Shallow Water FOCE Sensor Node Board
Hardware Interface Document, v0.6

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Overview

The Sensor Node (SN) is an open source board which is used to interface a wide range of oceanographic instruments. The SN provides individual power switching and communication to three instruments; a fourth high-current power only port can be used to drive simple devices, such as underwater lights. The SN can be configured to output 12Vdc to 48Vdc and can provide up to 75 watts of total power. The input and output communication protocol is RS-232 serial, at a maximum baud rate of 1Mbps. One of the instrument ports may also be configured to accept data from 4-20ma instruments. An onboard PIC24 microcontroller can be programmed in any manner to meet the user's needs.

System Level Description

The role of the SN as part of the Shallow Water Free Ocean Carbon Enrichment (swFOCE) experiment is to interface various underwater instruments such as pH probes, CTDs, PAR sensors, and ADCPs among others. The Gateway Node (GN) provides power and communication to four SNs; this configuration allows up to sixteen instruments to be attached to swFOCE. Data from the individual instruments are requested by the GN using Modbus protocol. The SN parses the requests to the appropriate instruments and routes the data back to the GN.

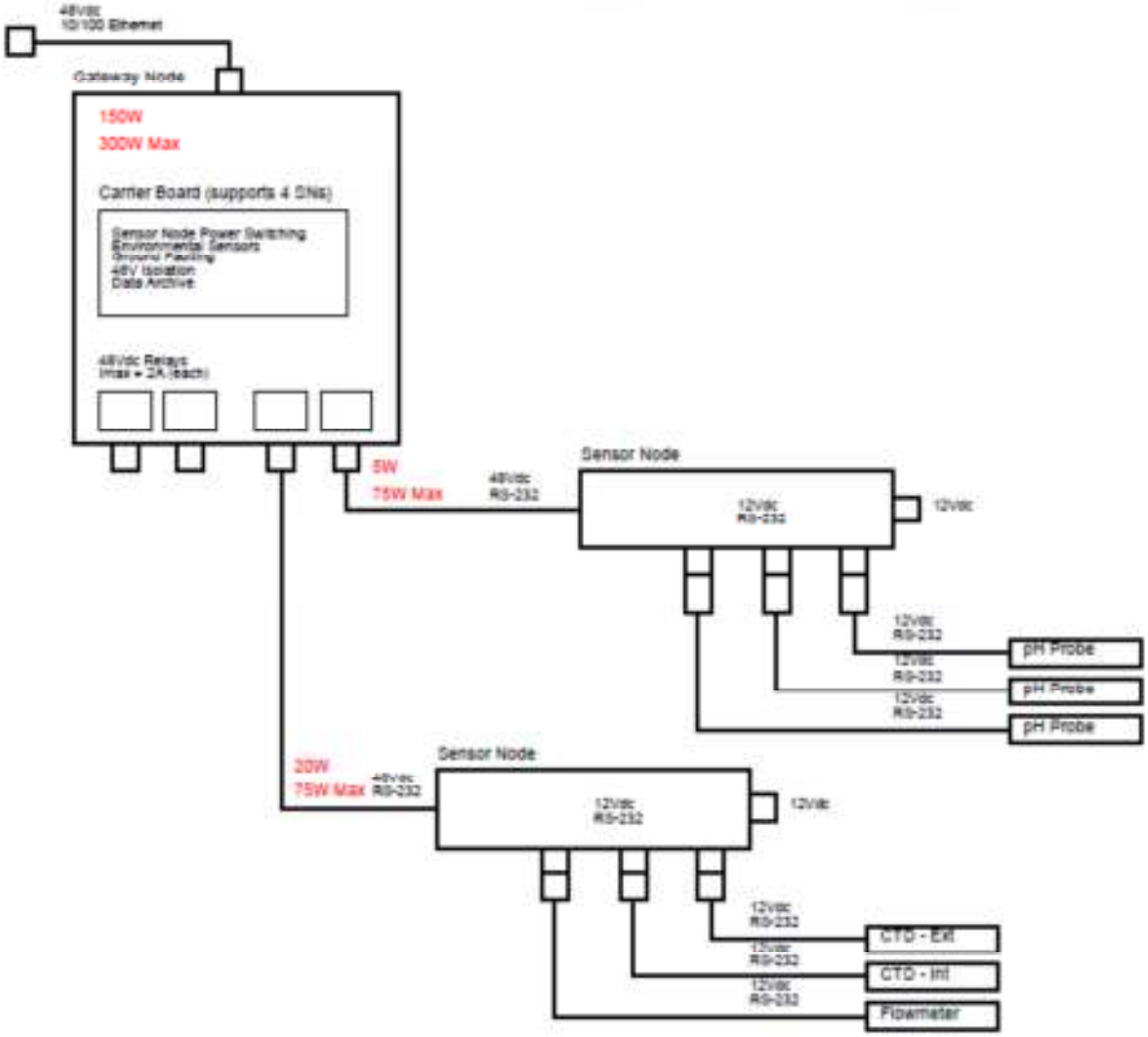

Figure 1: Possible Sensor Node configuration on swFOCE

Figure 2: Front side of Sensor Node board

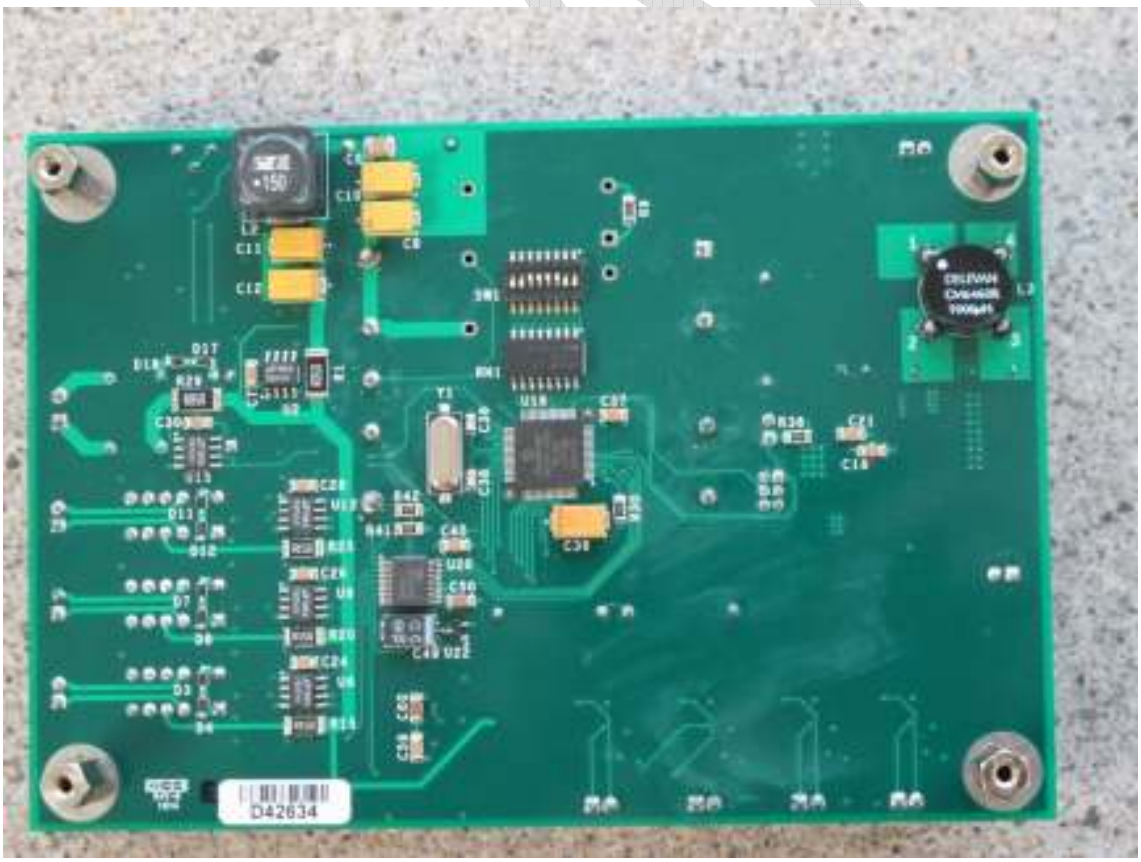

Figure 3: Rear side of Sensor Node board

Functional Description

DC-DC Conversion

The SN contains a single DC-DC converter which provides a common DC voltage for the attached instruments. The board has been designed to accept two families of converters which allow the user to determine the output voltage and the maximum output power (for greater system efficiency). The input and output filters were designed to accommodate all of the available converters. A jumper selectable trim up/down potentiometer is also included. The current and voltage level of the instrument bus voltage (BUS_VOLT) are monitored and recorded. A digital signal from the PIC can disable the DC-DC converter in the event power to all of the instruments needs to be removed quickly. The logic power is provided by a separate voltage regulator which is supplied directly by the input 48Vdc.

