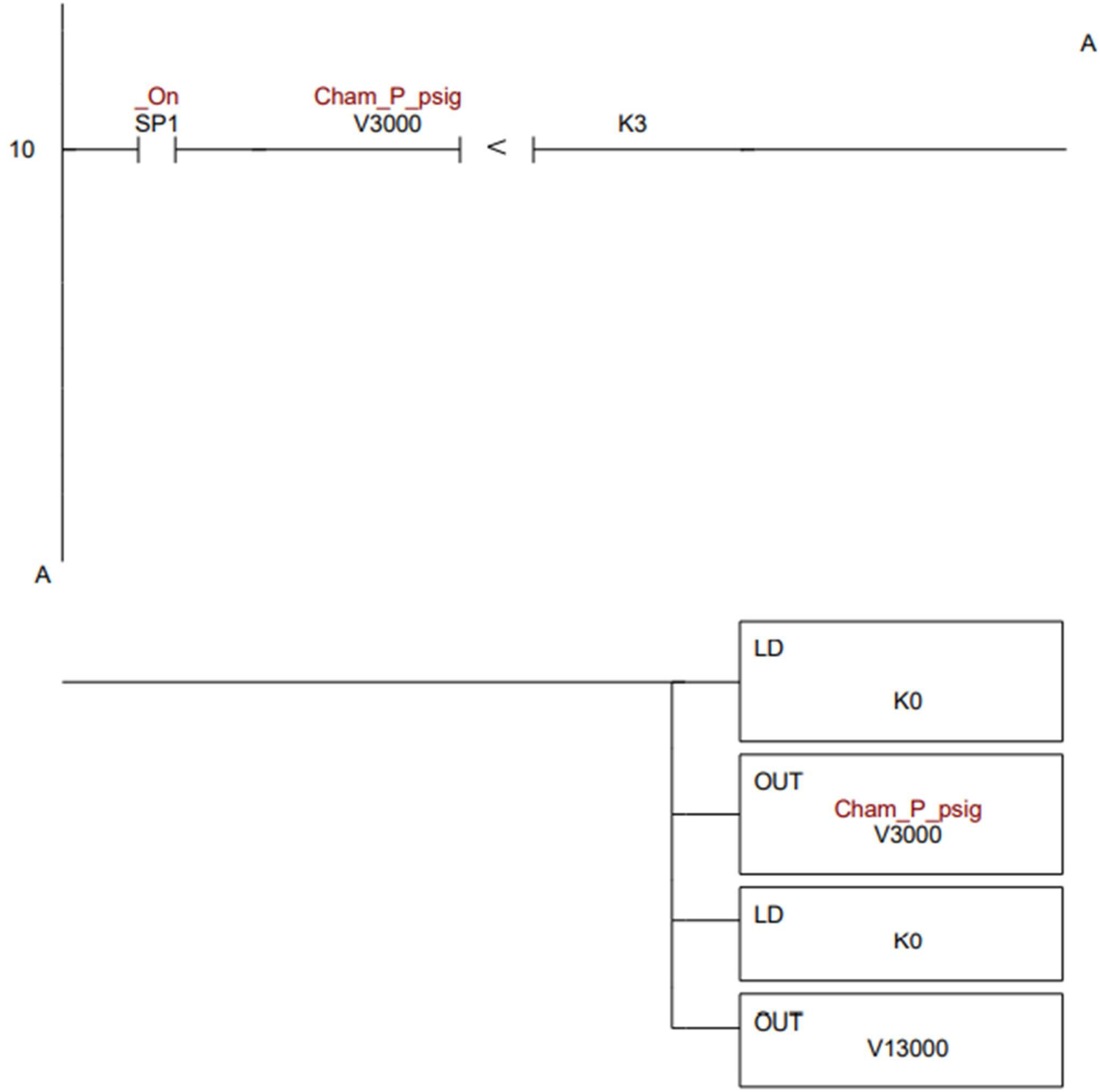
V2000 = Chamber pressure singnal (0-4095)
V3600 = Pressure signal minimum value (0-4095)
V3601 = Pressure signal maximum - Pressure signal minimum (0-4095)
V3000 = Chamber pressure psig

