Electronics Platform M3 Specification

# Overview

Greenlight Planet’s Electronics Platform M3 is a third-generation multifunction-lantern electronics platform based on STM’s STM32F030 low-cost 32-bit MCU family.

Platform M3 includes core features and functionality expected to be common to all products, plus additional optional features:

* 3.2 V LiFePO4 battery management
  + Coulomb-counter for state-of-charge (SOC) UI and facilitation of “low-battery mode”
* Linear charge management from a solar panel or other DC power supply
* Linear constant-current white LED driver
* Efficient synchronous DC-DC boost to 5 V DC for USB-style power output
* Optional: Built-in FM radio / MP3 player
* Optional: “Pay-as-you-go” technology compatible with the Angaza payment platform

This specification is intended to provide a high-level overview and full technical specifications for all products using Platform M3. The currently planned products are highlighted in Table 1, below.

**Table 1****: Products to be Developed Based on Platform M3**

|  |  |  |  |
| --- | --- | --- | --- |
| **Model No.** | **Development Codename** | **Radio** | **Angaza-Compatible** |
| SK-311 | All Day | **No** | **No** |
| SK-312 | All Day with Easybuy | **No** | Yes |
| SK-321 | Jackson | Yes | **No** |
| SK-322 | Jackson with Easybuy | Yes | Yes |

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# Battery Charging

Platform M3 can charge from a solar panel (typically 4.5 V / 3 W), or other DC power supply offering an output voltage between 3.8 V (VPV\_MIN) and 8.5 V (VPV\_MAX) **and** an output current limited to less than 2.5 A (IPV\_OCP).

Charging will be enabled upon both the voltage and the current.

First judgment is voltage, second is current (Try 15mA. Otherwise should set 2 LSB = 24mA as the minimum charging current).

Persistence: <1s.

At any given time, the MCU enables battery charging through (at most) one of two available current paths:

1. A current-limited, constant-voltage “CV-regulator path” composed of discrete analog hardware, allowing nominally 200 mA charging current (ICV), which is used under the following conditions:
   1. When the battery voltage is < 2.4 V, the power-down reset voltage (VPDR) of the ST MCU. Do not need to offer a separate mode for the 2.0 – 2.4 V range.
   2. After the battery voltage has increased to 3.55 (VCV\_ENTER) and has remained above 3.40 V (VCV\_EXIT).
2. A “pMOSFET-bypass path” that provides a low-RDS(on) bypass of the CV regulator, allowing up to 2.5 A charging current, which is used only when the battery voltage is between VPDR and VCV\_ENTER.

When charging raises the battery voltage to 3.55 V (Vcv\_enter) for a period of 500 ms (TCV\_PERSIST) or the voltage reaches 3.60V in 500ms, the pMOSFET-bypass path will be turned off, and the CV-regulator path will be activated. (Note that as usual, if the input voltage rises above VPV\_MAX during the transition to the CV-regulator path, the “PV Input OV Fault” will trigger.)

While charging through the CV-regulator path, when the battery voltage exceeds 3.60 V (VFULL\_CHRG) for a period of 250 ms (TFULL\_CHRG\_PERSIST), the battery will be considered fully charged, and charging will be stopped completely.

If the battery voltage “sags” (declines) below 3.40 V (VCV\_EXIT) while the CV regulator path is in use or after the battery has been fully charged, charging will resume using the pMOSFET bypass path.

If at any time the battery voltage exceeds 3.70 V (VBATT\_OV) for a period of 40 ms (TPV\_FAULT\_PERSIST), the “PV Battery OV Fault” will be triggered.

Exit Empty Fuel: Battery voltage is higher than 2.70V, and Fuel gauge is higher than 1.5mAh.

Exit Low Fuel: Fuel gauge is higher than 420mAh (14% of SOC).

*TBD: Reverse short circuit protection reacts within 40ms (Tpv\_rscp\_persist), to ensure a maximum reverse current of no more than 11A (Ipv\_rscp). When the voltage of PV port is lower than 2.50V during charging, it will trigger RSCP.*

The full list of charging protection faults are summarized below, in the order mentioned above. Faults are reset after a period of 15 seconds (TFAULT\_RESET). Note that reverse short-circuit protection as well as charger input over-voltage protection could be protected by the zero-battery-charge loop when the battery voltage is less than VPDR.

* PV Input OV Fault (will not begin charging)
* PV Forward OCP Fault (disables charging within TPV\_FAULT\_PERSIST)
* PV Input OV Fault during CV transition (disables charging within TPV\_FAULT\_PERSIST)
* PV Battery OV Fault (disables charging within TPV\_FAULT\_PERSIST)
* PV Reverse OCP Fault (disables charging within TPV\_FAULT\_PERSIST)

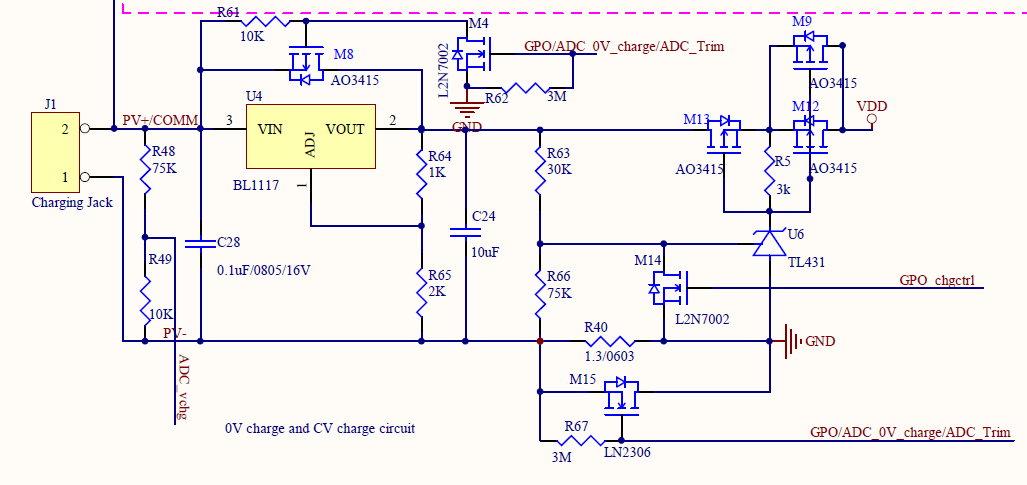
**Table 2****: PV Charging Electrical Characteristics @25℃ Ambient Temp**

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Description** | **Specification** |
| TFAULT\_RESET | Fault Reset Time | 15 seconds +/- 3 seconds |
| VCV\_ENTER | PV CV Voltage Enter Threshold | 3.55 V +/- 0.5% |
| VCV\_EXIT | PV CV Voltage Exit Threshold | 3.40 V +/- 0.5% |
| TCV\_PERSIST | PV CV Voltage Enter/Exit Persistence | 500 ms +/- 25 ms |
| VFULL\_CHRG | PV Full Charge Voltage Threshold | 3.60 V +/- 0.5% |
| TFULL\_CHRG\_PERSIST | PV Full Charge Persistence Threshold | 250 ms +/- 25 ms |
| VBATT\_OV | PV Battery Over-Voltage Threshold | 3.70 V +/- 0.5% |
| VPV\_MIN | PV Min Charge Voltage | 3.80 V +/- 0.1 V |
| VPV\_MAX | PV Max Charge Voltage | 8.50 V +/- 0.1 V |
| IPV\_OCP | PV Forward OCP Current Threshold | 2.5 A +/- 0.25 A |
| TPV\_FAULT\_PERSIST | PV Forward OCP Persistence Threshold | 40 ms +/- 12 ms |
| Vpv\_rscp | PV Reverse SCP Trigger Voltage | Vbat>2.50V and Vpv<2.5V during charging. |
| Ipv\_rscp | PV Reverse SCP Max Current | <11A |
| Tpv\_rscp\_persist | PV Reverse SCP Persistence Threshold | 40ms +/- 10ms |
| ICV | CV-Charge Circuit Current | If 0 V < Vbat < 2.5 V: 175 mA +/- 25 mA  If 3.55 V < Vbat < 3.65 V: 100 mA +/- 50 mA |
| VPDR | 0V Charge Circuit Disable Threshold | 1.88 V +/- 0.08V |