Load Paths

The instrument bus voltage is split into four paths: three standard instrument ports and one high-current power port. The standard instrument ports are limited to 2A of current, regardless of bus voltage. The high-current port can provide up to the maximum of 6A. The current usages of all four ports are monitored individually. Load switching to each port is accomplished via dual coil latching relays. Separate on and off pulses are used to change the relay states. Digital signals indicating the states of the individual relays are sent back to the PIC for independent confirmation. The high-current port has a different family of relay that allows for higher current usage; it can handle the maximum current at 75W for any of the chosen DC-DC converters.

The total power consumption of the four output ports should not exceed the rated power level of the installed DC-DC converter. There is no hardware monitoring of this power usage; this will need to be monitored in software.

PIC and Instrument Communication

The SN board contains a PIC24F microcontroller with four serial UARTs. Three are used for communication to the instruments, and the fourth is for communication back to the GN. Separate one-channel transceivers are used in the event of a failure only affecting one channel. The three instrument serial transceivers may be placed into a sleep mode to reduce overhead power consumption. The third port may be configured to accept 4-20ma instruments. In this case, serial port #3 is inactive and the 4-20ma data is read through the ADC. The PIC handles all of the digital input and output signals, the four UARTs, and the spi bus. An onboard boot loader allows the operating program to be loaded remotely.

Configuration Bits

Due to all of the possible hardware configurations of the Sensor Node board, and the fact that the board may be in a potted housing, there are eight bits which may be read back to confirm the hardware configuration. These are set by eight dip switches prior to potting.

Analog Signals

A SPI bus based 16-bit Analog-to-Digital Converter (ADC) is used to measure the various analog signals on board. All of the voltages are scaled to 3.0 volts. The signals measured are the bus voltage and current, the individual instrument currents, and the 4-20ma signal, if used.

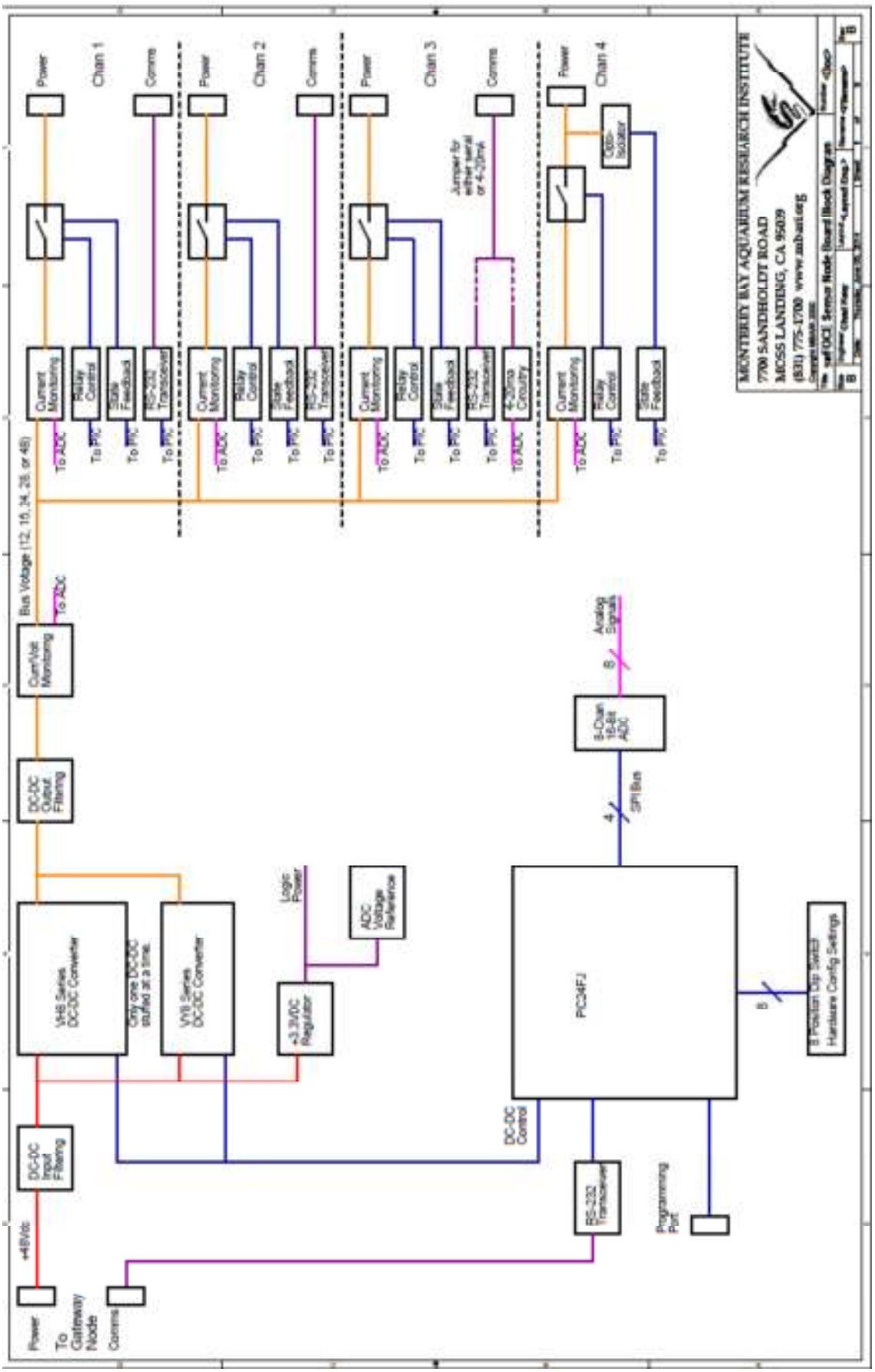

Figure 4: Sensor Node block diagram

Board Population Options

The Sensor Node can be configured in a number of ways to suit the needs of the end user. The board is initially populated in a default configuration; the user can modify it accordingly. Table one displays the default population of the Sensor Node board as well as a convenient form for the user to fill out. Each of the options are described below.

	Default	User
DC-DC Converter	Open	
Trim Up/Down	*None*	
R2	Open	
R6	Open	
Logic Power LED	*On*	
R12	Installed	
Port #3 Config	*Serial*	
R44	Open	
R45	0 ohms	
R46	0 ohms	
R47	Open	
R51	0 ohms	
Port #4 Feedback		
R33	Open	
Hearbeat LED		
D19	Open	
ADC Calibration		
R43	0 ohms	
R54	Open	

Table 1: Default and user configuration options

DC-DC Converter Selection

There are two families of CUI Inc. DC-DC converters, PYB and VHB, which can be used on the SN board. External filtering and control components have been selected to accommodate any voltage/power combination.

