Features of KS Power Pallet v1.11

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I. Component Control Logic

The PCU control logic monitors the reactor temperature and pressure, oxygen sensor reading, engine oil pressure, engine state, fuel level switch state, and auger current. If there are errors, the logic has the ability to shake the grate, reset the oxygen sensor, reverse the auger, shut down the engine, turn the auger off, and sound an alarm.

The user has the ability to change some of the values from the factory defaults through the menu display. Other change in the code can be made and uploaded to the board if desired.

Below is a chart of the errors that are displayed and the action taken by the system.

Displayed Alarms and System Responses

Alarm Name Displayed	Time till Alarm	System Action	Alarm Advice Displayed
Auger on too long	4 min	Auto Engine Shutdown at 6 min	Check Fuel
Auger off too long	8 min	Auto Engine Shutdown in 10 min	Bridging?
Bad Reactor P_ratio	immediate	Bad pressure ratio: >60 or <30 (0.6, 0.3). No action.	Reactor Fuel Issue
tred low for eng.	immediate	Engine on and temperatures below 790°C (hystersis between 790-800°C). No action.	Increase Load
bred high for eng.	immediate	Engine on and temperatures above 950°C (hystersis between 900-950°C). No action.	Low Fuel in Reactor?
Check Oil Pressure	immediate	Auto engine shutdown after 0.5 sec. Note: first 3 seconds during engine start up ignored	Check Oil Pressure
No O2 Sensor Signal	0.25 sec	Reset oxygen sensor at 0.25 sec Auto engine shutdown after 60 sec.	No O2 Sensor Signal
Auger Low Current	1 min (fuel level switch off) or 4 min (fuel level switch on).	Auto engine shutdown after 3 min (fuel level switch off) or 6 min (fuel level switch on).	Check Fuel
FuelSwitch/Auger Jam	Alarm at 10 auger fwd/rev cycles	Auto engine shutdown at 20 auger forward/reverse cycles	Check Fuel & Switch

The display will allow for multiple alarm conditions. If multiple alarm conditions are present, menu shows alarm count in the upper right corner. Time before shutdown is shown as a countdown on the display. Alarms that have not caused an automatic engine shutdown can be unset by removal of the alarm condition. Silencing of the alarm is allowed and turns off both the alarm and the red light. Any new alarm conditions will turn the alarm back on.

Notes About Component Logic:

- **Fuel Auger Current Sensing**
  The system senses the current draw of the auger motor and times the auger state to detect possible errors in feedstock transport.
- **Reactor Conditions**

The temperature and pressure ratio of the reactor are monitored. An error for exceeding below the minimum temperatures when the engine is running is alarmed due to the increase of tar that may be present in the gas stream at low temperatures.

  The pressure ratio between the combustion pressure (P_comb) and the reactor pressure (P_reac) is monitored and the grate is shaken at the specified values. If the grate is unable to purge the grate, an error state will be in effect. Manual inspection and cleaning of the grate may be needed.

- **Engine Oil Pressure**
  Low pressure reading for the first 3 seconds of running (startup) is ignored. For the 20kW PowerPallet, the low-pressure threshold is user configurable. The 10 kW PowerPallets use an oil pressure switch.
- **Oxygen Sensor and Mixture Control**
  In the case that there is a loss in signal from the oxygen sensor, the logic will attempt to reset the sensor while maintaining the mixture servo at the last position until signal returns to continue   normal operation.
- **Engine Control**
  - **Automatic Shutdown**
  When there is an automatic shutdown, the cause remains on display and the system will not resume until reset by the user via the control panel. Shutdown causes are persistent on the display after automatic shutdown for the user to view. Reset is required to clear the screen.
  - **Mixture on Shutdown**
  For engine shutdown either manually or automatic, the air mix servo will maintain the last servo angle for 2 seconds, fully opens, and then seals valve after a total of 4 seconds. The engine can not be restarted during this 4 second shutdown.

II. Functional Description
of Menu Screens and Values

Splash

```
KS GCU V 3.0
www.allpowerlabs.org
VVVVV
```

V - software version

Reactor

```
Ttred  TTT   Pcomb PPP
Tbred  TTT   Preac  PPP
Pratio RRR   Pfilt    PPP
Aug   AAA
```

T - temperature in °C
R - pressure ratio - Pcomb/Preac
A - time in seconds since auger has been in state
P - pressure in units of 0.1 inches of water (e.g. 10 is 1 inch of water (1 inWC))

Lambda

```
LamSetSSS LambdaLLL
P    PPP     I    III


|NEXT  ADV   +     -
```

SSS - lambda setpoint (lambda * 100)
   Default: 1.05
   Note: Setpoint should not be decreased below ~1.0 or above ~1.1
LLL - current lambda reading (lambda * 100)
PPP - lambda PID P value (P * 100)
   Default: 0.13
III - lambda PID I value (I * 100) (PID D value is 0, so control loop is actually PI)
   Default: 1.00
Note: Manual PID tuning can be difficult, only adjust if you understand how it works.