**Table 3****: Charging Path Control Pin Truth Table**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Product Status** | | **MCU Control Pin Status** | | **Status of key discrete components** | | | |
| **Charging Status** | **Charging current** | **GPO/ADC\_0V\_charge/ADC\_Trim** | **GPO\_chgctrl** | **LM1117** | **M4** | **M15** | **M13, M12, M9** |
| Under PDR (Vbat < 2 V) | 175 mA  +/- 25 mA | Floating w/ External Pulldown | Floating w/ External Pulldown | Enabled | OFF | OFF | ON |
| pMOSFET Bypass | < 2.5 A | Output High | Output Low | Bypassed | ON | ON | ON |
| CV Charging | 100 mA  +/- 50 mA | Output Low | Output Low | Enabled | OFF | OFF | ON |
| Charging Stopped | Zero | Output Low | Output High | Enabled | \* | \* | ON |

Figure 1: Charging Input Stage Schematic



# Battery Discharging

The Platform M3 micro-controller continuously monitors the battery state of charge, and disconnects peripherals to prevent over discharge.

When the light and radio are off and the USB ports are disabled, Platform M3 is in its lowest power mode, consuming less than 30uA (Iq). This results in a minimum shelf life of 3.0 years (Thibernate\_full). Additionally, Platform M3 is specified for a minimum shelf life of 0.5 years from an empty battery until it reaches 1.0V (Thibernate\_empty).

Platform M3 defaults to this lowest power mode when the battery is empty. Additionally, at any time, Platform M3 can be forced to enter this lowest power mode by holding the primary button for 3 seconds (Tpoweroff). While in this mode, Platform M3 continue to scan for a charge input once a second (`Thibernate\_wake).

When the light and radio are off and the USB port is enabled but has no load, the Platform M3 MCU remains in the same lowest power consumption state. However, the PCB power consumption is slightly higher because the USB switching regulator is powered. To reduce quiescent power usage, platform M3 will remove power to the USB port after 2.25 days of inactivity (Tusb\_standby). Furthermore, operating current is designed to be as low as possible (Ioperating < 650uA).

Regarding the operation of the primary button and those 5 keys which are using with PAYG purpose, if any of these 6 keys is accidentally pressed, product should minimize the power consumption. It won't turn on the lamp, and any additional power consumption will be limited to a period of < 30 seconds.

Specified run times under different useage scenarios are listed by (Trun\_full\_radio) (Trun\_full\_radio\_light) (Trun\_full\_light). These runtimes are based on a battery capacity of a standard Platform M3 product which is 3000mAh (FGfull), however the SK-4xx products use a larger battery pack.

During normal operation, Platform M3 uses coulomb counting and a slope detection algorithm to determine when to enter low battery and empty battery mode. The fuel gauge is updated every 15 seconds (Tfg\_update). In low fuel mode, the USB port and radio are powered down, and the LED light only operates in mode 1 (Ilight\_lowrestrict). In empty battery mode, the same applies, but the LED light will turn on only in mode 1 for no longer than 10 seconds up to ten times (Ilight\_emptyrestrict).

Platform M3 will enter low battery mode if the coulomb counter drops below 420mAh (14%) remaining capacity (FGlow), or if the slope detection mechanism is triggered (FGslope). As a fail-safe, a battery voltage below 2.80V will also cause entry into low battery mode (Vlowbatt\_backup). Platform M3 will enter empty battery mode ~~when the coulomb counter reaches 0%, or~~ if the battery voltage drops below 2.70V (Vemptybatt\_backup).

**Words Definition:**

Operation - system working @charge/discharge/PAYG.

Standby - battery higher than low fuel + USB @ON but no load + no charge/discharge

Sleep - USB @OFF + no charge/discharge

**Table 5****: Battery Discharge Electrical Characteristics**

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Description** | **Specification** |
| Trun\_full\_radio | Full Charge Run Time Radio (3000mAh pack) | 5 hours white noise (80dB at 1m) |
| Trun\_full\_radio\_light | Full Charge Run Time Radio and Light (3000mAh pack) | 3 hours with Light Mode 2 and Radio Playing |
| Trun\_full\_light | Full Charge Run Time Light (3000mAh pack) | fill in SK302 specs here |
| Thibernate\_full | Full Charge Shelf Life | > 3 years starting from 80% battery |
| Thibernate\_empty | Empty battery shelf life | > 0.5 years, starting from empty battery, until battery reaches 1.0V |
| Thibernate\_wake | Period for wake from hibernate | 1s +/- 200ms |
| Tfg\_update | Fuel Gauge Update Rate | 15 seconds +/- 1 second |
| FGfull | Battery Capacity | 3000mAh |
| FGlow | Low Battery Capacity Threshold | 420mAh |
| FGslope | Slope Detection Threshold | 14mV/40mAh |
| Vlowbatt\_backup | Low Battery Backup Voltage Threshold | 2.80V +/- 0.1V |
| Vemptybatt\_backup | Empty Battery Backup Voltage Threshold | 2.70V +/- 0.1V |
| Iq | Quiescent Current | <= 30uA |
| Ioperating | Operating Current | <= 650uA |

# Battery Capacity Measurement

The system will measure the battery capacity during usage. Since the battery capacity could only be measured from a full cycle of discharge, the system need to record the max battery discharged mAh between a full battery state to empty fuel.

During the measurement, the system has to work in charging mode. Then, the system fuel has to reach empty fuel status. In field, the user may not be able to 100% get the battery charged up. So, we will tweak that to take multiple measurements here and keep the highest reading between (i) the termination of a charge(after enters CV charging mode) and the end of a discharge reaching low fuel, (ii) the termination of a charge(after enters CV charging mode) and the end of a discharge reaching empty fuel.

The related data will be kept in UART output @H8, H9.

The procedure is listed below.

( BCM = Battery Capacity Measurement; BC = Batter Capacity)

1. BCM Method

- Method 1: "CV-to-Empty-Battery Previous Cycle Capacity" method

* Flag *BCM\_CV\_Flag*:
  + Set to 1 whenever CV charging mode is entered.
  + Reset to zero immediately when charging current is detected AND charging mode is in CC mode
* Counter *BCM\_CV\_to\_Empty\_This\_Cycle*
  + Counts mAh IF(Discharging && *BCM\_CV Flag*==1 && PV is disconnected)
  + At the moment when *BCM\_CV flag* is reset to zero:
    - If battery is in "EMPTY" status at this moment, BCM\_A\_This\_Cycle is stored (as "BCM-A Previous Cycle Capacity")
    - If battery is not in "EMPTY" status, the value is not stored.

- Method 2: "CV-to-Low-Battery Previous Cycle Capacity" method

* Flag *BCM\_CV\_Flag*: Same as above. Flag can be reused.
* Counter *BCM\_CV\_to\_Low\_This\_Cycle*: Same as above, but value is stored only if the battery is in "LOW" status at the time that *BCM\_CV\_Flag* is reset.

1. BCM Reset/Pause   
   - if there’s a charger plugged in during discharge fuel gauge accumulation, the BCM will be reset.   
   - if the battery stops discharge before reaching low fuel or empty fuel, the discharge fuel gauge accumulation will be paused and the BCM will be paused until the discharge continues.
2. BCM Data Replacement   
   - the BCM will continue to run during the lifeterm of the product. If the new BC measured is higher than the previous stored spec, the new data will replace the storage.
3. BCM Data Range and Error   
   - if the BC is measured to be > 150% of rated BC, the value would be considered as an error and discarded.   
   - if the BC is measured to be 0mAh to 150% of the rated BC, it’ll be considered as in range.
4. BCM Offset Correction   
   - the operation current and standby current will be added to the BC during fuel gauge accumulation of discharging and pause.

