The PMC

Preventive Maintenance Counter

User Manual, Installation Manual

Introduction

The PMC is a multi-mode device, and will count switch closure cycles (power presence cycles) and will measure the cumulative time a switch is closed (voltage presence duration). Additionally, the PMC will measure analog values, and measure temperature. It can be configured to close relays based upon counter value thresholds, counter duration threshold, and can set relays / alerts on user configurable analog values and user configurable temperature values.

- 8: Discrete Inputs [voltage presence] make / break counter, hold time
- 4: Analog Inputs 0 ... 10V (4)
- 2: Temperature probes -40C … 125C (2)
- 4: Relays / Alerts (4)
- Web Interface
- Device Event logging
- Remote logging
- Control / Command / Status Port / Log Port

The PMC can close relays based upon various configurable conditions.

Conditions include:

1.) Switch count,
2.) Switch ON time (duration),
3.) Temperature,
4.) Analog input voltage.

Alert relay(s) may be configured to energize if and when:

- Counter on switch exceeds a configured threshold,
- Cumulative switch ON time exceeds a configured threshold,
- Analog input voltage exceeds a configured threshold,
- Temperature value exceeds a configured threshold,

The Alert actions may be assigned to any of the relays. Multiple Alerts may be assigned to the same relay. Any Alert event can trigger / energize any of the relays, if desired.

The PMC device subsystems:

8 Counter inputs
2 Analog inputs
2 Temperature probe inputs
4 Alert Relays

The current readings of the PMC can be monitored from a web interface. The interface may be accessed with any WiFi capable device. (PC, Android, Mac, iPhone, Tablets) We used Firefox as the browser device, but all other browsers deliver compatible results.

Pleas note that there is more information on our github page: https://github.com/akostarinc/PMC-Support

Document Revisions:

Fri 12.Feb.2021	PG	Initial
Tue 11.May.2021	PG	Added Serial Sub. Sys.
Wed 19.May.2012	PG	Prep for Doc release
Mon 20.Sep.2012	PG	New Doc release

Product (Development) Revisions: (will be pruned on release[s])

Mon 21.Dec.2020	PG	Initial version.
Mon 01.Feb.2021	PG	Alert Implementation
Tue 11.May.2021	PG, CB	Board Rev, Manual page update
Wed 19.May.2012	PG	Firmware freeze
Tue 1.Jun.2012	PG	Auth admin, bug fixes
Mon 20.Sep.2012	CB, PG	New board rev, Sw logic and

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The Web Interface

The PMC can be connected to with a browser device. All of the PMC functions can be monitored / Controlled from this interface. The home page of the PMC is presented upon initial connection. To see the PMC page, connect to the WiFi access point named PMC-nnnn (nnnn is the device identifier) use

the default pass 12345678) and browse to the page URL 192.168.4.1. Most browsers open this page automatically at successful WiFi connection.

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Counter Readings:

The current activation counter reading as seen by the device at the last page load. An ON/OFF cycle counts as one activation. If you would like to monitor the switches and temperature in Real Time please see the Quick status page.

Input	Name	Maintainance Counter	Total Counts	Alert at	Alert Enabled
1	Counter Input 1	0	0	20	YES
2	Counter Input 2	0	0	0	NO
3	Counter Input 3	0	0	0	NO
4	Counter Input 4	0	0	0	NO
5	Counter Input 5	0	0	0	NO
6	Counter Input 6	1	1	0	NO
7	Counter Input 7	1	1	0	NO
8	Counter Input 8	0	0	0	NO

Part of the home page is presented to the left, depicting the default configuration.

The counters as seen by the PMC at page load.

For real time monitoring click on the ‘Quick Status’ link.

RunTime Readings:

The current time intervals reading as seen by the device at the last page load. This time interval counter starts at the switch activation (ON), and ends at the switch deactivation (OFF). The running total for this input is kept in the Maintainance Time field. The grand total for this input is kept in the Total Time field. The time value is maintained by hours with four digits accuracy. For example the value of 0.0001 represents 0.36 seconds. The internal time value is maintained accurate to the millisecond. If you would like to monitor the time values in real time please see the Quick status page.

Input	Name	Maintainance Time (hours)	Total Time (hours)	Alert at (hours)	Alert Enabled
1	Counter Input 1	0.0000	0.0000	0.0014	YES
2	Counter Input 2	0.0000	0.0000	0.0000	NO
3	Counter Input 3	0.0000	0.0000	0.0000	NO
4	Counter Input 4	0.0000	0.0000	0.0000	NO
5	Counter Input 5	0.0000	0.0000	0.0000	NO
6	Counter Input 6	21.0512	21.0512	0.0000	NO
7	Counter Input 7	21.0480	21.0480	0.0000	NO
8	Counter Input 8	0.0000	0.0000	0.0000	NO

Part of the home page is presented to the left, depicting the default configuration for Time readings.

In this scenario, the duration Alert is enabled for Counter 1 and the switch is held down on counter input six and seven.

Page Navigation

The PMC has multiple pages one can see status with, monitor the PMC real time, and configure all aspects of measurement and Alert. Below, the page menu with short descriptions of all the functions. (If you have a PMC connected to this computer, the links are live)

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Quick (real time) Status

This page shows the current Activation Counter readings and Activation Time lengths, the Analog input Readings, the Temperature readings and relay States as seen by the device real time. This page is updated regularly in a continuous cycle. Please note, that viewing this REAL TIME page, the page's automatic update consumes extra data. (appx. 200 bytes / sec)

The counter and interval readings are shown real time.

Counter And Interval Readings:

The current activation counter readings and activation time lengths seen by the device. This is updated regularly in a cycle. Please make note that viewing this REAL TIME the page automatic update consumes extra data.

Input	Name	Maint. Counts	Maint. Hours
1	Counter Input 1	0	0.0000
2	Counter Input 2	0	0.0000
3	Counter Input 3	0	0.0000
4	Counter Input 4	0	0.0000
5	Counter Input 5	0	0.0000
6	Counter Input 6	1	23.7520
7	Counter Input 7	1	23.7485
8	Counter Input 8	0	0.0000

The analog values have a range of 0 . . 10 V; the 12.xx Volts reading demonstrates the clipping of the analog channel. We chose this as the default display mode, it gives some headroom to the 10V range. (instead of displaying an OOR [OutOfRange] text)

Analog Input Readings:

The current analog input readings as seen by the device. Out of range results are displayed as OOR; These fields are updated regularly in a cycle.