Keypad:
1 - NEXT - Go to next menu
2 - ADV - Go to next menu item (LamSet/P/I)
3 - + - increase menu item value
4 - - - decrease menu item value

Grate

```
GraMinLLL  GraMaxHHH
GraLenSSS   Grate MMM

NEXT  ADV    +      -
```

L - Grate Minium Interval - min interval (sec) between grate shakes while reactor is running
H - Grate Maximum Interval - max interval (sec) between grate shakes while reactor is running
S - Grate Shake Length - length of grate shake (sec)
M - Grate Manual Control State - (ON/OFF)

Keypad:
1 - NEXT - Go to next menu
2 - ADV - Go to next menu item (GraMin/GraMax/GraLen/Grate)
3 - + - increase menu item value
4 - - - decrease menu item value
3 - ON - turn grate on
4 - OFF - turn grate off

Servo

```
ServoMinLLL  Max HHH
    Careful of Sides!

|NEXT  ADV   +     -
```

L - Servo Minimum (Closed) - min servo mixer angle (degrees)
        Note: Should be adjusted to the angle where the valve is fully closed, and then backed
        off a few degrees to avoid a mechanical stop which can damage the servo
H - Servo Maximum (Open) - maximum servo mixer angle (degrees)
        Note: Should be adjusted to the angle where the valve is fully open, and then backed off
        a few degrees to avoid a mechanical stop which can damage the servo
Note: Menu is not available while engine is running

Keypad:
1 - NEXT - Go to next menu
2 - ADV - Go to next menu item (ServoMin/ServoMax)
3 - + - increase menu item value
4 - - - decrease menu item value

Calibrate Pressure Sensors

```
Calibrate Pressure
Sensors to zero?


NEXT          YES
```

Keypad:
>   1 - NEXT - Go to next menu
>   3 - YES - calibrate pressure sensors

Note: This will zero pressure sensors to handle any sensor zero-offset. Only calibrate when the system is fully off and under no vacuum or pressure.
Note: Menu is not available while engine is running

Testing

```
Testing
Test:SSSSSSSSSSSSSSS
Value: VVVV
NEXT        TEST
```

Tests:
>   Auger - turn on auger foward relay (FET0)
>   Grate - turn on grate relay (FET1)
>   Engine - turn on engine ignition relay (FET2)
>   Starter - turn on engine starter relay (FET3)
>   Flare - turn on flare ignitor relay (FET4)
>   O2 Reset - turn on O2 reset relay (FET5)
>   Alarm - turn on alarm FET (FET6)
>   ANA_Lambda - display analog lambda reading (ANA0)
>   ANA_Eng_Switch - display analog lambda reading (ANA2)
>   ANA_Fuel_Switch - display fuel switch reading (ANA1)
>   ANA_Oil - display oil pressure reading (ANA3)

Note: Menu is not available while engine is running

Keypad:
>   1 - NEXT - Go to next menu
>   Note: If testing, advance through all tests before hitting NEXT
>   3 - TEST - Advance through tests

Configuration

```
  Configurations
 NNNNNNNNNNN:VVV
ADV to save choice
NEXT  ADV  HHH  LLL
```

>   N - Configuration value name

V - Configuration value
H - Text depending on configuration menu
L - Text depending on configuration menu

<u>Keypad:</u>
1 - NEXT - Go to next menu
2 - ADV - Go to next configuration menu
3 - Increase/Set - text depends on configuration menu
4 - Decrease/Set - text depends on configuration menu
Note: Menu is not available while engine is running

Configuration Screens and Options

Configuration Screens	Options	Default
Engine Type	10k 20k	Factory default matches original PowerPallet size.
Relay Board	NO : system DOES NOT have relay board installed YES : system DOES have relay board installed	YES
Auger Rev	+ : increase value - : decrease value (Units: 0.1 seconds)	3.0 sec
Auger Low	+ : increase value - : decrease value (Units: 0.1 Amps)	3.5 Amps
Auger High	+ : increase value - : decrease value (Units: 0.1 Amps)	10.0 Amps
Low Oil	+ : increase value - : decrease value (Units: 1 PSI)	

Alarm

```
        ALARM   XX/NN
Alarm Name
Alarm Advice
NEXT ADV QUIET RESET
```

<u>Keypad:</u>
1 - NEXT - Go to next menu
2 - ADV - Show next alarm

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3 - QUIET - Silence alarm and light (will be turn on again if a new alarm occurs)

4 - RESET - Reset conditions causing the alarm.

Note: If the alarm caused a shutdown of the engine or auger the alarm MUST be reset/acknowledged for the system to operate correctly