

PLCHIP-P13-51220

32-bit PLC on a Chip Integrated Circuit with up to 256KB Flash,
Ethernet, USB, LCD, Digital I/O, Analog I/O, PWM

Rev. 6 - 1/27/2021



DATA SHEET

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WARNING!!

The PLC on a Chip, must not be used alone in applications which could be hazardous to personnel in the event of failure of this device. Precautions must be taken by the user to provide mechanical and/or electrical safeguards external to this device. This device is **NOT APPROVED** for domestic or human medical use. All PLC on a Chip Specifications and Requirements subject to change without notice.

1. General Description

The PLCHIP-P13-51220 is a 32 bit microcontroller for embedded applications with full PLC functionality. The P-Series combines powerful peripherals with industry standard I/O for a complete package that provides the advanced features required while providing an easy-to-use ladder diagram programming interface; EZ LADDER Toolkit.

The PLCHIP-P13-51220 provides up to 256K of Program Flash Storage, 32K of RAM, up to 164 general purpose digital I/O, up to 3 I2C ports, up to 2 SPI Ports, up to 2 CAN Network Ports, up to 4 Serial Ports, up to 8 Analog Inputs, up to 1 Analog Output, up to 16 Pulse Width Modulation Outputs, 1 Ethernet Port, Internal Real Time Clock, SD Card Interface, up to 6 counter/timer inputs, up to 1 quadrature counter input, LCD Display Support and Keypad Support.

The PLCHIP-P13-51220 is programmed exclusively using EZ LADDER Toolkit.

2. Features and Benefits

■ Memory:

- Up to 256K Flash memory for Ladder Program storage.
- Up to 32K RAM memory program execution and variables.
- Up to 3500 bytes EEPROM memory for Set Point Storage and Retentive Variable Storage.

■ Serial Interfaces:

- Up to three I²C Ports. 1Mbit/s Data Rate
- Up to four TTL Serial Ports. One Supports full handshaking while 3 support RX/TX. Supports Modbus Master & Slave.
- TTL Ethernet Port, Supports Modbus over TCP
- Up to two Controller Area Network (CAN) Ports. Supports Divelbiss OptiCAN, SAE J1939
- Up to two SPI Ports.

■ HMI Support:

- Supports HD44780 Controller Compatible LCD Displays with up to 4 rows and up to 40 columns.
- Supports a Keypad matrix of 5 columns by 4 rows for numbers 0-9, decimal, function keys

■ Digital Interfaces:

- SD/MMC Memory Card Interface
- Up to six inputs that may be utilized as counters or timers.
- Up to three inputs when configured properly will interface to a quadrature encoder.
- Up to 164 General Purpose I/O (GPIO) that may be individually configured as inputs or outputs.
- Up to Sixteen Pulse Width Modulated Outputs
- Real Time Clock (requires external clock and power source).

- **Analog Interfaces:**
 - Up to 8 Channels, 12 bit Analog to Digital Converter (ADC).
 - Up to 1 Channel, 10 bit Digital to Analog Converter (DAC).

3. Ordering Information

PLCHIP-P13-51220 P-Series Integrated Circuits may be ordered by Part number. Pricing varies base on part number and quantity.

Part Number	Description
PLCHIP-P13-51220	PLC on a Chip P-Series, 208 Pin Low Profile, Quad Flat Package (LQFP208), 256 Flash, 32K RAM, 164 GPIO, 16 PWM Channels, 8 ADC Channels, 1 DAC Channel, 6 Timer/Counter Channels, Quadrature Encoder Input, LCD / Keypad Support, Ethernet, USB, 4 Serial Ports, 2 CAN Ports, SD/MMC Card Support. Shipped in Trays of 36.
PLCHIP-P13-51220X1	PLC on a Chip P-Series, P13 (PLCHIP-P13-512210). Shipped as Single piece.
PLCHIP-P13-51220X5	PLC on a Chip P-Series, P13 (PLCHIP-P13-512210). Shipped as 5 Pack.
PLCHIP-P13-51220X10	PLC on a Chip P-Series, P13 (PLCHIP-P13-512210). Shipped as 10 Pack.

4. Pin Summary

The PLCHIP-P13-51220 provides great flexibility in features by allowing pins to be assigned multiple functions. While each Pin may only be configured to be a single function, many pins provide multiple configuration options for functionality. These options are listed as Function 1 through Function 4 for each pin in TABLE 1.

Pin #	Function 1	Function 2	Function 3	Function 4
1	GPIO108	---	---	---
2	RES11	---	---	---
3	GPIO99	---	---	---
4	RES7	---	---	---
5	GPIO124	PWM4	---	---
6	RES8	---	---	---
7	GPIO109	---	---	---
8	RES6	---	---	---
9	GPIO160	---	---	---
10	RES9	---	---	---
11	GPIO125	PWM5	---	---

TABLE 1 - Pin Summary

Pin #	Function 1	Function 2	Function 3	Function 4
12	GPIO26	AI3	AO0	---
13	GPIO100	---	---	---
14	GPIO25	AI2	---	---
15	VDD4	---	---	---
16	GPIO24	AI1	---	---
17	GPIO101	---	---	---
18	GPIO23	AI0	---	---
19	GPIO126	---	---	---
20	VDD_AN	---	---	---
21	GPIO110	---	---	---
22	VSS_AN	---	---	---
23	GPIO102	---	---	---
24	VREF_AN	---	---	---
25	GPIO127	---	---	---
26	VDD1	---	---	---
27	GPIO103	---	---	---
28	GPIO111	---	---	---
29	$\overline{\text{RSTOUT}}$	---	---	---
30	GPIO161	---	---	---
31	GPIO94	---	---	---
32	VSS11	---	---	---
33	VSS1	---	---	---
34	RTCX1	---	---	---
35	$\sim\text{RESET}$	---	---	---
36	RTCX2	---	---	---
37	RES2	---	---	---
38	VBAT	---	---	---
39	GPIO95	---	---	---
40	GPIO63	AI5	---	---
41	GPIO12	AI6	---	---
42	GPIO62	AI4	---	---
43	GPIO93	---	---	---
44	XTAL1	---	---	---
45	GPIO13	AI7	---	---
46	XTAL2	---	---	---
47	GPIO91	---	---	---
48	GPIO28	I2C_SCL0	---	---
49	GPIO92	---	---	---
50	GPIO27	I2C_SDA0	---	---
51	GPIO31	---	---	---

TABLE 1 - Pin Summary

Pin #	Function 1	Function 2	Function 3	Function 4
52	---	---	---	---
53	GPIO88	---	---	---
54	GPIO89	---	---	---
55	GPIO122	PWM2	---	---
56	GPIO121	PWM1	---	---
57	GPIO90	---	---	---
58	GPIO120	PWM0	---	---
59	GPIO82	---	---	---
60	VDD5	---	---	---
61	GPIO29	---	---	---
62	GPIO30	---	---	---
63	VSS2	---	---	---
64	GPIO87	---	---	---
65	GPIO119	---	---	---
66	GPIO50	TMR_CAP1.0	---	---
67	GPIO83	---	---	---
68	GPIO51	TMR_CAP1.1	---	---
69	GPIO14	---	---	---
70	GPIO52	QEI_PHA	---	---
71	VDD6	---	---	---
72	GPIO53	---	---	---
73	GPIO84	---	---	---
74	GPIO54	TMR_MAT1	---	---
75	GPIO128	LCD_D0	---	---
76	GPIO55	QEI_PHB	---	---
77	VSS3	---	---	---
78	GPIO56	QEI_IDX	---	---
79	GPIO129	LCD_D1	---	---
80	GPIO57	---	---	---
81	GPIO85	---	---	---
82	GPIO58	TMR_CAP0.0	---	---
83	GPIO130	LCD_D2	---	---
84	VSS12	---	---	---
85	GPIO86	---	---	---
86	VDD2	---	---	---
87	GPIO80	---	---	---
88	GPIO59	TMR_CAP0.1	---	---
89	VDD7	---	---	---
90	GPIO60	TMR_MAT0	---	---
91	GPIO78	TMR_CAP2.0	---	---

TABLE 1 - Pin Summary

Pin #	Function 1	Function 2	Function 3	Function 4
92	GPIO61	MCI_CARD_PRESENT	---	---
93	VSS4	---	---	---
94	GPIO00	CAN_RX0	I2C_SDA1	---
95	GPIO81	---	---	---
96	GPIO01	CAN_TX0	I2C_SCL1	---
97	GPIO131	LCD_D3	---	---
98	GPIO10	I2C_SDA2	---	---
99	GPIO79	TMR_CAP2.1	---	---
100	GPIO11	I2C_SCL2	---	---
101	GPIO144	---	---	---
102	GPIO77	MCI_DATA3	---	---
103	GPIO132	LCD_D4	---	---
104	GPIO145	---	---	---
105	GPIO146	---	---	---
106	GPIO76	MCI_DATA2	---	---
107	GPIO133	LCD_D5	---	---
108	GPIO75	MCI_DATA1	---	---
109	GPIO148	---	---	---
110	LED_KERNEL	Pull to 3.3V	---	---
111	GPIO147	---	---	---
112	VDD8	---	---	---
113	GPIO134	LCD_D6	---	---
114	VSS5	---	---	---
115	GPIO149	---	---	---
116	GPIO22	MCI_DATA0	---	---
117	GPIO162	---	---	---
118	GPIO21	MCI_PWR	---	---
119	GPIO154	---	---	---
120	GPIO20	MCI_CMD	---	---
121	GPIO135	LCD_D7	---	---
122	GPIO19	MCI_CLK	---	---
123	GPIO150	---	---	---
124	GPIO18	SPI_MOSI0	---	---
125	VDD9	---	---	---
126	GPIO17	SPI_MISO0	---	---
127	GPIO136	LCD_RS	---	---
128	GPIO15	SPI_SCK0	---	---
129	GPIO151	---	---	---
130	GPIO16	LOW_VOLT_SENSE	---	---

TABLE 1 - Pin Summary

Pin #	Function 1	Function 2	Function 3	Function 4
131	GPIO137	LCD_RW	---	---
132	GPIO73	RXD2	---	---
133	VSS6	---	---	---
134	GPIO72	TXD2	---	---
135	GPIO138	LCD_E	---	---
136	GPIO71	RTS1	---	---
137	GPIO112	PWM6	---	---
138	GPIO70	RI1	---	---
139	GPIO155	---	---	---
140	GPIO69	DTR1	---	---
141	GPIO163	RXD4	---	---
142	GPIO68	DSR1	---	---
143	GPIO113	PWM7	---	---
144	GPIO67	DCD1	---	---
145	GPIO139	KEYPAD_COL1	---	---
146	VDD10	---	---	---
147	GPIO45	---	---	---
148	VSS7	---	---	---
149	GPIO140	KEYPAD_COL2	---	---
150	GPIO66	CTS1	---	---
151	GPIO114	PWM8	---	---
152	GPIO65	RXD1	---	---
153	GPIO39	---	---	---
154	GPIO64	TXD1	---	---
155	GPIO141	KEYPAD_COL3	---	---
156	GPIO37	---	---	---
157	GPIO44	---	---	---
158	GPIO9	SPI_MOS1	---	---
159	GPIO142	KEYPAD_COL4	---	---
160	GPIO8	SPI_MISO1	---	---
161	GPIO115	PWM9	---	---
162	GPIO7	SPI_SCK1	---	---
163	GPIO43	---	---	---
164	GPIO6	TMR_MAT2	---	---
165	VDD11	---	---	---
166	GPIO5	CAN_TX1	---	---
167	GPIO116	PWM10	---	---
168	GPIO4	CAN_RX1	---	---
169	VSS8	---	---	---
170	GPIO156	TXD3	---	---

TABLE 1 - Pin Summary

Pin #	Function 1	Function 2	Function 3	Function 4
171	GPIO38	---	---	---
172	VSS13	---	---	---
173	GPIO143	KEYPAD_COL5	---	---
174	VDD3	---	---	---
175	GPIO117	PWM11	---	---
176	GPIO157	RXD3	---	---
177	GPIO35	---	---	---
178	GPIO49	ETHER_MDIO	---	---
179	GPIO153	KEYPAD_ROW2	---	---
180	GPIO48	ETHER_MDC	---	---
181	VDD12	---	---	---
182	GPIO47	ETHER_REFCLK	---	---
183	GPIO152	KEYPAD_ROW1	---	---
184	GPIO46	ETHER_RXER	---	---
185	GPIO34	---	---	---
186	GPIO42	ETHER_RXD1	---	---
187	GPIO158	KEYPAD_ROW3	---	---
188	GPIO41	ETHER_RXD0	---	---
189	VSS9	---	---	---
190	GPIO40	ETHER_CRS	---	---
191	GPIO104	---	---	---
192	GPIO36	ETHER_TXEN	---	---
193	GPIO159	KEYPAD_ROW4	---	---
194	GPIO33	ETHER_TXD1	---	---
195	GPIO118	---	---	---
196	GPIO32	ETHER_TXD0	---	---
197	GPIO96	---	---	---
198	VDD13	---	---	---
199	GPIO105	---	---	---
200	VSS10	---	---	---
201	GPIO97	---	---	---
202	TXD0	---	---	---
203	GPIO123	PWM3	---	---
204	RXD0	---	---	---
205	GPIO106	---	---	---
206	GPIO164	TXD4	---	---
207	GPIO98	---	---	---
208	GPIO107	---	---	---

5. Pin Details

TABLE 2 lists details for each pins individual supported functions. Required pins and related pins are also listed.

TABLE 2 - Pin Details	
Pin #	Description
1	GPI108 General Purpose Digital I/O. May be configured as General Purpose Input 108 (GPI108) or General Purpose Output 108 (GPO108).
2	Not Connected Do Not Connect this pin.
3	GPI099 General Purpose Digital I/O. May be configured as General Purpose Input 99 (GPI99) or General Purpose Output 99 (GPO99).
4	Not Connected Do Not Connect this pin.
5	GPI0124 General Purpose Digital I/O. May be configured as General Purpose Input 124 (GPI124) or General Purpose Output 124 (GPO124).
	PWM4 Pulse Width Modulation Output 4 (PWM4).
6	Not Connected Do Not Connect this pin.
7	GPI0109 General Purpose Digital I/O. May be configured as General Purpose Input 109 (GPI109) or General Purpose Output 109 (GPO109).
8	Not Connected Do Not Connect this pin.
9	GPI0160 General Purpose Digital I/O. May be configured as General Purpose Input 160 (GPI160) or General Purpose Output 160 (GPO160).
10	Not Connected Do Not Connect this pin.
11	GPI0125 General Purpose Digital I/O. May be configured as General Purpose Input 125 (GPI125) or General Purpose Output 125 (GPO125).
	PWM5 Pulse Width Modulation Output 5 (PWM5).

TABLE 2 - Pin Details

Pin #	Description
12	<p>GPIO26 General Purpose Digital I/O. May be configured as General Purpose Input 26 (GPI26) or General Purpose Output 26 (GPO26).</p>
	<p>AI3 Analog Input 3. Not to exceed 3.3VDC. Resolution: 12 bit. The following pins are required for Analog Input functionality: 20, 22, 24. Related Analog Input Pins: 41, 45, 18, 16, 14, 12, 42, 40</p>
	<p>A00 Analog Output 0. 3.3VDC Maximum Output. Resolution 10 bit. The following pins are required for Analog Output functionality: 20, 22.</p>
13	<p>GPIO100 General Purpose Digital I/O. May be configured as General Purpose Input 100 (GPI100) or General Purpose Output 100 (GPO100).</p>
14	<p>GPIO25 General Purpose Digital I/O. May be configured as General Purpose Input 25 (GPI25) or General Purpose Output 25 (GPO25).</p>
	<p>AI2 Analog Input 2. Not to exceed 3.3VDC. Resolution: 12 bit. The following pins are required for Analog Input functionality: 20, 22, 24. Related Analog Input Pins: 41, 45, 18, 16, 14, 12, 42, 40</p>
15	<p>VDD4 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).</p>
16	<p>GPIO24 General Purpose Digital I/O. May be configured as General Purpose Input 24 (GPI24) or General Purpose Output 24 (GPO24).</p>
	<p>AI1 Analog Input 1. Not to exceed 3.3VDC. Resolution: 12 bit. The following pins are required for Analog Input functionality: 20, 22, 24. Related Analog Input Pins: 41, 45, 18, 16, 14, 12, 42, 40</p>
17	<p>GPIO101 General Purpose Digital I/O. May be configured as General Purpose Input 101 (GPI101) or General Purpose Output 101 (GPO101).</p>
18	<p>GPIO23 General Purpose Digital I/O. May be configured as General Purpose Input 23 (GPI23) or General Purpose Output 23 (GPO23).</p>
	<p>AIO Analog Input 0. Not to exceed 3.3VDC. Resolution: 12 bit. The following pins are required for Analog Input functionality: 20, 22, 24. Related Analog Input Pins: 41, 45, 18, 16, 14, 12, 42, 40</p>
19	<p>GPIO126 General Purpose Digital I/O. May be configured as General Purpose Input 126 (GPI126) or General Purpose Output 126 (GPO126).</p>

TABLE 2 - Pin Details

Pin #	Description
20	<p>VDD_AN +V Power Supply for on-board analog circuitry. Connect to 3.3VDC supply. This pin can be connected to the same 3.3VDC logic supply for the PLC on a Chip™ or a separate supply as required to minimize noise and error. This pin is used to power the on-board ADC and DAC components. The recommended bypass capacitor must be installed near this pin (this pin to the VSS_AN pin). If the ADC and DAC are not used, this pin should be connected to 3.3VDC. The following pins are required for Analog Input functionality: 20, 22, 24. Related Analog Input Pins: 41, 45, 18, 16, 14, 12, 42, 40</p>
21	<p>GPIO110 General Purpose Digital I/O. May be configured as General Purpose Input 110 (GPI110) or General Purpose Output 110 (GPO110).</p>
22	<p>VSS_AN Analog Ground. 0V Power Supply / Reference for the on-board ADC and DAC components. This should be the same potential as VSS (GND) or isolated as required to minimize noise and error. The following pins are required for Analog Input functionality: 20, 22, 24. Related Analog Input Pins: 41, 45, 18, 16, 14, 12, 42, 40</p>
23	<p>GPIO102 General Purpose Digital I/O. May be configured as General Purpose Input 102 (GPI102) or General Purpose Output 102 (GPO102).</p>
24	<p>VREF_AN On-board ADC Positive Reference Voltage. This should be the same voltage as VDD. It can be connected to VDD or isolated as required to minimize noise and error. The voltage level on this pin is used as a reference for the ADC and DAC. If the ADC and DAC are not used, this pin should be connected to 3.3VDC. The recommended bypass capacitor must be installed near this pin (this pin to the VSS_AN pin). The following pins are required for Analog Input functionality: 20, 22, 24. Related Analog Input Pins: 41, 45, 18, 16, 14, 12, 42, 40</p>
25	<p>GPIO127 General Purpose Digital I/O. May be configured as General Purpose Input 127 (GPI127) or General Purpose Output 127 (GPO127).</p>
26	<p>VDD1 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).</p>
27	<p>GPIO103 General Purpose Digital I/O. May be configured as General Purpose Input 103 (GPI103) or General Purpose Output 103 (GPO103).</p>
28	<p>GPIO111 General Purpose Digital I/O. May be configured as General Purpose Input 111 (GPI111) or General Purpose Output 111 (GPO111).</p>
29	<p>RSTOUT Reset Output. This pin is used to connect to other smart integrated circuits and provides the status of the PLC on a Chip™. When LOW, the PLC on a Chip™ is in the reset state.</p>

TABLE 2 - Pin Details

Pin #	Description
30	GPI0161 General Purpose Digital I/O. May be configured as General Purpose Input 161 (GPI161) or General Purpose Output 161 (GPO161).
31	GPI094 General Purpose Digital I/O. May be configured as General Purpose Input 94 (GPI94) or General Purpose Output 94 (GPO94).
32	VSS11 Connect to GND / 3.3V COMMON.
33	VSS1 Connect to GND / 3.3V COMMON.
34	RTXC1 Real Time Clock Power Oscillator Circuit Input. Ultra-low power. 32KHz oscillator required. The following pins are required for Real Time Clock (RTC) functionality: 34 , 36 , 38 . See Section 6.19 - Real Time Clock for details.
35	RESET Reset Input Pin. A Low on this pin places the PLC on a Chip™ in the reset state, causing all I/O and peripherals to return to their default states. This pin includes a 20 ns input glitch filter. This pin should be connected to an external power-on reset device.
36	RTXC2 Real Time Clock Power Oscillator Circuit Output. The following pins are required for Real Time Clock (RTC) functionality: 34 , 36 , 38 . See Section 6.19 - Real Time Clock for details.
37	Not Connected Do Not Connect this pin.
38	VBAT Real Time Clock Power Supply (3.3V nominal). Voltage on this pin supplies power to the Real Time Clock and provides a source of power to maintain RTC functionality when PLC on a Chip™ is not powered. If no RTC function is enabled (no battery), this pin should be connected to 3.3V. The following pins are required for Real Time Clock (RTC) functionality: 34 , 36 , 38 .
39	GPI095 General Purpose Digital I/O. May be configured as General Purpose Input 95 (GPI95) or General Purpose Output 95 (GPO95).
40	GPI063 General Purpose Digital I/O. May be configured as General Purpose Input 63 (GPI63) or General Purpose Output 63 (GPO63).
	A15 Analog Input 5. Not to exceed 3.3VDC. Resolution: 12 bit. The following pins are required for Analog Input functionality: 20 , 22 , 24 . Related Analog Input Pins: 41 , 45 , 18 , 16 , 14 , 12 , 42 , 40