	Input Name	Volts	Percent (to 10V)
1	Analog Input 1	5.14 V	51.39 %
2	Analog Input 2	0.00 V	0.00 %
3	Analog Input 3	0.00 V	0.00 %
4	Analog Input 4	12.86 V	128.57 %

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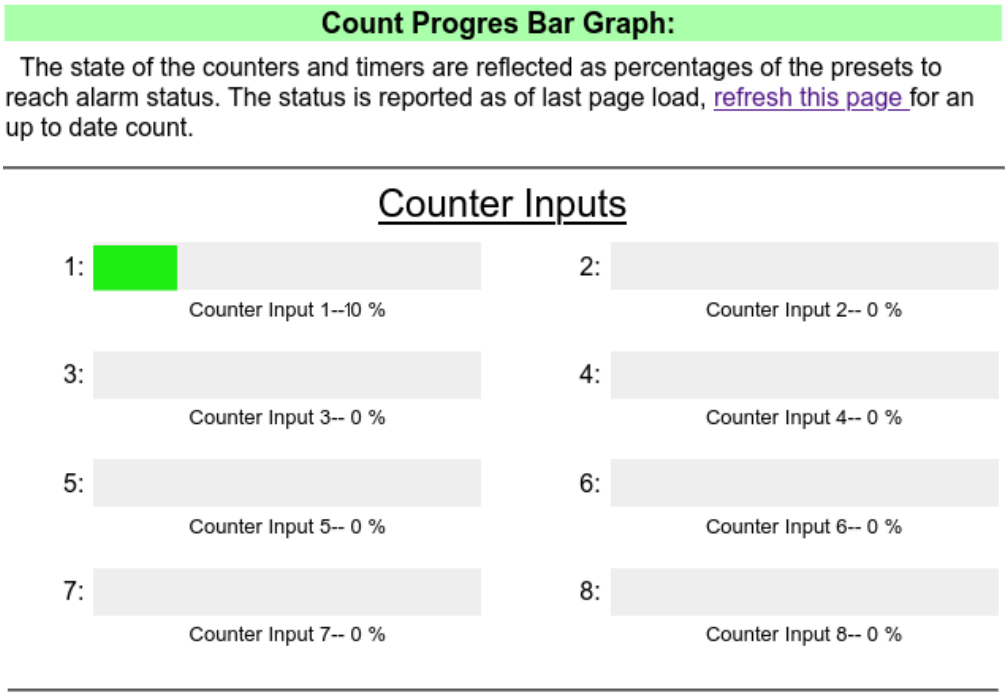
Progress Bar Page

The PMC attempts to be visually easy to read. The following chapter there are sample page fragments from the device:

The screenshot on the right presents the counter progress on the bar graph page.

Similar section exists for the time intervals as well.



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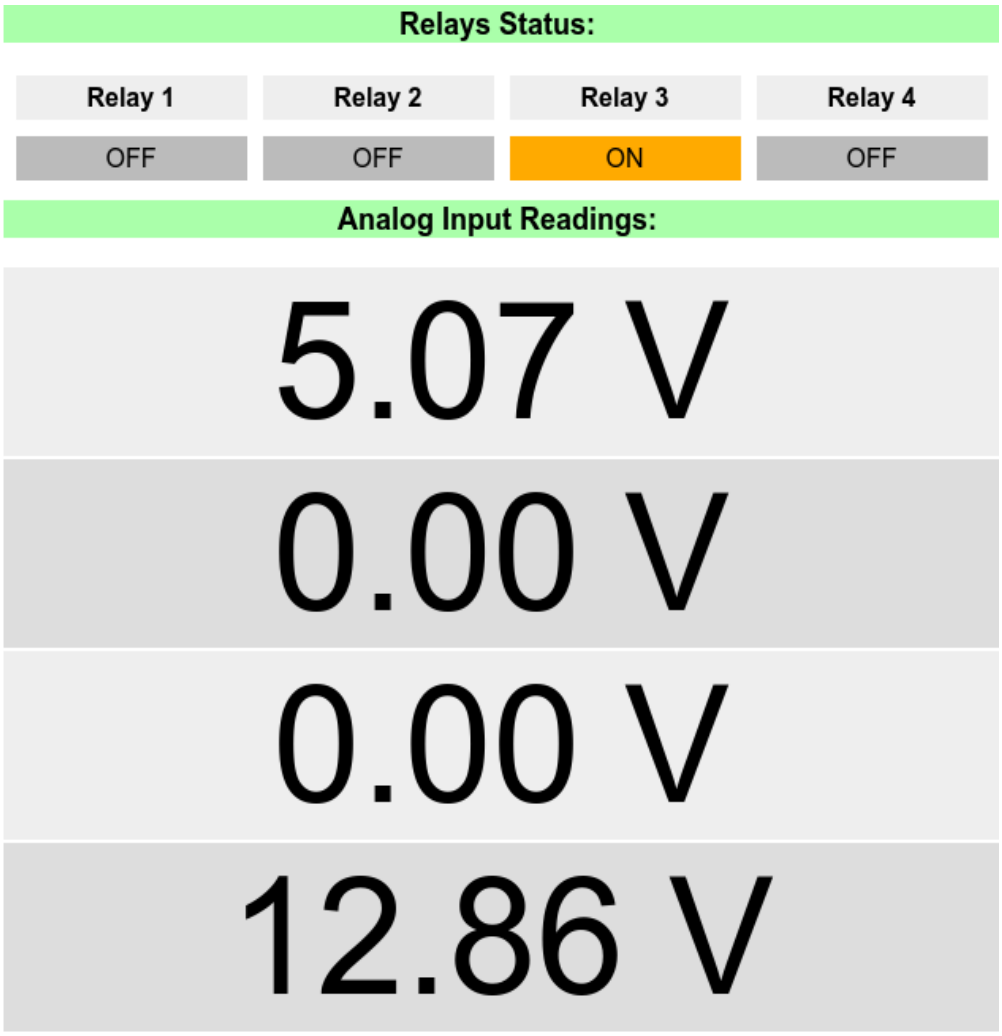
Analog Values and Relay Status Page



Keeping with the visual ease of read, a separate page exists for Relay Status and Analog Read.

This page is updated in real time, thus monitoring the PMC is easy and convenient.

This is a picture from the four analog port version, your dispay may be different.

Please note the clipping analog channel. For testing only. (see more info in the analog section)

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Network Name Setup

This page determines the Station Name and Password of this PMC. The device will appear on your WiFI network by this name. For safety and security, the PMC may be configured with a password of your choosing. The password needs to be at least 8 characters in length or longer. Please avoid using space, punctuation marks and foreign characters. You may use _ (underscore) - (minus) + (plus) sign.

Count / Alert Duration Alert Configuration

This page sets the counter limits and duration limits for all 8 channels / inputs. The alert relay will operate if the counter / duration exceeds a specified value.