# USB

Platform M3 has a single USB charging port, with an open circuit voltage of 5.4±0.1V (Vusb\_oc) and a maximum output current limit of 600mA (Iusb\_max). Note that this is limit by the hardware. The USB port is powered by a synchronous boost regulator, with an efficiency of 91% @ 3.2V input and 5.40V/300mA output (Eusb).

The USB port is powered for 2.25 days after the last activity (Tusb\_standby); otherwise it is shut down. If the USB current draw exceeds 2.5A (Iusb\_ocp) for 1000ms (Tusb\_ocp\_persist), it will trigger an over current protection fault. This OCP fault auto resets after 15 seconds (Tfault\_reset). There is no reverse short circuit protection (Iusb\_rscp).

The same USB port is also used for UART communication. The data lines of the USB ports are used to transmit proprietary GLP data to an attached computer. See section titled: Data Logging and Communication.

For products with the built in radio, a second powered USB port provides an additional USB charging port, and is used to read data from a connected USB flash drive. See section titled: Radio.

**Table 6****: USB Electrical Characteristics**

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Description** | **Specification** |
| Iusb\_max | USB Max Current | 600mA +/- 60mA |
| Vusb\_oc | USB OCV | 5.40V +/- 0.1V |
| Eusb | USB Efficiency | >= 91% @ 3.2V Vbat and 5.40V/300mA output |
| Tusb\_standby | USB Standby Time | 2.25 days +/- 0.25 days |
| Iusb\_ocp | USB Forward OCP Current Threshold | 2.5A +/- 0.25A |
| Tusb\_ocp\_persist | USB Forward OCP Persistence Threshold | 1000ms +/- 300ms |
| Tfault\_reset | Fault Reset Time | 15 seconds +/- 3 seconds |
| Iusb\_rscp | USB Reverse SCP | Does not exist |

# Light

Except for SK4xx products, all Platform M3 products include a white LED lamp, which consists of multiple individual white LEDs in parallel, driven by a linear constant-current regulator. The MCU itself serves as the current regulator’s feedback loop, measuring the LED current and adjusting a 4000-kHz (Flight) 10-bit PWM output, which (through a low-pass filter) drives the gate of a MOSFET current-regulating element.

The lamp provides three levels of constant-current light output (modes 1, 2, and 3) during normal battery state of charge (Ilight). During low battery, only mode 1 will function (Ilight\_lowrestrict). When the battery is empty, mode 1 will turn on for 10 seconds ten times, otherwise the light will no longer turn on (Ilight\_emptyrestrict). The light mode is cycled by pushing the primary button of the product.

**Table 7****: Light Electrical Characteristics**

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Description** | **Specification** |
| Ilight1 | Light Mode 1 Current | 40.7mA +/- 4mA |
| Ilight2 | Light Mode 2 Current | 126.1mA +/- 4mA |
| Ilight3 | Light Mode 3 Current | 359.2mA +/- 4mA  @160lm/W, 90% Transmittance, Vf\_LED=2.9V |
| Ilight\_lowrestrict | Light Mode Restriction Low Fuel | Mode 1 Only |
| Ilight\_emptyrestrict | Light Mode Restriction Empty Fuel | 10x Mode 1 for 10s, then disabled |
| Flight | Light Drive Frequency | 4000 kHz |
| Luminous | Brightness of Mode 3 | SK3xx: 150lm  SK4xx: |

# User Interface

Platform M3 uses the same user interface standard on all of Greenlight Planet’s products to display state of charge (SOC) and rate of charge (ROC). To reduce MCU pin count, the MCU powers both the SOC and ROC displays using the same pins at a 50% duty cycle.

The SOC display consists of one red LED and five green LEDs, which helps the user gauge remaining battery capacity. The SOC display is illuminated based on the status of the coulomb counter used to track SOC. The SOC display is illuminated when the light is on, when a charge input is connected, or when a minimum of 30mA is detected on the USB port (Isoc\_min). The SOC stays illuminated for up to 2 seconds of no activity (Tsoc\_off). When the battery is empty, the red LED will flash for 100ms either after the button is pushed or once every 10 seconds (Tredled\_empty), last for 1 minutes. When the battery is low, the red LED is solid on, and all green LEDs are off (Tredled\_low). Otherwise, the green LEDs are illuminated according to the fuel gauge (FGsoc).

The SOC display is also illuminated once radio module is turned ON, whether the current come through the USB port is higher than 30mA or not. The operating current of radio module (Ifm\_op) will be higher than 30mA. The coulomb counter should be calculated according to the real current consuming. The average standby current of radio module (Ifm\_sb) will be TBD mA. The coulomb counter should be calculated according to this constant current if system cannot detect the discharge current.

The ROC display consists of 5 green LEDs, which aids the user in aligning the solar panel for maximum power. The ROC display illuminates during regular charging, based on the charge current (Iroc). The rate of charge display does not illuminate if the battery voltage is below 2.5V (Vroc\_min). During CV charging, Iroc values are ignored and four green LEDs are displayed regardless of the charge current (Iroc\_cv).

The user interface also includes a push button, used to cycle through lamp modes 0~3 by short-pressing(<5s), and to power the unit off by long-pressing(Tpoweroff>5 seconds). Short-pressing means the time of press and hold the button is less than 5 seconds, otherwise it will be considered as long-pressing. MCU should monitor the raising edge of this button.

See the section on the FM radio module for additional UI dedicated to the radio.

**Table 8****: Standard User Interface Description**

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Description** | **Specification** |
| Tpoweroff | Primary button hold | Hold 3 seconds to power off |
| Iroc1 | ROC 1 LED displayed | 37mA ≤ charge current <108mA |
| Iroc2 | ROC 2 LEDs displayed | 108mA ≤ charge current <216mA |
| Iroc3 | ROC 3 LEDs displayed | 216mA ≤ charge current < 324mA |
| Iroc4 | ROC 4 LEDs displayed | 324mA ≤ charge current < 405mA |
| Iroc5 | ROC 5 LEDs displayed | 405mA ≤ charge current ≤ 2500mA |
| Iroc\_cv | ROC Over-ride Display in CV | 4 Green LEDs |
| Vroc\_min | ROC display min voltage | Vbat > 2.5V |
| Tsoc\_off | State of Charge Timeout | 2 seconds +/- 0.1 seconds |
| Isoc\_min | State of Charge Min Current | 30mA @ battery (7mA @ 5.5V USB) |
| Tredled\_empty | RED LED empty fuel display | 100ms at 0.1Hz |
| Tredled\_low | RED LED low fuel display | RED LED is solid on |
| FGsoc1 | SOC 1 LED displayed | 14%-20% of full charge |
| FGsoc2 | SOC 2 LEDs displayed | 20%-40% of full charge |
| FGsoc3 | SOC 3 LEDs displayed | 40%-60% of full charge |
| FGsoc4 | SOC 4 LEDs displayed | 60%-80% of full charge |
| FGsoc5 | SOC 5 LEDs displayed | 80%-100% of full charge |

# Radio

SK321 and SK322 include an FM radio module. This consists of a 2W speaker, a 3.5mm earphone jack, an internal FM antenna, an SD card slot, a USB flash drive read port, a four-digit display, and 16 buttons dedicated to FM radio module operations. These buttons include Numeric Keys 0-9, "Fast Forward / Next", "Fast Backward / Previous", "Volume Up", "Volume Down", "Play/Pause", and "Power/Mode".

The power/mode button is used to cycle through the various playback modes. These four available states are off, FM radio, SD card, or USB drive. Functionally the SD card and USB drive states are the same, as they are both playing back MP3 files, simply reading from a different location. If either of the MP3 playback modes is selected and no USB or SD card is detected within **3** seconds, the module will revert to the radio. If the radio is muted or MP3 playback is paused for more than 30 seconds, the radio module will power down.