TABLE 2 - Pin Details

Pin #	Description
41	<p>GPIO12 General Purpose Digital I/O. May be configured as General Purpose Input 12 (GPI12) or General Purpose Output 12 (GPO12).</p>
	<p>AI6 Analog Input 6. Not to exceed 3.3VDC. Resolution: 12 bit. The following pins are required for Analog Input functionality: 20, 22, 24. Related Analog Input Pins: 41, 45, 18, 16, 14, 12, 42, 40</p>
42	<p>GPIO62 General Purpose Digital I/O. May be configured as General Purpose Input 62 (GPI62) or General Purpose Output 62 (GPO62).</p>
	<p>AI4 Analog Input 4. Not to exceed 3.3VDC. Resolution: 12 bit. The following pins are required for Analog Input functionality: 20, 22, 24. Related Analog Input Pins: 41, 45, 18, 16, 14, 12, 42, 40</p>
43	<p>GPIO93 General Purpose Digital I/O. May be configured as General Purpose Input 93 (GPI93) or General Purpose Output 93 (GPO93).</p>
44	<p>XTAL1 Oscillator and internal clock generator circuit input. See Section 6.3 - Oscillator for details.</p>
45	<p>GPIO13 General Purpose Digital I/O. May be configured as General Purpose Input 13 (GPI13) or General Purpose Output 13 (GPO13).</p>
	<p>AI7 Analog Input 7. Not to exceed 3.3VDC. Resolution: 12 bit. The following pins are required for Analog Input functionality: 20, 22, 24. Related Analog Input Pins: 41, 45, 18, 16, 14, 12, 42, 40</p>
46	<p>XTAL2 On-board Oscillator Amplifier output. See Section 6.3 - Oscillator for details.</p>
47	<p>GPIO91 General Purpose Digital I/O. May be configured as General Purpose Input 91 (GPI91) or General Purpose Output 91 (GPO91).</p>
48	<p>GPIO28 General Purpose Digital I/O. May be configured as General Purpose Input 28 (GPI28) or General Purpose Output 28 (GPO28). Pin is Open Drain. When used as GPIO, a pull-up resistor is required for proper operation.</p>
	<p>I2C_SCL0 I²C Port 0 Clock Line. This line is used to communicate to I²C devices. Pull-up resistors (1.4K Ohm) are required for proper operation. The following pins are required for Port 0 I²C functionality: 50, 48.</p>
49	<p>GPIO92 General Purpose Digital I/O. May be configured as General Purpose Input 92 (GPI92) or General Purpose Output 92 (GPO92).</p>

TABLE 2 - Pin Details

Pin #	Description
50	<p>GPIO27 General Purpose Digital I/O. May be configured as General Purpose Input 27 (GPI27) or General Purpose Output 27 (GPO27). Pin is Open Drain. When used as GPIO, a pull-up resistor is required for proper operation.</p>
	<p>I2C_SDA0 I²C Port 0 Data Line. This line is used to communicate to I²C devices. Pull-up resistors (1.4K Ohm) are required for proper operation. The following pins are required for Port 0 I²C functionality: 50, 48.</p>
51	<p>GPIO31 General Purpose Digital I/O. May be configured as General Purpose Input 31 (GPI31) or General Purpose Output 31 (GPO31).</p>
52	<p>No Connect</p>
53	<p>GPIO88 General Purpose Digital I/O. May be configured as General Purpose Input 88 (GPI88) or General Purpose Output 88 (GPO88).</p>
54	<p>GPIO89 General Purpose Digital I/O. May be configured as General Purpose Input 89 (GPI89) or General Purpose Output 89 (GPO89).</p>
55	<p>GPIO122 General Purpose Digital I/O. May be configured as General Purpose Input 122 (GPI122) or General Purpose Output 122 (GPO122).</p>
	<p>PWM2 Pulse Width Modulation Output 2 (PWM2).</p>
56	<p>GPIO121 General Purpose Digital I/O. May be configured as General Purpose Input 121 (GPI121) or General Purpose Output 121 (GPO121).</p>
	<p>PWM1 Pulse Width Modulation Output 1 (PWM1).</p>
57	<p>GPIO90 General Purpose Digital I/O. May be configured as General Purpose Input 90 (GPI90) or General Purpose Output 90 (GPO90).</p>
58	<p>GPIO120 General Purpose Digital I/O. May be configured as General Purpose Input 120 (GPI120) or General Purpose Output 120 (GPO120).</p>
	<p>PWM0 Pulse Width Modulation Output 0 (PWM0).</p>
59	<p>GPIO82 General Purpose Digital I/O. May be configured as General Purpose Input 82 (GPI82) or General Purpose Output 82 (GPO82).</p>

TABLE 2 - Pin Details

Pin #	Description
60	VDD5 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).
61	GPIO29 General Purpose Digital I/O. May be configured as General Purpose Input 29 (GPI29) or General Purpose Output 29 (GPO29). Note: GPIO29 and GPIO30 must both be input or output as a pair. One cannot be input while the other is an output.
62	GPIO30 General Purpose Digital I/O. May be configured as General Purpose Input 30 (GPI30) or General Purpose Output 30 (GPO30). Note: GPIO29 and GPIO30 must both be input or output as a pair. One cannot be input while the other is an output.
63	VSS2 Connect to GND / 3.3V COMMON.
64	GPIO87 General Purpose Digital I/O. May be configured as General Purpose Input 87 (GPI87) or General Purpose Output 87 (GPO87).
65	GPIO119 General Purpose Digital I/O. May be configured as General Purpose Input 119 (GPI119) or General Purpose Output 119 (GPO119).
66	GPIO50 General Purpose Digital I/O. May be configured as General Purpose Input 50 (GPI50) or General Purpose Output 50 (GPO50).
	TMR_CAP1.0 Capture input for Timer Module 1, Channel 0. Timer Module 1 supports two input pins: Channel 0 and Channel 1. Only one channel may be used as a timer capture pin in any Timer Module. This setting must match the configuration in EZ LADDER Toolkit. Based on the software configuration, either pin (when selected) will operate as a counter or will calculate the time/frequency of pulses. The following pins are related for Timer Module 1 functionality: 66 , 68 , 74 .
67	GPIO83 General Purpose Digital I/O. May be configured as General Purpose Input 83 (GPI83) or General Purpose Output 83 (GPO83).
68	GPIO51 General Purpose Digital I/O. May be configured as General Purpose Input 51 (GPI51) or General Purpose Output 51 (GPO51).
	TMR_CAP1.1 Capture input for Timer Module 1, Channel 1. Timer Module 1 supports two input pins: Channel 0 and Channel 1. Only one channel may be used as a timer capture pin in any Timer Module. This setting must match the configuration in EZ LADDER Toolkit. Based on the software configuration, either pin (when selected) will operate as a counter or will calculate the time/frequency of pulses. The following pins are related for Timer Module 1 functionality: 66 , 68 , 74 .

TABLE 2 - Pin Details

Pin #	Description
69	GPIO14 General Purpose Digital I/O. May be configured as General Purpose Input 14 (GPI14) or General Purpose Output 14 (GPO14).
70	GPIO52 General Purpose Digital I/O. May be configured as General Purpose Input 52 (GPI52) or General Purpose Output 52 (GPO52).
	QEI_PHA Quadrature Encoder Encoder Phase A (A Channel) input. The P13-Series supports an on-board quadrature encoder that provides inputs for Phase A, Phase B and Index. The following pins are required for on-board Quadrature Encoder Interface functionality: 70 , 76 , 78 .
71	VDD6 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).
72	GPIO53 General Purpose Digital I/O. May be configured as General Purpose Input 53 (GPI53) or General Purpose Output 53 (GPO53).
73	GPIO84 General Purpose Digital I/O. May be configured as General Purpose Input 84 (GPI84) or General Purpose Output 84 (GPO84).
74	GPIO54 General Purpose Digital I/O. May be configured as General Purpose Input 54 (GPI54) or General Purpose Output 54 (GPO54).
	TMR_MAT1 <small>NOTE 1</small> Timer/Capture Channel 1 Match output. This output is HIGH based on Timer/Capture Channel 1's configuration and when the captured or timed value equals a predetermined set point. The following pins are related for TMR_MAT1 functionality: 66 , 68 , 74 .
75	GPIO128 General Purpose Digital I/O. May be configured as General Purpose Input 128 (GPI128) or General Purpose Output 128 (GPO128).
	LCD_D0 Data 0 Line for LCD Display Port. Supports up to 4 Line, 20 Character Liquid Crystal Display (LCD). See LCD under <i>Section 5: Functional Descriptions</i> . The following pins are required for LCD functionality: 75 , 79 , 83 , 97 , 103 , 107 , 113 , 121 , 127 , 131 , 135
76	GPIO55 General Purpose Digital I/O. May be configured as General Purpose Input 55 (GPI55) or General Purpose Output 55 (GPO55).
	QEI_PHB Quadrature Encoder Encoder Phase B (B Channel) input. The P13-Series supports an on-board quadrature encoder that provides inputs for Phase A, Phase B and Index. The following pins are required for on-board Quadrature Encoder Interface functionality: 70 , 76 , 78 .
77	VSS3 Connect to GND / 3.3V COMMON.

TABLE 2 - Pin Details

Pin #	Description
78	<p>GPIO56 General Purpose Digital I/O. May be configured as General Purpose Input 56 (GPI56) or General Purpose Output 56 (GPO56).</p>
	<p>QEI_IDX Quadrature Encoder Encoder Phase Index input. The P13-Series supports an on-board quadrature encoder that provides inputs for Phase A, Phase B and Index. The index input must be pulled high or low based on desired functionality if the connected encoder does not support the index channel. The following pins are required for on-board Quadrature Encoder Interface functionality: 70, 76, 78.</p>
79	<p>GPIO129 General Purpose Digital I/O. May be configured as General Purpose Input 129 (GPI129) or General Purpose Output 129 (GPO129).</p>
	<p>LCD_D1 Data 1 Line for LCD Display Port. Supports up to 4 Line, 20 Character Liquid Crystal Display (LCD). See LCD under <i>Section 5: Functional Descriptions</i>. The following pins are required for LCD functionality: 75, 79, 83, 97, 103, 107, 113, 121, 127, 131, 135</p>
80	<p>GPIO57 General Purpose Digital I/O. May be configured as General Purpose Input 57 (GPI57) or General Purpose Output 57 (GPO57).</p>
81	<p>GPIO85 General Purpose Digital I/O. May be configured as General Purpose Input 85 (GPI85) or General Purpose Output 85 (GPO85).</p>
82	<p>GPIO58 General Purpose Digital I/O. May be configured as General Purpose Input 58 (GPI58) or General Purpose Output 58 (GPO58).</p>
	<p>TMR_CAP0.0 Capture input for Timer Module 0, Channel 0. Timer Module 0 supports two input pins: Channel 0 and Channel 1. Only one channel may be used as a timer capture pin in any Timer Module. This setting must match the configuration in EZ LADDER Toolkit. Based on the software configuration, either pin (when selected) will operate as a counter or will calculate the time/frequency of pulses. The following pins are related for Timer Module 0 functionality: 82, 88, 90.</p>
83	<p>GPIO130 General Purpose Digital I/O. May be configured as General Purpose Input 130 (GPI130) or General Purpose Output 130 (GPO130).</p>
	<p>LCD_D2 Data 2 Line for LCD Display Port. Supports up to 4 Line, 20 Character Liquid Crystal Display (LCD). See LCD under <i>Section 5: Functional Descriptions</i>. The following pins are required for LCD functionality: 75, 79, 83, 97, 103, 107, 113, 121, 127, 131, 135</p>
84	<p>VSS12 Connect to GND / 3.3V COMMON.</p>

TABLE 2 - Pin Details

Pin #	Description
85	GPIO86 General Purpose Digital I/O. May be configured as General Purpose Input 86 (GPI86) or General Purpose Output 86 (GPO86).
86	VDD2 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).
87	GPIO80 General Purpose Digital I/O. May be configured as General Purpose Input 80 (GPI80) or General Purpose Output 80 (GPO80).
88	GPIO59 General Purpose Digital I/O. May be configured as General Purpose Input 59 (GPI59) or General Purpose Output 59 (GPO59).
	TMR_CAP0.1 Capture input for Timer Module 0, Channel 1. Timer Module 0 supports two input pins: Channel 0 and Channel 1. Only one channel may be used as a timer capture pin in any Timer Module. This setting must match the configuration in EZ LADDER Toolkit. Based on the software configuration, either pin (when selected) will operate as a counter or will calculate the time/frequency of pulses. The following pins are related for Timer Module 0 functionality: 82 , 88 , 90 .
89	VDD7 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).
90	GPIO60 General Purpose Digital I/O. May be configured as General Purpose Input 60 (GPI60) or General Purpose Output 60 (GPO60).
	TMR_MAT0 <small>NOTE 1</small> Timer/Capture Channel 0 Match output. This output is HIGH based on Timer/Capture Channel 0's configuration and when the captured or timed value equals a predetermined set point. The following pins are related for TMR_MAT0 functionality: 82 , 88 , 90 .
91	GPIO78 General Purpose Digital I/O. May be configured as General Purpose Input 78 (GPI78) or General Purpose Output 78 (GPO78).
	TMR_CAP2.0 Capture input for Timer Module 2, Channel 0. Timer Module 2 supports two input pins: Channel 0 and Channel 1. Only one channel may be used as a timer capture pin in any Timer Module. This setting must match the configuration in EZ LADDER Toolkit. Based on the software configuration, either pin (when selected) will operate as a counter or will calculate the time/frequency of pulses. The following pins are related for Timer Module 2 functionality: 91 , 99 , 164 .

TABLE 2 - Pin Details

Pin #	Description
92	<p>GPIO61 General Purpose Digital I/O. May be configured as General Purpose Input 61 (GPI61) or General Purpose Output 61 (GPO61).</p>
	<p>MCI_CARD_PRESENT Detects when SD Card is installed in SD Socket. Only required if SD Card socket supports a card present function. The following pins are required for SD Card functionality: 122, 120, 118, 116, 92, 108, 106, 102</p>
93	<p>VSS4 Connect to GND / 3.3V COMMON.</p>
94	<p>GPIO0 General Purpose Digital I/O. May be configured as General Purpose Input 0 (GPIO) or General Purpose Output 0 (GPO0).</p>
	<p>CAN_RX0 Receive Line for CAN Port 0. Supports OptiCAN, SAE 1939. The following pins are required for CAN Port 0 functionality: 94, 96</p>
	<p>I2C_SDA1 I²C Port 1 Data Line. This line is used to communicate to I²C devices. Pull-up resistors (1.4K Ohm) are required for proper operation. The following pins are required for Port 1 I²C functionality: 94, 96</p>
95	<p>GPIO81 General Purpose Digital I/O. May be configured as General Purpose Input 81 (GPI81) or General Purpose Output 81 (GPO81).</p>
96	<p>GPIO1 General Purpose Digital I/O. May be configured as General Purpose Input 1 (GPI1) or General Purpose Output 1 (GPO1).</p>
	<p>CAN_TX0 Transmit Line for CAN Port 0. Supports OptiCAN, SAE 1939. The following pins are required for CAN Port 0 functionality: 94, 96</p>
	<p>I2C_SCL1 I²C Port 1 Clock Line. This line is used to communicate to I²C devices. Pull-up resistors (1.4K Ohm) are required for proper operation. The following pins are required for Port 1 I²C functionality: 94, 96</p>
97	<p>GPIO131 General Purpose Digital I/O. May be configured as General Purpose Input 131 (GPI131) or General Purpose Output 131 (GPO131).</p>
	<p>LCD_D3 Data 3 Line for LCD Display Port. Supports up to 4 Line, 20 Character Liquid Crystal Display (LCD). See LCD under <i>Section 5: Functional Descriptions</i>. The following pins are required for LCD functionality: 75, 79, 83, 97, 103, 107, 113, 121, 127, 131, 135</p>

TABLE 2 - Pin Details

Pin #	Description
98	<p>GPIO10 General Purpose Digital I/O. May be configured as General Purpose Input 10 (GPI10) or General Purpose Output 10 (GPO10).</p>
	<p>I2C_SDA2 I²C Port 2 Data Line. This line is used to communicate to I²C devices. Pull-up resistors (1.4K Ohm) are required for proper operation. The following pins are required for Port 2 I²C functionality: 98, 100</p>
99	<p>GPIO79 General Purpose Digital I/O. May be configured as General Purpose Input 79 (GPI79) or General Purpose Output 79 (GPO79).</p>
	<p>TMR_CAP2.1 Capture input for Timer Module 2, Channel 1. Timer Module 2 supports two input pins: Channel 0 and Channel 1. Only one channel may be used as a timer capture pin in any Timer Module. This setting must match the configuration in EZ LADDER Toolkit. Based on the software configuration, either pin (when selected) will operate as a counter or will calculate the time/frequency of pulses. The following pins are related for Timer Module 2 functionality: 91, 99, 164.</p>
100	<p>GPIO11 General Purpose Digital I/O. May be configured as General Purpose Input 11 (GPI11) or General Purpose Output 11 (GPO11).</p>
	<p>I2C_SCL2 I²C Port 2 Clock Line. This line is used to communicate to I²C devices. Pull-up resistors (1.4K Ohm) are required for proper operation. The following pins are required for Port 2 I²C functionality: 98, 100</p>
101	<p>GPIO144 General Purpose Digital I/O. May be configured as General Purpose Input 144 (GPI144) or General Purpose Output 144 (GPO144).</p>
102	<p>GPIO77 General Purpose Digital I/O. May be configured as General Purpose Input 77 (GPI77) or General Purpose Output 77 (GPO77).</p>
	<p>MCI_DATA3 Data Line 3 for SD Card Interface. The following pins are required for SD Card functionality: 122, 120, 118, 116, 92, 108, 106, 102</p>
103	<p>GPIO132 General Purpose Digital I/O. May be configured as General Purpose Input 132 (GPI132) or General Purpose Output 132 (GPO132).</p>
	<p>LCD_D4 Data 4 Line for LCD Display Port. Supports up to 4 Line, 20 Character Liquid Crystal Display (LCD). See LCD under <i>Section 5: Functional Descriptions</i>. The following pins are required for LCD functionality: 75, 79, 83, 97, 103, 107, 113, 121, 127, 131, 135</p>
104	<p>GPIO145 General Purpose Digital I/O. May be configured as General Purpose Input 145 (GPI145) or General Purpose Output 145 (GPO145).</p>

TABLE 2 - Pin Details

Pin #	Description
105	<p>GPIO146 General Purpose Digital I/O. May be configured as General Purpose Input 146 (GPI146) or General Purpose Output 146 (GPO146).</p>
106	<p>GPIO76 General Purpose Digital I/O. May be configured as General Purpose Input 76 (GPI76) or General Purpose Output 76 (GPO76).</p> <hr/> <p>MCI_DATA2 Data Line 2 for SD Card Interface. The following pins are required for SD Card functionality: 122, 120, 118, 116, 92, 108, 106, 102</p>
107	<p>GPIO133 General Purpose Digital I/O. May be configured as General Purpose Input 133 (GPI133) or General Purpose Output 133 (GPO133).</p> <hr/> <p>LCD_D5 Data 5 Line for LCD Display Port. Supports up to 4 Line, 20 Character Liquid Crystal Display (LCD). See LCD under <i>Section 5: Functional Descriptions</i>. The following pins are required for LCD functionality: 75, 79, 83, 97, 103, 107, 113, 121, 127, 131, 135</p>
108	<p>GPIO75 General Purpose Digital I/O. May be configured as General Purpose Input 75 (GPI75) or General Purpose Output 75 (GPO75).</p> <hr/> <p>MCI_DATA1 Data Line 1 for SD Card Interface. The following pins are required for SD Card functionality: 122, 120, 118, 116, 92, 108, 106, 102</p>
109	<p>GPIO148 General Purpose Digital I/O. May be configured as General Purpose Input 148 (GPI148) or General Purpose Output 148 (GPO148).</p>
110	<p>LED_KERNEL This connects to an LED and provides the current status of the PLC on a Chip™'s condition: No Kernel Installed, User Program not executing, User Program executing. This pin must be pulled to 3.3V by approximately a 4.7K ohm resistor. If this pin is not pulled high, the PLC on a Chip will not operate. See Section 6.20 - Watchdog LED Circuit for details.</p>
111	<p>GPIO147 General Purpose Digital I/O. May be configured as General Purpose Input 147 (GPI147) or General Purpose Output 147 (GPO147).</p>
112	<p>VDD8 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).</p>