Figure 5: PYB series (left) and the higher power VHB series (right) DC-DC converters

			Power	Input	Output	Current
Manuf	**Series**	**Manufacturer PN#**	**(Watts)**	**(Volts)**	**(Volts)**	**(Amps)**
CUI Inc	PYB10	PYB10-Q48-S12	10	18-75	12	0.833
CUI Inc	PYB10	PYB10-Q48-S15	10	18-75	15	0.667
CUI Inc	PYB15	PYB15-Q48-S12	15	18-75	12	1.250
CUI Inc	PYB15	PYB15-Q48-S15	15	18-75	15	1.000
CUI Inc	PYB20	PYB20-Q48-S12	20	18-75	12	1.667
CUI Inc	PYB20	PYB20-Q48-S15	20	18-75	15	1.333
CUI Inc	PYB20	PYB20-Q48-S24	20	18-75	24	0.834
CUI Inc	VHB50W	VHB50W-Q48-S12	50	18-75	12	4.160
CUI Inc	VHB50W	VHB50W-Q48-S15	50	18-75	15	3.330
CUI Inc	VHB50W	VHB50W-Q48-S24	50	18-75	24	2.080
CUI Inc	VHB50W	VHB50W-Q48-S28	50	18-75	28	1.780
CUI Inc	VHB50W	VHB50W-Q48-S48	50	18-75	48	1.040
CUI Inc	VHB75W	VHB75W-Q48-S12	75	18-75	12	6.250
CUI Inc	VHB75W	VHB75W-Q48-S15	75	18-75	15	5.000
CUI Inc	VHB75W	VHB75W-Q48-S24	75	18-75	24	3.120
CUI Inc	VHB75W	VHB75W-Q48-S48	75	18-75	48	1.560

Table 2: List of available DC-DC converter

Bus Voltage Trim Up/Down

The main bus voltage may be trimmed up or down based on the needs of the user. To trim up, populate R6 with a zero ohm resistor, leaving R2 open. To trim down, populate R2 with a zero ohm resistor and leave R6 open. In both cases, the potentiometer R5 adjusts the bus voltage.

Logic Power LED

During the bench top test and debug phase it may be useful to have a power on indication. When R12 is populated with a zero ohm resistor, LED D2 indicates the presence of +3.3Vdc. Removing R12 reduces the power consumption by approximately 9mW.

Port #3 Configuration

In place of serial communication, instrument port #3 can be configured to accept 4-20ma devices. Resistors R44-R47, and R51 are used to select between serial communication and 4-20ma signals.

	R44	R45	R46	R47	R51
Serial	OPEN	0 OHMS	0 OHMS	OPEN	0 OHMS
4-20ma	0 OHMS	OPEN	OPEN	0 OHMS	OPEN

Table 3: Jumper selection for instrument port #3

In addition, the user has the option of not populating certain components if one or the other port #3 options will not be used.

If the user plans on using serial communication only and never 4-20ma, the following components can be considered No Stuff: F1, R44, R47, R48, R49, R50, R52, R53, C58, C59, C60, C62, U24, and U25.

If the user plans on using 4-20ma on port #3 and never serial communication, the following components can be considered No Stuff: R45, R46, C53, C54, C55, C56, C57, and U23.

Note on R51: Special attention must be made with respect to R51. If using serial communication, it needs to be populated with a zero ohm resistor. This prevents electrical noise from interfering with the ADC (U20). If using 4-20ma, R51 needs to be No Stuff in order to present the 4-20ma signal to the ADC.

Port #4 Feedback Resistor

Due to the switching relay on port #4 not having a second set of poles, an opto-isolator is used to read the relay state feedback. In order to keep the forward diode current in the nominal operating range, the current limiting resistor has to match the bus voltage.

BUS_VOLT	R33	Watts
12 Vdc	12k	0.250 W
15 Vdc	12k	0.250 W
24 Vdc	24k	0.250 W
28Vdc	24k	0.250 W
48 Vdc	47k	0.250 W

Table 4: Current limiting resistors for U17

Heartbeat LED

D19 is a through-hole LED on extended legs. This allows the user to mount the LED in such a way that it is visible through any potting compound. D19 can be used during initial test, final deployment, or both.

ADC Calibration

Channel 7 of the ADC (U20) is unused and by default is tied to ground via a zero ohm resistor. The user has the option of creating a voltage divider via R54 and R43 to calibrate the analog-to-digital hardware and software. If Vmeas is the voltage to be measured by the ADC, then:

R54 = R43 * (3.0V – Vmeas) / Vmeas))

Vmeas = 3.0V * (R43 / (R43 + R54))

For optimal use of the voltage reference, U22, the current draw should be between 100uA and 1mA. For example, R43 = 10k and R54 = 20k results in Vmeas = 1.0V and the current drawn is 100uA.

If no calibration is desired, install a zero ohm resistor for R43 and leave R54 open.

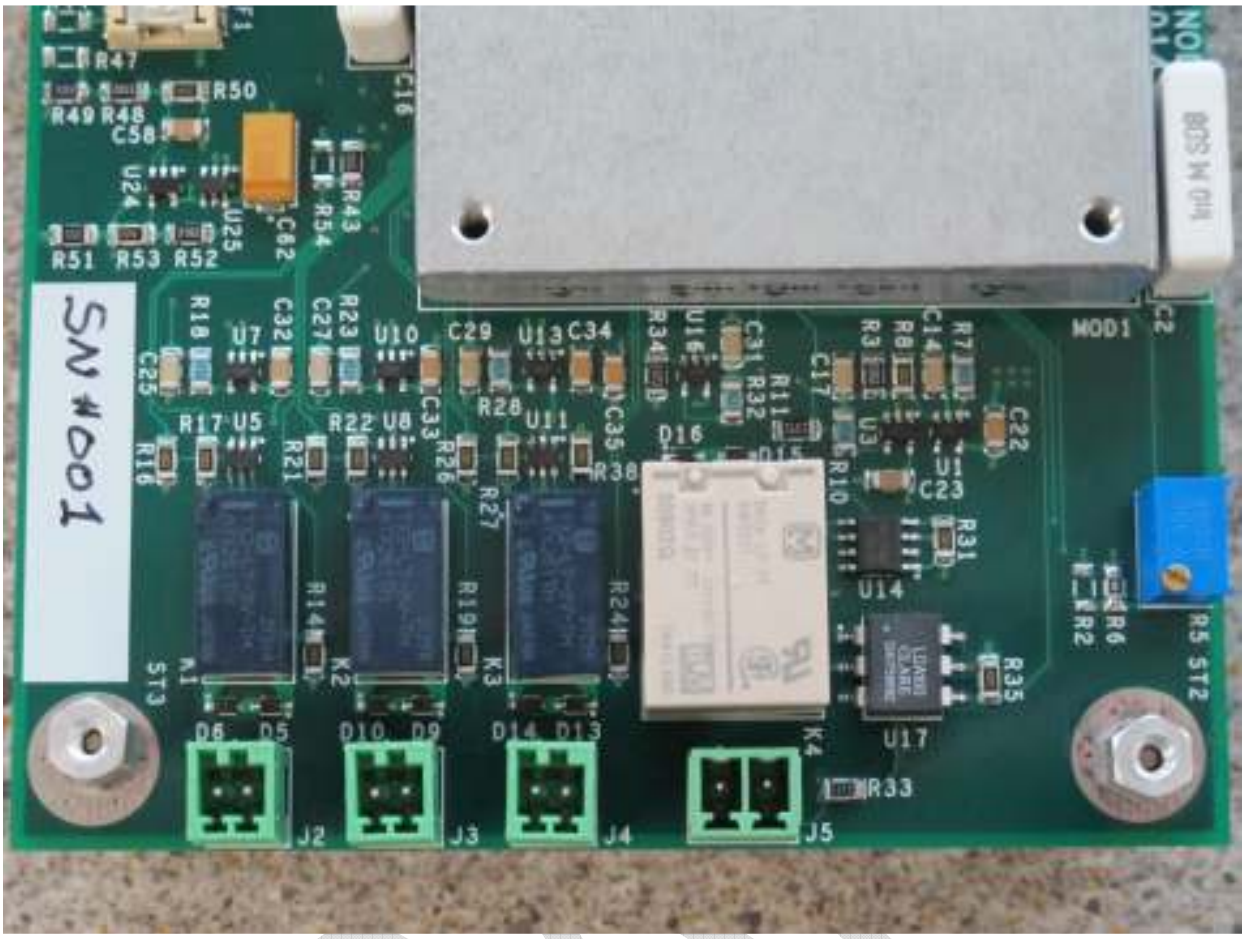

Figure 6: Output relays and connectors with trim circuit on far left (configured for trim up)

Figure 7: Serial transceiver circuits and connectors

Connector Population

The power and signal connectors for the SN board should be populated during initial testing; this facilitates easier bench testing. If ultimately potting the SN board in an underwater housing, the connectors can be removed and the whips can be directly soldered to the board. However, depending on the user's final deployment method, the power and signal connectors can remain populated. The power connectors (J1, J2, J3, J4, and J5) were designed to accommodate 18AWG wire. The communication connectors (J7, J8, J9, and J10) were designed to accommodate 24AWG wire. In addition, the programming connector, J6, may be removed prior to deployment, if desired.