The MCU controls power to the radio through a MOSFET. When the radio is off, the MCU monitors the radio power/mode button for a falling edge, with a 20ms debouncing. If an edge is detected, the MCU will power up the radio module. The radio asserts that it is on by outputting high on the FM status line. When the radio turns itself off, it will output low on the FM status line, and the MCU responds by removing power to the radio to minimize quiescent current after 2 minutes.

FM radio stations (76-108MHz) can be selected in one of four ways.

Manual tuning by pushing the next/previous buttons <0.5s will increment or decrement the radio frequency by 0.1MHz. Holding these same keys for >0.5 second will enable auto tuning to the next/previous available station. Up to 10 stations can be stored by holding one of the numbered keys for > 1.5 seconds. These stations can be recalled by pressing any of the numbered keys for < 1.5 seconds. Finally, a 3-4 digit radio frequency can be entered directly on the numeric keypad, with <1s in-between keystrokes.

MP3 playback capacity is limited to 32GB in exFAT, FAT, FAT32, NTFS format. No folder selection is supported, and all tracks are sorted alphabetically. Tracks can be selected using the Next/Previous buttons, or by entering the track number on the numeric keypad. Manual tuning by pressing the next/previous buttons <0.5s will jump to the next/previous track. Holding these same keys for >0.5 second will enable auto fast forward/fast backward. The tracks can be entered directly on the numeric keypad, with <1s in-between keystrokes.

If in FM or MP3 playback an invalid numeric entry is made, the display will display “Err” for 2 second and return to its previous state.

After entering the track number or the frequency, the display will jump to the track number entered or the station chosen after 2 second.

When press two buttons or more are pressed down at the same time, if the interval between the buttons is more than 30ms, the Radio MCU will detect the last pressed key. If the interval between the buttons is less than 30ms, the function will follow the priority: Power/Mode > Numeric Key > Fast forward/ Next > Fast backward/ Previous > Play/Pause > Volume Up > Volume Down.

For earphone jack, SD card slot, if a <3.6V power insert in, there’s protection for MCU. For USB slot, the protection is <7V. There’s no reverse power protection for the USB card slot and SD card slot.

Table U, Cells U6-U10: UI Spec Specific to Radio Module

|  |  |  |  |
| --- | --- | --- | --- |
| **Table U** | **Description** | **Specification** | **Graphic** |
| U6 | Radio buttons | Numeric Keys 0-9, "Fast Forward /  Next", "Fast Backward / Previous", "Volume Up", "Volume Down", "Play/Pause", "Power/Mode" |  |
| U7 | Radio Display | 4 8-Segment digits with a dot between 3rd and 4th digit. Displays up to 65535 by scrolling |  |
| U8a | FM Mode Display | "FM". Displays stored station for 2 seconds when selected, otherwise displays FM frequency |  |
| U8b | SD Mode Display | "SD" |  |
| U8c | USB Mode Display | "USB" |  |
| U8d | MP3 mode Display | "MP3". Displays MP3 track number. |  |
| U8e | Track Playback Display | “笆ｶ” |  |
| U8f | Track Pause Display | “笆娯膜” |  |
| U8g | Invalid Frequency or Track | "Err" (how long does it display this? 2 seconds?) |  |
| U9 | Volume Display | 00 - 31 (displays when volume is being adjusted). |  |
| U10a | Pause / Mute Display Flash Rate | 1.0Hz +/- 0.1Hz |  |
| U10b | Pause / Mute Display Contents | Track Number / FM Frequency |  |

Table R: Radio Specifications

|  |  |  |
| --- | --- | --- |
| **Table R** | **Description** | **Specification** |
| R1a | Internal FM Antenna Sensitivity | >15dbuV |
| R1b | Internal FM Antenna RX Frequency | 76MHz - 108MHz |
| R1c | Internal FM Antenna Voltage Standing Wave Ratio | <= 2 |
| R2a | Speaker Sensitivity | 85 - 90 db/W |
| R2b | Speaker Signal to Noise Ratio | 65 - 70 db |
| R2c | Speaker Rated Power | 2W |
| R3a | Ear Phone Jack Type | 3.5mm |
| R3b | Ear Phone Jack Internal Resistance | 8 - 32 Ohm |
| R4 | Volume Adjustment Rate | Press "Volume Up" or "Volume Down" to step, or hold to step at 5 steps / second |
| R5 | Radio Mode Selection Min Hold Time | 100mS +/- 10ms |
| R6a | SD Card File Format | MP3 Only, No Folder Detection, Tracks sorted alphabetically |
| R6b | SD Card Maximum Size | 32GB |
| R6c | SD Card Detection Time | 3 seconds +/- 0.1 seconds before transition to FM mode if no SD Card present |
| R7a | USB Flash Drive File Format | MP3 Only, No Folder Detection, Tracks sorted alphabetically |
| R7b | USB Flash Drive Maximum Size | 32GB |
| R7c | USB Detection Time | 3 seconds +/- 0.1 seconds before transition to FM mode if no USB present |
| R8a | FM Radio Auto Tuning | Scans to next detectable statio by pressing "Next" or "Previous" > 0.5s |
| R8b | FM Radio Manual Tuning | Increments or Decrements 0.1 MHz by pressing "Next" or "Previous" < 0.5s |
| R8c | FM Radio Numeric Tuning | Frequency digits must be entered at <1.0s rate |
| R8d | FM Radio Station Storage | Hold keypad number 0-9 for >1.5s to store, press keypad number <1.5s to recall |
| R10 | FM Mute and MP3 Pause Standby Time | 30 seconds +/- 1 second before transition to OFF |
| R11 | MP3 Fast Forward / Backward Hold Time | Hold "Next/Previous" for >1.5s |
| R12 | MP3 Numeric Track Selection Time | Track Digits must be entered at <1.0s rate |

# Angaza Pay-As-You-Go

The Angaza integration, available on SK312 and SK322, provides Pay-As-You-Go functionality to Platform M3. Pay-As-You-Go allows users to purchase a Platform M3 device for less than the full cost, and make regular installment payments to unlock the device and pay for the device over an extended period of time.

The Angaza integration includes both hardware and software. On the hardware side, the Angaza integration requires two pins on the Platform M3 MCU – a data input external interrupt pin (Ain\_pin), used for detecting and reading data from a connected Angaza data cable, and a GPIO pin used for controlling power to the Angaza circuitry (Aout\_pin).

An Angaza specified circuit is tied to the PV+ input node, which is used to decode data sent using an Angaza interface cable. The Angaza specified circuit requires that the PV+ input node have no capacitance on it, as this would interfere with the rapid rise/fall times needed for the data signal. The maximum voltage on the Angaza signal bus is typically 2Vpp between the PV+ and GND (Avbus\_max), so it is below the minimum solar panel voltage, making it easy to differentiate.

Angaza’s and GLP’s software reside on the same MCU, and communicate using a set of public functions. Additional, GLP UART data receive is also transmitted on the PV+ input line at a similar voltage level to the Angaza signal – software will be used to differentiate between an Angaza and a Greenlight Planet UART signal.

Angaza provides two functions allowing the GLP software to monitor the current status of the Angaza system, and if necessary, prevent normal product operation.

bool payg\_state\_is\_enabled();

enum PAYGState payg\_state\_get\_current();

GLP provides the following functions to Angaza (these will be fully defined during the collaborative integration effort).

* I/O functions: these provide I/O access for the two pins required by Angaza:

bool prod\_cable\_get\_rx\_pin();

void prod\_cable\_set\_tx\_pin(bool level);

* Nonvolatile storage functions to opaquely store data in NVM

bool prod\_nv\_read(struct prod\_nv\_data\* data);

void prod\_nv\_write(const struct prod\_nv\_data\* data);

* Message driven user feedback: custom behavior, to be determined during Angaza and GLP integration.
* Time keeping functions, including access to RTC (Artc) and Timer (Atimer): to be determined once GLP timekeeping is finalized.
* Product usage data functions: make usage data available to pass via Angaza smartphone bridge. Exact functions to be determined.
* The execution time of each interrupt should not longer than 500us – Derek suggested
* Should always be ready to enter into PAYG mode whenever the PAYG cable plug in and as long as MCU is working.
* UI: The main white LED, which should blink rapidly if the button is pressed while PAYG disabled. If the button is pressed while near-disabled it should blink and then turn on.
* USB and radio/mp3 should be disabled while PAYG disabled. But PV charging always remains enabled.
* Five keys will not use for PAYG mode enter or exit. They will only use for payment input.