V3000=(V2000-V3600)*K3000/V3601

_On
SP1

9

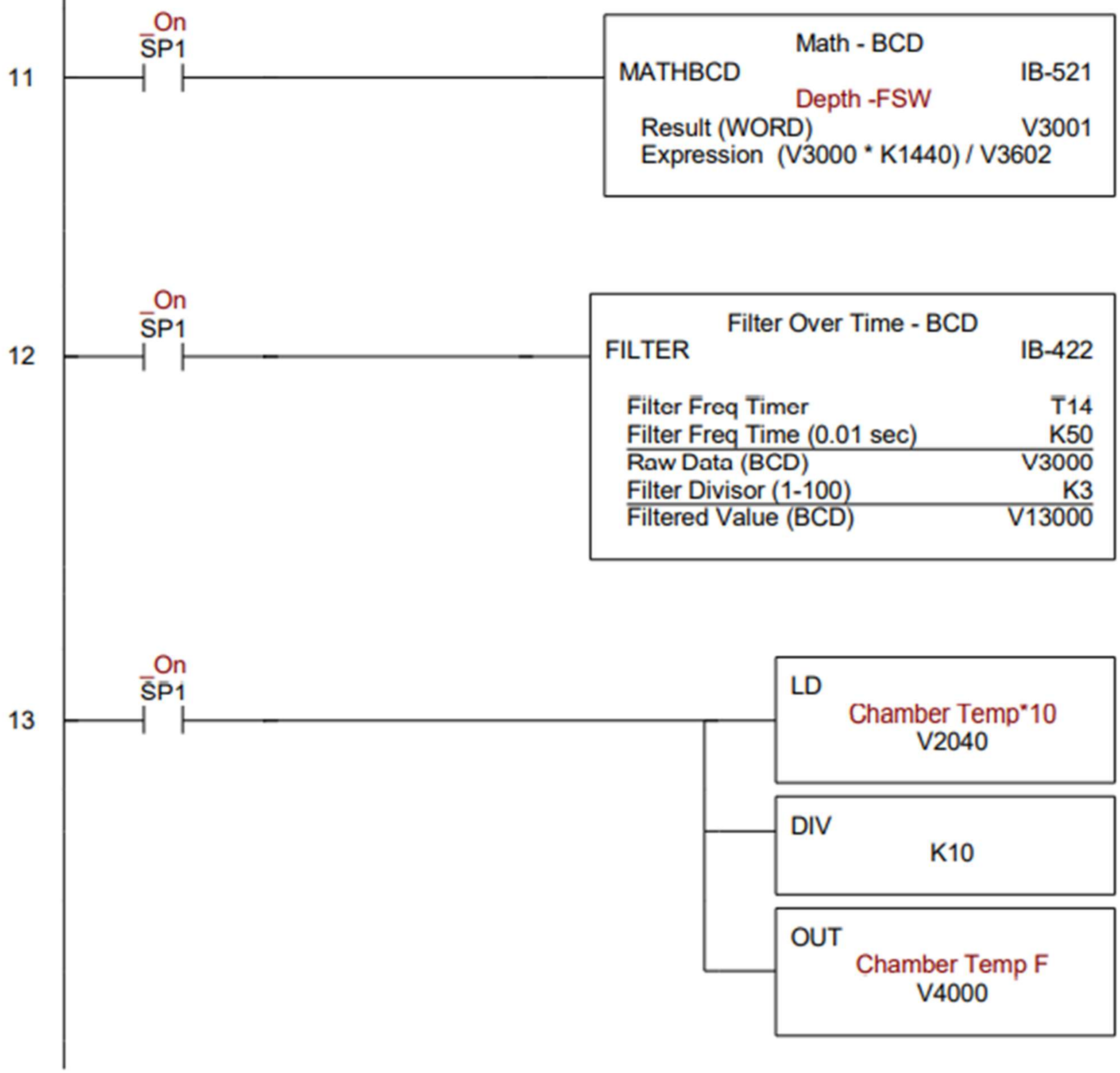
Math - BCD
MATHBCD IB-521
Cham_P_psig
Result (WORD) V3000
Expression ((V2000 - V3600) * K3000) / V3601


A
_On
SP1
Cham_P_psig
V3000
<
K3
10
A
LD
K0
OUT
Cham_P_psig
V3000
LD
K0
OUT
V13000

This rung calculates the equvalent water depth using the chamber pressure and the density.