Show Logs

Events related to the operation of the PMC are logged into non volatile memory. The PMC logs all Alerts, all switch (power presence) changes, Power ON events, WiFi connection events, Configuration changes. The log stack is 150 deep, events older than that are discarded. Please note, that this log is separate from the main status storage, as that is kept indefinitely.

Boot Count	Event	Params	Notes	Time from Boot
59	LOG_ALERT_CHECK	1	Disabled	12:15:05
59	LOG_ALERT_TRIG	1	Dur-ON	00:00:28
59	LOG_ALERT_TRIG	0	Cnt-ON	00:00:23
59	LOG_WEB_LOGON	1	19	00:00:19
59	LOG_POWER_ON	0	None	00:00:01

Description of columns:

Boot Count: The PMC starts a new log cycle on boot. This can aid in the interpretation of the ‘Time from boot’ field. For instance, if the time of last power on is known, (ex: shift change and/or daily power up) the time of the event can be calculated.

Event: The shorthand notation of the event that happened. The interpretation of the shorthand is intuitive, for instance the LOG_POWER_ON translates to PMC power on event, LOG_ALERT_TRIG translates to alert event triggered and the parameters/notes denote the alarm source and target; line two in the example above: Alert on Relay channel 1, and Duration-Alarm came ON. Note that the counter input number and relay output numbers are zero based.

Params: The parameter(s) attached to the event. The meaning of the parameter is dependent on the event. For example, in most cases, 1 is a substitute for ‘ON’ and 0 is a substitute for ‘OFF’. In other cases parameter is the numeric value attached to the event. See developer’s manual for more information.

Notes: Additional information about the command. For instance Dur-ON signals that the duration counter has triggered a duration ON alert.

Time from Boot: This field is the time elapsed from boot in HH:MM:SS notation. The actual time of event can be calculated from the last power up time plus the ‘Time from Boot’ field. For instance if the last power up time is known (ex: 8 AM, shift start) and the ‘Time from Boot” field is 01:22:00, the time of the event can be deduced as 9:22 AM.

Analog / Temperature Alert Configuration

The analog sensors may trigger an alert, and the analog threshold may be set here. The alert normally triggers when the analog value exceeds the threshold. The reverse alert triggers when the analog value falls below a certain value. This may be used for sensors that provide reversed interpretations of values. (ex. Distance measurement vs. Proximity sensor)

The temperature sensor triggers an alert, and the trigger threshold can be set here. The alert normally triggers when the temperature exceeds the threshold value. The reverse alert triggers when the temperature falls below a certain value. This may be used for freeze warning or refrigeration monitoring. The temperature Alert's settable range is from -50 ℃ to +120 ℃

Analog Sensor calibration

The measured analog values are accurate to +-1%. The calibration values on this page can improve this, by filling in values that are acquired via empirical observation. The configuration values are interpreted as % deviation in the +-5 % range. If larger values entered, the calibration clips it to +-5%;

The calibration method is a three point deviation adjustment. Permitting ‘low’ medium’ and ‘high’ deviation adjustment. It is possible to calibrate the analog inputs to a degree, to act as a precision voltage measuring device. One simple trick is to open up the calibration page on one browser window and the real time measurement page on another browser window, and apply known voltages to the input.

Reset Counts Page

The counters can be reset at any time. The reset action is committed by pressing the "Save Counter Values' button on the bottom of the page. If Alert is set, after resetting the corresponding counter will clear the Alert. The Alert queue is re-evaluated, and the corresponding Alerts are re-issued. The on-board syslog will create a record of the old count with the input number and the time offset.

When clearing **Total Count** and **Total Hours**, an additional Yes/No dialog pops up to confirm clearing of totals.

Input	Name	Maintenance Counter	Total Counts	Maint. Hours	Total Hours
1	Counter Input 1	0 Reset	0 Reset	0.0000 Reset	0.0000 Reset
2	Counter Input 2	0 Reset	0 Reset	0.0000 Reset	0.0000 Reset
3	Counter Input 3	0 Reset	0 Reset	0.0000 Reset	0.0000 Reset
4	Counter Input 4	0 Reset	0 Reset	0.0000 Reset	0.0000 Reset
5	Counter Input 5	0 Reset	0 Reset	0.0000 Reset	0.0000 Reset
6	Counter Input 6	1 Reset	1 Reset	19.9274 Reset	19.9274 Reset
7	Counter Input 7	1 Reset	1 Reset	19.9243 Reset	19.9243 Reset
8	Counter Input 8	0 Reset	0 Reset	0.0000 Reset	0.0000 Reset

The table to the left shows a device that has been accumulating time on inputs six and seven.

Resetting the individual Counter / Hours is intuitive, and the items at the Total fields are protected with an additional ‘Are you sure?’ dialog.

When all desired counters are reset, used the ‘Save Counter Values’ button to commit the changes.

Relay / Alert Assignments

The relay configuration page may be used to route / assign alert events to specific relays. Multiple events can be assigned to the same relay. It is the operator's responsibility to assure that the routing is configured as expected.

Routing is a very powerful mechanism to achieve any combination of sensor *event to alert* route. For instance the four analog inputs can be configured to route to individual relays, giving a four channel analog to relay connectivity. Or one can route any *count alert to any relay*, or all count alerts to a single relay.

The default configuration is to route:

Count_1 to Relay_1	Duration_1 to Relay_2	Analog Input_1 to Relay_3	Temperature Probe_1 to Relay_4

This permits the user to test all subsystems and routing on an out of box PMC unit. To aid initial testing, the PMC comes with the default configuration as stated below. The duration is specified in hours, (0.0014 hours is appx. five seconds)

Relay	Input Condition	Default

Relay #1	Count Exceeds Alert Value	20
Relay #2	Duration Exceeds Alert Value	0.0014 hours
Relay #3	Analog Input. Voltage Exceeds	2.5 V
Relay #4	Temperature Exceeds	30 ℃

The temperature value is chosen to allow the user to test the trigger by holding the probe in hand, and after a couple of seconds, probe heats up above the trigger temperature. Letting go will demonstrate the cool down trigger.

Analog Configuration Page

The analog sensors may trigger an alert, and the analog threshold may be set on this page. The alert normally triggers when the analog value exceeds the threshold. The reverse alert triggers when the analog value falls below a certain value. This may be used for sensors that provide reversed interpretations of values. Additional parameters can be found on this page, to tailor the response of the analog sensor.

1.) Adding hysteresis. The trigger point of the analog sensor may be configured with a hysteresis value. This is applied digitally to the current trigger point, increasing it on up slope, decreasing it on down slope. [Much like a Schmitt Trigger] The range of configurable hysteresis is 0 .. 1 V.