**Table 9****: Angaza Integration Requirements**

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Description** | **Specification** |
| Avbus\_max | Angaza Max Bus Voltage | 2Vpp |
| Ain\_pin | Angaza Input Pin | 1x GPIO input pin with EXTI |
| Aout\_pin | Angaza Output Pin | 1x GPIO output pin |
| Atimer | Angaza Communication Timer | 1x timer, min 1MHz clock base |
| Artc | Angaza Real Time Timer | RTC access required |
| Aflash\_size | Angaza Estimated Code Size | 6kB |
| Aram\_size | Angaza Estimated RAM Size | 750 Bytes |
| Anvm\_size | Anagaza Estimated NVM Size | 64B stored across 2kB flash using wear leveling |

# Angaza PAYG Firmware Library (Cable, Keypad, IR)

## Structure Overview

The Angaza PAYG Firmware Library ("PAYG Library") implements cross-platform PAYG functionality, including:

* PAYG Credit Tracking (Time/Usage Remaining)
* PAYG Communications (In/Out)
* PAYG Message Interpretation (Add Credit, Unlock Unit, etc)
* PAYG-related Cryptography
* PAYG State Management (Enabled/Disabled, etc)
* PAYG Feedback Modes
* Data Transfer over PAYG Communications (Usage Data, Battery State, etc)

As the library is cross-platform, some functions must be implemented by the manufacturer (e.g. PAYG communications GPIO, timers, etc). Functions that **must** be implemented by the product manufacturer begin with prod\_. The PAYG library expects to have access to all prod\_ functions defined in this library in order to operate as expected.  
Additionally, the PAYG Library provides the product manufacturer with functions to easily assess the PAYG state of the product. For instance, if product firmware requires to know if the product is currently "PAYG Enabled", simply call [**payg\_state\_is\_enabled()**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\payg__state_8h.html#acf9b966eb9b45951f046d82d6803afd3).

**Note:**

* prod\_ functions are defined by the PAYG library, and implemented by product code
* payg\_ functions are defined and implemented by the PAYG library, and may be called by product code as needed.

The product manufacturer is responsible for implementing all prod\_ functions in a way appropriate for their particular architecture/platform.

## Understanding the Library

The code in this library can be broken into four general sections:

1. PAYG State/Core Process:
   * [**angaza.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\angaza_8h.html) - Defines manufacturer and product/model PAYG identifiers
   * config\_defaults.h - Default configuration settings. Do not modify.
   * angaza\_config.h - Product-specific parameters (e.g. keypad or cable support) defined here.
   * [**payg\_all.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\payg__all_8h.html) - Init/deinitialize PAYG library, and periodically allow it processing time.
   * [**payg\_state.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\payg__state_8h.html) - Provides functions for product to access the PAYG state, and instruct the PAYG library to 'consume' credit (e.g. time has elapsed or product usage has occurred).
   * [**prod\_mainloop.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__mainloop_8h.html) - Allows PAYG library to request non-interrupt main loop time.
2. PAYG Communications/IO:
   * [**prod\_cable.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__cable_8h.html) - Only relevant if cable-based PAYG is used.
   * [**prod\_ir.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__ir_8h.html) - Only relevant if Angaza infrared PAYG is used.
   * [**prod\_keypad.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__keypad_8h.html) - Only relevant if keypad or Angaza infrared PAYG is used.
   * [**payg\_interrupts.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\payg__interrupts_8h.html) - Required for any PAYG communications.
   * [**prod\_timcmp.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__timcmp_8h.html) - Required for any PAYG communications.
3. UI Feedback:
   * [**prod\_feedback.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__feedback_8h.html) - PAYG library uses these functions to inform product firmware of appropriate kind of feedback to provide to user for keypresses/cable interactions.
4. Nonvolatile Access:
   * [**prod\_nv.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__nv_8h.html) - Allows PAYG library to write and read in payg\_nv\_block format
   * [**payg\_nv\_block.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\payg__nv__block_8h.html) - Defines a generic PAYG data 'block', used for NV data storage.
   * [**prod\_diag.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__diag_8h.html) - Allows PAYG library to access diagnostic/usage data from product.

The above code must be included/compiled alongside the core product firmware.

**Note:** AppNotes are available for nonvolatile storage and RTC implementation assistance. See AppNote "PAYG Library prod\_nv" and "PAYG Library RTC" for more details.

## How to Use

Two directories are contained here: "inc" and "src". These make up the entire Angaza PAYG firmare library.

The "inc" directory should be added to the compiler's header search path. Contains header files for use both by library code and by any new code written to interact with the library. These header files contain additional documentation in the form of extended source comments.

All files within the "src" directory should be compiled and linked along with the rest of the product's source files. These files are not intended for modification, and may be obfuscated, depending on the terms of any corresponding license agreement.

Header files declare a number of functions. Each function has either a "payg\_" or a "prod\_" prefix. All functions with the "payg\_" prefix, such as "payg\_all\_init()", are implemented within the library. All functions declared with the "prod\_" prefix, such as "prod\_nv\_write()", must be implemented by the partner within their product code. In addition to the documentation in source comments, application notes will be provided that describe suggested implementation strategies for these functions.

Detailed function usage notes are available in the library header files. These notes have also been rendered in HTML form, which you can browse by opening the doc/index.html file in your browser. (That may be how you are already viewing this content!)

## Basic Program Flow with Library

1. Program powers up
   * calls product specific initialization code (power\_init, clocks, etc)
   * call [**payg\_all\_init()**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\payg__all_8h.html#a43813c6a62c58b37f6fb237243ea7eaa)
2. (Executive Loop) Program enters main loop
   * Call product-specific processing functions (read buttons, regulate output, etc)
     + Before enabling product functionality, program calls [**payg\_state\_get\_current()**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\payg__state_8h.html#a61e55ec593bc32baf63e3c3132a0b650) and ensures it is "enabled".
     + If user is 'using' product, program calls [**payg\_state\_consume\_credit()**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\payg__state_8h.html#a8f97fbf3a0db84d1bdac43a92efa6c8c) periodically to "use up" PAYG credit.
   * Call *payg\_all\_process* (per it's return value, and also as requested by [**prod\_mainloop\_request\_processing()**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__mainloop_8h.html#ab3acff38f020118e4064dd2e7540bd58))
   * Program sleeps for a period (no greater than the time value returned by *payg\_all\_process*)
   * Repeat indefinitely
3. Interrupts during Executive Loop (from I/O pins or dedicated PAYG timer)
   * If keypad support is used, [**payg\_interrupts\_keypad\_handle\_key()**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\payg__interrupts_8h.html#a82ce459435c5aee4c086a8a25298c136) is called every time a keypress interrupt is received.
   * If cable support is used, [**payg\_interrupts\_cable\_handle\_rx\_edge()**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\payg__interrupts_8h.html#aa885ce89bbfb3fe46a356ea2e2c6ceb0) is called every time a rising \*or\* falling edge is received on the PAYG cable RX pin.
   * If Angaza infrared (IR) support is used, payg\_interrupts\_ir\_handle\_edge() is called every time a rising \*or\* falling edge is received on the PAYG IR RX pin.
   * If infrared or cable support is used (not keypad),**[payg\_interrupts\_timcmp\_handle\_elapsed()](file:///F:\\Sun%20King%20Jackson\\Firmware\\Angaza%20Library\\1.10.17\\Angaza_PAYG_Library_1_10_17\\doc\\payg__interrupts_8h.html" \l "ad1c6e6f1ef0479c72ef7e79e46f1d032" \o "PAYG library functions to be called on specific interrupt events. )**is called whenever the high precision timer dedicated to PAYG ends/expires (see [**prod\_timcmp.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__timcmp_8h.html)` for more details).
4. Product-Function calls from PAYG Library
   * As PAYG library processes PAYG messages, it may call [**prod\_feedback\_start()**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__feedback_8h.html#ad0a3b1ff7105583aab1e070c620715c0); which is product code to initiate a proper feedback pattern to the user.
   * Other "prod\_" functions may be called by the PAYG library at any time (including [**prod\_nv.h**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\prod__nv_8h.html) functions)
5. Product rarely turns off completely/clears RAM
   * Program calls [**payg\_all\_deinit()**](file:///F:\Sun%20King%20Jackson\Firmware\Angaza%20Library\1.10.17\Angaza_PAYG_Library_1_10_17\doc\payg__all_8h.html#aecbb34d9afaf467de682fd540c9a6dc9)
   * Program executes product off/clear RAM code