Programming and Serial Debugging

The PIC is programmed through J6; these signals are compatible with Microchip's ICD programmers. See the Sensor Node PIC Test Code document for details on programming. Jumper JP1 allows the user to manually reset the PIC in the event of a programmer lockup or malfunction. Serial port #4 (J10) can be used a debug port during the testing phase.

Board Configuration Feedback

The user configuration settings can be set into memory by using the 8 position dip switch, SW1, as indicated in table five. The 8-bit word can be read back using CONFIG_BIT_0 through CONFIG_BIT_7; these correspond to digital port B, signals 8 through 15. See table six.

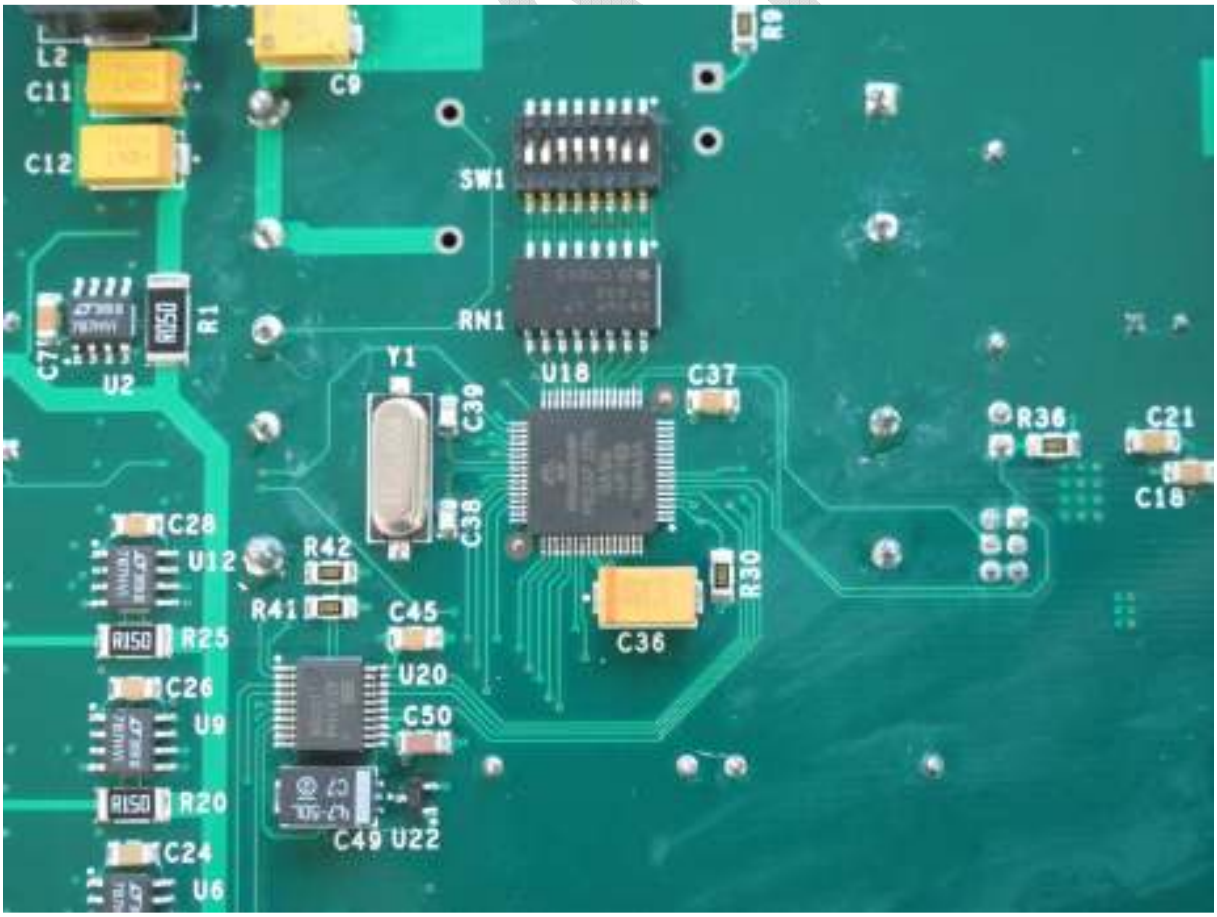

Figure 8: User settable dip switch (SW1) and the microcontroller (U18)

Watts	Voltage	Port #3	SW1-1	SW1-2	SW1-3	SW1-4	SW1-5	SW1-6	SW1-7	SW1-8
75	48	Serial	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
75	24	Serial	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
75	15	Serial	OFF	ON	OFF	OFF	OFF	OFF	ON	ON
75	12	Serial	ON	ON	OFF	OFF	OFF	OFF	ON	ON
50	48	Serial	OFF	OFF	ON	OFF	OFF	OFF	ON	ON
50	28	Serial	ON	OFF	ON	OFF	OFF	OFF	ON	ON
50	24	Serial	OFF	ON	ON	OFF	OFF	OFF	ON	ON
50	15	Serial	ON	ON	ON	OFF	OFF	OFF	ON	ON
50	12	Serial	OFF	OFF	OFF	ON	OFF	OFF	ON	ON
20	24	Serial	ON	OFF	OFF	ON	OFF	OFF	ON	ON
20	15	Serial	OFF	ON	OFF	ON	OFF	OFF	ON	ON
20	12	Serial	ON	ON	OFF	ON	OFF	OFF	ON	ON
15	15	Serial	OFF	OFF	ON	ON	OFF	OFF	ON	ON
15	12	Serial	ON	OFF	ON	ON	OFF	OFF	ON	ON
10	15	Serial	OFF	ON	ON	ON	OFF	OFF	ON	ON
10	12	Serial	ON	ON	ON	ON	OFF	OFF	ON	ON
75	48	4-20ma	OFF	OFF	OFF	OFF	ON	OFF	ON	ON
75	24	4-20ma	ON	OFF	OFF	OFF	ON	OFF	ON	ON
75	15	4-20ma	OFF	ON	OFF	OFF	ON	OFF	ON	ON
75	12	4-20ma	ON	ON	OFF	OFF	ON	OFF	ON	ON
50	48	4-20ma	OFF	OFF	ON	OFF	ON	OFF	ON	ON
50	28	4-20ma	ON	OFF	ON	OFF	ON	OFF	ON	ON
50	24	4-20ma	OFF	ON	ON	OFF	ON	OFF	ON	ON
50	15	4-20ma	ON	ON	ON	OFF	ON	OFF	ON	ON
50	12	4-20ma	OFF	OFF	OFF	ON	ON	OFF	ON	ON
20	24	4-20ma	ON	OFF	OFF	ON	ON	OFF	ON	ON
20	15	4-20ma	OFF	ON	OFF	ON	ON	OFF	ON	ON
20	12	4-20ma	ON	ON	OFF	ON	ON	OFF	ON	ON
15	15	4-20ma	OFF	OFF	ON	ON	ON	OFF	ON	ON
15	12	4-20ma	ON	OFF	ON	ON	ON	OFF	ON	ON
10	15	4-20ma	OFF	ON	ON	ON	ON	OFF	ON	ON
10	12	4-20ma	ON	ON	ON	ON	ON	OFF	ON	ON