V3000 = Chamber pressure psig
V3602 = Water density * 10 (0-4095)

V3001=V3000 *K14400/V3602



This rung converts the signal for LP chamber pressure sensor, rangeing from 0-4095, into psig*100. Sensor range is 0 to 5 psig.

V2001 = LP Chamber pressure singnal (0-4095)
V5000 = LP Pressure signal minimum value (0-4095)
V5002 = P Pressure signal maximum - Pressure signal minimum (0-4095)
V5004 = LP Chamber pressure psig*100

V5004=(V2002-V5000)*K500/V5002

14 _On SP1

Math - BCD
MATHBCD IB-521
LP Pc*100
Result (WORD) V5004
Expression ((V2001 - V5000) * K500) / V5002

15 _On SP1

Filter Over Time - BCD
FILTER IB-422

Filter Freq Timer	T15
Filter Freq Time (0.01 sec)	K50
Raw Data (BCD)	V5004
Filter Divisor (1-100)	K3
Filtered Value (BCD)	V15004

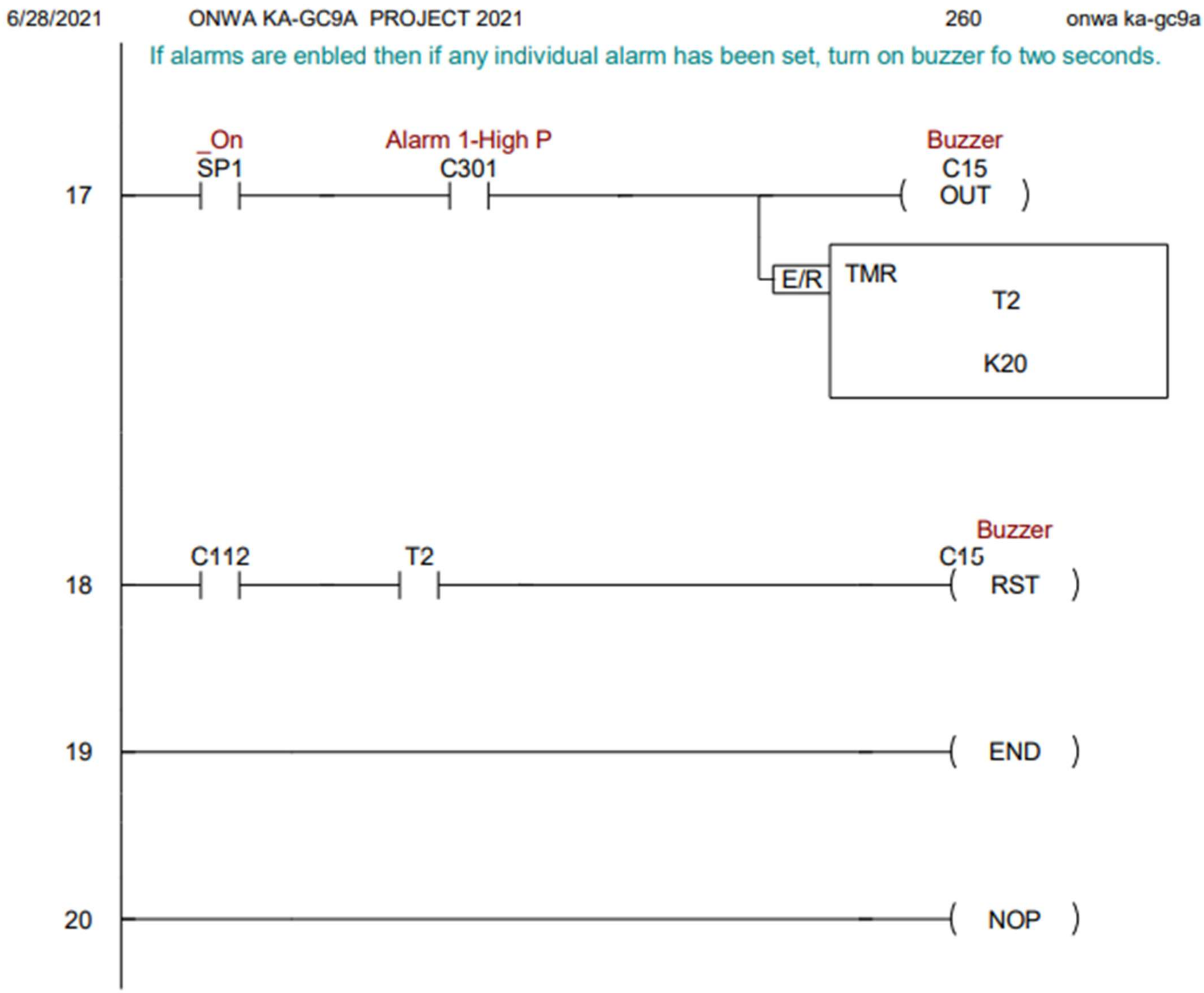
BCD to Real with Implied Decimal Point
BCDTOR IB-560
LP Pc*100 FILTER