2.) Low pass filtering. The input signal can have a low pass filter applied to it to smooth out transients. This is also applied digitally, and the Filter coefficient can be specified. The range of filter coefficients are 1 … 6, with 1 as no filtering, an 6 is maximum filtering. The filter coefficient of 6 yields about 3 seconds settling time. (Measured on up / down slope to 90% of settled diff.)

On Device Quick Start Manual

This page is consise on-device manual to aid the user in setting up and using the PMC.

Device Reboot

Rebooting (restarting) the device has no effect on the counters and relay statuses. These will be restored upon boot. The alerts resume according to the current state of the device. There is a short time period, while the device is booting, where the relays are de-energized. The device boot timing is 600 msec to chip boot, 1900 msec to WiFi readiness op and 2100 msec to restoring all status / alert relays.

Please note, that – dependent on the browser device - the PMC may need to be reconnected to the browser to continue viewing the built in web page. Upon reconnection, a page refresh will deliver up to date information, and the real time page will resume delivering data.

Inputs, Counter Counts, Durations

The PMC measures activation count and activation duration. This is achieved by monitoring inputs. The inputs are opto isolated and high voltage tolerant. The input is active when voltage is applied to it. In the remaining of this document, we call this the ON cycle. When the voltage removed, we call it the OFF cycle. One ON / OFF cycle counts as one activation. The counter is incremented at the cycle completion. The log output is delivered on the at the ON cycle.

Inputs and Counters

The current activation counter values as seen by the device. The log output is delivered on the ON part of the cycle. The counter value is kept in the Maintenance Counter field, the total count is kept in the Total Count field. The Total counters have separate reset facilities, so the total count can be retained for the monitored device.

Inputs and Duration

The current time interval reading as seen by the device. This time interval counter starts at the switch activation (ON), and ends at the switch de-activation (OFF). The running total for this value is kept in the Maintenance Time field. The grand Total for this input is kept in the Total Time field. The time value is maintained by hours with four digits accuracy. For example the value of 0.0001 represents 0.36 seconds. This time / duration value is maintained with millisecond accuracy.

The device is capable of generating duration Alerts real time, even in the middle of an ON cycle. This might be useful for inputs that are always ON or mostly ON. The Total durations have separate reset facilities, so the total count can be kept for the monitored device.

Analog Measurements

The four analog inputs have a 12 bit resolution and range from 0 … 10 V; The sampling time is 250 milliseconds. The analog measurement has adjustable hysteresis and a configurable low pass filter. The analog measurements are equipped with threshold detector, which can be assigned to any of the relays. It is feasible to assign the four analog input to the four relays, creating a four channel analog alert device.

Triggers, thresholds, filters

The alert can be triggered by voltage exceeding the configured threshold, or - in reverse mode - triggered by voltage lower than the threshold. The trigger has additional options: 1.) hysteresis and 2.) low pass filter. These configuration properties are detailed in the analog configuration section.

Measurement Accuracy

The voltage measurement is accurate to 1%. The voltage calibration is done by the manufacturer as a two point calibration process at 1V and at 10V, covering the whole measurement range.

The voltage measurement accuracy can be improved by a user accessible calibration. This configuration can be done as a three point calibration, refining the measured values and linearity even further.

The *open circuit* analog inputs display a small fluctuating value of tens of millivolts, consistent of incidental voltage on any probe. It is the same phenomena that is observable on any multimeter / oscilloscope. If this phenomena is undesirable, one may configure the low pass filter of the input for filtration of the artifact. The noise phenomena does not occur if the input is connected to a voltage source.

Measurement Limits

The Analog Input has a nominal range 0 .. 10 V. Enough accuracy to cover the range of 0 .. 5 V with precision. The maximum voltage the Input can measure is 12.5x V (+-0.4V), at which the A2D clips. After the clipping voltage, the A2D saturates and the measured value stays at this clipping voltage. We do not display any ‘out of range’ messages, it is the operators responsibility to interpret the incoming voltage measurement. The A2D linearity is within specification, all the way to saturation.

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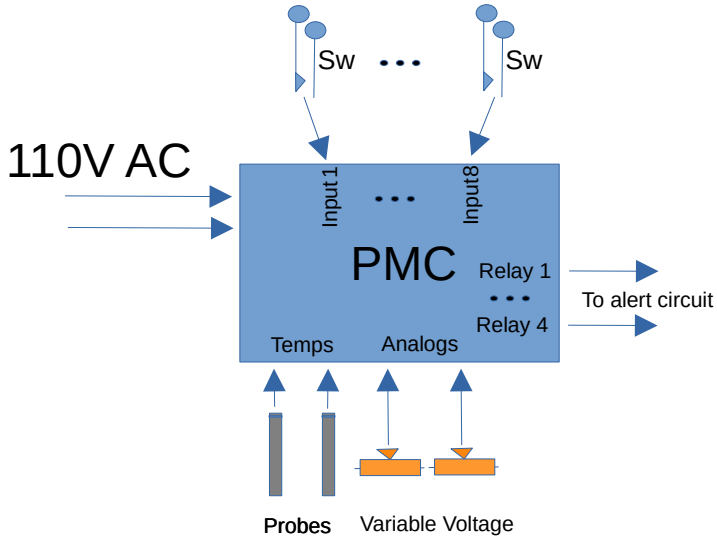
Deploying the PMC

The PMC needs 110Vac power to function. It continuously monitors its inputs, and stores counts and durations. It monitors temperature and analog voltage. It operates the alarm circuits as configured on the alarm(s) and router pages.



The figure on the left depicts a high level overview of the PMC electrical deployment. The actual wiring reflects that the inputs are configured to read the presence of 110Vac signal, these 8 high voltage inputs are opto-isolated from the rest of the circuit

The outputs are relay contacts, dry, volt-free, that are electrically isolated from the power supplied to the PMC

The Temperature and Analog inputs are connected to device ground, which is independent from frame ground.

Input Specifications

Category	quantity	Nominal	Max
Switch inputs:	8	110Vac	as rated
Temperature Inputs:	2	(-20 ... 100)C	as rated
Analog Inputs:	2	0 … 10 Vdc	12Vdc

Output Specifications

Category	quantity	Nominal	Max
Relay Outputs:	4	110Vac 10 A, Res.	as rated

Administering the PMC

The PMC parameters may be viewed by all logged in users. These same parameters can only be changed by logged-in administrators. If you would like to administer the PMC device (like resetting counters, changing counter thresholds ...) please go to the ‘Admin Authentication’ Page and enter the Administrator’s password. (by default, the admin pass is the same as the default WiFi pass)

A shortcut here, is that one may use a different browser tab / window to log in as administrator. Then switching back to the original page allows editing / saving the changed parameters.