Table 5: User configuration settings for SW1

			B8	B9	B10	B11	B12	B13	B14	B15	Dec
Watts	**Voltage**	**Port #3**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
75	48	Serial	1	1	1	1	1	1	0	0	63
75	24	Serial	0	1	1	1	1	1	0	0	62
75	15	Serial	1	0	1	1	1	1	0	0	61
75	12	Serial	0	0	1	1	1	1	0	0	60
50	48	Serial	1	1	0	1	1	1	0	0	59
50	28	Serial	0	1	0	1	1	1	0	0	58
50	24	Serial	1	0	0	1	1	1	0	0	57
50	15	Serial	0	0	0	1	1	1	0	0	56
50	12	Serial	1	1	1	0	1	1	0	0	55
20	24	Serial	0	1	1	0	1	1	0	0	54
20	15	Serial	1	0	1	0	1	1	0	0	53
20	12	Serial	0	0	1	0	1	1	0	0	52
15	15	Serial	1	1	0	0	1	1	0	0	51
15	12	Serial	0	1	0	0	1	1	0	0	50
10	15	Serial	1	0	0	0	1	1	0	0	49
10	12	Serial	0	0	0	0	1	1	0	0	48
75	48	4-20ma	1	1	1	1	0	1	0	0	47
75	24	4-20ma	0	1	1	1	0	1	0	0	46
75	15	4-20ma	1	0	1	1	0	1	0	0	45
75	12	4-20ma	0	0	1	1	0	1	0	0	44
50	48	4-20ma	1	1	0	1	0	1	0	0	43
50	28	4-20ma	0	1	0	1	0	1	0	0	42
50	24	4-20ma	1	0	0	1	0	1	0	0	41
50	15	4-20ma	0	0	0	1	0	1	0	0	40
50	12	4-20ma	1	1	1	0	0	1	0	0	39
20	24	4-20ma	0	1	1	0	0	1	0	0	38
20	15	4-20ma	1	0	1	0	0	1	0	0	37
20	12	4-20ma	0	0	1	0	0	1	0	0	36
15	15	4-20ma	1	1	0	0	0	1	0	0	35
15	12	4-20ma	0	1	0	0	0	1	0	0	34
10	15	4-20ma	1	0	0	0	0	1	0	0	33
10	12	4-20ma	0	0	0	0	0	1	0	0	32

Table 6: Software settings for user configuration settings

Board Level Signal Descriptions

Analog Signals

INSTR_CURR
This is a 0-3V analog voltage signal which corresponds to the total current usage of the DC-DC converter. The conversion factor is Y(amps) = 2.0 x INSTR_CURR.

INSTR_VOLT
This is a 0-3V analog voltage signal which corresponds to the output voltage of the DC-DC converter. The conversion factor is Y(volts) = 16.0 x INSTR_VOLT.

INSTR_1_CURR
This is a 0-3V analog voltage signal which corresponds to the current usage of the instrument being monitored on port #1. The conversion factor is Y(amps) = 0.667 x INST_1_CURR.

INSTR_2_CURR
This is a 0-3V analog voltage signal which corresponds to the current usage of the instrument being monitored on port #2. The conversion factor is Y(amps) = 0.667 x INST_2_CURR.

INSTR_3_CURR
This is a 0-3V analog voltage signal which corresponds to the current usage of the instrument being monitored on port #3. The conversion factor is Y(amps) = 0.667 x INST_3_CURR.

INSTR_4_CURR
This is a 0-3V analog voltage signal which corresponds to the current usage of the instrument being monitored on port #4. The conversion factor is Y(amps) = 2.0 x INST_4_CURR.

4_20MA_VOLT
This is a 0-3V analog voltage signal which corresponds to the 4-20ma circuit, if used. The conversion factor is Y(milliamps) = 6.1 x 4_20MA_VOLT + 4.0. The scaling for 4 to 20mA ends at 2.62V. A reading of 2.97 volts (22.1ma) indicates an error in the measurement.

SPI Bus Signals

SPI_SCLK
The clock input for the SPI bus; it can also be used to control the ADC conversion steps.

SPI_MISO
The SPI data output of the ADS8344.

SPI_MOSI
The SPI data input to the ADS8344.

SPI_*CS
This is the active low SPI chip select signal.

Digital Output Signals

ADC_*SHDN
This is an active low input to the ADS8344 ADC. Pulling this line low puts the ADS8344 in a low power shutdown mode.

UART_1_*SHDN
This is a logic low digital signal which puts the serial transceiver for port #1 into a low power shutdown mode.

UART_2_*SHDN
This is a logic low digital signal which puts the serial transceiver for port #2 into a low power shutdown mode.

UART_3_*SHDN
This is a logic low digital signal which puts the serial transceiver for port #3 into a low power shutdown mode.

INSTR_1_ON
This is a logic high level positive going pulse which turns on the power relay to the instrument on port #1. The minimum pulse width is 10msec and should not exceed 50msec.

INSTR_1_OFF
This is a logic high level positive going pulse which turns off the power relay to the instrument on port #1. The minimum pulse width is 10msec and should not exceed 50msec.

INSTR_2_ON
This is a logic high level positive going pulse which turns on the power relay to the instrument on port #2. The minimum pulse width is 10msec and should not exceed 50msec.

INSTR_2_OFF
This is a logic high level positive going pulse which turns off the power relay to the instrument on port #2. The minimum pulse width is 10msec and should not exceed 50msec.

INSTR_3_ON
This is a logic high level positive going pulse which turns on the power relay to the instrument on port #3. The minimum pulse width is 10msec and should not exceed 50msec.

INSTR_3_OFF
This is a logic high level positive going pulse which turns off the power relay to the instrument on port #3. The minimum pulse width is 10msec and should not exceed 50msec.

INSTR_4_ON
This is a logic low level positive going pulse which turns on the power relay to the instrument on port #4. The minimum pulse width is 10msec and should not exceed 50msec.

INSTR_4_OFF
This is a logic low level positive going pulse which turns off the power relay to the instrument on port #4. The minimum pulse width is 10msec and should not exceed 50msec.

DC-DC_CNTL
This is an active low control signal which disables the onboard DC-DC converter. This removes power to all of the attached instruments simultaneously.

Digital Inputs

INSTR_1_STATE
This is a logic level feedback signal which corresponds to the state of the relay on port #1. Logic level high indicates the relay is on.

INSTR_2_STATE
This is a logic level feedback signal which corresponds to the state of the relay on port #2. Logic level high indicates the relay is on.

INSTR_3_STATE
This is a logic level feedback signal which corresponds to the state of the relay on port #3. Logic level high indicates the relay is on.

INSTR_4_STATE
This is a logic level feedback signal which corresponds to the state of the relay on port #4. Logic level high indicates the relay is on.

ADC_BUSY
This is an output of the ADS8344 that indicates the operating status of the ADC. Its operation is different depending on whether using internal or external clocking. It is in a high impedance state when *CS is high.

CONFIG_BIT_x (0-7)
These are 8 digital bits which can be read back by the user to verify the hardware configuration of the SN module. CONFIG_BIT_7 is the MSB. See tables four and five for the exact codes.

Appendices

Appendix 1: Electrical Specifications

Input Voltage	48Vdc
No Load Conditions	
Nominal Current	29ma
Power Usage	1.4W
Max Current Out	
Channel 1-3	2A
Channel 4	6A
Max Power Out	75W
Converter Effiiciency (max)	83%

Appendix 2: Mechanical Specifications

Length	5.75 in
Width	4.0 in
Height	1.0 in
Operating Temperature	
Min	32 degF
Max	70 degF
Operating Depth	300m