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# Data Logging and Communication

Platform M3 logs and stores usage data on the MCU for warranty and R&D purposes. This data is broadcasted via the data lines of the USB port continuously, and can be read by attaching connecting Platform M3 to a computer using a UART to USB module. The UART data is broadcast using a standard protocol of baud rate 4800, 8 data bits, 1 stop bit, and no parity (Duart).

The Angaza module handles some data collection functions. All data collection parameters, and the UART output spec, are listed in Table 10 below.

NOTE: EEPROM(Flash) can be erased and written only 1,000 times. One page (1K) will be erased one time. There are 32 pages (32K) in total. So, the data should be written at different page once needs update. And it will be erased from the first page after all pages are written. So this method will provide n x 1000 times data update.

For the UART data, there are 27 items need to be saved in flash, which list in Table 10 that marked with “Y” in the column of “NV”. And there actually will be 29 items in total, because the additional two items, “Flash Written Times” and “Checksum”, also need to be written in the NV flash at the same time. To achieve the goal of 5 ~ 10 years of user time recording and the best accuracy for these data if there is only one page of flash available, four methods need to be run separately.

1. Periodically save these data at the same time. Currently once per day. And the data in RAM will be lost if when the product got power OFF intentionally.
2. Save these data once battery voltage lower than 2.80V.
3. Resume these data once system reset.
4. Only start these counters while product is under usage.