Once the PMC Admin is successfully authenticated, all the save buttons become active, and new parameters may be saved. The PMC admin authentication has a two step implementation, step one is browser (submit) button enable/disable, and the second step is the on-device authentication.

Securing the Admin credentials

Securing the PMC administrator's password may be done from the ‘Admin Configuration’ page. On the Admin Config page, a new password can be assigned. Knowledge of the old password is needed, so the admin function authenticationis traceable. If the admin credentials have never been changed, the default PMC admin pass is the same as the default WiFi pass.

Please note, that the admin name field is not significant, only the password. However it is stored for future expansion.

Input De-bounce Config

When a switch closes / opens it emits significant amount of mechanically induced bouncing artifacts. This happens as the contacts mate, and bounce as a mechanical resonator. While this bounce is in the milli seconds range, microcomputers are able to respond to this fast artifact. De-bounce filtering is needed to compensate.

As different switches have different properties, the PMC can be adjusted to compensate for longer de-bounce. On the ‘Input De-bounce Config’ page there is a timing adjustment, that accounts for the large majority of switches. The minimum de-bounce delay is 40 mSec and the maximum is 1000 mSec (one second) Please note, the the longer the de-bounce time, the more sluggish the PMC’s input response feels. Please set this to be as short as needed, but not shorter. The manufacturer’s default (50 mSec) has been carefully chosen to accommodate all but the most extreme cases.

SysLog Extensions

The syslog has new additions in the form of counter backup. If someone erases the counters by way of super long press reset, the syslog makes note of the old values of the counters. This is in case of accidental erasure or an out of order reset.

The logged items (as an example) are:

Boot Count	Event	Params	Notes	Time from Boot
193	LOG_RESET_DURA	8	0.0000,	00:41:18
193	LOG_RESET_DURA	7	0.0000,	00:41:18
193	LOG_RESET_DURA	6	0.0000,	00:41:18
193	LOG_RESET_DURA	5	0.0000,	00:41:18
193	LOG_RESET_DURA	4	0.0064,	00:41:18
193	LOG_RESET_DURA	3	0.0000,	00:41:18
193	LOG_RESET_DURA	2	0.0047,	00:41:18
193	LOG_RESET_DURA	1	0.0868,	00:41:18
193	LOG_RESET_COUNT	8	0	00:41:18
193	LOG_RESET_COUNT	7	0	00:41:18
193	LOG_RESET_COUNT	6	0	00:41:18
193	LOG_RESET_COUNT	5	0	00:41:18
193	LOG_RESET_COUNT	4	0	00:41:18
193	LOG_RESET_COUNT	3	0	00:41:18
193	LOG_RESET_COUNT	2	68	00:41:17
193	LOG_RESET_COUNT	1	20	00:41:17
193	LOG_DEEP_RESET	2477	Initiated	00:41:17
193	LOG_LOG_CLEAR	2477	Cleared	00:41:17

Please pay no mind of the actual values in this table, these where created during test / development.

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Diagnostic Indicator Lights (LED's)

The device is equipped with five LED's visible on the top panel.

The **first** LED is the Power LED, lit up as soon as power is applied to the unit. There are additional LEDs inside the unit, to aid in diagnostic. This is illuminated when 110V power is present.

The **second** LED is the 'Heart Beat'. This turns on and off with an approx one second period. This indicates that the CPU is operational.

The **third** LED is the event LED. This blinks when an external event is taking place. For instance it blinks when an external voltage is applied, and blinks when an external voltage is removed. The intent of this LED is to have a visual indication on applied events.

The **fourth** LED is the 'Configuration' LED, it blinks when a browser device is connected. The PMC can have four browser devices connected simultaneously. Reading PMC values operates the same as if one browser present, however updating configuration at the same time will result in the last update overwrites all previous ones.

The **fifth** LED is the 'Alert' LED, and it flickers when an alert is triggered. The number of flickers contains a hint of the subsystem that triggered the alert. One blink for Count Alert, two for Duration Alert, three for Analog alert, four for Temperature alert.

Button Codes

The push button on the top of the unit may be used to operate different aspects of the PMC. There are three allocated functions that those buttons do. 1.) Soft reset 2.) Hard reset 3.) Device erase;

Following, is a table of button presses and the functionality they map to. Not all button codes have functionality, but this may change in the future.

Button Press Code	Function	Notes
Single Click	No function	
Double click (2x)**	No function	May assign functionality in the future
Triple Click (3x)***	Soft reset	Reboot without any side effects; Relays restore as the status of the device prescribes it.
Quad Click (4x)	Manufacturer's Relay Self Test	Relays click ON and then OFF in 500 mSec steps. May be used to test the alarm circuits.
Long click	Reset all settings; WiFi passes and Wifi Access point name.	Hold button for 10+ seconds, then release it; System reboots.
Super Long click	Reset all settings, as above and erase all data from long term on board storage. This function erases everything and restores original manufacturer's default.	Hold button for 20+ seconds, release it. System reboots. The old counter values are saved in the syslog.

** Like the double click on a computer mouse
*** Like the (double) click on a computer mouse, but three times;

Command Line

The PMC can be controlled from the serial port / terminal on board. It also responds to status queries, and can emit status change events in the form of a serial string. The command line offers insight to the device's particulars, allows the user to query the state of the device, and to collect data form the operation of the device. The command line offers a built in help, that lists all the commands and a brief description of its command functions.

The commands

Command name	Description	Notes
help	Print the list of registered commands.	This table is an extract of the frequently used commands. See the real device's response for a complete, up to date list.
verbose	Set verbosity	Verbosity level (0=None, 10=max) This prints all

		sorts of internal workings information.
erase	Erase all settings	Will prompt the user for y/n confirmation before deleting anything.
counters	Show counter values	
analogs	Show analog values	
temps	Show temperature values	
Alerts	Show Alert status	Synonym for Relay Status
rtalarm	Toggle Alert real time to serial	By default, the PMC emits a line when an Alert status is changed. This will toggle that message delivery ON/OFF.
rtcounter	Toggle counter real time to serial	By default, the PMC emits a line when a switch status is changed. This will toggle that message delivery ON/OFF.
nvs	Show nvs details	Internal
stat	Show device details	This is the sum of counters, analogs, temps, Alerts in human readable text form. Please see attached utilities for parsing this string.
conf	Show device configuration	This is the list of all alarm thresholds.
smart	Turn on smart command line. Enables command recall, command completion.	This is OFF by default so the serial utilities are not misled by the smart console output / escape sequences. Device reboot will reset this to default.
?	Short help	Displays the a short list of commands available.