TABLE 2 - Pin Details

Pin #	Description
113	<p>GPIO134 General Purpose Digital I/O. May be configured as General Purpose Input 134 (GPI134) or General Purpose Output 134 (GPO134).</p>
	<p>LCD_D6 Data 6 Line for LCD Display Port. Supports up to 4 Line, 20 Character Liquid Crystal Display (LCD). See LCD under <i>Section 5: Functional Descriptions</i>. The following pins are required for LCD functionality: 75, 79, 83, 97, 103, 107, 113, 121, 127, 131, 135</p>
114	<p>VSS5 Connect to GND / 3.3V COMMON.</p>
115	<p>GPIO149 General Purpose Digital I/O. May be configured as General Purpose Input 149 (GPI149) or General Purpose Output 149 (GPO149).</p>
116	<p>GPIO22 General Purpose Digital I/O. May be configured as General Purpose Input 22 (GPI22) or General Purpose Output 22 (GPO22).</p>
	<p>MCI_DATA0 Data Line 0 for SD Card Interface. The following pins are required for SD Card functionality: 122, 120, 118, 116, 92, 108, 106, 102</p>
117	<p>GPIO162 General Purpose Digital I/O. May be configured as General Purpose Input 162 (GPI162) or General Purpose Output 162 (GPO162). Pin is Open Drain. A pull-up resistor is required for proper operation.</p>
118	<p>GPIO21 General Purpose Digital I/O. May be configured as General Purpose Input 21 (GPI21) or General Purpose Output 21 (GPO21).</p>
	<p>MCI_PWR Power Supply Enable for external SD Card power supply. The following pins are required for SD Card functionality: 122, 120, 118, 116, 92, 108, 106, 102</p>
119	<p>GPIO154 General Purpose Digital I/O. May be configured as General Purpose Input 154 (GPI154) or General Purpose Output 154 (GPO154).</p>
120	<p>GPIO20 General Purpose Digital I/O. May be configured as General Purpose Input 20 (GPI20) or General Purpose Output 20 (GPO20).</p>
	<p>MCI_CMD Command line for SD Card Interface. The following pins are required for SD Card functionality: 122, 120, 118, 116, 92, 108, 106, 102</p>

TABLE 2 - Pin Details

Pin #	Description
121	<p>GPIO135 General Purpose Digital I/O. May be configured as General Purpose Input 135 (GPI135) or General Purpose Output 135 (GPO135).</p>
	<p>LCD_D7 Data 7 Line for LCD Display Port. Supports up to 4 Line, 20 Character Liquid Crystal Display (LCD). See LCD under <i>Section 5: Functional Descriptions</i>. The following pins are required for LCD functionality: 75, 79, 83, 97, 103, 107, 113, 121, 127, 131, 135</p>
122	<p>GPIO19 General Purpose Digital I/O. May be configured as General Purpose Input 19 (GPI19) or General Purpose Output 19 (GPO19).</p>
	<p>MCI_CLK Clock output line for SD Card Interface. The following pins are required for SD Card functionality: 122, 120, 118, 116, 92, 108, 106, 102</p>
123	<p>GPIO150 General Purpose Digital I/O. May be configured as General Purpose Input 150 (GPI150) or General Purpose Output 150 (GPO150).</p>
124	<p>GPIO18 General Purpose Digital I/O. May be configured as General Purpose Input 18 (GPI18) or General Purpose Output 18 (GPO18).</p>
	<p>SPI_MOSIO Master Out - Slave In Output for SPI Port 0. The following pins are required for SPI Port 0 functionality: 128, 126, 124, Any <i>GPIO</i> to act as a Chip Select for each SPI device on the bus.</p>
125	<p>VDD9 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).</p>
126	<p>GPIO17 General Purpose Digital I/O. May be configured as General Purpose Input 17 (GPI17) or General Purpose Output 17 (GPO17).</p>
	<p>SPI_MIS00 Master In - Slave Out Input for SPI Port 0. The following pins are required for SPI Port 0 functionality: 128, 126, 124, Any <i>GPIO</i> to act as a Chip Select for each SPI device on the bus.</p>
127	<p>GPIO136 General Purpose Digital I/O. May be configured as General Purpose Input 136 (GPI136) or General Purpose Output 136 (GPO136).</p>
	<p>LCD_RS Register Select Line for LCD Display Port. Supports up to 4 Line, 20 Character Liquid Crystal Display (LCD). See LCD under <i>Section 5: Functional Descriptions</i>. The following pins are required for LCD functionality: 75, 79, 83, 97, 103, 107, 113, 121, 127, 131, 135</p>

TABLE 2 - Pin Details

Pin #	Description
128	<p>GPIO15 General Purpose Digital I/O. May be configured as General Purpose Input 15 (GPI15) or General Purpose Output 15 (GPO15).</p>
	<p>SPI_SCK0 Serial Clock Output for SPI Port 0. The following pins are required for SPI Port 0 functionality: 128, 126, 124, Any <i>GPIO</i> to act as a Chip Select for each SPI device on the bus.</p>
129	<p>GPIO151 General Purpose Digital I/O. May be configured as General Purpose Input 151 (GPI151) or General Purpose Output 151 (GPO151).</p>
130	<p>GPIO16 General Purpose Digital I/O. May be configured as General Purpose Input 16 (GPI16) or General Purpose Output 16 (GPO16).</p>
	<p>LOW_VOLT_SENSE Low voltage sense input. Used for Retentive Memory Storage. When low, the all retentive variables are written to non-volatile memory.</p>
131	<p>GPIO137 General Purpose Digital I/O. May be configured as General Purpose Input 137 (GPI137) or General Purpose Output 137 (GPO137).</p>
	<p>LCD_RW Read / Write Line for LCD Display Port. Supports up to 4 Line, 20 Character Liquid Crystal Display (LCD). See LCD under <i>Section 5: Functional Descriptions</i>. The following pins are required for LCD functionality: 75, 79, 83, 97, 103, 107, 113, 121, 127, 131, 135</p>
132	<p>GPIO73 General Purpose Digital I/O. May be configured as General Purpose Input 73 (GPI73) or General Purpose Output 73 (GPO73).</p>
	<p>RXD2 UART 2 Receive Line. UART 2 supports transmit and receive only. If handshaking is required, use UART 1. The following pins are related for UART2 functionality: 134, 132.</p>
133	<p>VSS6 Connect to GND / 3.3V COMMON.</p>
134	<p>GPIO72 General Purpose Digital I/O. May be configured as General Purpose Input 72 (GPI72) or General Purpose Output 72 (GPO72).</p>
	<p>TXD2 UART 2 Transmit Line. UART 2 supports transmit and receive only. If handshaking is required, use UART 1. The following pins are related for UART2 functionality: 134, 132.</p>

TABLE 2 - Pin Details

Pin #	Description
135	<p>GPIO138 General Purpose Digital I/O. May be configured as General Purpose Input 138 (GPI138) or General Purpose Output 138 (GPO138).</p>
	<p>LCD_E Enable Line for LCD Display Port. Supports up to 4 Line, 20 Character Liquid Crystal Display (LCD). See LCD under <i>Section 5: Functional Descriptions</i>. The following pins are required for LCD functionality: 75, 79, 83, 97, 103, 107, 113, 121, 127, 131, 135</p>
136	<p>GPIO71 General Purpose Digital I/O. May be configured as General Purpose Input 71 (GPI71) or General Purpose Output 71 (GPO71).</p>
	<p>RTS1 UART 1 Request To Send Line. UART 1 supports full handshaking hardware functionality. The following pins are related for UART 1 functionality: 154, 152, 150, 144, 142, 140, 138, 136</p>
137	<p>GPIO112 General Purpose Digital I/O. May be configured as General Purpose Input 112 (GPI112) or General Purpose Output 112 (GPO112).</p>
	<p>PWM6 Pulse Width Modulation Output 6 (PWM6).</p>
138	<p>GPIO70 General Purpose Digital I/O. May be configured as General Purpose Input 70 (GPI70) or General Purpose Output 70 (GPO70).</p>
	<p>R1 UART 1 Ring Indicator Line. UART 1 supports full handshaking hardware functionality. The following pins are related for UART 1 functionality: 154, 152, 150, 144, 142, 140, 138, 136</p>
139	<p>GPIO155 General Purpose Digital I/O. May be configured as General Purpose Input 155 (GPI155) or General Purpose Output 155 (GPO155).</p>
140	<p>GPIO69 General Purpose Digital I/O. May be configured as General Purpose Input 69 (GPI69) or General Purpose Output 69 (GPO69).</p>
	<p>DTR1 UART 1 Data Terminal Ready Line. UART 1 supports full handshaking hardware functionality. The following pins are related for UART 1 functionality: 154, 152, 150, 144, 142, 140, 138, 136</p>
141	<p>GPIO163 General Purpose Digital I/O. May be configured as General Purpose Input 163 (GPI163) or General Purpose Output 163 (GPO163). Pin is Open Drain. When used as GPIO, a pull-up resistor is required for proper operation.</p>
	<p>RXD4 UART 4 Receive Line. UART 4 supports transmit and receive only. If handshaking is required, use UART 1. The following pins are related for UART4 functionality: 141, 206</p>

TABLE 2 - Pin Details

Pin #	Description
142	<p>GPIO68 General Purpose Digital I/O. May be configured as General Purpose Input 68 (GPI68) or General Purpose Output 68 (GPO68).</p>
	<p>DSR1 UART 1 Data Set Ready Line. UART 1 supports full handshaking hardware functionality. The following pins are related for UART 1 functionality: 154, 152, 150, 144, 142, 140, 138, 136</p>
143	<p>GPIO113 General Purpose Digital I/O. May be configured as General Purpose Input 113 (GPI113) or General Purpose Output 113 (GPO113).</p>
	<p>PWM7 Pulse Width Modulation Output 7 (PWM7).</p>
144	<p>GPIO67 General Purpose Digital I/O. May be configured as General Purpose Input 67 (GPI67) or General Purpose Output 67 (GPO67).</p>
	<p>DCD1 UART 1 Data Carrier Detect Line. UART 1 supports full handshaking hardware functionality. The following pins are related for UART 1 functionality: 154, 152, 150, 144, 142, 140, 138, 136</p>
145	<p>GPIO139 General Purpose Digital I/O. May be configured as General Purpose Input 139 (GPI139) or General Purpose Output 139 (GPO139).</p>
	<p>KEYPAD_COL1 Keypad Column 1 line. Supports a 5 column, 4 row keypad matrix. The following pins are required for KEYPAD functionality: 145, 149, 155, 159, 173, 183, 179, 187, 193</p>
146	<p>VDD10 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).</p>
147	<p>GPIO45 General Purpose Digital I/O. May be configured as General Purpose Input 45 (GPI45) or General Purpose Output 45 (GPO45).</p>
148	<p>VSS7 Connect to GND / 3.3V COMMON.</p>
149	<p>GPIO140 General Purpose Digital I/O. May be configured as General Purpose Input 140 (GPI140) or General Purpose Output 140 (GPO140).</p>
	<p>KEYPAD_COL2 Keypad Column 2 line. Supports a 5 column, 4 row keypad matrix. The following pins are required for KEYPAD functionality: 145, 149, 155, 159, 173, 183, 179, 187, 193</p>

TABLE 2 - Pin Details

Pin #	Description
150	<p>GPIO66 General Purpose Digital I/O. May be configured as General Purpose Input 66 (GPI66) or General Purpose Output 66 (GPO66).</p>
	<p>CTS1 UART 1 Clear To Send Line. UART 1 supports full handshaking hardware functionality. The following pins are related for UART 1 functionality: 154, 152, 150, 144, 142, 140, 138, 136</p>
151	<p>GPIO114 General Purpose Digital I/O. May be configured as General Purpose Input 114 (GPI114) or General Purpose Output 114 (GPO114).</p>
	<p>PWM8 Pulse Width Modulation Output 8 (PWM8).</p>
152	<p>GPIO65 General Purpose Digital I/O. May be configured as General Purpose Input 65 (GPI65) or General Purpose Output 65 (GPO65).</p>
	<p>RXD1 UART 1 Receive Line. UART 1 supports full handshaking hardware functionality. The following pins are related for UART 1 functionality: 154, 152, 150, 144, 142, 140, 138, 136</p>
153	<p>GPIO39 General Purpose Digital I/O. May be configured as General Purpose Input 39 (GPI39) or General Purpose Output 39 (GPO39).</p>
154	<p>GPIO64 General Purpose Digital I/O. May be configured as General Purpose Input 64 (GPI64) or General Purpose Output 64 (GPO64).</p>
	<p>TXD1 UART 1 Transmit Line. UART 1 supports full handshaking hardware functionality. The following pins are related for UART 1 functionality: 154, 152, 150, 144, 142, 140, 138, 136</p>
155	<p>GPIO141 General Purpose Digital I/O. May be configured as General Purpose Input 141 (GPI141) or General Purpose Output 141 (GPO141).</p>
	<p>KEYPAD_COL3 Keypad Column 3 line. Supports a 5 column, 4 row keypad matrix. The following pins are required for KEYPAD functionality: 145, 149, 155, 159, 173, 183, 179, 187, 193</p>
156	<p>GPIO37 General Purpose Digital I/O. May be configured as General Purpose Input 37 (GPI37) or General Purpose Output 37 (GPO37).</p>
157	<p>GPIO44 General Purpose Digital I/O. May be configured as General Purpose Input 44 (GPI44) or General Purpose Output 44 (GPO44).</p>

TABLE 2 - Pin Details

Pin #	Description
158	<p>GPIO9 General Purpose Digital I/O. May be configured as General Purpose Input 9 (GPI9) or General Purpose Output 9 (GPO9).</p>
	<p>SPI_MOSI1 Master Out - Slave In Output for SPI Port 1. The following pins are required for SPI Port 1 functionality: 162, 160, 158, Any <i>GPIO</i> to act as a Chip Select for each SPI device on the bus.</p>
159	<p>GPIO142 General Purpose Digital I/O. May be configured as General Purpose Input 142 (GPI142) or General Purpose Output 142 (GPO142).</p>
	<p>KEYPAD_COL4 Keypad Column 4 line. Supports a 5 column, 4 row keypad matrix. The following pins are required for KEYPAD functionality: 145, 149, 155, 159, 173, 183, 179, 187, 193</p>
160	<p>GPIO8 General Purpose Digital I/O. May be configured as General Purpose Input 8 (GPI8) or General Purpose Output 8 (GPO8).</p>
	<p>SPI_MISO1 Master In - Slave Out Input for SPI Port 1. The following pins are required for SPI Port 1 functionality: 162, 160, 158, Any <i>GPIO</i> to act as a Chip Select for each SPI device on the bus.</p>
161	<p>GPIO115 General Purpose Digital I/O. May be configured as General Purpose Input 115 (GPI115) or General Purpose Output 115 (GPO115).</p>
	<p>PWM9 Pulse Width Modulation Output 9 (PWM9).</p>
162	<p>GPIO7 General Purpose Digital I/O. May be configured as General Purpose Input 7 (GPI7) or General Purpose Output 7 (GPO7).</p>
	<p>SPI_SCK1 Serial Clock Output for SPI Port 1. The following pins are required for SPI Port 1 functionality: 162, 160, 158, Any <i>GPIO</i> to act as a Chip Select for each SPI device on the bus.</p>
163	<p>GPIO43 General Purpose Digital I/O. May be configured as General Purpose Input 43 (GPI43) or General Purpose Output 43 (GPO43).</p>
164	<p>GPIO6 General Purpose Digital I/O. May be configured as General Purpose Input 6 (GPI6) or General Purpose Output 6 (GPO6).</p>
	<p>TMR_MAT2 <small>NOTE 1</small> Timer/Capture Channel 2 Match output. This output is HIGH based on Timer/Capture Channel 2's configuration and when the captured or timed value equals a predetermined set point. The following pins are related for TMR_MAT0 functionality: 91, 99, 164.</p>
165	<p>VDD11 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).</p>

TABLE 2 - Pin Details

Pin #	Description
166	<p>GPIO5 General Purpose Digital I/O. May be configured as General Purpose Input 5 (GPI5) or General Purpose Output 5 (GPO5).</p>
	<p>CAN_TX1 Transmit Line for CAN Port 1. Supports OptiCAN, SAE 1939. The following pins are required for CAN Port 1 functionality: 168, 166</p>
167	<p>GPIO116 General Purpose Digital I/O. May be configured as General Purpose Input 116 (GPI116) or General Purpose Output 116 (GPO116).</p>
	<p>PWM10 Pulse Width Modulation Output 10 (PWM10).</p>
168	<p>GPIO4 General Purpose Digital I/O. May be configured as General Purpose Input 4 (GPI4) or General Purpose Output 4 (GPO4).</p>
	<p>CAN_RX1 Receive Line for CAN Port 1. Supports OptiCAN, SAE 1939. The following pins are required for CAN Port 1 functionality: 168, 166</p>
169	<p>VSS8 Connect to GND / 3.3V COMMON.</p>
170	<p>GPIO156 General Purpose Digital I/O. May be configured as General Purpose Input 156 (GPI156) or General Purpose Output 156 (GPO156).</p>
	<p>TXD3 UART 3 Transmit Line. UART 3 supports transmit and receive only. If handshaking is required, use UART 1. The following pins are related for UART3 functionality: 170, 176.</p>
171	<p>GPIO38 General Purpose Digital I/O. May be configured as General Purpose Input 38 (GPI38) or General Purpose Output 38 (GPO38).</p>
172	<p>VSS13 Connect to GND / 3.3V COMMON.</p>
173	<p>GPIO143 General Purpose Digital I/O. May be configured as General Purpose Input 143 (GPI143) or General Purpose Output 143 (GPO143).</p>
	<p>KEYPAD_COL5 Keypad Column 5 line. Supports a 5 column, 4 row keypad matrix. The following pins are required for KEYPAD functionality: 145, 149, 155, 159, 173, 183, 179, 187, 193</p>
174	<p>VDD3 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).</p>

TABLE 2 - Pin Details

Pin #	Description
175	<p>GPIO117 General Purpose Digital I/O. May be configured as General Purpose Input 117 (GPI117) or General Purpose Output 117 (GPO117).</p> <hr/> <p>PWM11 Pulse Width Modulation Output 11 (PWM11).</p>
176	<p>GPIO157 General Purpose Digital I/O. May be configured as General Purpose Input 157 (GPI157) or General Purpose Output 157 (GPO157).</p> <hr/> <p>RXD3 UART 3 Receive Line. UART 3 supports transmit and receive only. If handshaking is required, use UART 1. The following pins are related for UART3 functionality: 170, 176.</p>
177	<p>GPIO35 General Purpose Digital I/O. May be configured as General Purpose Input 35 (GPI35) or General Purpose Output 35 (GPO35).</p>
178	<p>GPIO49 General Purpose Digital I/O. May be configured as General Purpose Input 49 (GPI49) or General Purpose Output 49 (GPO49).</p> <hr/> <p>ETHER_MDIO Ethernet MDIO input/output. Used as Ethernet MII/m data input and output. Typically connects to MDIO port on an Ethernet Physical Integrated Circuit. The following pins are required for Ethernet functionality: 178, 180, 182, 184, 186, 188, 190, 192, 194, 196.</p>
179	<p>GPIO153 General Purpose Digital I/O. May be configured as General Purpose Input 153 (GPI153) or General Purpose Output 153 (GPO153).</p> <hr/> <p>KEYPAD_ROW2 Keypad Row 2 line. Supports a 5 column, 4 row keypad matrix. The following pins are required for KEYPAD functionality: 145, 149, 155, 159, 173, 183, 179, 187, 193</p>
180	<p>GPIO48 General Purpose Digital I/O. May be configured as General Purpose Input 48 (GPI48) or General Purpose Output 48 (GPO48).</p> <hr/> <p>ETHER_MDC Ethernet MDIO/MIIM Clock output. Typically connects to MDC port on an Ethernet Physical Integrated Circuit. The following pins are required for Ethernet functionality: 178, 180, 182, 184, 186, 188, 190, 192, 194, 196.</p>
181	<p>VDD12 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).</p>