Value (WORD BCD)	V15004
Number of Decimal Points	K2
Result (DWORD REAL)	V15006 - V15007

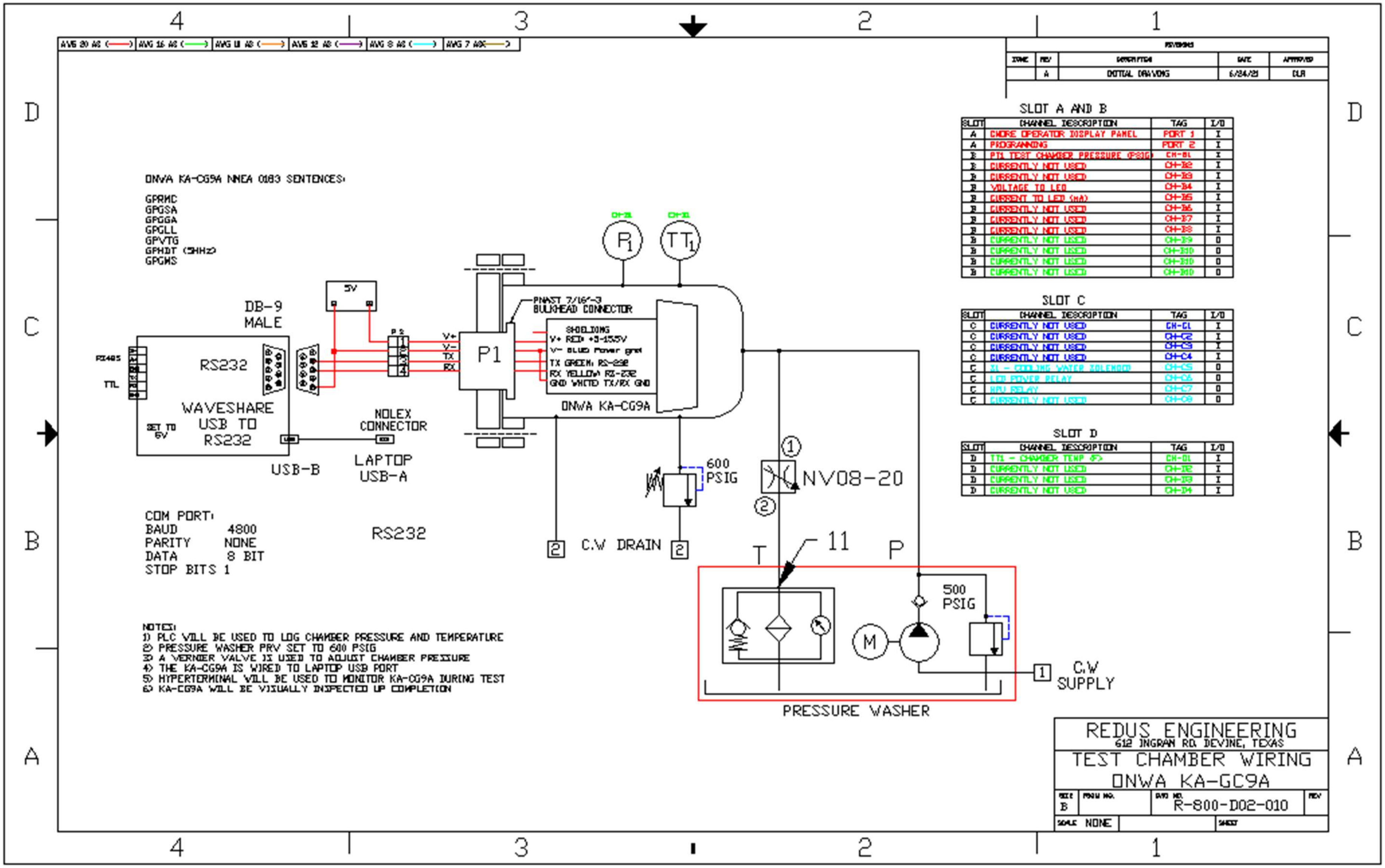
The following six rungs text for alarm conditions and set discreet flags that are used to sound an alarm buzzer.