**Table 10****: Data Logging and Communication Specification**

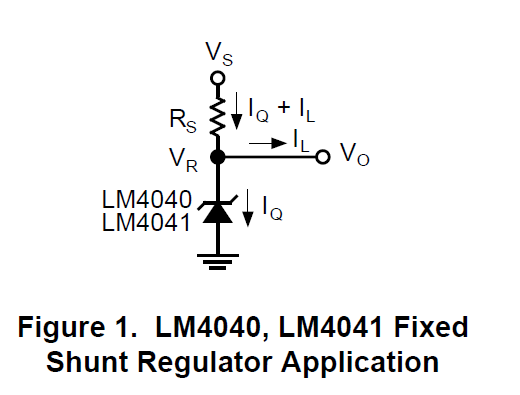
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **ID** | **Name** | **Specification** | **Storage (RAM, NVRAM, or Read-Only Flash)** | **Timed Counter Lockout** | **Cleared on Delivery** | **Underlying Variable Type** |
| A1 | LED Current | Instantaneous computed value (mA) | RAM | NA | NA |  |
| A2 | USB Current | Instantaneous computed value (mA) | RAM | NA | NA |  |
| A3 | PV Current | Instantaneous computed value (mA) | RAM | NA | NA |  |
| A4 | PV Voltage | Instantaneous computed value (mV) | RAM | NA | NA |  |
| A5 | Battery Voltage | Instantaneous computed value (mV) | RAM | NA | NA |  |
| A6 | Battery Current | Instantaneous computed value (mA).   Positive (“+”) means current going into battery battery (charging), negative (“-“) means current going out of the battery (discharging). | RAM | NA | NA |  |
| A7 | Keypad Raw ADC Value | Instantaneous ADC value  Power Key: 0 - 46 Key 1: 47 - 135 Key 2: 136 - 260 Key 3: 261 - 416 Key 4: 417 - 631 Key 5: 632 - 1025 | RAM | NA | NA |  |
| B1 | LED Mode | Instantaneous value  0 = off, 1 = mode 1, 2 = mode 2, 3 = mode 3 | RAM | NA | NA |  |
| B2 | USB Port Status | Instantaneous value  0 = off, 1 = manual off, 2 = fault, 3 = on | RAM | NA | NA |  |
| B3 | PV Status | Instantaneous value  0 = off, 1 = fault, 2 = battery full, 3 = ov, 4 = fast charge, 5 = cv | RAM | NA | NA |  |
| B4 | Fuel Gauge Level | Instantaneous value (mAh) | RAM | NA | NA |  |
| B5 | LED Duty Cycle | Instantaneous value  Scale: 0 to 2000 represents 0% to 100% | RAM | NA | NA |  |
| B6 | Radio Status | State of Radio Module.  0 = OFF, 1 = ON | RAM | NA | NA |  |
| C1 | PV\_Bat\_OV Fault Counter |  | NVRAM | Note 1 | Yes | uint |
| C2 | PV\_Fwd\_OCP Fault Counter |  | NVRAM | Note 1 | Yes | uint |
| C3 | PV\_Rev\_OCP Fault Counter |  | NVRAM | Note 1 | Yes | uint |
| C4 | PV\_Inp\_OV Fault Counter |  | NVRAM | Note 1 | Yes | uint |
| C5 | USB\_OCP Fault Counter |  | NVRAM | Note 1 | Yes | uint |
| C6 | Any-Fault Counter | Increments if any fault is triggered.  With the 14-hour lockout, this counter is Intended to check how many faults are being triggered on a typical day. (Individual fault counters may be triggered many times in one short period, so they are not useful for determining frequency of faults over long periods of time.) | NVRAM | 14 hr | Yes | uint |
| D1 | Fuel-Gauge Low-Battery-Trigger Counter | Increments when the low-fuel flag is triggered (set) by the fuel gauge | NVRAM | 14 hr | Yes | uint |
| D2 | Slope Low-Battery-Trigger Counter | Increments when the low-fuel flag is triggered (set) by the battery voltage slope (dV/dCapacity) monitor | NVRAM | 14 hr | Yes | uint |
| D3 | Voltage Low-Battery-Trigger Counter | Increments when the low-fuel flag is triggered (set) by the battery voltage monitor. | NVRAM | 14 hr | Yes | uint |
| D4 | Previous Low Battery Trigger | Records the trigger of low-battery detection immediately prior.  0 = FG Triggered, 1 = Slope Triggered, 2 = Voltage Triggered | NVRAM | NA | NA | uchar |
| ~~D5~~ | ~~Fuel Empty Battery Trigger~~ | ~~TBD - may be deleted?~~ |  |  |  | ~~Uint~~  ~~max 65535~~ |
| D5 | Voltage Empty Battery Trigger Counter | Increments when the lamp enters empty-battery mode (triggered by the battery voltage monitor). | NVRAM | 14 hr | Yes | uint |
| ~~D7~~ | ~~Empty Battery Flag~~ | ~~TBD - may be deleted?~~ |  |  |  | ~~Uint~~  ~~max 65535~~ |
| D6 | CV Charge Entry Counter | Increments on entry of CV-regulated battery charging | NVRAM | 14 hr | Yes |  |
| D7 | Full Battery Counter | Increments on completion (termination) of PV charging. | NVRAM | 14 hr | Yes |  |
| ~~E1~~ | ~~MCU Reboot Counter~~ | ~~Increments when the MCU is reboot for MCU reset or Bootloader reboot.~~ | ~~Yes~~ | ~~NA~~ | ~~NO~~ | ~~max 400~~ |
| E1 | Watch Dog Reset Counter | Increments when the MCU is reset for Watch Dog timeout. | NVRAM | NA | Yes | char |
| E2 | Low Voltage Reset Counter | Increments when the MCU is reset for PDR caused by low voltage battery. After the reset, the MCU should read a voltage <2.7V. | NVRAM | NA | Yes | char |
| E3 | Battery Disconnection Counter | Increments when the MCU is reset for PDR caused by battery disconnection. After the reset, the MCU should read a voltage >2.7V. | NVRAM | NA | Yes | char |
| E4 | Long-Press Shutdown Counter | Increments when the power button is manually long-pressed to enter hibernation (USB port off). | NVRAM | NA | Yes |  |
| E5 | Automatic Hibernation Counter | Increments when hibernation mode is entered after 2.25 days of inactivity (USB port turns off automatically) | NVRAM | NA | Yes |  |
| E6 | Bandgap Trim Flag | Flag is set to "1" once the bandgap voltage is trimmed between 1.16V~1.24V. (The main program will not start to run until this flag is set.) | NVRAM | NA | NA |  |
| E7 | PAYG credit status | PAYG credit status   1 = Disable, 2= Near disabled, 3 = Enabled | RAM (From PAYG NVRAM) | NA | NA |  |
| E8 | Light Button Press Counter | increments for one button press | NVRAM | NA | Yes |  |
| F1 | Product Delivery Flag | Initialized to "0" at time of manufacturing. Set to "1" after 60 minutes of usage (PV charging, lamp, or USB load).   This flag is intended to mark the start of consumer usage of the lamp. The moment it is set, all usage counters and max/min data are cleared to zero, unless otherwise noted. | NVRAM | NA | NA |  |
| F2 | Inventory Time | Increments once per real-world hour (whether in run or hibernation mode) as long as the Product Delivery Flag is not set (product is still in inventory/transit).  This counter does NOT clear upon the product delivery flag being set (so it can be read after delivery as the time between manufacturing and delivery to the customer). | NVRAM | NA | NO |  |
| F3 | Working Life Time. | Increments once per real-world day (whether in run or hibernation mode). This counter (like all others, unless otherwise noted) is cleared upon the product delivery flag being set. So it can be read after delivery as the amount of calendar time the product has been in use by the consumer. | NVRAM | NA | Yes |  |
| G1 | Max PV Charge Rate | Retains the maximum PV charging current (mA) over all time. | NVRAM | NA | Yes |  |
| G2 | CV Charge Time | Increments for every 60 minutes of CV charging | NVRAM | NA | Yes |  |
| G3 | PV Charge Level\_1 Time | Increments for every 60 minutes of level 1 charging (37mA ≤ charge current <108mA) | NVRAM | NA | Yes |  |
| G4 | PV Charge Level\_2 Time | increments for every 60 minutes of level 2 charging (108mA ≤ charge current <216mA) | NVRAM | NA | Yes |  |
| G5 | PV Charge Level\_3 Time | increments for every 60 minutes of level 3 charging (216mA ≤ charge current < 324mA) | NVRAM | NA | Yes |  |
| G6 | PV Charge Level\_4 Time | increments for every 60 minutes of level 4 charging (324mA ≤ charge current < 405mA) | NVRAM | NA | Yes |  |
| G7 | PV Charge Level\_5 Time | increments for every 60 minutes of level 5 charging (405mA ≤ charge current ≤ 2500mA) | NVRAM | NA | Yes |  |
| H1 | Low-Battery Mode LED Time | Increments for every half 60 minutes of LED lamp usage while in low-battery mode. | NVRAM | NA | Yes |  |
| H2 | LED Mode 1 Time | Increments for every 60 minutes of LED lamp usage in mode 1. | NVRAM | NA | Yes |  |
| H3 | LED Mode 2 Time | Increments for every 60 minutes of LED lamp usage in mode 2. | NVRAM | NA | Yes |  |
| H4 | LED Mode 3 Time | Increments for every 60 minutes of LED lamp usage in mode 3 ("Turbo" mode). | NVRAM | NA | Yes |  |
| H5 | Music Time | Increments for every 60 minutes of music player usage time. | NVRAM | NA | Yes |  |
| H6 | USB Heavy-Load Time | Increments for every 60 minutes of USB load detected with battery current >250 mA | NVRAM | NA | Yes |  |
| H7 | USB Light-Load Time | Increments for every 60 minutes of USB load detected with battery current <250 mA | NVRAM | NA | Yes |  |
| H8 | CV-to-Low-Battery Previous Cycle Capacity | This will record the max battery discharge mAh between a CV charge to empty fuel. The value will be recorded when the battery reaches low fuel during discharge only. | NVRAM | NA | Yes |  |
| H9 | CV-to-Empty-Battery Previous Cycle Capacity | This will record the max battery discharge mAh between a CV charge to empty fuel. The value will be recorded when the battery reaches empty fuel during discharge only. | NVRAM | NA | Yes |  |
| I1 | Fuel Level | This will show the fuel gauge level.  0 = Empty, 1 = Low, 2 = Level 1, 3 = Level 2, 4 = Level 3, 5 = Level 4, 6 = Level 5. | NVRAM | NA | NA | uchar |
| I2 | NV Erase Count | ??? | NVRAM | NA | NO | uint |
| I3 | Bandgap Reference Voltage | The bandgap voltage measured in the trimming process (mV) | Read-only Flash | NA | NA | uint |
| I4 | Model | The SKU ID of product, eg. SK-312 for Sun King Pro Easy Buy. | Read-only Flash | NA | NA | String |
| I5 | Version Number | The firmware version: Typical format: Vx.y - x for big changes, y for small changes. | Read-only Flash | NA | NA | String |
| I6 | Serial Number | A 13-digit serial number programmed on the production line. | Read-only Flash | NA | NA | long? |
| I7 | Manufacturing Week | The production day number of the year.  Format: YYDDD, eg. 15200 is the 200th day of 2015 | Read-only Flash | NA | NA | uint |

Note 1: By design, each fault triggers a 15-second disablement of the associated function (for example, a PV short circuit fault triggers disablement of the PV charger for 15 seconds. The fault cannot be re-triggered while the function is disabled. So in the case of these counters, no additional timed counter lockout is applied, but it should be noted that these fault counters will not increment faster than once per 15 seconds.

**Table 12: Communication Specification with Radio Module**

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Description** | **Specification** |
| Duart | UART Communication Spec | Baud rate: 4800Hz, 8 data bits, 1 stop bit, no parity |
| Da1 | Start bit | \*# |
| Da2 | Key number | 01 ~ 05 (Button short press)  11 ~ 15 (Button long press) |
| Da3 | Checksum | Computed checksum from the start bit to the key number. Example: \*#01XX |

# Internal Reference Voltage Trimming

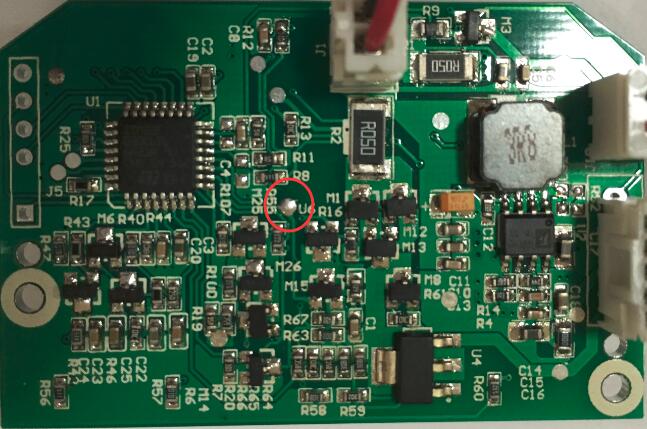
The embedded reference voltage of the platform M30 is rated @ 1.20V±0.04V with 100ppm/℃ temp-coefficient. During PCBA test, each board will be trimmed on the fixture. LM4040AIM3-2.5 2.500V ±0.1%, 100ppm/℃, voltage reference IC will be used as the ref source. When the platform M30 receives a UART command of “Trim 2xxx”, “2xxx” means the applied voltage in mV, the MCU would start to do ADC for the 2.5V applied on the pin of GPO/ADC\_0V\_charge/ADC\_Trim. At the same time, they platform M30 will also do ADC for the internal reference voltage. The calculation algorithm is very close to the trim method in SHS. However, since it’s a 32-bit MCU, we could use more \* and / calculation.