TABLE 2 - Pin Details

Pin #	Description
182	<p>GPIO47 General Purpose Digital I/O. May be configured as General Purpose Input 47 (GPI47) or General Purpose Output 47 (GPO47).</p>
	<p>ETHER_REFCLK Ethernet Reference Clock. Typically connects to X1 port on an Ethernet Physical Integrated Circuit. The following pins are required for Ethernet functionality: 178, 180, 182, 184, 186, 188, 190, 192, 194, 196.</p>
183	<p>GPIO152 General Purpose Digital I/O. May be configured as General Purpose Input 152 (GPI152) or General Purpose Output 152 (GPO152).</p>
	<p>KEYPAD_ROW1 Keypad Row 1 line. Supports a 5 column, 4 row keypad matrix. The following pins are required for KEYPAD functionality: 145, 149, 155, 159, 173, 183, 179, 187, 193</p>
184	<p>GPIO46 General Purpose Digital I/O. May be configured as General Purpose Input 46 (GPI46) or General Purpose Output 46 (GPO46).</p>
	<p>ETHER_RXER Ethernet Receive Error input. Typically connects to RXER port on an Ethernet Physical Integrated Circuit. The following pins are required for Ethernet functionality: 178, 180, 182, 184, 186, 188, 190, 192, 194, 196.</p>
185	<p>GPIO34 General Purpose Digital I/O. May be configured as General Purpose Input 34 (GPI34) or General Purpose Output 34 (GPO34).</p>
186	<p>GPIO42 General Purpose Digital I/O. May be configured as General Purpose Input 42 (GPI42) or General Purpose Output 42 (GPO42).</p>
	<p>ETHER_RXD1 Ethernet Recieve Data 1 Input. Typically connects to RXD1 port on an Ethernet Physical Integrated Circuit. The following pins are required for Ethernet functionality: 178, 180, 182, 184, 186, 188, 190, 192, 194, 196.</p>
187	<p>GPIO158 General Purpose Digital I/O. May be configured as General Purpose Input 158 (GPI158) or General Purpose Output 158 (GPO158).</p>
	<p>KEYPAD_ROW3 Keypad Row 3 line. Supports a 5 column, 4 row keypad matrix. The following pins are required for KEYPAD functionality: 145, 149, 155, 159, 173, 183, 179, 187, 193</p>
188	<p>GPIO41 General Purpose Digital I/O. May be configured as General Purpose Input 41 (GPI41) or General Purpose Output 41 (GPO41).</p>
	<p>ETHER_RXD0 Ethernet Recieve Data 0 Input. Typically connects to RXD0 port on an Ethernet Physical Integrated Circuit. The following pins are required for Ethernet functionality: 178, 180, 182, 184, 186, 188, 190, 192, 194, 196.</p>

TABLE 2 - Pin Details

Pin #	Description
189	VSS9 Connect to GND / 3.3V COMMON.
190	GPIO40 General Purpose Digital I/O. May be configured as General Purpose Input 40 (GPI40) or General Purpose Output 40 (GPO40).
	ETHER_CRS Ethernet Carrier Sense Input. Typically connects to CRS port on an Ethernet Physical Integrated Circuit. The following pins are required for Ethernet functionality: 178 , 180 , 182 , 184 , 186 , 188 , 190 , 192 , 194 , 196 .
191	GPIO104 General Purpose Digital I/O. May be configured as General Purpose Input 104 (GPI104) or General Purpose Output 104 (GPO104).
192	GPIO36 General Purpose Digital I/O. May be configured as General Purpose Input 36 (GPI36) or General Purpose Output 36 (GPO36).
	ETHER_TXEN Ethernet Transmit Data Enable. Typically connects to TXEN port on an Ethernet Physical Integrated Circuit. The following pins are required for Ethernet functionality: 178 , 180 , 182 , 184 , 186 , 188 , 190 , 192 , 194 , 196 .
193	GPIO159 General Purpose Digital I/O. May be configured as General Purpose Input 159 (GPI159) or General Purpose Output 159 (GPO159).
	KEYPAD_ROW4 Keypad Row 4 line. Supports a 5 column, 4 row keypad matrix. The following pins are required for KEYPAD functionality: 145 , 149 , 155 , 159 , 173 , 183 , 179 , 187 , 193
194	GPIO33 General Purpose Digital I/O. May be configured as General Purpose Input 33 (GPI33) or General Purpose Output 33 (GPO33).
	ETHER_TXD1 Ethernet Transmit Data 1 Output. Typically connects to TXD1 port on an Ethernet Physical Integrated Circuit. The following pins are required for Ethernet functionality: 178 , 180 , 182 , 184 , 186 , 188 , 190 , 192 , 194 , 196 .
195	GPIO118 General Purpose Digital I/O. May be configured as General Purpose Input 118 (GPI118) or General Purpose Output 118 (GPO118).
196	GPIO32 General Purpose Digital I/O. May be configured as General Purpose Input 32 (GPI32) or General Purpose Output 32 (GPO32).
	ETHER_TXD0 Ethernet Transmit Data 0 Output. Typically connects to TXD0 port on an Ethernet Physical Integrated Circuit. The following pins are required for Ethernet functionality: 178 , 180 , 182 , 184 , 186 , 188 , 190 , 192 , 194 , 196 .

TABLE 2 - Pin Details

Pin #	Description
197	GPIO96 General Purpose Digital I/O. May be configured as General Purpose Input 96 (GPI96) or General Purpose Output 96 (GPO96).
198	VDD13 Connect to 3.3VDC Supply. The recommended bypass capacitor must be installed near this pin (this pin to GND / 3.3V COMMON).
199	GPIO105 General Purpose Digital I/O. May be configured as General Purpose Input 105 (GPI105) or General Purpose Output 105 (GPO105).
200	VSS10 Connect to GND / 3.3V COMMON.
201	GPIO97 General Purpose Digital I/O. May be configured as General Purpose Input 97 (GPI97) or General Purpose Output 97 (GPO97).
202	TXDO UART 0 (Program Port) Transmit Line. Used as EZ LADDER Programming Port only. UART 0 supports transmit and receive only. The following pins are related for UART0 functionality: 202 , 204
203	GPIO123 General Purpose Digital I/O. May be configured as General Purpose Input 123 (GPI123) or General Purpose Output 123 (GPO123).
	PWM3 Pulse Width Modulation Output 3 (PWM3).
204	RXDO UART 0 (Program Port) Receive Line. Used as EZ LADDER Programming Port only. UART 0 supports transmit and receive only. The following pins are related for UART0 functionality: 202 , 204
205	GPIO106 General Purpose Digital I/O. May be configured as General Purpose Input 106 (GPI106) or General Purpose Output 106 (GPO106).
206	GPIO164 General Purpose Digital I/O. May be configured as General Purpose Input 164 (GPI164) or General Purpose Output 164 (GPO164).
	TXD4 UART 4 Transmit Line. UART 4 supports transmit and receive only. If handshaking is required, use UART 1. The following pins are related for UART4 functionality: 141 , 206
207	GPIO98 General Purpose Digital I/O. May be configured as General Purpose Input 98 (GPI98) or General Purpose Output 98 (GPO98).

TABLE 2 - Pin Details

Pin #	Description
208	GPIO107 General Purpose Digital I/O. May be configured as General Purpose Input 107 (GPI107) or General Purpose Output 107 (GPO107).
NOTE 1: This functionality is not available at this time, but may be implemented with future EZ LADDER Toolkit releases.	

6. Functional Descriptions & Circuit Examples

NOTICE

Divelbiss reserves the right to discontinue or make changes to its products without notice. As the circuits are provided for reference only, customers assume the responsibility for the appropriate application of Divelbiss components. It is the customer's responsibility to ensure that adequate design and operating safeguards are addressed to eliminate any hazards inherent to their application.

To aid in implementing the PLCHIP-P13-51220, this section is organized by circuit function and provides details for electrical requirements, connections recommendations, example circuit diagrams and layout considerations.

This datasheet provides hardware information and support only. For programming, including functions and supported features, please refer to the P-Series EZ LADDER Toolkit User Manual.

It is recommended the PLCHIP-P13-51220 be designed for use with at least a 4-layer printed circuit board (with inner ground and power planes).

6.1 VDD Power Pins

The PLCHIP-P13-51220 power supply is 3.3VDC. The power is connected to the following pins [Description (Pin #)]:

Function	Pin #	Function	Pin#	Function	Pin#	Function	Pin#
VDD 1	26	VDD 5	60	VDD 9	125	VDD 12	181
VDD 2	86	VDD 6	71	VDD 10	146	VDD 13	198
VDD 3	174	VDD 7	89	VDD 11	165		
VDD 4	15	VDD 8	112				

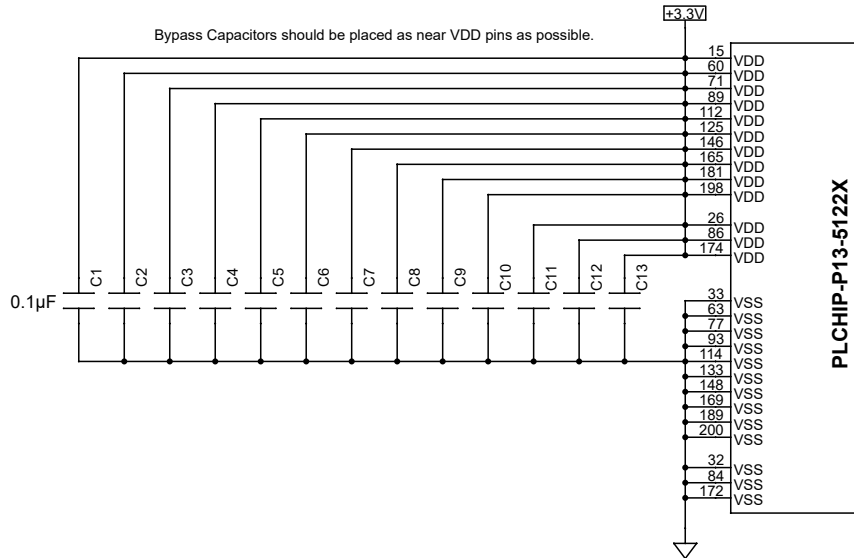


Diagram 6.1A - Example Power Connections & Bypass Capacitors Schematic

A .1 μ F bypass capacitor should be connected from each VDDx pin to the ground / common connected to the PLCHIP-P13-51220 VSS pins. These bypass capacitors should be physically located near each of the VDDx pins as possible. Diagram 6.1A is a sample schematic of the required P-Series power and bypass filtering. Refer to Diagram 6.3B for a sample layout of the P-13 Chip, power pins, oscillator and Ethernet.

6.2 VSS Power Pins (GND)

The PLCHIP-P13-51220 must be connected to the digital ground (3.3V Common) for proper operation. The ground is connected to the following pins [Description (Pin #)]:

Function	Pin #	Function	Pin#	Function	Pin#
VSS 1	33	VSS 6	133	VSS 11	32
VSS 2	63	VSS 7	148	VSS 12	84
VSS 3	77	VSS 8	169	VSS 13	172
VSS 4	93	VSS 9	189		
VSS 5	114	VSS 10	200		

Diagram 6.1A is a sample schematic of the required P-Series power and bypass filtering. Refer to Diagram 6.3B for a sample layout of the P-13 Chip, power pins, oscillator and Ethernet.

6.3 Oscillator Input

The PLCHIP-P13-51220 requires an external oscillator input as a source to internal clock generator circuits. This oscillator provides the basis for all internal on-chip clocking and timing functions. The following pins are required to connect the oscillator to the PLCHIP-P13-51220: [44](#) and [46](#).

A Crystal is recommended as the external oscillator. The following specifications must be adhered to when selecting a crystal.

Frequency: 12 MHz

Crystal Load Capacitance: 20 pF (approximate)
Maximum Crystal Series Resistance: < 60 Ω
External Load Capacitors C_{X1} , C_{X2} : 22 pF (approximate)

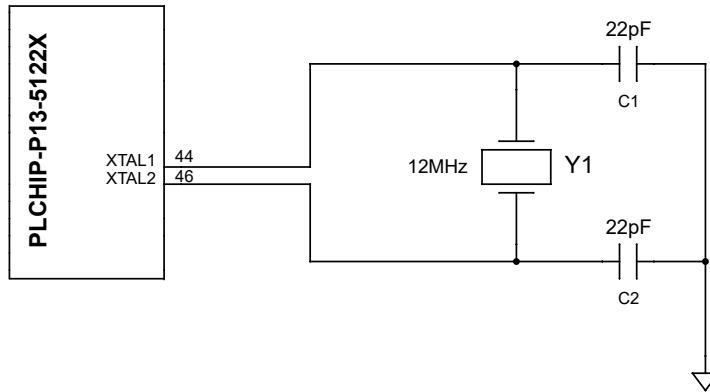


Diagram 6.3A - Example Oscillator Circuit Schematic

Diagram 6.3A is a sample schematic of the recommended oscillator circuit. Refer to Diagram 6.3B for a sample layout of the P-13 Chip, power pins, oscillator and Ethernet.

Layer StackUp - Name, Material, Thickness, Dielectric Constant

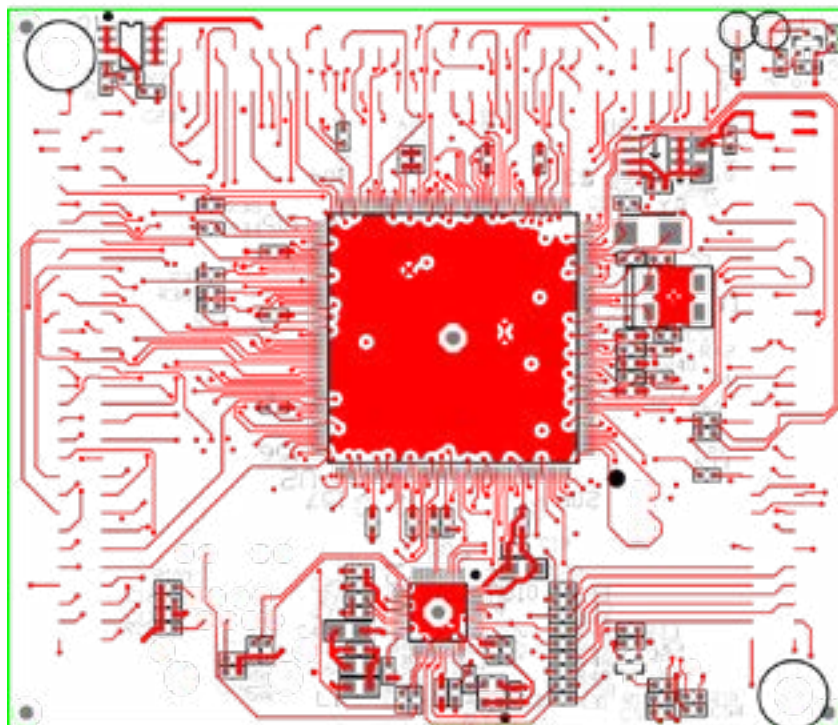
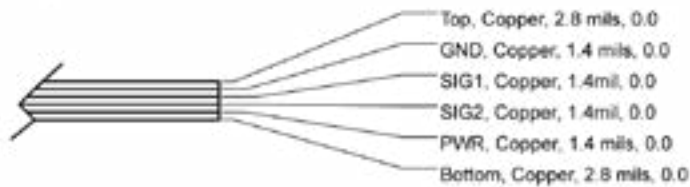


Diagram 6.3B - Sample P-13, Power, Oscillator and Ethernet Layout with 6 Layer PCB

6.4 General Purpose I/O (GPIO)

A versatile feature of the PLCHIP-P13-51220 is its large number of configurable Input/Output Points (I/O). These are referred to as General Purpose I/O or GPIO for short. Each GPIO point can be used as either a digital input or a digital output. All GPIO are TTL level designed to operate at 3.3VDC but are 5VDC tolerant. Additional circuitry is required external to the PLCHIP-P13-51220 for interfacing to devices (input or output).

GPIO functionality is configured using the EZ LADDER Toolkit (programming software). In EZ LADDER Toolkit, each GPIO can be configured independently as an input or an output (provided it is not in use as another feature).

GPIO as Inputs

When configuring the GPIO as digital inputs, each I/O pin is **active low**, requiring a low TTL signal for the input to be considered true. When using GPIO as digital inputs, if debounce is required for interfaces to push-buttons or other mechanical devices that may not have a clean transition, it must be added in the interface circuitry. While no debounce is included in the basic (kernel) operation of the chip, it can be added in the actual ladder diagram using inputs and timers function blocks if required.

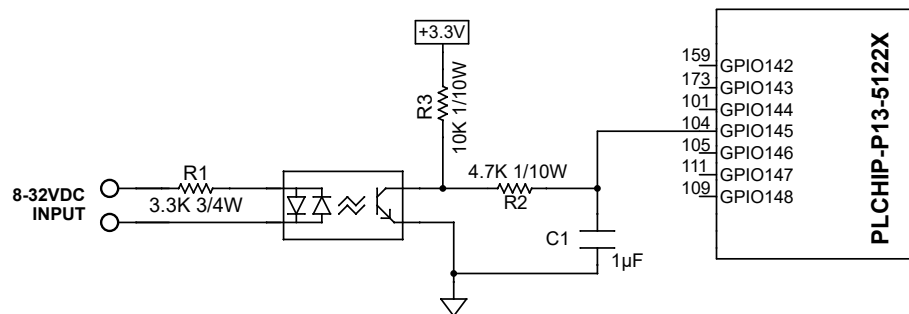


Diagram 6.4A - Example Circuit using GPIO as a Digital Input

Diagram 6.4A is a sample schematic of using a GPIO as a digital input. The example includes the use of an opto-coupler for noise immunity and built in debounce.

GPIO as Outputs

When configuring the GPIO as digital outputs, each I/O pin is **active high**, meaning when the Output is true in the ladder diagram, the actual pin is at a high TTL Level (3.3VDC).

When the PLCHIP-P13-51220 powers up, all GPIO will revert to a default level, enabling internal pull-up resistors. The duration of this time is from power on until the ladder diagram begins executing code. During this time, the pull-ups can cause the outputs can glitch to a true state. If GPIO is used to drive real world outputs such as solenoids, contactors or other devices, a pull-down resistor is recommended on the GPIO pin. This pull-down resistor will illuminate this power-on glitch.

Please note that while most all pins have a defined GPIO address, many of the pins share functionality with other features such as analog inputs, UARTs or more. Each pin can only function as a single feature; therefore, other features should be implemented and configured (UARTS, analog inputs, Ethernet, etc.) prior to assigning GPIO.

Diagram 6.4B is a sample schematic of using a GPIO as a digital output. The example includes the use of an a relay with a de-glitch pull-down resistor.

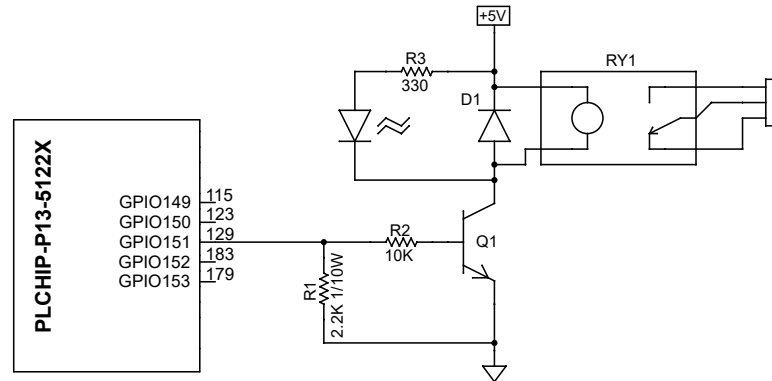


Diagram 6.4B - Example Circuit using GPIO as a Digital Output

6.5 Pulse Width Modulation (PWM) Outputs

Twelve of the General Purpose I/O (GPIO) are designed to be operated as Pulse Width Modulation (PWM) Outputs. These outputs are TTL level (3.3VDC) and require additional circuitry to interface to real world devices (loads). Pulse Width Modulation output channels 0 to 11 are located on pins [58](#), [56](#), [55](#), [203](#), [5](#), [11](#), [137](#), [143](#), [151](#), [161](#), [167](#) and [175](#) respectively.

These PWM pins may also be used as General Purpose I/O (GPIO). They do not share any additional functionality other than GPIO.

A Load when connected to a PWM output is controlled essentially by turning a switch between supply and load on and off at a fast pace. The longer the switch is on compared to the off periods, the higher the power supplied to the load is.

When the PLCHIP-P13-51220 powers up, all PWM channels will revert to a default level, enabling internal pull-up resistors. The duration of this time is from power on until the ladder diagram begins executing code. During this time, the pull-ups can cause the outputs can glitch to a true state. If GPIO is used to drive real world outputs such as solenoids, contactors and more, a pull-down resistor is recommended on the GPIO pin. This pull-down resistor will eliminate this power-on glitch.

There are two basic elements to control a PWM output: *Frequency* and *Duty Cycle*.

Frequency

The Frequency is the base frequency of the switching described earlier. The frequency must be sized according to the application. The PWM channels are separated into two groups of six PWM outputs (PWM0 - PWM5, PWM6 - PWM11). Each group of six outputs has a unique operating frequency allowing for loads that require different frequencies. Frequency is set in the ladder diagram program in EZ LADDER Toolkit. The frequency can also be changed during program execution using function blocks in the ladder diagram.

Duty Cycle

Duty Cycle represents the proportion of 'on' time to the regular interval or 'period' of time; a low duty cycle corresponds to lower power, because the power is off for most of the time. Duty cycle is

expressed in percent where 10% would be low power to the load and 100% would be the load on fully.

Diagram 6.5A is a sample schematic of using a PWM output to drive a load. The example includes the use of a de-glitch pull-down resistor.