The PMC device can be queried in a loop to achieve a similar effect than that of the remote logging. The advantage of the wired communication is increased reliability and simpler implementation. See the logging chapter for more info.

There are additional commands implemented. They can be queried from the command line with the ‘help’ function. The ‘?’ command produces a short list of frequently used commands.

Stat command example

Below, is an example response from issuing the ‘stat’ command:

Current counter values:
Counter 1 Count: 40 Hours: 0.0021
Counter 2 Count: 0 Hours: 0.0000
Counter 3 Count: 0 Hours: 0.0000
Counter 4 Count: 0 Hours: 0.0000
Counter 5 Count: 0 Hours: 0.0000
Counter 6 Count: 0 Hours: 0.0000
Counter 7 Count: 0 Hours: 0.0000
Counter 8 Count: 0 Hours: 0.0000
Current analog values:
Input 1 Value: 2.2495
Input 2 Value: 0.0000
Current probe temperatures:
Probe 1 Value: 25.5000
Probe 2 Value: 25.5000
Current Alert (relay) status:
Relay 1 Value: 1 ON
Relay 2 Value: 1 ON
Relay 3 Value: 0 OFF
Relay 4 Value: 0 OFF

The above values can be parsed easily for individual fields. Pseudo code for parsing: 1.) break into space separated fields. 2.) check for sub-system string in the first field (ex: “Input”) use field two for index, field four for value. (see attached sample code for parsing or on our github.com page github.com/akostarinc/pmc)

Wiring the Serial connection

The serial connection is exposed on the RF board next to the microprocessor. The pin-out of the connection: Pin0→Ground Pin3→Tx Pin4→Rx . The serial port is NOT galvanically isolated from the CPU, but it is isolated from the Power Leads and the Counter Inputs. The cable coming from the serial port is marked appropriately.

Unexpected power loss procedure

The PMC will save event counts and durations to permanent memory as soon as they occur, and are complete. Incomplete event counts have a timeout expectation of five seconds before they are saved. For instance, when an ON event (without an OFF event) occurs, the duration of the event is logged every five seconds. The unexpected power loss can only effect the time reading - at most - by five seconds.

Temperature measurement

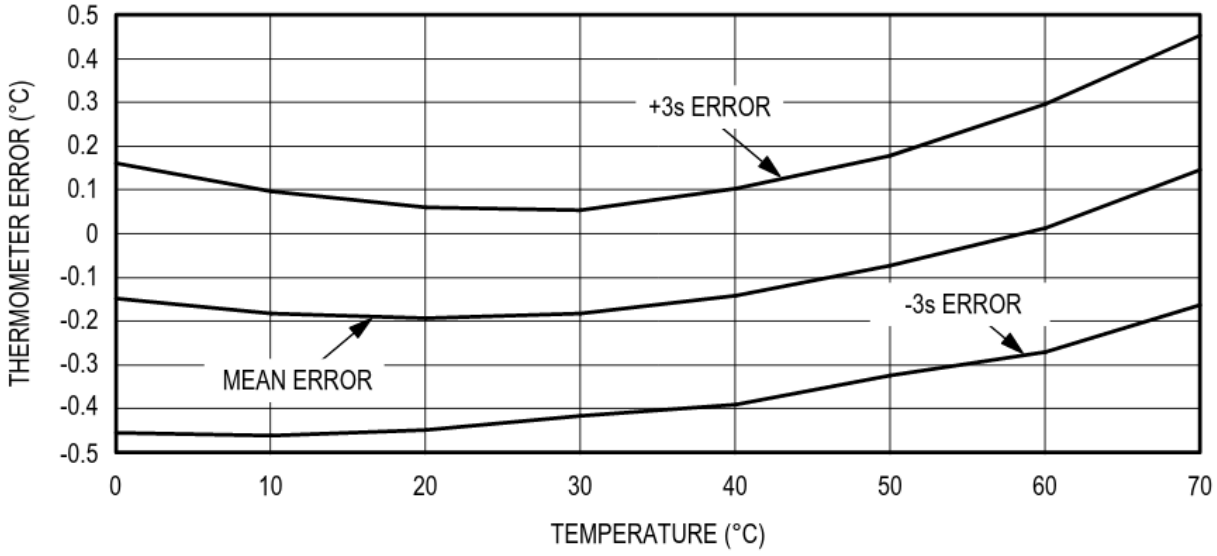
The temperature measurement operates with two DS18B20 devices. These measure temperature in the range of -55 °C to +125 °C with a 0.5 °C accuracy. On the PMC, Probe 1‘s default configuration is set is set to 30 °C, so the temperature alert can be triggered by hand.

The measuring device specifications:

Operating Temperature Range ……...-55°C to +125°C
Measurement accuracy …….. ±0.5°C from -10°C to +85°C
PMC Alert Temperature Range ……....-50°C to +120°C
PMC Temperature Meas. Cycle ……..…950 milliseconds / Channel
PMC Temperature Settling Time ……..…530 milliseconds / °C (naked probe)
PMC Temperature Measuring resolution …….. 12 bits full range

Temperature Probe Performance curve

Temperature measurement accuracy performance curve:



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Alert Configuration

The Alert events may come asynchronously from four different subsystems, most with multiple sources. To afford the most flexibility, one can assign any **of the Alerts** to any of the **Relays**.

Assignments / Routing

The Alert is assigned to four different routing targets, or Relays. The routing table has the capacity to connect any of the Alert sources to any of the Alert targets. The configuration screenshots below depict the default PMC routing configuration.

Counter / Duration Alert Routing / Assignment

When checked (enabled) , the relay is triggered by inputs exceeding configured count. For instance, on the table to the right: Input 1 will trigger Relay 1

Relay Routing / Counts:

These relay events are triggered when the counter **count** matches or exceeds the configured threshold values. The alarm is triggered at the completion of the cycle. (At the break section of the make/brake cycle) The alarm will automatically reset when the alarm condition ceases. As multiple sources can trigger / reset the alarm, the alarm state will be as instructed by the last event.

Relay	Input 1	Input 2	Input 3	Input 4	Input 5	Input 6	Input 7	Input 8
Relay 1	☑	☐	☐	☐	☐	☐	☐	☐
Relay 2	☐	☐	☐	☐	☐	☐	☐	☐
Relay 3	☐	☐	☐	☐	☐	☐	☐	☐
Relay 4	☐	☐	☐	☐	☐	☐	☐	☐

The relays may be triggered by any of the inputs exceeding configured duration. On the table to the right, exceeding Duration 1 will trigger Relay 2.