Vactual\_intref\*10000 (0.1mV per count)= ADC(Vactual\_intref)\* (2.5\*10000/ADC(2.5V))

**1 LSB in 0.1 mV =** Vactual\_intref\*10000 / **ADC(Vactual\_intref)** (0.1mV per count)

Trim procedure:

1. Power ON system with 3.3V battery source.
2. Check UART output, if system hasn’t been trimmed, it will output 'T' once per second.
3. Add external reference voltage (Vref) between “trim” point and GND. Please find the location of this “trim” point on the PCBA as below. It has been marked with a red circle.



Send a .txt file or a suggested sentence to UTU through UART port. (Check the contents of this txt file below.) For example: SN:3120011000001 1545 2485 E

1. UART will feedback as:

If succeed:

SN:3120011000001 1545 2485

TRIM OK

E

If fail:

SN:3120011000001 1545 2485

TRIM FAIL

E

1. Remove the reference voltage.
2. Check UART data. If E4 is 1, then it means system has been trimmed successfully.

Contents in the .txt file:

SN:3120011000001 1545 2485 E

“SN:” is fixed.

“3120011000001” is a 13 digits product serial number.

“1545” is the birth week. “15” is the year, 2015, “45” means the 45th week of this year.

“2485” is the reference voltage in mV. Vref is 2485mV.

“E”: means: exit trim

Note: there are 3 spaces in total. There is no any space between “SN:” and “13 digits serial number”.

# 

# Appendix

**Table 11****: Mechanical Properties**

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Description** | **Specification** |
| M1 | Waterproof Test | Meets IPx3, or IPx2/IPx1 with notice (should meet LGQTM standard) |
| M2 | Drop Test | 1.5m drop on all six sides, 3 drops per side |
| M3 | Dustproof Test | Meets IPx5 |
| M4 | Salt Spray Test (for metal parts) | Meet IRT standard (pass at least 24 hrs) |
| M5 | Electrical Component Longevity | > 5 years |
| M6 | Mechanical Component Longevity | > 5 years |
| M7 | PV Panel Longevity | > 5 years |
| M8a | LiFePO4 Battery Longevity (shelf life) | 5 years |
| M8b | LiFePO4 Battery Longevity (cycle life) | 5 years |
| M9 | White LED Longevity | < 5% degradation after 6000 hours |
| M10a | Operational Conditions (Ambient Temp) | 0C - 40C |
| M10b | Operational Conditions (Relative Humidity) | 10% - 95% |
| M11 | Weight | 300 grams |
| M12 | Color | fill in SK302 specs here |

|  |  |  |
| --- | --- | --- |
| E29 | EMI | Meets IEC 61000-4-2, IEC61000-4-3 |

# History

V3.2 Jonas/June 12, 2015  
 -- initial setup by Jonas, and questions added by Patrick, Martin, Kerwen and Derek for Platform M3 Solar System.

V3.3 Kerwen/June 30, 2015  
--There are a few minor modifications in three sections based on Derek's suggestion.  
i. Battery Discharging -- Page 8  
Modified the fuel gauge update rate(Tfg\_update) from 18 seconds to 15 seconds for easy calculating in the firmware.  
ii. Radio -- Page 14  
Modified the debounce time from 30ms to 40ms. Same reason as the first modification.  
iii. Internal Reference Voltage Trimming -- Page 22  
Change the trim method a little bit due to this new platform.  
Iv. Table 22 is added to describe the communication specification with the radio module based on the radio supplier's suggestion. -- Page 21

V3.4 Kerwen/July 7, 2015  
 -- More UART data has been defined and the offset of fuel gauge and ADC has been clarified.

V3.5 Kerwen/July 8, 2015  
 -- Trim mechanism has been clarified, and the NV flash erase time limit has been added into the specs.

V3.6 Kerwen/Aug 7, 2015  
 -- PAYG definition has been introduced briefly on Page20. And the info for Angaza has been marked in red.

V3.7 Kerwen/Aug20, 2015  
 -- UART data of counters and timers were marked to be stored in NV flash.

V3.8 Kerwen/Aug21, 2015  
 -- More UART data was introduced and defined.

V3.9 Kerwen/Aug25, 2015  
 --  internal reference voltage and raw ADC value of those 5 keys were added in UART logging.

V4.0 Derek/Sep 9, 2015  
 -- ADC values were stored in physical value format, such as mA/mV.   
 -- Time related counters were defined to 99,999 counts.   
 -- FM ASIC key protocol has been updated to the format of \*#NNCC (\*# is the start bits; NN is the number bits; CC is the checksum bits)

V4.4 Kerwen/Oct 30, 2015  
 -- Modified the specs of UART data a little bit.  
 -- Add the requirement of the brightness of turbo mode for different models.  
 -- Add the procedure of "System Trim".  
 -- Add the instructions of PAYG library.  
 -- Add the requirement of power consumption when any of those 5 PAYG keys is accidentally pressed.

V4.5/4.5b/4.5c Patrick and Martin/Nov 9, 2015   
-- specs updated for UART data logging, incl the items below:  
time locks to avoid repeatedly accumulating the same counters in one day for 7 counters below  
 any-fault counter;  
 fuel-gauge low-battery-trigger counter;   
 slope low-battery-trigger counter;   
 voltage low-battery-trigger counter;   
 empty battery counter;   
 CV charging counter and full battery counter.  
clarify for usage timing related counters of usage, non-usage and working.  
introduce battery capacity measurement method.  
counter split for different low fuel triggering mechanisms of voltage, slope and fuel.  
Any-fault counter introduced.  
UART protocol clarification for data logging and bootloader.

V4.6/V4.6b Martin/Kerwen /Nov 10, 2015  
 -- History paged introduced into the Platform M3 Specification.  
 -- Further clarification for Battery Capacity Measurement(BCM).  
 -- Key press description -- Page 13.  
 -- Split the UART interface protocol out from the data logging table.   
 -- Fuel Empty Battery Trigger deleted.   
 -- Product Delivery Flag introduced to UART.   
 -- UART Max. Charge Rate updated to catch the max charge rate in the life of product.  
 -- The following counters were updated from increment for each hour to for each 15 min.

UART CV Charge Time  
UART Charge Level\_1 Time  
UART Charge Level\_2 Time  
UART Charge Level\_3 Time  
UART Charge Level\_4 Time  
UART Charge Level\_5 Time  
UART Low Battery Discharge Time  
UART LED Mode 1 Discharge Time  
UART LED Mode 2 Discharge Time  
UART LED Mode 3 Discharge Time  
UART Radio Working Time

-- Three extra counters were introduced and counted once per 15min:   
 USB Heavy-Load Time; USB Light-Load Time; Battery Capacity.  
 -- Date record updated from week of the year(WWYY) to day of the year (DDDYY).   
 -- Set Delivery Flag when the product is operated under charged/discharge continuously for more than 60min.  
 -- Resume the working hour to record over the life time of product, instead of the inventory only.   
V4.6c Martin/Kerwen /Nov 12, 2015  
 -- Further clarification for the method of entering Empty Fuel – Page 8  
 -- Increase the current of Mode 3 to meet 150 lm of brightness – Page 13  
 V4.6d Martin/Kerwen /Nov 18, 2015  
 -- Modify the current of Mode 3 to 359.2mA. Forgot to consider the transmittance in the previous version. – Page 12  
 -- Update UART data logging and communication specification according to “Usage Data to Angaza – Draft v0.3” – Page 25

V4.6e Martin/Kerwen /Nov 19, 2015  
 -- Update the BCM method – Page 9  
 -- Update UART data logging and communication specification. Modify H8 to “CV-to-Low-Battery Previous Cycle Capacity”, add H9 as “CV-to-Empty-Battery Previous Cycle Capacity”. – Page 28