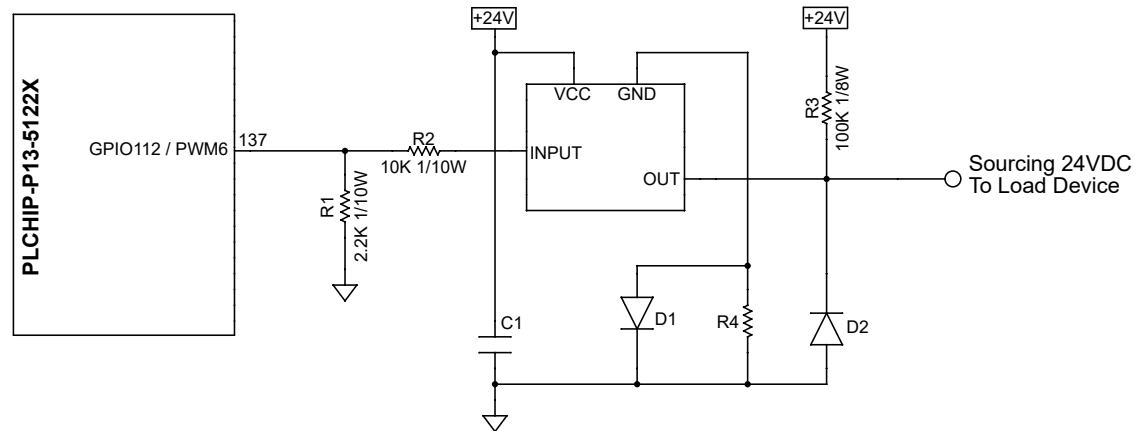


Diagram 6.5A - Example Pulse Width Modulation Output

6.6 Analog I/O

The PLCHIP-P13-51220 supports up to eight on-board analog channels. Some of these eight channels also share functionality with other features; therefore, it is recommended to map all feature pins prior to beginning any design.

Of the eight analog input channels, seven are designated as analog inputs (channels 0, 1, 2, 4, 5, 6, 7). One channel (3) may be configured and used as an analog input (AI3) or as an analog output (AO0). The analog inputs (Channels 0 -7) are located on pins [18](#), [16](#), [14](#), [12](#), [42](#), [40](#), [41](#) and [45](#) respectively. The analog output is located on pin [12](#).

Additional pin connections are required to use analog I/O. The analog I/O provides pins for its own individual power source ([VDD_AN](#) and [VSS_AN](#)) and the analog reference voltage ([VREF_AN](#)).

VDD_AN

The VDD_AN pin ([PIN 20](#)) is the 3.3 VDC analog supply voltage. Based on application and cost requirements, this pin may be connected to the same 3.3 VDC supply as the VDDx pins or be isolated (separate 3.3V supply) to minimize noise and error. This pin is used to power the analog inputs (ADC) and analog output (DAC). Whenever the analog inputs or analog output is not used, this pin should be connected to 3.3 VDC.

This pin does not share any functionality with other P-13 PLC on a Chip features.

VSS_AN

The VSS_AN pin ([PIN 22](#)) is the 0 VDC power supply and reference for the analog inputs (ADC) and analog output (DAC). This should be connected to the same supply as the VSSx pins but can be isolated to minimize noise and error.

This pin does not share any functionality with other P-13 PLC on a Chip features.

VREF_AN

The VREF_AN pin ([pin 24](#)) is the analog positive reference voltage. This should be the same voltage level as the supply connected to the VDD_AN (3.3 VDC). It may be connected to the same supply as VDD_AN, but it is recommended to use a precise reference voltage source to minimize noise and error. The voltage level on this pin is used as the reference for the ADC and DAC. The maximum input is 3.3 VDC. Whenever the analog inputs or analog output is not used, this pin should be connected to 3.3 VDC.

This pin does not share any functionality with other P-13 PLC on a Chip features.

AI0 - AI7 (Analog Inputs)

AI0 through AI7 are the analog input pins ([18](#), [16](#), [14](#), [12](#), [42](#), [40](#), [41](#) and [45](#)). Each pin can accept an input signal of 3.3VDC (supply connected to VDD_AN, VREF_AN). The resolution for all on-board analog inputs is 12 bit. Additional circuitry will be required for converting real world analog signals into a 3.3 VDC signal. Any analog input channel with an input voltage higher than 3.3 VDC will cause all analog channels to operate improperly, therefore, steps must be taken to ensure that the voltage of no channel is greater than 3.3 VDC.

Pins 18, 16, 14, 12, 42, 40, 41 and 45 share functionality and may be used as General Purpose I/O (GPIO). Additionally, Pin 12 may also be used as an analog output ([A00](#)).

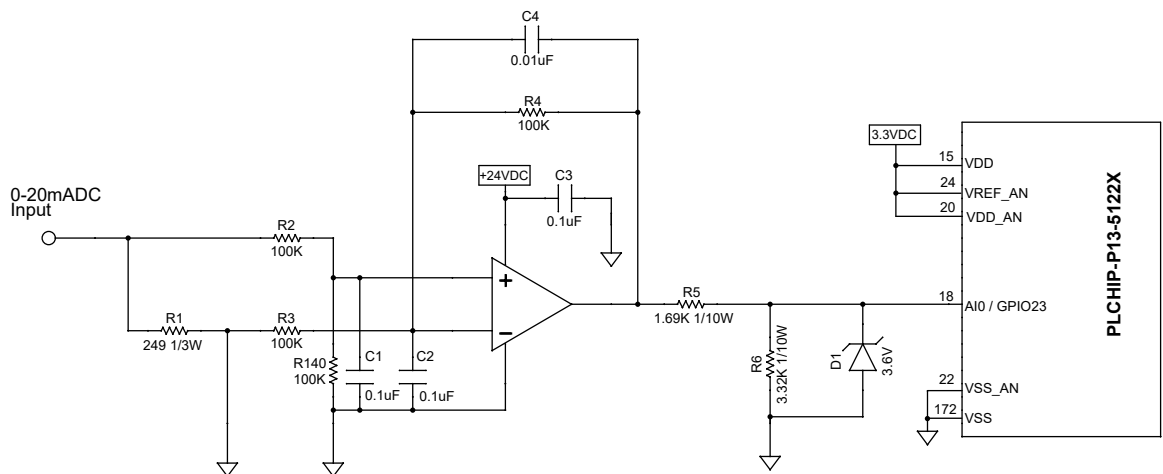


Diagram 6.6A - Example Analog Input Circuit with Scaling

Diagram 6.6A is a sample schematic of an interface circuit for a real world analog input 0-20mADC with conversion for the PLCHIP-P13-51220 analog inputs (3.3 VDC). R5 and R6 provide the voltage divider for the op-amp output and D1 is a 3.6V zener diode for limiting the input to the ADC.

A00 (Analog Output)

A00 is the analog output pin ([12](#)). This pin can output a variable analog signal from 0 V to 3.3 VDC (supply applied to VDD_AN, VREF_AN). The DAC output resolution is 10 bit.

Pins 12 shares functionality and may be used as General Purpose I/O ([GPIO26](#)) or as an analog input ([AI3](#)).

Diagram 6.6B is a sample schematic of an interface circuit for a real world device connected to the DAC output.

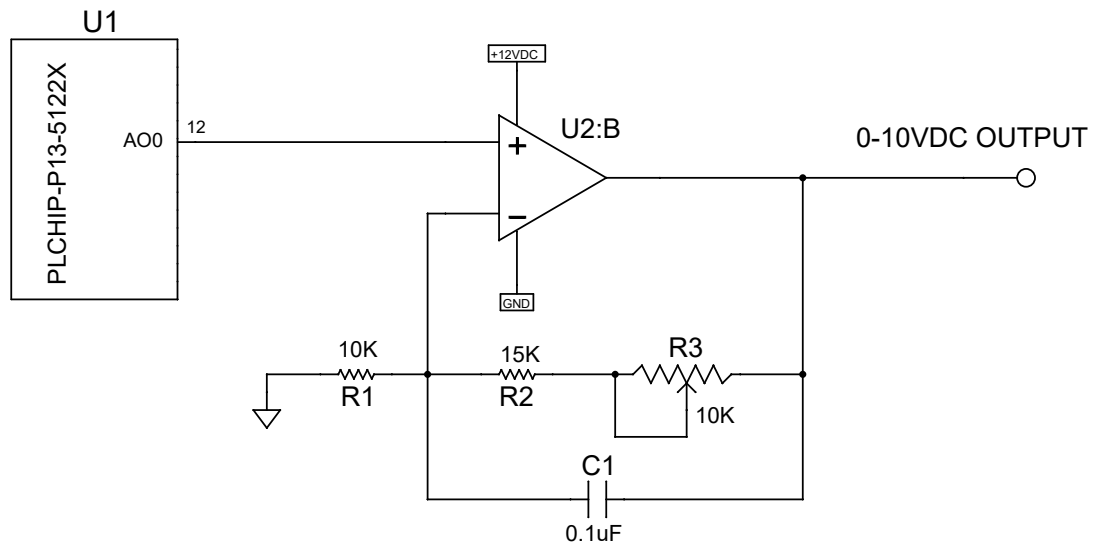


Diagram 6.6B - Example Analog Output Circuit

6.7 SD Card Interface

The PLCHIP-P13-51220 will interface to an SD Card (Secure Digital Card). An SD card is a non-volatile memory card that can be used to store information, update the PLC on a Chip™ kernel and / or ladder diagram and be the 'disk' for files of a local webserver. The SD Card is typically 'plugged-in' to the interface's socket.

To use the SD Card interface functionality, several pins must be used for the interface itself. The following pins are associated with SD Card functionality: [122](#), [120](#), [118](#), [116](#), [92](#), [108](#), [106](#), [102](#). All the pins except pin 92 are required to interface to an SD Card while pin 92 is an optional feature. These pins only currently share functionality as SD Card Interface I/O or as General Purpose I/O (GPIO).

The required pins are [MCI_CLK](#), [MCI_CMD](#), [MCI_PWR](#), [MCI_DATA0](#), [MCI_DATA1](#), [MCI_DATA2](#) and [MCI_DATA3](#).

The [MCI_CARD_PRESENT](#) is an optional pin that is used to detect when an SD Card has been inserted into the SD Card Socket. The socket must also support this feature.

These SD Card pins may also be used as General Purpose I/O (GPIO). They do not share any additional functionality except GPIO.

Diagram 6.7A is a sample schematic of an interface for an SD card using a socket that does not support MCI_CARD_PRESENT.

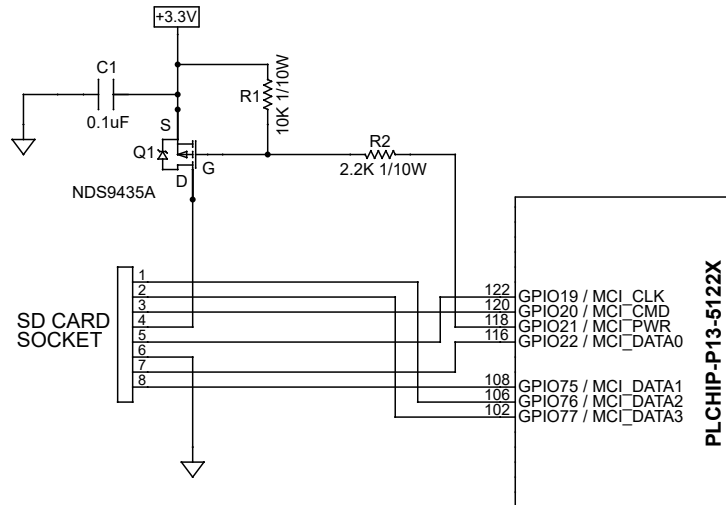


Diagram 6.7B - Example SD Card Interface Circuit

6.8 Timer / Capture Inputs

The PLCHIP-P13-51220 provides I/O pins that may be configured to be used in timing and frequency measurement. There are three timer modules on the PLCHIP-P13-51220: TMR_CAP0.X, TMR_CAP1.X and TMR_CAP2.x. Each of the three modules provides three I/O pins; two capture (CAP) pins and one match (MAT) pin. These pins in each module operate together to provide the full counter / timer features supported.

All Timer/Capture pins operate at 3.3V and all circuits that interface to these pins should be limited to 3.3V.

Diagram 6.8A is a sample schematic of using a Timer Capture input as a pulse input.

Timer / Capture Module 0

Timer module 0 consists of two capture (input) pins. These are located on pins [82](#) and [88](#) as [TMR_CAP0.0](#) and [TMR_CAP0.1](#) respectively. In addition to the capture input pins, an output pin is provided on pin [90](#) as [TMR_MAT0](#).

While two capture pins are provided per module, only one pin per module may be used as a counter / timer input capture pin.

The TMR_MAT0 pin operates as a status output. This output is HIGH based on Timer/Capture Channel 0's configuration and when the captured or timed value equals a predetermined set point. The configuration is handled using the EZ LADDER Toolkit. **The TMR_MAT0 functionality is currently not supported, but may be added in a future EZ LADDER Toolkit release.**

Pin 82 shares functionality and may be used as General Purpose I/O ([GPIO58](#)).

Pin 88 shares functionality and may be used as General Purpose I/O ([GPIO59](#)).

Pin 90 shares functionality and may be used as General Purpose I/O ([GPIO60](#)).

Timer / Capture Module 1

Timer module 1 consists of two capture (input) pins. These are located on pins [66](#) and [68](#) as [TMR_CAP1.0](#) and [TMR_CAP1.1](#) respectively. In addition to the capture input pins, an output pin is provided on pin [74](#) as [TMR_MAT1](#).

While two capture pins are provided per module, only one pin per module may be used as a counter / timer input capture pin.

The TMR_MAT1 pin operates as a status output. This output is HIGH based on Timer/Capture Channel 1's configuration and when the captured or timed value equals a predetermined set point. The configuration is handled using the EZ LADDER Toolkit. **The TMR_MAT1 functionality is currently not supported, but may be added in a future EZ LADDER Toolkit release.**

Pin 66 shares functionality and may be used as General Purpose I/O ([GPIO50](#)).

Pin 68 shares functionality and may be used as General Purpose I/O ([GPIO51](#)).

Pin 74 shares functionality and may be used as General Purpose I/O ([GPIO54](#)).

Timer / Capture Module 2

Timer module 2 consists of two capture (input) pins. These are located on pins [91](#) and [99](#) as [TMR_CAP2.0](#) and [TMR_CAP2.1](#) respectively. In addition to the capture input pins, an output pin is provided on pin [164](#) as [TMR_MAT2](#).

While two capture pins are provided per module, only one pin per module may be used as a counter / timer input capture pin.

The TMR_MAT2 pin operates as a status output. This output is HIGH based on Timer/Capture Channel 1's configuration and when the captured or timed value equals a predetermined set point. The configuration is handled using the EZ LADDER Toolkit. **The TMR_MAT2 functionality is currently not supported, but may be added in a future EZ LADDER Toolkit release.**

Pin 91 shares functionality and may be used as General Purpose I/O ([GPIO78](#)).

Pin 99 shares functionality and may be used as General Purpose I/O ([GPIO79](#)).

Pin 164 shares functionality and may be used as General Purpose I/O ([GPIO6](#)).

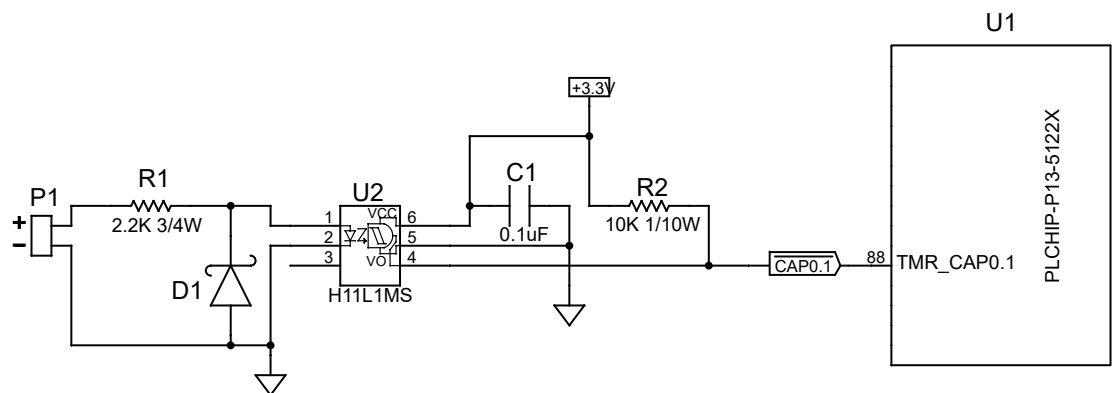


Diagram 6.8A - Example Timer / Capture Input as a Pulse Input

6.9 Retentive Memory / Loss of Power Detection

The PLCHIP-P13-51220 supports retentive memory functionality. Values of variables declared as retentive in EZ LADDER Toolkit are automatically stored into non-volatile memory when loss of power is detected and then automatically read from non-volatile memory and the variables are set to their last stored value when power is restored.

For retentive features to function properly, an external FRAM integrated circuit must be connected to an I²C bus and the \sim LOW_VOLT_SENSE pin must be connected to a circuit to monitor the input voltage.

The internal EEPROM or an external FRAM device may be used as the storage device for all retentive features. The amount of retentive memory available and the details to store retentive are dependent upon the device implemented. Contact Divelbiss Corporation or refer to the P-Series EZ LADDER Toolkit for a listing of supported FRAM / I²C devices. FRAM devices must be connected to either I²C bus.

An input voltage monitor circuit then causes the P-13 Series PLC on a Chip to go into shut-down when the input voltage reaches a nominal value (signalling loss of power). The \sim LOW_VOLT_SENSE pin is active low; therefore, a low signal on this input will cause the PLC on a Chip to go into shut-down and store all retentive variables.

The actual voltage where the hardware should go into shut-down depends upon the power supply capacitance, amount of retentive variables and the operating voltage. On a hardware unit that will operate from 8-32VDC, a typical detection point would be about 7.5V. Enough power supply capacitance must be designed into the power supply for the 3.3V PLC on a Chip supply (+VDD) to be maintained long enough for all retentive variables to be written into the non-volatile memory.

For the FRAM devices listed above, the write time is approximately 1mS to write 100 bytes of retentive memory. The time between the Loss of Power detection (on the \sim LOW_VOLT_SENSE pin) and the actual PLC on a Chip reset (\sim RESET pin) being active must be at least 1mS per 100 bytes of retentive memory to be written.

When using the internal EEPROM, the write time is longer and will require additional power hold time / capacitance to complete the write, again being dependent upon the number of variables being stored.

The loss of power requires pin [130, \$\sim\$ LOW_VOLT_SENSE](#). This pin should be connected to a circuit that will detect the loss of power early enough to allow retentive writing as described earlier.

The \sim LOW_VOLT_SENSE pin may also be used as General Purpose I/O ([GPIO16](#)). It does not share any additional functionality except GPIO.

Diagram 6.9A is a sample schematic of a loss of power detection circuit.

Diagram 6.15A is a sample schematic of an Ramtron FRAM interfaced to the PLCHIP-P13-51220 as the storage device for retentive memory.

