Ocean Engineering Technical Data Sheet

Theory of Operation - Category I Solar Powered Lighthouse System (Regulated)

This Category I Solar Powered Lighthouse is designed to be a self-sufficient, low-maintenance, highly reliable major aid system intended for installation at remote lighthouses that are difficult and costly to access and where no reliable commercial power is available.

Refer to standard Office of Civil Engineering lighthouse drawing 140410 Rev. G, 3 sheets, CATEGORY I SOLAR POWERED LIGHTHOUSE SYSTEM (REGULATED).

Coast Guard standard AtoN DVM Fluke 77 (or 87), or equivalent, should be used to conduct various system checks during system installation and final system checkout to ensure proper operation including voltage, continuity, and logic confirmation checks.

INITIAL CONDITIONS

Before wiring the system, ensure all four circuit breakers in the charge controller and all twelve circuit breakers in the Solar Distribution Box (SDB) are in the **off** position. Also ensure all five fuses are removed from the PV Combiner Box (PVCB). After the sub-arrays are wired up and all connections are made to the Local Terminal Boxes (LTB) make the necessary wiring connections to the PVCB, Charge Controller, and SDB. Ensure switch S1 (or SW-1) is in the "1" position on both Solar Aid Controller IIs (SACII).

Finish by wiring up all loads; including power, all remote monitoring, remote control, and remote reset connections to the Low Energy ACMS (LEACMS); the auxiliary array; and the auxiliary battery. Ensure main battery bank is fully charged; and, when confirmed to be so, connect to Charge Controller.

Power Up.

After all system wiring is completed, carefully install the five 30A fuses back in the PVCB. Switch on the circuit breakers one, two, and three in the Charge Controller. If no problems occur, switch on circuit breaker four. In the SDB, check for proper system voltage by reading voltage level on the on-board voltmeter with Voltage Select Switch, SW1, set to the "MAIN POWER" position. If appropriate voltage level is present, switch on circuit breakers one breaker at a time in the following sequence: #1 (Main Light), #12 (Main Light Motor), and #3 (Main Sound), and #4 (RACON). Cover the photoresistor and power up the Main Light and Main Sound signals by switching on the SACII Power circuit breaker, breaker #9. Main Light and Main Sound signals should come on line. Switch on circuit breakers #5 (LEACMS), #6 (Emergency Light), #7 (Fog Detector), #8 (Emergency Sound), #10 (Aux Array In), and #11 (Aux Batt In).

SOLAR POWER SYSTEM

Up to five Photovoltaic (PV) sub-arrays of up to eight solar panels (modules) each, tied together at the LTBs, are combined at the PVCB to form the main solar array. Combined power from the PVCB is then distributed to the Charge Controller on three separate power lines (feeders). The Charge Controller monitors main battery bank voltage and disconnects a large portion of the array from the battery bank when battery voltage reaches a high of about 15.0-VDC (exact value is user settable but depends on location and temperature - confirm the installation of a temperature compensator circuit card assembly (CCA) in the charge controller; the temperature compensator CCA was a field change installation in earlier version Charge Controllers). It continues to monitor the main battery voltage and then reconnects all arrays when battery voltage falls to a low of 12.5-VDC, in effect, regulating the solar charge system. Regulated power from the main battery bank via the Charge Controller is then sent directly on a single high current power feeder to the SDB. The SDB, under normal conditions, distributes 12-VDC power to all the loads through ten independent protected circuits, including a spare (circuit breaker #2). Power to the Main Light and Main Sound signals are provided via SACIIs which are installed against the mounting panel inside the SDB. Power to the emergency sound signal is provided via a solid state relay (SSR) which is also mounted to the front of the mounting panel inside the SDB. An auxiliary array is connected to the SDB at the AUX ARRAY IN terminals and an auxiliary battery at the AUX BATTERY IN terminals for emergency backup power.

The main solar array charges the main battery bank during sunlight hours to provide continuous power to the loads, with heaviest power demands at night. The auxiliary solar array keeps the auxiliary battery continually charged in case main battery voltage drops to unsafe levels due to system malfunctions. Loads on SDB's circuits #1 (Main Light), #2 (Spare), and #5 (LEACMS) are protected by 20A circuit breakers while the rest are protected by 10A breakers. The breakers double as on/off load switches to monitor individual aid operation or to help with troubleshooting.