Same interpretation should be applied for all of the inputs / relays.

Relay Routing / Intervals:

These are the relay events when the **interval (duration)** exceeds the configured threshold values. The relay is triggered real time at the time point specified on the alarm / time configuration page. The alarm will automatically reset when the alarm condition ceases. As multiple sources can trigger / reset the alarm, the alarm state will be as instructed by the last event.

Relay	Input 1	Input 2	Input 3	Input 4	Input 5	Input 6	Input 7	Input 8
Relay 1	☐	☐	☐	☐	☐	☐	☐	☐
Relay 2	☑	☐	☐	☐	☐	☐	☐	☐
Relay 3	☐	☐	☐	☐	☐	☐	☐	☐
Relay 4	☐	☐	☐	☐	☐	☐	☐	☐

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Analog / Temperature Alert Routing / Assignment

On this screenshot Relay 3 will be energized if Analog 1 exceeds configured threshold.

Relay Routing / Analog:

These are the relay events when the **analog input** value exceeds the configured threshold values. The relay will automatically de-energize if the analog value is below the threshold.

Relay	Analog 1	Analog 2	Analog 3	Analog 4
Relay 1	☐	☐	☐	☐
Relay 2	☐	☐	☐	☐
Relay 3	☑	☐	☐	☐
Relay 4	☐	☐	☐	☐

On this screenshot Relay 4 and 4 will be energized if any of Temp 1 exceeds threshold

Relay Routing / Temperature:

These are the relay events when the **temperature** value exceeds the configured threshold values. The relays will automatically de-energize if the temperature value is below the threshold.

Relay	Temp 1	Temp2
Relay 1	☐	☐
Relay 2	☐	☐
Relay 3	☐	☐
Relay 4	☑	☐

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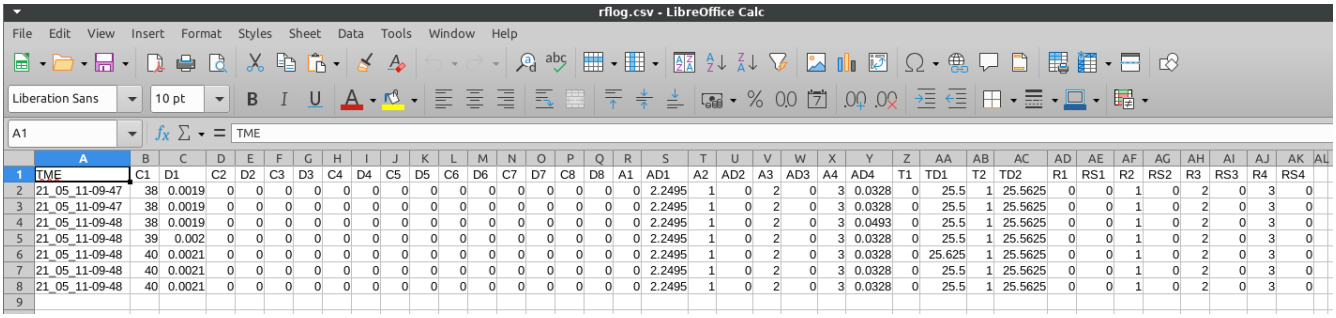
Remote Event logging

The PMC has remote event logging capability. Once the PMC is connected to a browser device (Computer … PC/MAC/Linux/Android/IOS) requesting the file 'csvdata.txt' contains a current snapshot of the device data. The data can be captured by simply requesting it over HTTP; or can be queried from a script, or queried unattended. Like below: (wget is open source and available for all platforms)

wget -q 192.168.4.1/csvdata.txt -O - >> $LOGFILE

The resulting file is pictured below, loaded into a spread sheet. The csvdata.txt delivers one record at a time, and formats it into a friendly, CSV format. (the screen shot below was taken in LibreOffice)



TME	C1	D1	C2	D2	C3	D3	C4	D4	C5	D5	C6	D6	C7	D7	C8	D8	A1	AD1	A2	AD2	A3	AD3	A4	AD4	T1	TD1	T2	TD2	R1	RS1	R2	RS2	R3	RS3	R4	RS4
21_05_11-09-47	38	0.0019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2495	1	0	2	0	3	0.0328	0	25.5	1	25.5625	0	0	1	0	2	0	3	0
21_05_11-09-47	38	0.0019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2495	1	0	2	0	3	0.0328	0	25.5	1	25.5625	0	0	1	0	2	0	3	0
21_05_11-09-48	38	0.0019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2495	1	0	2	0	3	0.0493	0	25.5	1	25.5625	0	0	1	0	2	0	3	0
21_05_11-09-48	39	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2495	1	0	2	0	3	0.0328	0	25.5	1	25.5625	0	0	1	0	2	0	3	0
21_05_11-09-48	40	0.0021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2495	1	0	2	0	3	0.0328	0	25.625	1	25.5625	0	0	1	0	2	0	3	0
21_05_11-09-48	40	0.0021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2495	1	0	2	0	3	0.0328	0	25.5	1	25.5625	0	0	1	0	2	0	3	0
21_05_11-09-48	40	0.0021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2495	1	0	2	0	3	0.0328	0	25.5	1	25.5625	0	0	1	0	2	0	3	0

The header of the CSV format is outlined in the first line. This first line contains:

TME, C1, D1, C2, D2, C3, D3, C4, D4, C5, D5, C6, D6, C7, D7, C8, D8, A1, AD1, A2, AD2, A3, AD3, A4, AD4, T1, TD1, T2, TD2, R1, RS1, R2, RS2, R3, RS3, R4, RS4,

The Comma Separated Values (CSV) line

The default output format of the PMC is Comma Separated Values (CSV). This lends itself to easy import / export. It is outputted in a line oriented format, and contains the following fields:

- Current time (of capture) [TME]
- Switch closure Counter values [C1 .. C8]
- Switch hold / Duration time in hours [D1 .. D8]
- Analog Channel Number [A1 .. A4] (please note that the 2 channel version has zeros at the end)
- Analog Channel Data [AD1 .. AD4],
- Temperature channel Number [T1 .. T2]
- Temperate channel Data [T2 .. TD2]
- Relay number [R1 .. R4]

- Relay State [RS1 .. RS4]