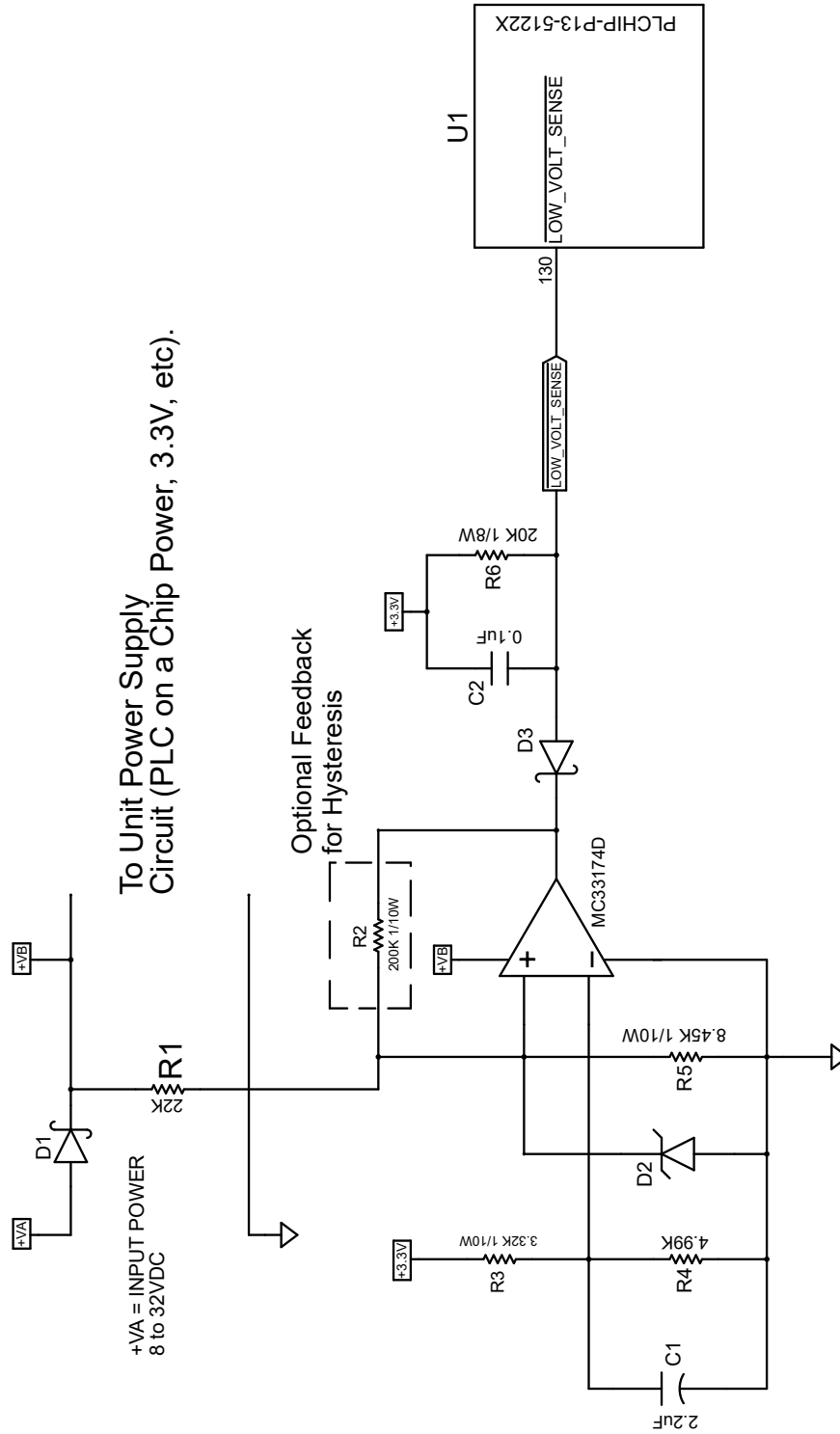


Diagram 6.9A - Example Loss of Power Detection Circuit

6.10 Programming Port

The programming port on the PLCHIP-P13-51220 is used to communicate from the chip to EZ LADDER Toolkit. This connection is used to install the PLC on a Chip kernel, download ladder diagram programs and to monitor the program's ladder execution in EZ LADDER Toolkit.

The programming port is factory set and requires the use of pins [202](#) and [204](#) which are [TXD0](#) and [RXD0](#) respectively. As the PLC on a Chip operates at a digital 3.3V level, an RS232 transceiver is required for using this port to communicate to a computer with EZ LADDER Toolkit. For communication using the programming port, a connection to digital ground ([VSS](#)) is required in addition to the transmit and receive pins.

These programming port pins do not share any functionality with other P-13 PLC on a Chip features.

The programming port baud rate is factory controlled and cannot be set in EZ LADDER Toolkit or the PLC on a Chip.

Diagram 6.10A is a sample schematic of an interface circuit for a communication link to a computer operating EZ LADDER Toolkit.

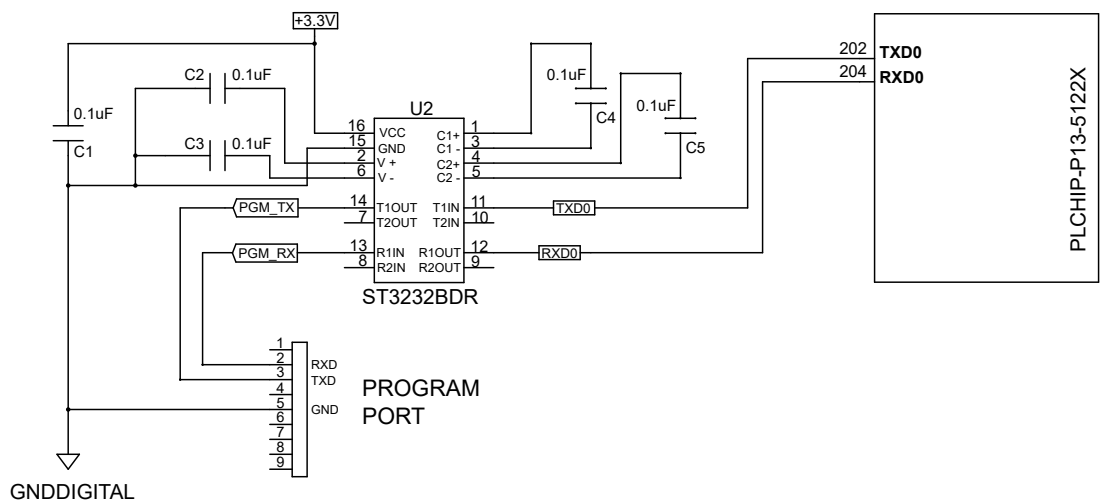


Diagram 6.10A - Example Programming Port Circuit

6.11 Ethernet Port

The PLCHIP-P13-51220 supports Ethernet communication. For ethernet functionality, external interface integrated circuits (Physical Ethernet IC) and components are required. The P-Series PLC on a Chip™ connects and interfaces directly to these external integrated circuits.

The PLCHIP-P13-51220 supports ethernet as Modbus TCP (Master or Slave). Ethernet functionality is configured in the PLC on a Chip's bootloader and kernel.

The Ethernet port requires the use of pins [196](#), [194](#), [192](#), [190](#), [188](#), [186](#), [184](#), [182](#), [180](#) and [178](#) which are [ETHER_TXD0](#), [ETHER_TXD1](#), [~ETHER_TXEN](#), [ETHER_CRS](#), [ETHER_RXD0](#), [ETHER_RXD1](#), [ETHER_RXER](#),

[ETHER_REFCLK](#), [ETHER_MDC](#) and [ETHER_MDIO](#) respectively. Each of these pins is required for the ethernet port to operate correctly.

Additionally, the [~RSTOUT](#) pin should be connected to the ethernet physical chip if it supports the used of an external reset.

The Ethernet pins as with other I/O pins on the PLC on a Chip P-Series operate at a 3.3V level. All interface circuits and components should be 3.3V.

ETHERNET PIN DESCRIPTIONS

ETHER_TXD0

Ethernet Transmit Data 0 Output. Typically connects to TXD0 port on an Ethernet Physical Integrated Circuit.

This Ethernet Port pin shares functionality with General Purpose I/O, [GPIO32](#).

ETHER_TXD1

Ethernet Transmit Data 1 Output. Typically connects to TXD1 port on an Ethernet Physical Integrated Circuit.

This Ethernet Port pin shares functionality with General Purpose I/O, [GPIO33](#).

ETHER_TXEN

Ethernet Transmit Data Enable. Typically connects to TXEN port on an Ethernet Physical Integrated Circuit.

This Ethernet Port pin shares functionality with General Purpose I/O, [GPIO36](#).

ETHER_CRS

Ethernet Carrier Sense Input. Typically connects to CRS port on an Ethernet Physical Integrated Circuit.

This Ethernet Port pin shares functionality with General Purpose I/O, [GPIO40](#).

ETHER_RXD0

Ethernet Recieve Data 0 Input. Typically connects to RXD0 port on an Ethernet Physical Integrated Circuit.

This Ethernet Port pin shares functionality with General Purpose I/O, [GPIO41](#).

ETHER_RXD1

Ethernet Recieve Data 1 Input. Typically connects to RXD1 port on an Ethernet Physical Integrated Circuit.

This Ethernet Port pin shares functionality with General Purpose I/O, [GPIO42](#).

ETHER_RXER

Ethernet Receive Error input. Typically connects to RXER port on an Ethernet Physical Integrated Circuit.

This Ethernet Port pin shares functionality with General Purpose I/O, [GPIO46](#).

ETHER_REFCLK

Ethernet Reference Clock. Typically connects to X1 port on an Ethernet Physical Integrated Circuit.

This Ethernet Port pin shares functionality with General Purpose I/O, [GPIO47](#).

ETHER_MDC

Ethernet MDIO/MIIM Clock output. Typically connects to MDC port on an Ethernet Physical Integrated Circuit.

This Ethernet Port pin shares functionality with General Purpose I/O, [GPIO48](#).

ETHER_MDIO

Ethernet MDIO input/output. Used as Ethernet MIIM data input and output. Typically connects to MDIO port on an Ethernet Physical Integrated Circuit.

This Ethernet Port pin shares functionality with General Purpose I/O, [GPIO49](#).

Diagram 6.11A is a sample schematic of an interface circuit for an ethernet communication port.

Refer to Diagram 6.3B for a sample layout of the P-13 Chip, power pins, oscillator and Ethernet.

Multiple Ethernet Ports

The PLCHIP-P13-51220 supports the implementation of an Ethernet Physical with built-in switch. Currently there are two supported part numbers, but contact Divelbiss Corporation for any updates to the supported Ethernet devices.

The supported devices are:

Mfg: Microchip P/N: KSZ8775CLXIC
5 Port Ethernet Switch with Physical (80LQFP)

Mfg: Microchip P/N: KSZ8873RLLI
3 Port Ethernet Switch with Physical (64LQFP)

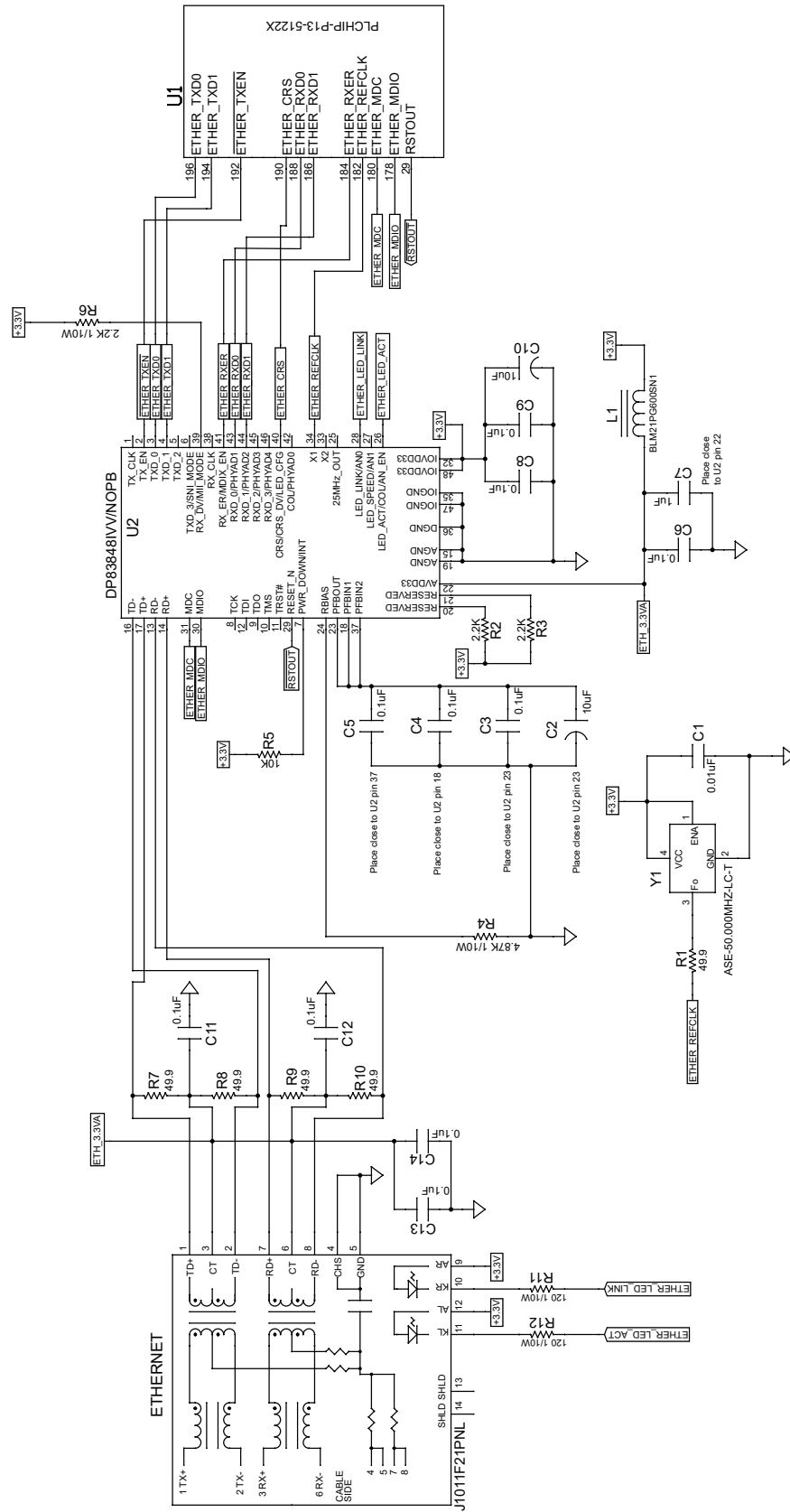


Diagram 6.11A - Example Ethernet Port Circuit

6.12 Controller Area Network (CAN) Ports

The PLCHIP-P13-51220 supports up to two Controller Area Network (CAN) Ports. These ports allow communication to other devices that support SAE J1939 or Divelbiss OptiCAN.

CAN Port 0

CAN Port 0 requires the use of pins **94** and **96** which are **CAN_RX0** and **CAN_TX0** respectively. As the PLC on a Chip operates at a digital 3.3V level, a CAN transceiver is required interface these pin of the PLC on a Chip to the external CAN network.

The PLC on a Chip pins for CAN Port 0 share functionality with these other P-13 PLC on a Chip features: Pin 94 (**I2C_SDA1**, **GPIO0**), Pin 96 (**I2C_SCL1**, **GPIO1**).

CAN Port 1

CAN Port 1 requires the use of pins **168** and **166** which are **CAN_RX1** and **CAN_TX1** respectively. As the PLC on a Chip operates at a digital 3.3V level, a CAN transceiver is required interface these pin of the PLC on a Chip to the external CAN network.

The PLC on a Chip pins for CAN Port 1 share functionality with these other P-13 PLC on a Chip features: Pin 168 (**GPIO4**), Pin 166 (**GPIO5**).

To use the PLCHIP-P13-51220 as a device on a J1939 or OptiCAN network, all rules governing the network must be adhere to including the use of terminating resistors, cable size, type and length.

Figure 6.12A is a typical interface circuit for OptiCAN. A configurable terminating resistor is shown.

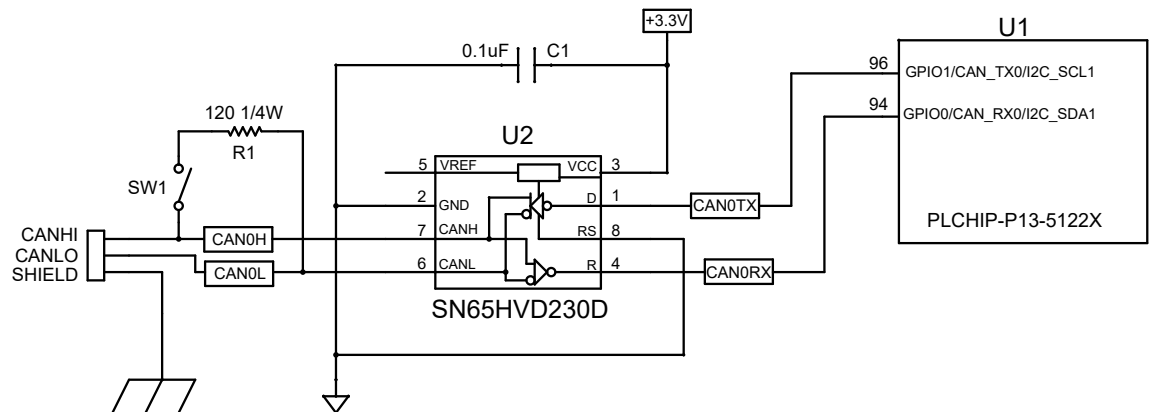


Diagram 6.12A - Example CAN Port Interface Circuit

6.13 Serial (UART) Ports

The PLCHIP-P13-51220 supports up to four TTL Serial Ports via on-board UARTs. One UART supports full hardware handshaking while the other three support transmit and receive only. These UART ports are 3.3V TTL level; therefore they require additional interface circuitry to communicate with other device external to the PLC on a Chip.

The PLC on a Chip UARTs support Modbus Master and Modbus Slave. The maximum baud rate for all UARTs is 115,200 baud (115K).

Figure 6.13A is a typical RS232 Interface circuit.

Figure 6.13B is a typical RS422 Interface circuit.

Figure 6.13C is a typical RS485 Interface circuit.

UART 1

UART 1 supports full hardware handshaking on pins [154](#), [152](#), [150](#), [144](#), [142](#), [140](#), [138](#), [136](#) as [TXD1](#), [RXD1](#), [CTS1](#), [DCD1](#), [DSR1](#), [DTR1](#), [RI1](#), [RTS1](#) respectively. With full handshaking support, UART 1 is ideal for interfacing to items such as modems, radios, etc. When interfacing to these types of devices, refer to their documentation for connection requirements.

The PLC on a Chip pins for UART 1 share functionality with these other P-13 PLC on a Chip features: Pin 154 ([GPIO64](#)), Pin 152 ([GPIO65](#)), Pin 150 ([GPIO66](#)), Pin 144 ([GPIO67](#)), Pin 142 ([GPIO68](#)), Pin 140 ([GPIO69](#)), Pin 138 ([GPIO70](#)), Pin 136 ([GPIO71](#)).

UART 2

UART 2 supports transmit and receive only. These connections are on pins [134](#) and [132](#), which are [TXD2](#) and [RXD2](#) respectively.

The PLC on a Chip pins for UART 2 share functionality with these other P-13 PLC on a Chip features: Pin 134 ([GPIO72](#)), Pin 132 ([GPIO73](#)).

UART 3

UART 3 supports transmit and receive only. These connections are on pins [170](#) and [176](#), which are [TXD3](#) and [RXD3](#) respectively.

The PLC on a Chip pins for UART 3 share functionality with these other P-13 PLC on a Chip features: Pin 170 ([GPIO156](#)), Pin 176 ([GPIO157](#)).

UART 4

UART 4 supports transmit and receive only. These connections are on pins [141](#) and [206](#), which are [TXD4](#) and [RXD4](#) respectively.

The PLC on a Chip pins for UART 4 share functionality with these other P-13 PLC on a Chip features: Pin 141 ([GPIO163](#)), Pin 206 ([GPIO164](#)).

Pin 141 (RXD4) is open-drain. A pull-up resistor is required if the pin is being used as GPIO.

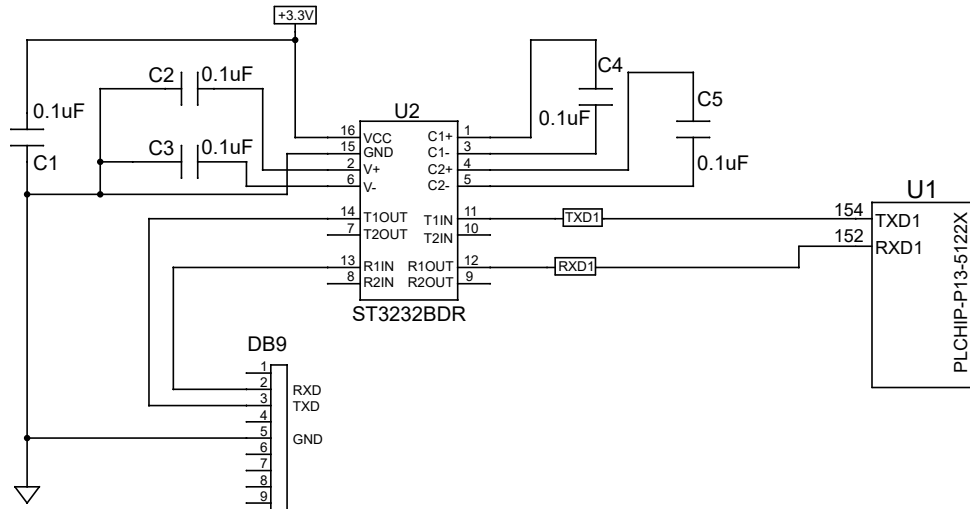


Diagram 6.13A - Example RS232 Interface Circuit

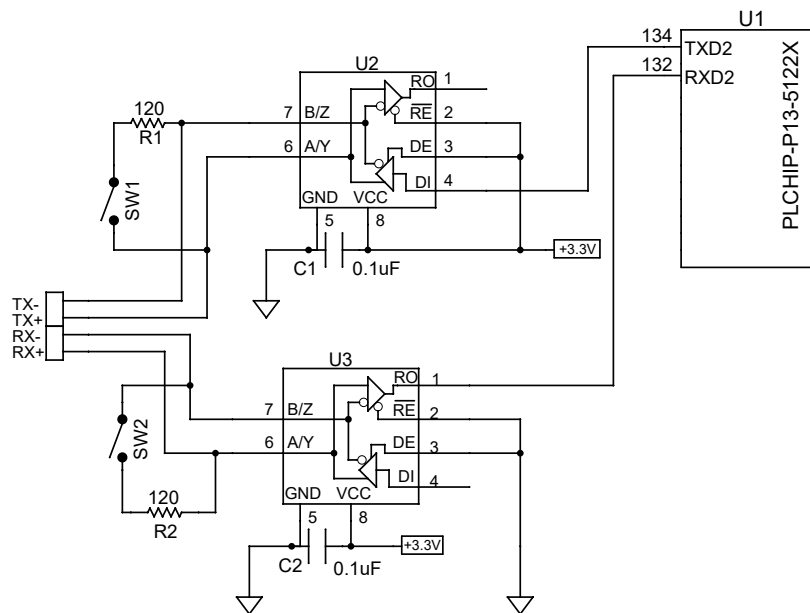


Diagram 6.13B - Example RS422 Interface Circuit

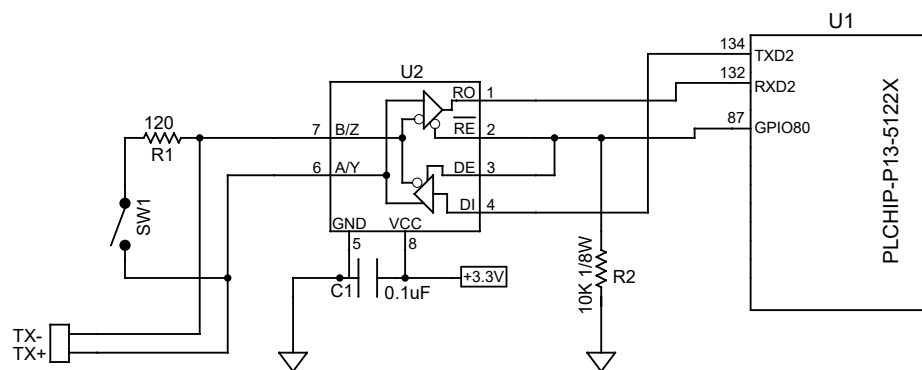


Diagram 6.13C - Example RS485 Interface Circuit

6.14 SPI Ports

The PLCHIP-P13-51220 supports up to two SPI (Serial Peripheral Interface) Ports. These SPI ports may be used to interface to a multitude of SPI devices, extending the PLC on a Chip's versatility. SPI devices must be supported in EZ LADDER Toolkit or you must write your own interface using the EZ LADDER structured text editor. As supported devices may change periodically, refer to the EZ LADDER Toolkit Manual for a list of supported devices.