Appendix 3: PIC pin assignment for SN board

PIC24FJ256GA106 Pinout for swFOCE Sensor Node Board								
Pin #	**Func1**	**Func2**	**Func3**	**Func4**	**Func5**	**Func6**	**Func7**	**Functional Description**
1	CN63	PMD5	**RE5**					INSTR_3_OFF
2	SCL3	CN64	PMD6	**RE6**				INSTR_4_OFF
3	SDA3	CN65	PMD7	**RE7**				INSTR_4_ON
4	PMA5	RP21	C1IND	CN8	**RG6**			SPI_*CS
5	C1INC	**RP26**	CN9	PMA4	RG7			SPI_SCLK
6	C2IND	**RP19**	CN10	PMA3	RG8			SPI_MISO
7	***MCLR**							*MCLR
8	C2INC	**RP27**	CN11	PMA2	RG9			SPI_MOSI
9	**Vss**							Vss
10	**Vdd**							Vdd
11	PGEC3	AN5	C1INA	RP18	CN7	**RB5**		OPEN
12	PGED3	AN4	C1IN	RP28	CN6	**RB4**		OPEN
13	AN3	C2INA	CN5	**RB3**				OPEN
14	AN2	C2INB	RP13	CN4	**RB2**			OPEN
15	PGEC1	AN1	Vref-	RP1	CN3	**RB1**		OPEN
16	PGED1	AN0	Vref+	RP0	CN2	PMA6	**RB0**	OPEN
17	**PGEC2**	AN6	RP6	CN24	RB6			PROG_CLK
18	**PGED2**	AN7	RP7	CN25	RB7			PROG_DATA
19	**AVdd**							AVdd
20	**AVss**							AVss
21	AN8	RP8	CN26	**RB8**				CONFIG_BIT_0
22	AN9	RP9	CN27	PMA7	**RB9**			CONFIG_BIT_1
23	TMS	AN10	CVref	CN28	PMA13	**RB10**		CONFIG_BIT_2
24	TDO	AN11	CN29	PMA12	**RB11**			CONFIG_BIT_3
25	**Vss**							Vss
26	**Vdd**							Vdd
27	TCK	AN12	CTED2	CN30	PMA11	**RB12**		CONFIG_BIT_4
28	TDI	PMA10	AN13	CTED1	CN31	**RB13**		CONFIG_BIT_5
29	AN14	CTPLS	RP14	CN32	PMA1	**RB14**		CONFIG_BIT_6
30	AN15	REFO	RP29	CN12	PMA0	**RB15**		CONFIG_BIT_7
31	SDA2	RP10	CN17	PMA9	**RF4**			OPEN
32	SCL2	RP17	CN18	PMA8	**RF5**			"Test LED"
33	RP16	CN71	**RF3**					INSTR_4_STATE
34	RP30	CN70	**RF2**					INSTR_3_STATE
35	ASCK1	RPI45	INT0	CN72	**RF6**			DC-DC_CNTL
36	SDA1	CN84	**RG3**					ADC_BUSY
37	SCL1	CN83	**RG2**					ADC_*SHDN
38	**Vdd**							Vdd
39	**OSCI**	CLKI	CN32	RC12				OSCI
40	**OSCO**	CLKO	CN22	RC15				OSCO
41	**Vss**							Vss
42	RTCC	RP2	CN53	**RD8**				UART_3_*SHDN
43	**RP4**	CN54	RD9					UART4_TTL_TXD
44	**RP3**	CN55	PMCS2	RD10				UART4_TTL_RXD
45	RP12	CN56	PMCS1	**RD11**				OPEN
46	**RP11**	CN49	RD0					UART1_TTL_TXD
47	SOSCI	C3IND	CN1	**RC13**				OPEN
48	SOSCO	C3INC	RPI37	CN0	**RC14**			OPEN
49	**RP24**	CN50	RD1					UART1_TTL_RXD
50	**RP23**	CN51	RD2					UART2_TTL_TXD
51	**RP22**	CN52	PMBE	RD3				UART2_TTL_RXD
52	**RP25**	CN13	PMWR	RD4				UART3_TTL_TXD
53	**RP20**	CN14	PMRD	RD5				UART3_TTL_RXD
54	C3INB	CN15	**RD6**					UART_1_*SHDN
55	C3INA	CN16	**RD7**					UART_2_*SHDN
56	**Vcap**	Vddcore						Vcap
57	**ENVREG**							ENVREG
58	CN68	**RF0**						INSTR_1_STATE
59	CN69	**RF1**						INSTR_2_STATE
60	CN58	PMD0	**RE0**					INSTR_1_ON
61	CN59	PMD1	**RE1**					INSTR_1_OFF
62	CN60	PMD2	**RE2**					INSTR_2_ON
63	CN61	PMD3	**RE3**					INSTR_2_OFF
64	CN62	PMD4	**RE4**					INSTR_3_ON

Appendix 4: PIC pin software assignment

PIC24FJ256GA106 Pin and Coding Assignments				
Pin #	**Func1**	**Signal Type**	**Default State**	**Schematic Name**
1	RE5	Digital Output	LOW	INSTR_3_OFF
2	RE6	Digital Output	HIGH	INSTR_4_OFF
3	RE7	Digital Output	HIGH	INSTR_4_ON
4	RG6	SPI	HIGH	SPI_*CS
5	RP26	SPI		SPI_SCLK
6	RP19	SPI		SPI_MISO
7	*MCLR	Programming		*MCLR
8	RP27	SPI		SPI_MOSI
9	Vss			Vss
10	Vdd			Vdd
11	RB5	Digital Output	HIGH	OPEN
12	RB4	Digital Output	HIGH	OPEN
13	RB3	Digital Output	HIGH	OPEN
14	RB2	Digital Output	HIGH	OPEN
15	RB1	Digital Output	HIGH	OPEN
16	RB0	Digital Output	HIGH	OPEN
17	PGEC2	Programming		PROG_CLOCK
18	PGED2	Programming		PROG_DATA
19	AVdd			AVdd
20	AVss			AVss
21	RB8	Digital Input		CONFIG_BIT_0
22	RB9	Digital Input		CONFIG_BIT_1
23	RB10	Digital Input		CONFIG_BIT_2
24	RB11	Digital Input		CONFIG_BIT_3
25	Vss			Vss
26	Vdd			Vdd
27	RB12	Digital Input		CONFIG_BIT_4
28	RB13	Digital Input		CONFIG_BIT_5
29	RB14	Digital Input		CONFIG_BIT_6
30	RB15	Digital Input		CONFIG_BIT_7
31	RF4	Digital Output	HIGH	OPEN
32	RF5	Digital Output	LOW	"Test LED"
33	RF3	Digital Input		INSTR_4_STATE
34	RF2	Digital Input		INSTR_3_STATE
35	RF6	Digital Output	HIGH	DC-DC_CNTL
36	RG3	Digital Input		ADC_BUSY
37	RG2	Digital Output	HIGH	ADC_*SHDN
38	Vdd			Vdd
39	OSCI	Clock		OSCI
40	OSCO	Clock		OSCO
41	Vss			Vss
42	RD8	Digital Output	HIGH	UART_3_*SHDN
43	RP4	Serial		UART4_TTL_TXD
44	RP3	Serial		UART4_TTL_RXD
45	RD11	Serial	HIGH	OPEN
46	RP11	Serial		UART1_TTL_TXD
47	RC13	Digital Output	HIGH	OPEN
48	RC14	Digital Output	HIGH	OPEN
49	RP24	Serial		UART1_TTL_RXD
50	RP23	Serial		UART2_TTL_TXD
51	RP22	Serial		UART2_TTL_RXD
52	RP25	Serial		UART3_TTL_TXD
53	RP20	Serial		UART3_TTL_RXD
54	RD6	Digital Output	HIGH	UART_1_*SHDN
55	RD7	Digital Output	HIGH	UART_2_*SHDN
56	Vcap			Vcap
57	ENVREG			ENVREG
58	RF0	Digital Input		INSTR_1_STATE
59	RF1	Digital Input		INSTR_2_STATE
60	RE0	Digital Output	LOW	INSTR_1_ON
61	RE1	Digital Output	LOW	INSTR_1_OFF
62	RE2	Digital Output	LOW	INSTR_2_ON
63	RE3	Digital Output	LOW	INSTR_2_OFF
64	RE4	Digital Output	LOW	INSTR_3_ON