The CSV contains one snapshot per line. The lines pictured above are acquired by the following script:

```
#!/bin/bash
# Script to monitor PMC status, and create a log file
# Written for Linux, but same programs are available for windows.
# Use resulting file in a spreadsheet.
# Results are in LOGFILE

LOGFILE=rflog.csv

# Period of reading is derived from $SLEEP in seconds

SLEEP=10

echo TME, C1, D1, C2, D2, C3, D3, C4, D4, C5, D5, C6, D6, C7, D7, C8, D8, A1, AD1, A2, \
AD2, A3, AD3, A4, AD4, T1, TD1, T2, TD2, R1, RS1, R2, RS2, R3, RS3, R4, RS4, > $LOGFILE
echo "Log started, saved to $LOGFILE. Stop with Control-C"
while [ 1==1 ] ;
do
   echo -n "`date +%y_%m_%d-%H-%M-%S`, " >> $LOGFILE
   # Get the latest table, append to file
   wget -q 192.168.4.1/csvdata.txt -O - >> $LOGFILE
   # Adjust for desired sampling frequency in $SLEEP (in seconds, floating point OK)
   sleep $SLEEP
done
#  E0F
```

Please note that the above script is operating on Linux, the windows version is stated below:

```
@echo * Log started, saved to rflog.csv - Stop logging with Control-C
:again
   rem # Get the latest table, append to file
   wget -q 192.168.4.1/csvdata.txt -O - >> rflog.csv
   rem  # Adjust for desired sampling frequency (in seconds)
   sleep 10
goto again
rem # EOF
```

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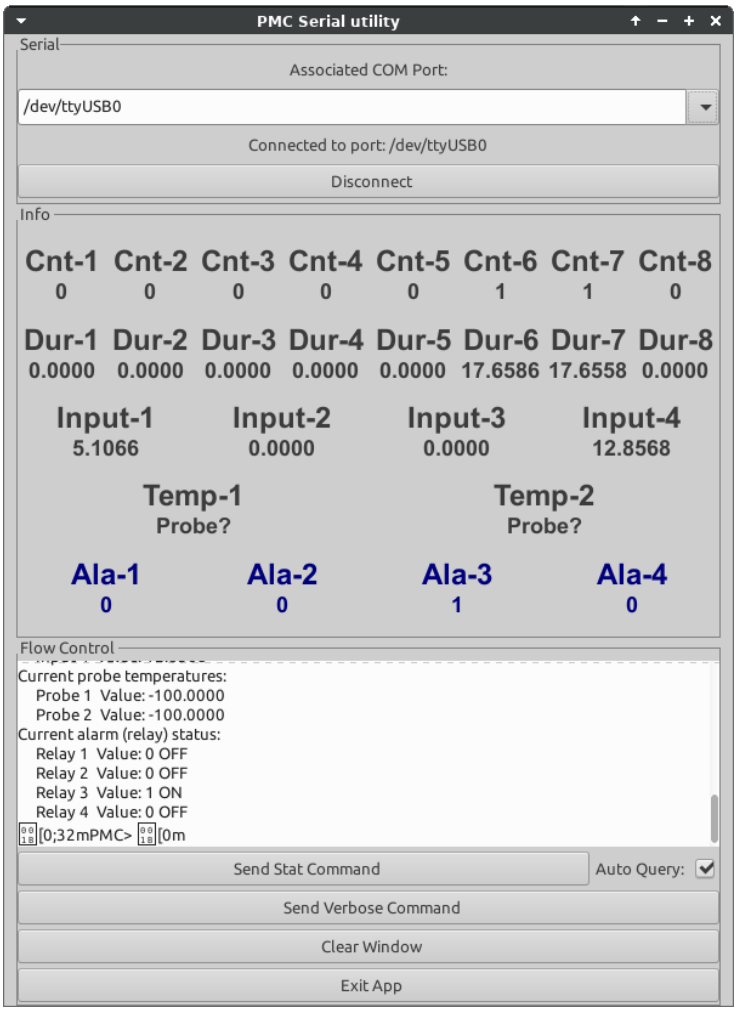
Serial Monitor Utility

The PMC is equipped with a serial port, and can be monitored with said port. Referring to the ‘Command Line’ section, one can issue several commands that deliver PMC status. For instance, issuing the ‘stat’ command results in the PMC outputs its status on the terminal.



The screenshot to the left is a picture of a small utility that captures the PMC’s stat output, and outputs it in an easy to read format.

Aside from monitoring it visually, one may print or save any value coming from the PMC. Because the attached computer has a built in time mechanism, the real time occurrence of the event can be noted. This service is similar to the over the air log subsystem, with the distinction of attached physical wires for more reliability.

The logging utility is written in python, and its source is included with the PMC. Please note, that this example code carries no fitness for purpose assumptions, no warranty, delivered as is.

Connecting the serial port is relatively straightforward; only ground, the TX pin and the RX pin is needed. Please be aware of possible ground connectivity issues between the monitor device and the PMC. For qualified personnel only.

The screenshot above was created in Linux, but the used tools are multi platform. One may recreate this utility in Windows, Linux, Mac …. [Source code on attached jump drive]

Real time serial outputs

While the PMC is operating, it outputs the following serial sequences: a.) Count change event b.) Duration change event c.) Relay change / Alert event d.) Analog alert change event e.) Temp alert change event. These then can be parsed, and utilized for logging / control / statistical purpose. For example, operating the PMC at the default settings, the following strings are output:

- Count changed input=0 count: 20
- Alert to relay 0 from Count - 1 ON
- Alert to relay 1 from Duration - 1 ON
- Alert to relay 2 from Analog - 1 ON
- Alert to relay 2 from Analog - 0 OFF
- Alert to relay 3 from Temperature - 1 ON
- Alert to relay 3 from Temperature - 0 OFF

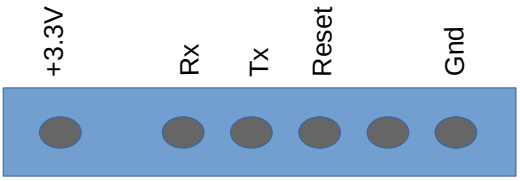
Please note that the counter inputs and relay numbers start form zero.

If required, the command line can enable / disable the emission of these output strings. The ‘rtalarm’ and ‘rtcounter’ commands toggle the display of these real time messages ON / OFF. Below a sample session of turning it off.

```
PMC> rtcounter
New counter real time serial status: 0 (OFF)
```

Serial Port Connection Pin-out

To access the debug port for additional information coming out of the PMC, one may connect to the serial header within the device. This header is located next to the on-board processor, and contains the serial port connections. These are standard 1/10th inch (2.54 mm) pitch female pin headers.



Please note, the the Rx and Tx are denoted from the chip’s perspective, the Rx Tx lines may need to be cross connected to the DTE device. The other pins can be safely left unconnected.

Summary

The PMC device fulfills many functions aiding scheduled maintenance. If you find a function that misses the intention of the maintenance prediction, or if you think of a function that would improve overall device usefulness, please let us know.

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