Diagram 6.14A represents a sample SPI Port connection to an SPI device.

SPI Port 0

SPI port 0 consists of three individual pins that work together to allow complete functionality of the SPI bus. SPI port 0 is located on pins [128](#), [126](#) and [124](#) which are [SPI_SCK0](#), [SPI_MISO0](#) and [SPI_MOSI0](#) respectively. Additionally, for each SPI device on the bus (port), a select line must be used. Any GPIO pin may be used as the select line for an SPI device.

SPI_SCK0

Serial Clock Output for SPI Port 0.

Pin 128 shares functionality and may be used as General Purpose I/O ([GPIO15](#)).

SPI_MISO0

Master In - Slave Out Input for SPI Port 0

Pin 126 shares functionality and may be used as General Purpose I/O ([GPIO17](#)).

SPI_MOSI0

Master Out - Slave In Output for SPI Port 0

Pin 124 shares functionality and may be used as General Purpose I/O ([GPIO18](#)).

SPI Port 1

SPI port 1 consists of three individual pins that work together to allow complete functionality of the SPI bus. SPI port 1 is located on pins [162](#), [160](#) and [158](#) which are [SPI_SCK1](#), [SPI_MISO1](#) and [SPI_MOSI1](#) respectively. Additionally, for each SPI device on the bus (port), a select line must be used. Any GPIO pin may be used as the select line for an SPI device.

SPI_SCK1

Serial Clock Output for SPI Port 1.

Pin 162 shares functionality and may be used as General Purpose I/O ([GPIO7](#)).

SPI_MISO1

Master In - Slave Out Input for SPI Port 1

Pin 160 shares functionality and may be used as General Purpose I/O ([GPIO8](#)).

SPI_MOSI1

Master Out - Slave In Output for SPI Port 1

Pin 158 shares functionality and may be used as General Purpose I/O ([GPIO9](#)).

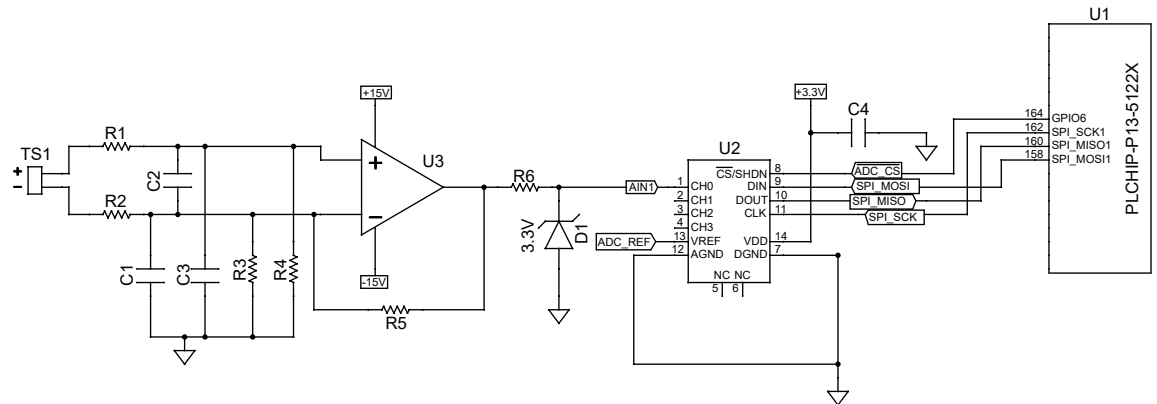


Diagram 6.14A - Example SPI Port Circuit

6.15 I²C Ports

The PLCHIP-P13-51220 supports up to three 1Mbit I²C Ports. These ports support standard I²C devices (up to 1Mbit) using Data and Clock lines. I²C port lines require an external pull-up resistor of 1.5K Ω for proper operation.

While the PLCHIP-P13-51220 provides hardware support for I²C devices, only supported devices will be functional and available in EZ LADDER Toolkit. As supported devices may change periodically, refer to the P-Series EZ LADDER Toolkit Manual for a list of supported devices.

Figure 6.15A is an example circuit schematic for an I²C FRAM retentive memory storage.

I²C Port 0

Port 0 requires the use of pins [50](#) and [48](#) which are [I2C_SDA0](#) and [I2C_SCL0](#) respectively. As the PLC on a Chip operates at a digital 3.3V level, all I²C devices connected to this port should be 3.3V compliant.

The PLC on a Chip pins for I²C Port 0 share functionality with these other P-13 PLC on a Chip features: Pin 50 ([GPIO27](#)), Pin 48 ([GPIO28](#)).

I²C Port Pins 48 and 50 are open-drain. A pull-up resistor is required if the pin(s) are being used as GPIO.

I²C Port 1

Port 1 requires the use of pins [94](#) and [96](#) which are [I2C_SDA1](#) and [I2C_SCL1](#) respectively. As the PLC on a Chip operates at a digital 3.3V level, all I²C devices connected to this port should be 3.3V compliant.

The PLC on a Chip pins for I²C Port 1 share functionality with these other P-13 PLC on a Chip features: Pin 94 ([GPIO0](#), [CAN_RX0](#)), Pin 96 ([GPIO1](#), [CAN_TX0](#)).

I²C Port 2

Port 2 requires the use of pins [98](#) and [100](#) which are [I2C_SDA2](#) and [I2C_SCL2](#) respectively. As the PLC on a Chip operates at a digital 3.3V level, all I²C devices connected to this port should be 3.3V compliant.

The PLC on a Chip pins for I²C Port 2 share functionality with these other P-13 PLC on a Chip features: Pin 98 ([GPIO10](#)), Pin 100 ([GPIO11](#)).

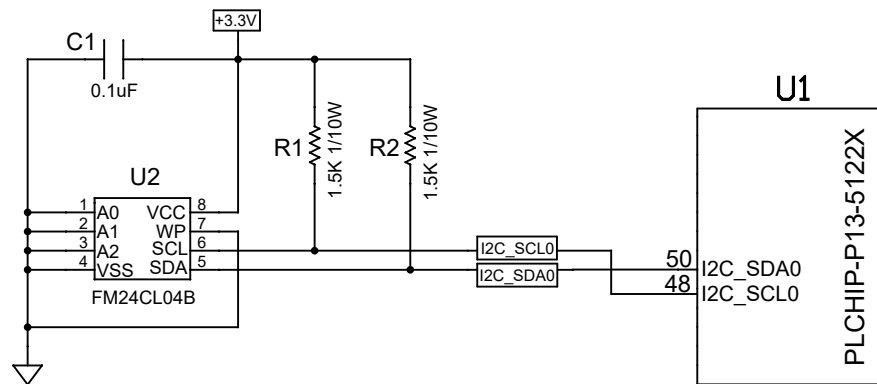


Diagram 6.15A - Example I²C FRAM storage device for Retentive Memory

6.16 Quadrature Encoder Interface

The PLCHIP-P13-51220 supports a three (3) channel quadrature input (Channel A, Channel B and Index). As with all other I/O pins, the quadrature input requires 3.3VDC input signals for proper operation. The Quadrature Encoder Interface supports X1, X4 and Up/Down plus additional features based on software configuration. Refer to the P-Series EZ LADDER Toolkit Manual for details of supported features.

The Quadrature Encoder Interface requires the use of pins [70](#), [76](#) and [78](#) which are [QEI_PHA](#), [QEI_PHB](#) and [QEI_IDX](#) respectively. Each of these pins is required for the interface port to operate correctly. Diagram 6.16A represents a sample circuit and connection to the Quadrature Encoder Interface.

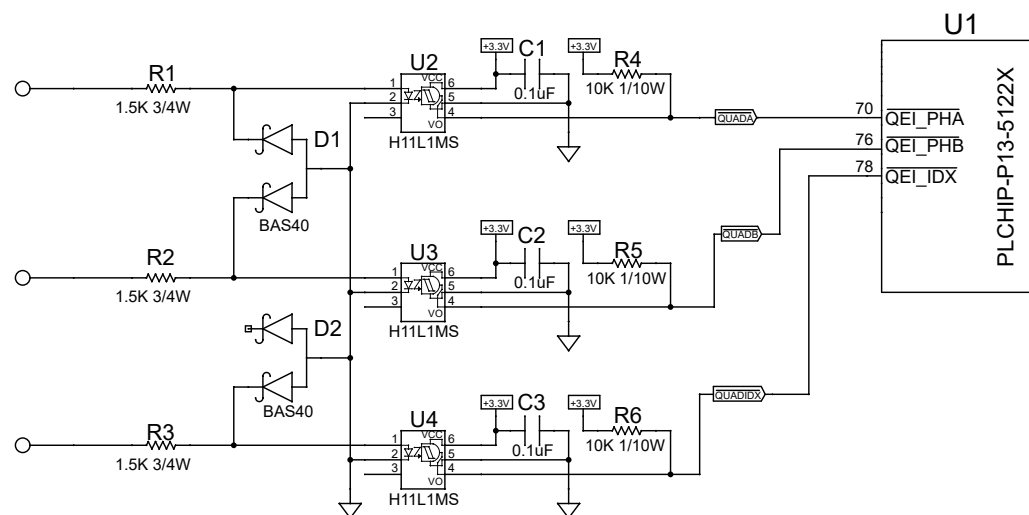


Diagram 6.16A - Example Quadrature Encoder Interface Circuit

The PLC on a Chip pins for the Quadrature Encoder Interface share functionality with these other P-13 PLC on a Chip features: Pin 70 ([GPIO52](#)), Pin 76 ([GPIO55](#)), Pin 78 ([GPIO56](#)).

6.17 Liquid Crystal Display (LCD) Interface

The PLCHIP-P13-51220 supports an LCD (Liquid Crystal Display) Interface. This LCD Interface supports the industry standard HD44780 Controller Emulation. LCD displays connected to this interface must support the HD44780 standard.

The LCD Interface supports displays from 1-4 Rows and from 8 to 42 columns.

The LCD Interface requires the use of pins [75](#), [79](#), [83](#), [97](#), [103](#), [107](#), [113](#), [121](#), [127](#), [131](#) and [135](#) which are [LCD_D0](#), [LCD_D1](#), [LCD_D2](#), [LCD_D3](#), [LCD_D4](#), [LCD_D5](#), [LCD_D6](#), [LCD_D7](#), [LCD_RS](#), [LCD_RW](#) and [LCD_E](#) respectively. Each of these pins is required for the interface port to operate correctly. Diagram 6.17A represents a sample circuit and connection to the LCD Interface.

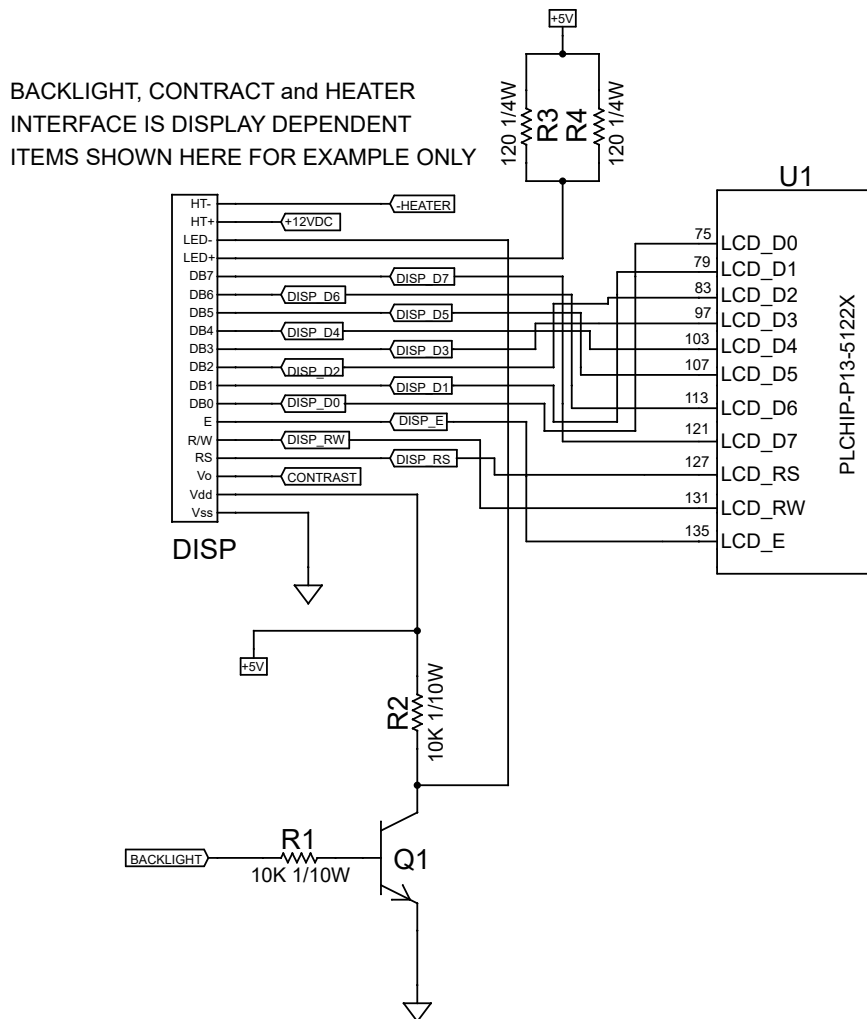


Diagram 6.17A - Example LCD Display Interface Circuit

The PLC on a Chip pins for the LCD Interface share functionality with these other P-13 PLC on a Chip features: Pin 75 ([GPIO128](#)), Pin 79 ([GPIO129](#)), Pin 83 ([GPIO130](#)), Pin 97 ([GPIO131](#)), Pin 103 ([GPIO132](#)), Pin 107 ([GPIO133](#)), Pin 113 ([GPIO134](#)), Pin 121 ([GPIO135](#)), Pin 127 ([GPIO136](#)), Pin 131 ([GPIO137](#)), Pin 135 ([GPIO138](#)).

6.18 Keypad Interface

The PLCHIP-P13-51220 supports a 4 row by 5 column keypad matrix. The PLC on a Chip™ scans the keypad matrix, detecting keys that are pressed.

The Keypad Interface requires the use of pins [145](#), [149](#), [155](#), [159](#), [173](#), [179](#), [183](#), [187](#), and [193](#) which are [KEYPAD_COL1](#), [KEYPAD_COL2](#), [KEYPAD_COL3](#), [KEYPAD_COL4](#), [KEYPAD_COL5](#), [KEYPAD_ROW2](#), [KEYPAD_ROW1](#), [KEYPAD_ROW3](#) and [KEYPAD_ROW4](#) respectively. Each of these pins is required for the interface port to operate correctly.

Diagram 6.18A represents the standard 4x5 matrix keypad circuit.

The PLC on a Chip pins for the Keypad Interface share functionality with these other P-13 PLC on a Chip features: Pin 145 ([GPIO139](#)), Pin149 ([GPIO140](#)), Pin155 ([GPIO141](#)), Pin159 ([GPIO142](#)), Pin173 ([GPIO143](#)), Pin179 ([GPIO153](#)), Pin183 ([GPIO152](#)), Pin187 ([GPIO158](#)) and Pin193 ([GPIO159](#)).

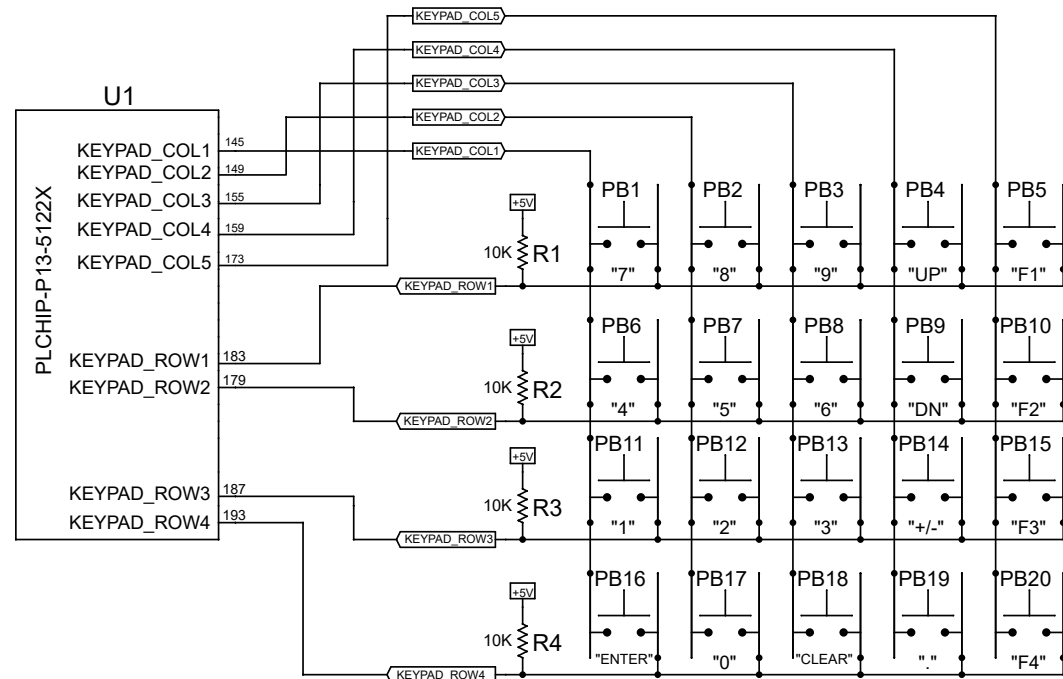


Diagram 6.18A - Example Keypad Interface Circuit

6.19 Graphics LCD Display Interface

The PLCHIP-P13-51220 supports specific LCD graphics displays. These LCD graphics displays provide the ability for PLC on a Chip products to display graphics, multiple sized text and variables.

The following graphics displays are supported:

1. Crystal Fontz part number: CFAG12864A-xxxx
 2. New Haven part number: NHD-12864AZ-xxxx
- xxxx are optional items in the part number for specifying features.

The LCD graphics display uses the same PLC on a Chip pins as the standard (non-graphics) LCD display with a requirement for three additional **GPIO** pins for RESET, CS1 and CS2.

The pins used are [75](#), [79](#), [83](#), [97](#), [103](#), [107](#), [113](#), [121](#), [127](#), [131](#) and [135](#) which are [LCD_D0](#), [LCD_D1](#), [LCD_D2](#), [LCD_D3](#), [LCD_D4](#), [LCD_D5](#), [LCD_D6](#), [LCD_D7](#), [LCD_RS](#), [LCD_RW](#) and [LCD_E](#) respectively. Each of these pins is required for the interface port to operate correctly. Diagram 6.19A represents a sample circuit and connection to the the graphics LCD Interface.

The graphics display requires RESET, CS1 and CS2 pins be connected to any available GPIO pins on the PLC on a Chip. Refer to Table 1, Table 2 and Section 6.4 for possible General Purpose I/O (GPIO).