Appendix 5: Bill of Materials for Sensor Node Board

Ref	Value	Manufacturer	Manufacturer PN	Description
C1	1000pF	Kemet	PME295RB4100MR30	CAP FILM 1000PF 480VAC RADIAL
C2	1000pF	Kemet	PME295RB4100MR30	CAP FILM 1000PF 480VAC RADIAL
C3	1.0uF	TDK Corporation	CKG57KX7R2A105M	CAP CER 1UF 100V 20% X7R SMD
C4	22uF	Vishay Sprague	597D226X9063F2T	CAP TANT 22UF 63V 10% 2924
C5	22uF	Vishay Sprague	597D226X9063F2T	CAP TANT 22UF 63V 10% 2924
C6	100uF	Panasonic	EEV-FK2A101M	CAP ALUM 100UF 100V 20% SMD
C7	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C8	1.0uF	TDK Corporation	CKG32KX7R1H105M335AH	CAP CER 1UF 50V 20% X7R SMD
C9	10uF	Kemet	T521X106M063ATE050	CAP TANT 10UF 63V 20% 2917
C10	10uF	Kemet	T521X106M063ATE050	CAP TANT 10UF 63V 20% 2917
C11	22uF	AVX Corporation	TPME226K050R0075	CAP TANT 22UF 50V 10% 2917
C12	22uF	AVX Corporation	TPME226K050R0075	CAP TANT 22UF 50V 10% 2917
C13	1.0uF	TDK Corporation	CKG57KX7R2A105M	CAP CER 1UF 100V 20% X7R SMD
C14	0.033uF	Yageo	CC1206KRX7R9BB333	CAP CER 0.033UF 50V 10% X7R 1206
C15	1000pF	Kemet	PME295RB4100MR30	CAP FILM 1000PF 480VAC RADIAL
C16	1000pF	Kemet	PME295RB4100MR30	CAP FILM 1000PF 480VAC RADIAL
C17	0.033uF	Yageo	CC1206KRX7R9BB333	CAP CER 0.033UF 50V 10% X7R 1206
C18	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C19	47uF	Panasonic	EEU-EB1J470S	CAP ALUM 47UF 63V 20% RADIAL
C20	33uF	AVX Corporation	TPSC336K010R0150	CAP TANT 33UF 10V 10% 2312
C21	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C22	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C23	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C24	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C25	0.033uF	Yageo	CC1206KRX7R9BB333	CAP CER 0.033UF 50V 10% X7R 1206
C26	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C27	0.033uF	Yageo	CC1206KRX7R9BB333	CAP CER 0.033UF 50V 10% X7R 1206
C28	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C29	0.033uF	Yageo	CC1206KRX7R9BB333	CAP CER 0.033UF 50V 10% X7R 1206
C30	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C31	0.033uF	Yageo	CC1206KRX7R9BB333	CAP CER 0.033UF 50V 10% X7R 1206
C32	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C33	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C34	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C35	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C36	10uF	AVX Corp	TPSD106K035R0125	CAP TANT LOESR 10UF 35V 10% SMD
C37	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C38	15pF	Kemet	C0805C150J5GACTU	CAP CERAMIC 15PF 50V NP0 0805
C39	15pF	Kemet	C0805C150J5GACTU	CAP CERAMIC 15PF 50V NP0 0805
C40	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C41	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C42	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C43	0.1uF	AVX Corp	TAJA104K035RNJ	CAP TANTALUM .10UF 35V 10% SMD
C44	0.1uF	AVX Corp	TAJA104K035RNJ	CAP TANTALUM .10UF 35V 10% SMD
C45	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C46	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C47	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C48	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C49	4.7uF	Vishay Sprague	593D475X9050D2TE3	CAP TANT 4.7UF 50V 10% 2917
C50	1.0uF	TDK Corporation	C3216X7R2A105K	CAP CER 1.0UF 100V X7R 1206
C51	0.1uF	AVX Corp	TAJA104K035RNJ	CAP TANTALUM .10UF 35V 10% SMD
C52	0.1uF	AVX Corp	TAJA104K035RNJ	CAP TANTALUM .10UF 35V 10% SMD
C53	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C54	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C55	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C56	0.1uF	AVX Corp	TAJA104K035RNJ	CAP TANTALUM .10UF 35V 10% SMD
C57	0.1uF	AVX Corp	TAJA104K035RNJ	CAP TANTALUM .10UF 35V 10% SMD
C58	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C59	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C60	1.0uF	Kemet	C1206C105K3RAC	CAP, CER, 1.0uF, 25V, 10%, X7R, 1206
C61	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C62	10uF	AVX Corp	TPSD106K035R0125	CAP TANT LOESR 10UF 35V 10% SMD
C63	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO

Ref	Value	Manufacturer	Manufacturer PN	Description
C64	0.1uF	Kemet	C1206F104K3RACTU	CAP CER .1UF 25V X7R 1206 FO
C65	0.1uF	AVX Corp	TAJA104K035RNJ	CAP TANTALUM .10UF 35V 10% SMD
C66	0.1uF	AVX Corp	TAJA104K035RNJ	CAP TANTALUM .10UF 35V 10% SMD
D1	B360A-13-F	Diodes Inc	B360A-13-F	DIODE SCHOTTKY 60V 3A SMA
D2	LTST-C150GKT	Lite-On Inc	LTST-C150GKT	LED GREEN CLEAR 1206 SMD
D3	BZX384	NXP	BZX384-C3V3,115	DIODE ZENER 3.3V 300MW SOD323
D4	DB2J31700L	Panasonic	DB2J31700L	DIODE 30V 1A SMINI2
D5	BZX384	NXP	BZX384-C3V3,115	DIODE ZENER 3.3V 300MW SOD323
D6	DB2J31700L	Panasonic	DB2J31700L	DIODE 30V 1A SMINI2
D7	BZX384	NXP	BZX384-C3V3,115	DIODE ZENER 3.3V 300MW SOD323
D8	DB2J31700L	Panasonic	DB2J31700L	DIODE 30V 1A SMINI2
D9	BZX384	NXP	BZX384-C3V3,115	DIODE ZENER 3.3V 300MW SOD323
D10	DB2J31700L	Panasonic	DB2J31700L	DIODE 30V 1A SMINI2
D11	BZX384	NXP	BZX384-C3V3,115	DIODE ZENER 3.3V 300MW SOD323
D12	DB2J31700L	Panasonic	DB2J31700L	DIODE 30V 1A SMINI2
D13	BZX384	NXP	BZX384-C3V3,115	DIODE ZENER 3.3V 300MW SOD323
D14	DB2J31700L	Panasonic	DB2J31700L	DIODE 30V 1A SMINI2
D15	DB2J31700L	Panasonic	DB2J31700L	DIODE 30V 1A SMINI2
D16	BZX384	NXP	BZX384-C3V3,115	DIODE ZENER 3.3V 300MW SOD323
D17	DB2J31700L	Panasonic	DB2J31700L	DIODE 30V 1A SMINI2
D18	BZX384	NXP	BZX384-C3V3,115	DIODE ZENER 3.3V 300MW SOD323
D19	WP710A10	Kingbright	WP710A10SEC/J4	3MM ORANGE LED ROUND
F1	0154.125DR	Littelfuse Inc	0154.125DR	FUSEBLOCK W/.125A FUSE SMD FST
J1	1881558	Phoenix Contact	1881558	CONN TERM BLK HDR 2.5MM 2POS
J2	1881558	Phoenix Contact	1881558	CONN TERM BLK HDR 2.5MM 2POS
J3	1881558	Phoenix Contact	1881558	CONN TERM BLK HDR 2.5MM 2POS
J4	1881558	Phoenix Contact	1881558	CONN TERM BLK HDR 2.5MM 2POS
J5	1803426	Phoenix Contact	1803426	CONN HEADER VERT 2POS 3.81MM
J6	87831-0620	Molex	87831-0620	CONN HEADER 6POS 2MM VERT GOLD
J7	70543-0001	Molex Inc	70543-0001	CONN HEADER 2POS .100 VERT GOLD
J8	70543-0001	Molex Inc	70543-0001	CONN HEADER 2POS .100 VERT GOLD
J9	70543-0001	Molex Inc	70543-0001	CONN HEADER 2POS .100 VERT GOLD
J10	70543-0001	Molex Inc	70543-0001	CONN HEADER 2POS .100 VERT GOLD
JP1	87224-2	Tyco Electronics	87224-2	CONN HEADER VERT .100 2POS 15AU
K1	TX2-LT-3V-TH	Panasonic	TX2-LT-3V-TH	RELAY GENERAL PURPOSE DPDT 2A 3V
K2	TX2-LT-3V-TH	Panasonic	TX2-LT-3V-TH	RELAY GENERAL PURPOSE DPDT 2A 3V
K3	TX2-LT-3V-TH	Panasonic	TX2-LT-3V-TH	RELAY GENERAL PURPOSE DPDT 2A 3V
K4	DK2a-L2-3V	Panasonic	DK2a-L2-3V	2 Form A, 3VDC 2 Form A 10A 250VAC
L1	22uH	Taiyo Yuden	NR10050T220M	INDUCTOR 22UH 2.6A 20% SMD
L2	15uH	Wurth	7447709150	INDUCTOR POWER 15UH 6.5A SMD
L3	1mH	API Delevan Inc	CM6460R-105	CHOKE COMMON MODE 1000.0UH SMD
L4	22uH	Taiyo Yuden	NR10050T220M	INDUCTOR 22UH 2.6A 20% SMD
L5	68uH	EPCOS Inc	B82464G4683M	INDUCTOR POWER 68UH 1.3A SMD
MOD1	VHB	CUI Inc		CONVERTER DC/DC 50W, 75W
MOD2	PYB	CUI Inc		CONVERTER DC/DC 10W, 15W, 20W
R1	0.05	Stackpole	CSRN2512FK50L0	RES .05 OHM 2W 1% 2512 SMD
R2	TBD			TO BE DETERMINED, HEIGHT 0.6mm
R3	158.0K	Vishay	CRCW1206158KFKEA	RES 158K OHM 1/4W 1206 SMD
R4	5k	Vishay Dale	ALSR015K000JE12	RES 5.0K OHM 5% WW AXIAL
R5	1M	Bourns Inc.	3299Y-1-105LF	TRIMMER 1M OHM 0.5W PC PIN
R6	TBD			TO BE DETERMINED, HEIGHT 0.6mm
R7	475	Vishay	CRCW1206475RFKEA	RES 475 OHM 1/4W 1206 SMD
R8	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R9	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R10	475	Vishay	CRCW1206475RFKEA	RES 475 OHM 1/4W 1206 SMD
R11	23.7K	Vishay	CRCW120623K7FKEA	RES 23.7K OHM 1/4W 1206 SMD
R12	0	Vishay/Dale	CRCW12060000Z0EA	RES 0.0 OHM 1/4W 1206 SMD
R13	120	Vishay	CRCW1206120RJNEA	RES 120 OHM 1/4W 1206 SMD
R14	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R15	0.15	Stackpole	CSRN2010FKR150	RES .15OHM 1W 1% 2010 SMD
R16	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R17	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R18	475	Vishay	CRCW1206475RFKEA	RES 475 OHM 1/4W 1206 SMD
R19	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R20	0.15	Stackpole	CSRN2010FKR150	RES .15OHM 1W 1% 2010 SMD
R21	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD

Ref	Value	Manufacturer	Manufacturer PN	Description
R22	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R23	475	Vishay	CRCW1206475RFKEA	RES 475 OHM 1/4W 1206 SMD
R24	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R25	0.15	Stackpole	CSRN2010FKR150	RES .15OHM 1W 1% 2010 SMD
R26	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R27	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R28	475	Vishay	CRCW1206475RFKEA	RES 475 OHM 1/4W 1206 SMD
R29	0.05	Stackpole	CSRN2512FK50L0	RES .05 OHM 2W 1% 2512 SMD
R30	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R31	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R32	475	Vishay	CRCW1206475RFKEA	RES 475 OHM 1/4W 1206 SMD
R33	TBD			TO BE DETERMINED, HEIGHT 0.6mm
R34	23.7K	Vishay	CRCW120623K7FKEA	RES 23.7K OHM 1/4W 1206 SMD
R35	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R36	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R37	39	Vishay	CRCW120639R0JNEA	RES 39 OHM 1/4W 1206 SMD
R38	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R39	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R40	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R41	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R42	10.0K	Vishay	CRCW120610K0FKEA	RES 10K OHM 1/4W 1206 SMD
R43	0	Vishay/Dale	CRCW12060000Z0EA	RES 0.0 OHM 1/4W 1206 SMD
R44	TBD			TO BE DETERMINED, HEIGHT 0.6mm
R45	TBD			TO BE DETERMINED, HEIGHT 0.6mm
R46	TBD			TO BE DETERMINED, HEIGHT 0.6mm
R47	TBD			TO BE DETERMINED, HEIGHT 0.6mm
R48	31.6K	Vishay	CRCW120631K6FKEA	RES 31.6K OHM 1/4W 1206 SMD
R49	316	Vishay	CRCW1206316RFKEA	RES 316 OHM 1/4W 1206 SMD
R50	16.5K	Vishay	CRCW120616K5FKEA	RES 16.5K OHM 1/4W 1206 SMD
R51	TBD			TO BE DETERMINED, HEIGHT 0.6mm
R52	31.6K	Vishay	CRCW120631K6FKEA	RES 31.6K OHM 1/4W 1206 SMD
R53	16.5K	Vishay	CRCW120616K5FKEA	RES 16.5K OHM 1/4W 1206 SMD
R54	TBD			TO BE DETERMINED, HEIGHT 0.6mm
RN1	33k	Bourns Inc.	4816P-T01-333LF	RES ARRAY 33K OHM 8 RES 16SOIC
ST1	#4 Screw			#4 SCREW TERMINAL W/ WASHER
ST2	#4 Screw			#4 SCREW TERMINAL W/ WASHER
ST3	#4 Screw			#4 SCREW TERMINAL W/ WASHER
ST4	#4 Screw			#4 SCREW TERMINAL W/ WASHER
SW1	TDA08	C&K	TDA08H0SB1	SWITCH DIP 8POS HALF PITCH SMD
U1	AD8603	Analog Devices	AD8603AUJZ-REEL7	IC OPAMP GP R-R CMOS TSOT23-5
U2	LT1787	Linear Technology	LT1787HVIS8#PBF	IC AMP PREC CURR SENSE HV 8-SOIC
U3	AD8603	Analog Devices	AD8603AUJZ-REEL7	IC OPAMP GP R-R CMOS TSOT23-5
U4	MAX5033	Maxim IC	MAX5033AASA+	IC BUCK 3.3V 0.5A 8SOIC
U5	QS6K21TR	Rohm	QS6K21TR	MOSFET N-CH 45V 1A TSMT6
U6	LT1787	Linear Technology	LT1787HVIS8#PBF	IC AMP PREC CURR SENSE HV 8-SOIC
U7	AD8603	Analog Devices	AD8603AUJZ-REEL7	IC OPAMP GP R-R CMOS TSOT23-5
U8	QS6K21TR	Rohm	QS6K21TR	MOSFET N-CH 45V 1A TSMT6
U9	LT1787	Linear Technology	LT1787HVIS8#PBF	IC AMP PREC CURR SENSE HV 8-SOIC
U10	AD8603	Analog Devices	AD8603AUJZ-REEL7	IC OPAMP GP R-R CMOS TSOT23-5
U11	QS6K21TR	Rohm	QS6K21TR	MOSFET N-CH 45V 1A TSMT6
U12	LT1787	Linear Technology	LT1787HVIS8#PBF	IC AMP PREC CURR SENSE HV 8-SOIC
U13	AD8603	Analog Devices	AD8603AUJZ-REEL7	IC OPAMP GP R-R CMOS TSOT23-5
U14	STS4DPF30L	STMicroelectronics	STS4DPF30L	MOSFET 2P-CH 30V 4A 8-SOIC
U15	LT1787	Linear Technology	LT1787HVIS8#PBF	IC AMP PREC CURR SENSE HV 8-SOIC
U16	AD8603	Analog Devices	AD8603AUJZ-REEL7	IC OPAMP GP R-R CMOS TSOT23-5
U17	LDA100STR	IXYS	LDA100STR	OPTOCOUPLER SGL TRANS-OUT 6-SMD
U18	PIC24FJ256GA106	Microchip	PIC24FJ256GA106-I/PT	IC PIC MCU FLASH 256K 64TQFP
U19	MAX3226E	Maxim IC	MAX3226ECUE+	IC TXRX RS232 250KBPS SD 16TSSOP
U20	ADS8344	Analog Devices	ADS8344NB	IC 16-BIT 8-CH A/D CONV 20-SSOP
U21	MAX3226E	Maxim IC	MAX3226ECUE+	IC TXRX RS232 250KBPS SD 16TSSOP
U22	AD1583	Analog Devices	AD1583ARTZ-REEL7	IC VREF SERIES PREC 3V SOT-23-3
U23	MAX3226E	Maxim IC	MAX3226ECUE+	IC TXRX RS232 250KBPS SD 16TSSOP
U24	AD8603	Analog Devices	AD8603AUJZ-REEL7	IC OPAMP GP R-R CMOS TSOT23-5
U25	LT1790-1.25	Linear Technology	LT1790BCS6-1.25#TRMPBF	IC VREF SERIES 1.25V SOT-23-6
U26	MAX3226E	Maxim IC	MAX3226ECUE+	IC TXRX RS232 250KBPS SD 16TSSOP
Y1	3.6864MHz	ECS Inc	ECS-36-20-5PXDU-TR	CRYSTAL 3.6864 MHZ 20PF SMD