Alarm 1 - High Pressure in Test Chamber, >3000psig

16 _On SP1 — V13000 ≥ K3000 — Alarm 1-High P C301 (OUT)



Appendix E – Drawings



SLOT A AND B

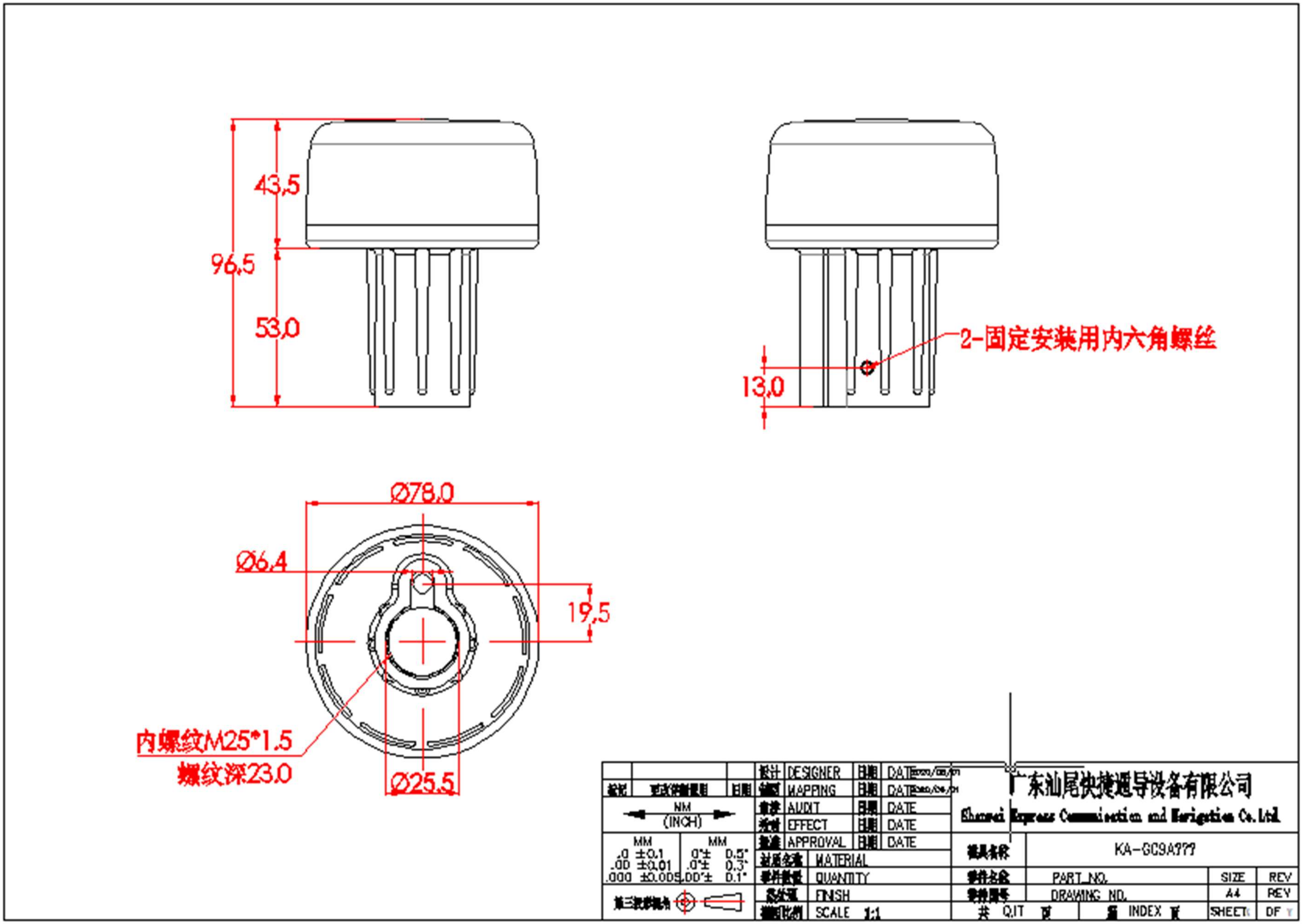
SLOT	CHANNEL DESCRIPTION	TAG	I/O
A	CHORE OPERATOR DISPLAY PANEL	PORT 1	I
A	PROGRAMMING	PORT 2	I
B	PT1 TEST CHAMBER PRESSURE (PSIG)	CH-B1	I
B	CURRENTLY NOT USED	CH-B2	I
B	CURRENTLY NOT USED	CH-B3	I
B	VOLTAGE TO LED	CH-B4	I
B	CURRENT TO LED (mA)	CH-B5	I
B	CURRENTLY NOT USED	CH-B6	I
B	CURRENTLY NOT USED	CH-B7	I
B	CURRENTLY NOT USED	CH-B8	I
B	CURRENTLY NOT USED	CH-B9	O
B	CURRENTLY NOT USED	CH-B10	O
B	CURRENTLY NOT USED	CH-B10	O
B	CURRENTLY NOT USED	CH-B10	O

SLOT C

SLOT	CHANNEL DESCRIPTION	TAG	I/O