The PLC on a Chip logic operates at 3.3VDC and the graphics display operates at 5VDC. For the graphics display to see a logic high from the PLC on a Chip, the graphics display interface circuit requires logic level translators (in this example, MC74HCT245N).

Diagram 6.19A represents the graphics LCD display interface circuit.

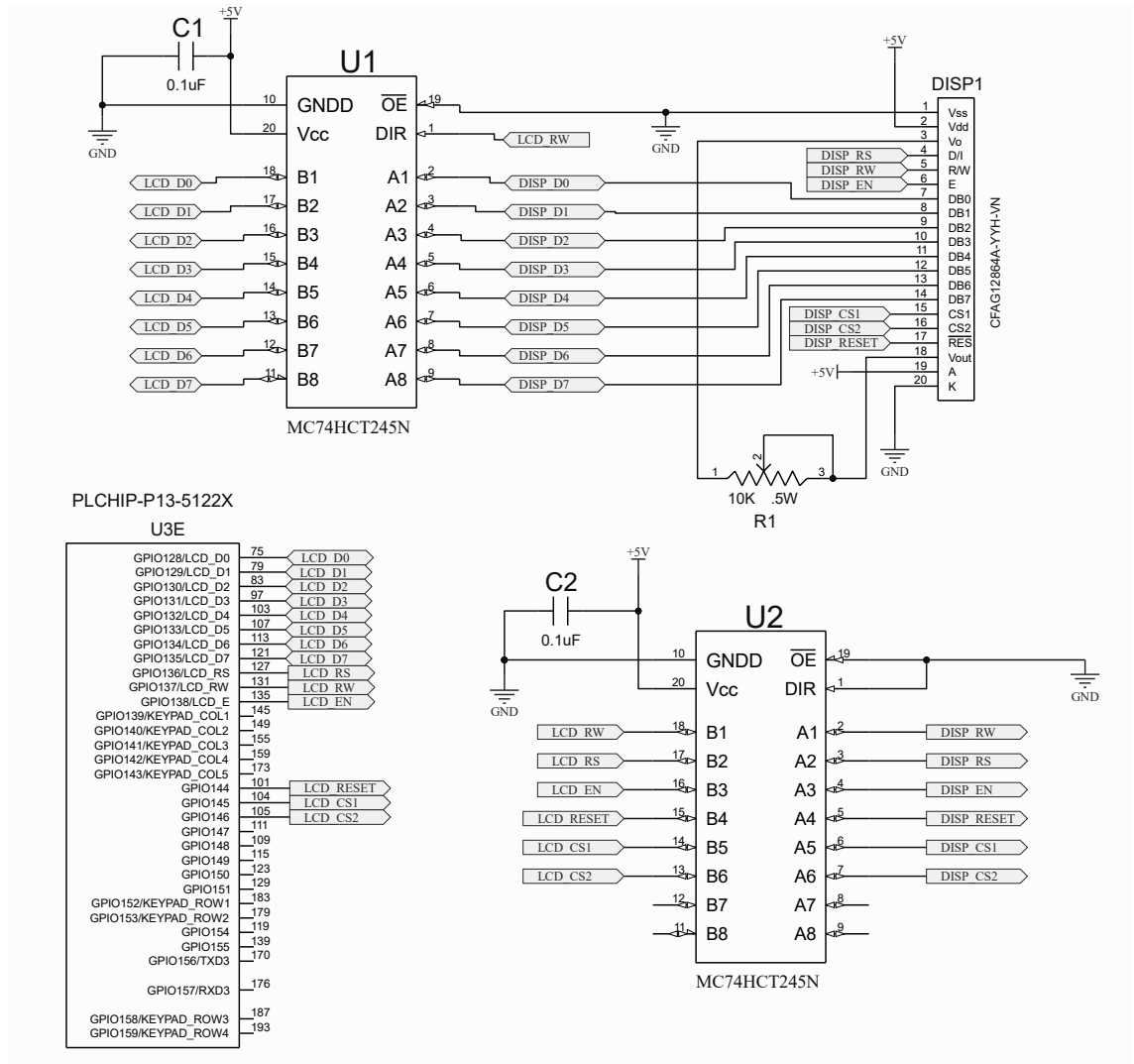


Diagram 6.19A - Example Graphics LCD Display Interface Circuit

6.20 Real Time Clock Circuit

The PLCHIP-P13-51220 supports an internal real time clock. This real time clock must have external circuitry to function. The external circuit is comprised of two capacitors, a battery and a crystal. The crystal should be 32.768KHz and the capacitors should be 22pF. The battery should be a 3V battery with a sufficient mA/H rating to support the application.

The real time clock requires the use of pins [34](#), [36](#) and [38](#) which are [RTCX1](#), [RTCX2](#) and [VBAT](#) respectively. Each of these pins is required for the real time clock to operate correctly.

Diagram 6.20A represents the required real time clock circuit.

The PLC on a Chip pins for the for the Real Time clock do not share functionality with any other pins or features.

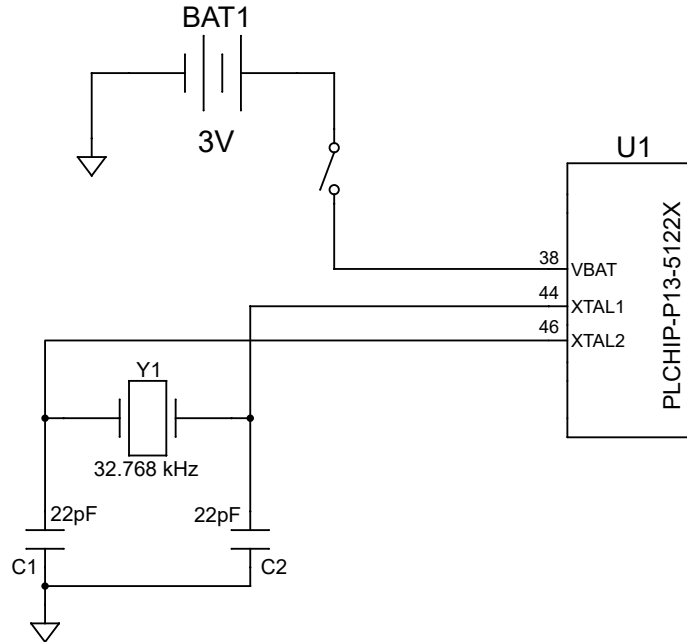


Diagram 6.20A - Example Real Time Clock Circuit

6.21 Watchdog LED Circuit

The PLCHIP-P13-51220 supports an LED indicator for status of the PLC on a Chip. The LED is connected to the [LED_KERNEL](#) pin (pin [110](#)). This pin must be pulled high for proper PLC on a Chip operation.

Diagram 6.21A represents a recommended Watchdog LED Circuit.

The PLC on a Chip pin for the for the LED KERNEL does not share functionality with any other pins or features.

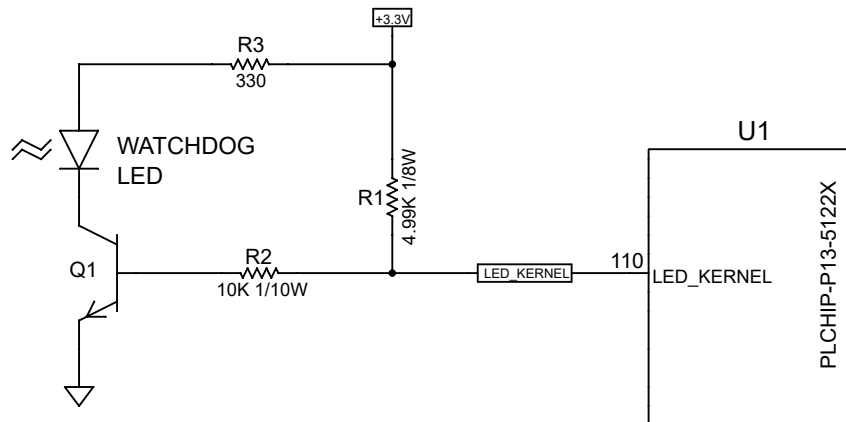


Diagram 6.21A - Example Watchdog / Kernel LED Circuit

7. Electrical Characteristics

TABLE 3 - Power Pins					
Pin #	Symbol	Min	Typ	Max	Unit
15	VDD4	2.4	3.3	3.6	V
20	VDD_AN	2.7	3.3	3.6	V
24	VREF_AN	2.7	3.3	VDD_AN	V
26	VDD1	2.4	3.3	3.6	V
38	VBAT	2.1	3.3	3.6	V
60	VDD5	2.4	3.3	3.6	V
71	VDD6	2.4	3.3	3.6	V
86	VDD2	2.4	3.3	3.6	V
89	VDD7	2.4	3.3	3.6	V
112	VDD8	2.4	3.3	3.6	V
125	VDD9	2.4	3.3	3.6	V
146	VDD10	2.4	3.3	3.6	V
165	VDD11	2.4	3.3	3.6	V
174	VDD3	2.4	3.3	3.6	V
181	VDD12	2.4	3.3	3.6	V
198	VDD13	2.4	3.3	3.6	V

TABLE 4 - General Purpose I/O Pins (GPIO) as Digital Inputs					
Symbol	Parameter	Min	Typ	Max	Unit
V_I	Input Voltage	0	---	5.0*	V
V_{IH}	High Level Input Voltage	0.7 x VDD	---	---	V
V_{IL}	Low Level Input Voltage	---	---	0.3 x VDD	V

* GPIO input pins are designed to operate at 3.3V but are 5V tolerant.

TABLE 5 - General Purpose I/O Pins (GPIO) as Digital Outputs						
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_I	Output Voltage	---	0	---	VDD	V
V_{IH}	High Level Input Voltage	$I_{OH} = -4mA$	VDD - 0.4	---	---	V
V_{IL}	Low Level Input Voltage	$I_{OL} = 4mA$	---	---	0.4	V

TABLE 6 - I²C Bus Pins

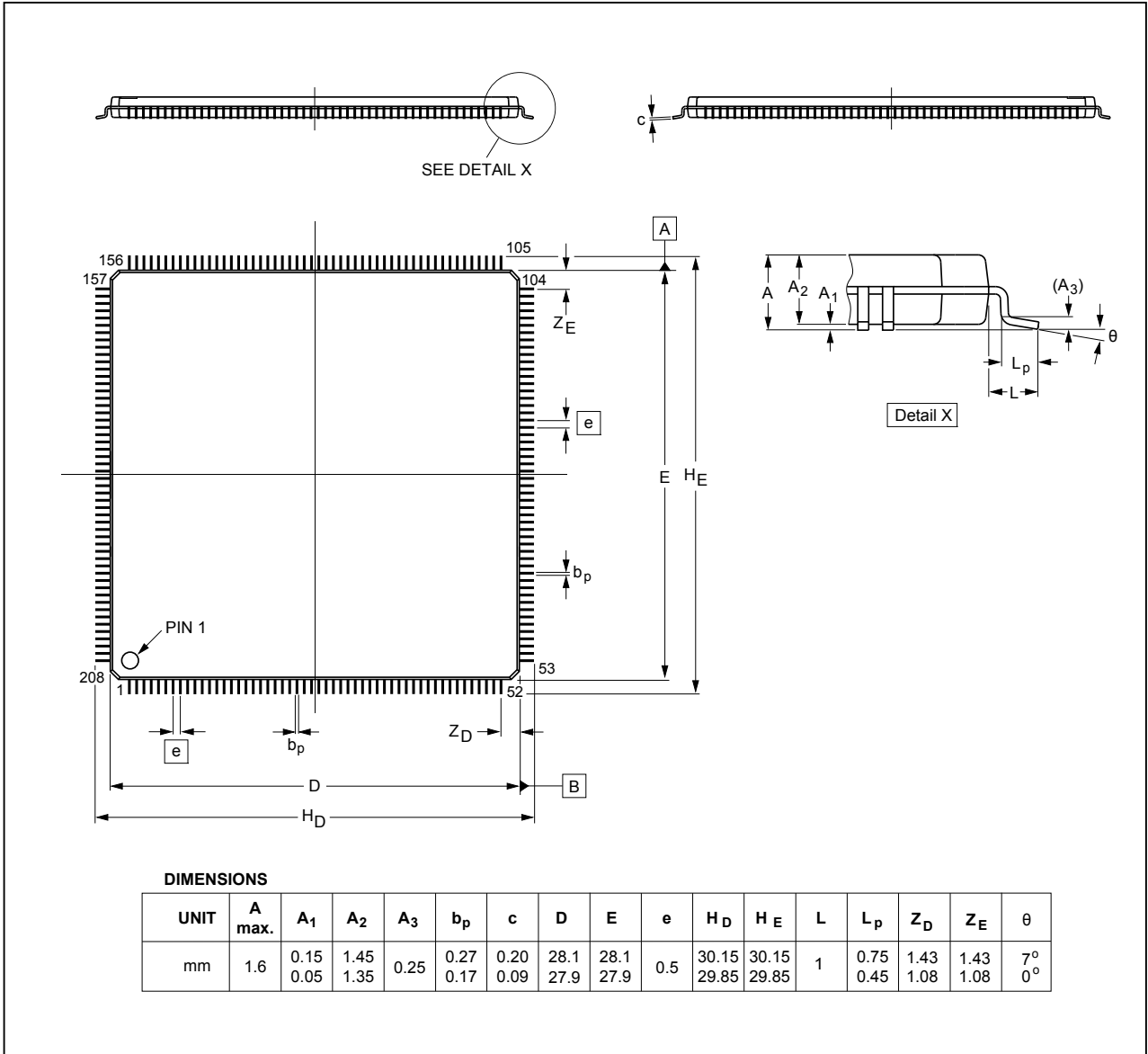
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V _{IH}	High Level Input Voltage		0.7 x VDD	---	---	V
V _{IL}	Low Level Input Voltage		---	---	0.3 x VDD	V
V _{hys}	Hysteresis Voltage		---	0.05 x VDD	---	V
V _{OL}	Low Level Output Voltage		---	---	.4	V

8. Thermal Characteristics

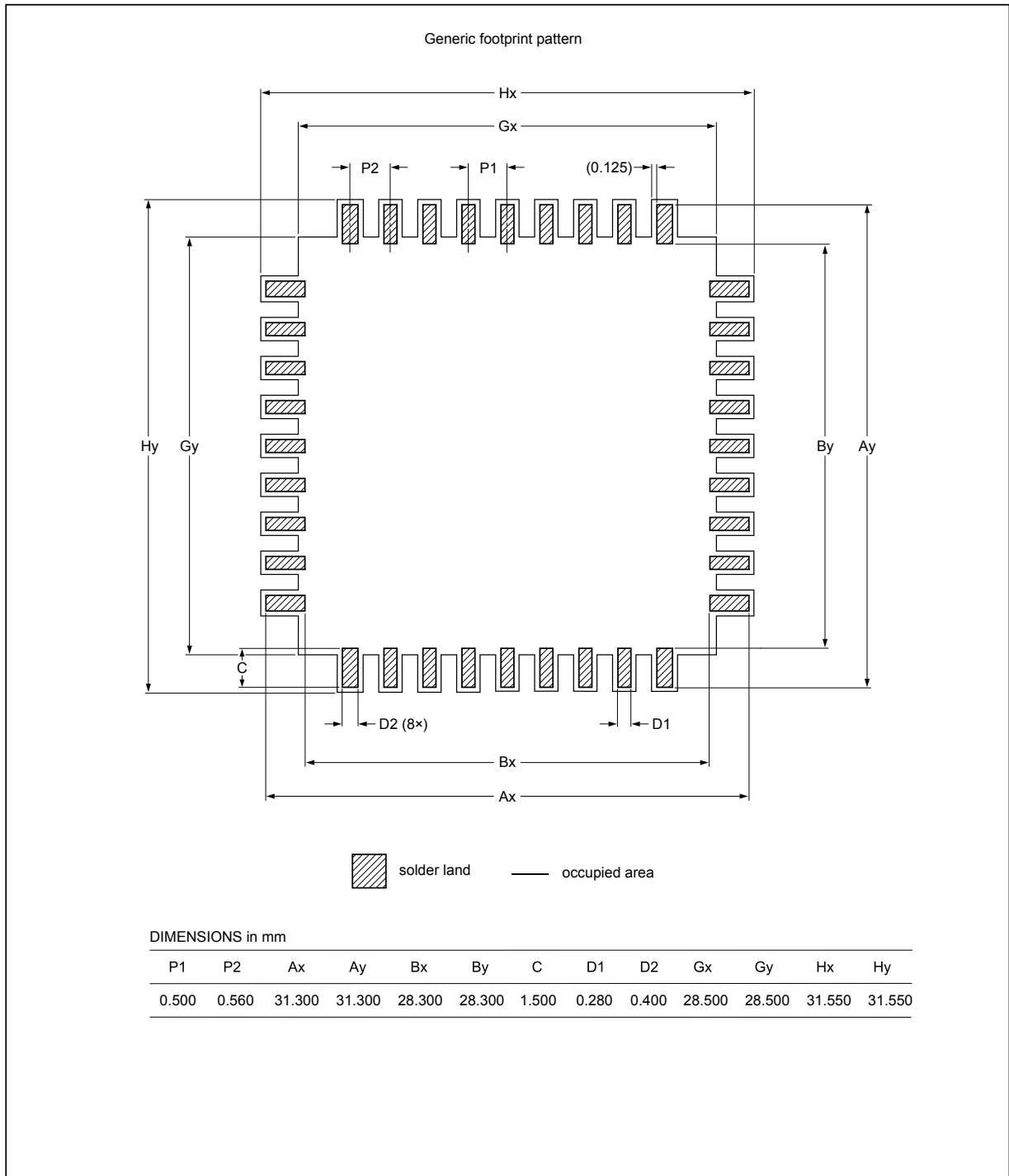
The maximum junction temperature the the PLC on Chip™, PLCHIP-P13-51220 is 125 °C with ambient from -40 °C to +85 °C.

9. Package & Soldering Details

PLCHIP-P13-51220 Packaging / Mechanical Dimensions



PLCHIP-P13-51220 Footprint Information for Reflow Soldering



10. Software Information

While this datasheet has been devoted to the hardware design of the PLCHIP-P13-51220 PLC on a Chip Integrated Circuit, the chip itself does require software to operate.

10.1 EZ LADDER Toolkit

EZ LADDER Toolkit is the only programming platform for PLC on a Chip targets (controllers, modules and integrated circuits). EZ LADDER provides the platform for installing the necessary target kernels to each target, developing ladder diagrams and the tools to download and debug the ladder diagram programs. Refer to the P-Series EZ LADDER Toolkit Manual for details on using EZ LADDER with P-Series PLC on a Chip targets.

10.2 Target Kernel

The first primary software needed is the PLC on a Chip Module's kernel. This software is loaded on the PLC on a Chip Module using the Bootloader feature in EZ LADDER Toolkit. This software essentially becomes the Module's operating system allowing ladder diagrams to be downloaded and ran on the PLC on a Chip Module (also identified as the target).

All PLC on a Chip targets (controllers, modules and chips) ship from the factory without a kernel installed for greater versatility for customers. It is the customer's responsibility to install the correct kernel (and version they require) on each PLC on a Chip Module (target). As new features are added, some customers may wish to 'freeze' their versions while others do not. With each customer installing the kernel for each target, they have the option of loading the latest kernel and taking advantage of new features or installing a previous kernel version.

The PLC on a Chip Module (PLCMOD-P13-51220) and the PLC on a Chip Integrated Circuit (PLCHIP-P13-51220) use the same kernel as the integrated circuit is installed on the module.

All kernel files are automatically installed when EZ LADDER Toolkit is installed and by default are loaded in a subdirectory under where EZ LADDER Toolkit is installed named **Kernel**.

All kernel files have the .dat file extension. **The file named PLCHIP-P13-5122X.dat is the correct file for the PLC on a Chip (PLCHIP-P13-51220) and PLC on a Chip Module (PLCMOD-P13-51220).** This file and only this file should be installed on the hardware target. Refer to the P-Series EZ LADDER Toolkit Manual for details on installing kernels.

11. Revision History

1/25/2013	Revision 1	Initial Datasheet Release.
11/26/2013	Revision 2	Added SMT Reflow / Oven Information.
03/17/2020	Revision 3	Removed USB, Added I ² C port2, Updated diagrams, spelling and grammar correction.
03/31/2020	Revision 4	Corrected EEPROM storage.
06/17/2020	Revision 5	Updated Ordering Information (Part Numbers and Ship Quantities)
01/27/2021	Revision 6	Added Graphics LCD Display Information

PLCHIP-P13-51220 Pb-free Profile Feature and Specification

Profile Feature	Pb-Free Assembly
Average Ramp-Up Rate	3°C / second max
Preheat Temperature Minimum	150°C
Preheat Temperature Maximum	200°C
Preheat Temperature Time	60-180 seconds
Temperature - Time maintained above	217°C
Time maintained above Temperature	60-150 seconds
Peak / Classification Temperature	260°C
Time within 5°C of actual Peak Temperature	20-40 seconds
Ramp-Down Rate	6°C / second maximum
Time 25°C to Peak Temperature	8 minutes maximum

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