C	CURRENTLY NOT USED	CH-C1	I
C	CURRENTLY NOT USED	CH-C2	I
C	CURRENTLY NOT USED	CH-C3	I
C	CURRENTLY NOT USED	CH-C4	I
C	X1 - COOLING WATER SOLENOID	CH-C5	O
C	LED POWER RELAY	CH-C6	O
C	HPU RELAY	CH-C7	O
C	CURRENTLY NOT USED	CH-C8	O

SLOT D

SLOT	CHANNEL DESCRIPTION	TAG	I/O
D	TT1 - CHAMBER TEMP (F)	CH-D1	I
D	CURRENTLY NOT USED	CH-D2	I
D	CURRENTLY NOT USED	CH-D3	I
D	CURRENTLY NOT USED	CH-D4	I



43.5
96.5
53.0
13.0
2-固定安装用内六角螺丝
Ø78.0
Ø6.4
19.5
内螺纹M25*1.5
螺纹深23.0
Ø25.5
DESIGNER
DATE
MAPPING
AUDIT
EFFECT
APPROVAL
MM
(INCH)
.0 ±0.1
.00 ±0.01
.000 ±0.005
MATERIAL
QUANTITY
FINISH
SCALE 1:1
广东汕尾快捷通导设备有限公司
KA-GC9A777
PART NO.
DRAWING NO.
SIZE
A4
REV
共 Q.IT 页
INDEX
SHEET
OF