LIGHT SIGNAL SYSTEM

Continuing discussion from the last paragraph, in solar powered lighthouse systems with high-current Main Light lamps (50- or 110-Watt lamps) and SACII-provided lampchanging, unless SACII L1's (Main Light control) lampchanging signal (F-function) is interrupted, or SACII power is first switched off (at breaker #9), interrupting power to the Main Light by turning off the Main Light circuit breaker (breaker #1) will cause the Main Light's lampchanger to advance until power is restored to the light or the sixth and final position of the lampchanger is reached. An alternative method of turning the Main Light off for servicing purposes, without disabling the SACIIs, is by applying a ground to the SACII L1's CONTROL terminal, TB1-5. This can be achieved manually or by exposing the photoresistor's light-sensitive surface to a sufficient amount of light. This will turn the Main Light signal off without causing unwanted lampchanger advance. Please note that the SACII L1 will monitor lamp current and beacon rotation only when TB1-5 is ***not*** grounded or while the photoresistor is registering darkness (nighttime).

By the same token, when Main Light Motor circuit breaker (breaker #12) is turned off while the Main Light is being controlled **on** by SACII L1, the SACII will post a rotation failure and switch over to auxiliary mode of operation (emergency light on) in about 100 seconds. Once again, an

application of ground to TB1-5 will prevent this from happening and allow the servicing technician to turn off power to the Main Light Motor as needed.

Similarly, unless TB1-5 of SACII S1 is grounded either manually, by the Fog Detector, or by LEACMS remotely, turning the Main Sound signal circuit breaker off (breaker #3) for servicing will cause the SACII S1 to switch the sound signal system to auxiliary mode of operation (emergency sound on) in about 100 seconds. Please note that if the sound signal is fog detector-controlled and visibility is good, the sound signal will already be commanded off.

The SDB has two on-board voltage monitoring circuits that continuously measure the voltage at the Main Power In terminals (i.e., main battery bank voltage). When main battery voltage falls to 11.5-VDC (about 40% state of charge), SDB's first voltage monitoring circuit posts a low voltage alarm (contact closure to ground) to the LEACMS. If and when main battery voltage reaches 11.0-VDC (about 20% state of charge), the SDB's transfer circuit disconnects the main battery from **all** the loads, connects the auxiliary battery to loads connected to circuit breakers #4 through #9 and #12 ***only***, notifies the LEACMS (contact closure to ground), and interrupts the lampchanging "F" pulse signal generated by SACII L1 from reaching the Main Light lampchanger. Confirm the presence of the Auxiliary Reset Module (ARM) circuit card assembly as it was a field change installation in earlier generation SDBs. This transfer to auxiliary battery also simultaneously disconnects all power to circuit breakers #1 (Main Light), #2 (Spare), and #3 (Main Sound). About 100 seconds after power cutoff to the main signals, both SACIIs will detect system malfunction, switch to auxiliary mode of operation, and activate the emergency light and sound signals.

The SDB will reconnect the main battery and disconnect the auxiliary battery if and when the solar array is able to recharge the main battery to 12.75-VDC. If and when the main battery reconnects, the ARM will automatically send a system-resetting ground pulse to the RESET terminals of both SACIIs resetting the entire system to the primary mode of operation. The system can also be reset either manually or remotely by the LEACMS (see next paragraph for details). This low voltage transfer function saves the main battery from deep discharge damage. Both the low voltage alarm and battery transfer alarm voltage thresholds are user adjustable; however, the thresholds are factory set to optimum levels and should not ever require adjustment. In the rare event that adjustment becomes necessary, contact equipment manager in COMDT (G-SEC-2A). The SDB does not provide deep discharge (low voltage) protection for the auxiliary battery.

Upon power up, given that main battery bank voltage exceeds 11.0-VDC after system settles into steady state operation, the SACIIs will automatically reset and begin running the system in the primary mode. To manually reset the SACIIs after a time-out for any reason, either turn off breaker #9 for approximately 15 seconds, apply a momentary ground to the RESET terminal (TB1-6) manually or remotely through LEACMS (A/V RESET via the ARM), or press the reset button on top of the SACII (this last option is available only on newer version SACIIs). Switch S1 should remain in the "1" position on both SACIIs for all standard solar powered lighthouse configurations. Position "2" is for special applications only. With the SACIIs in primary mode, the system should begin normal operation, i.e., Main Light on at night, Main Sound on if low visibility (or fog detector off), and logic "low" (ground) at TB1-7 on both SACIIs.

Daylight Control.

SACII L1 directly controls and monitors the operation of the Main Light while the photoresistor controls its on/off operation, at TB1-5. A photoresistor is a light-sensitive solid state device that changes resistance as light levels change. The resistance increases as the light level decreases. One side of the photoresistor is grounded at J(-) terminal, TB1-2, and the other side is connected to the CONTROL terminal, TB1-5, of SACII L1. During the daytime when the photoresistor's resistance is low, a ground level, in effect, is applied through it to TB1-5 of SACII L1 keeping the Main Light off. At nightfall, the resistance of the photoresistor goes high removing ground from TB1-5, turning the Main Light on. In primary mode when the Main Light is on, logic level at TB1-8 should be "low."

SACII L1.

SACII's power port (TB2-1 & 2) is an open-drain power MOSFET switch. The main lamp current is sensed within the SACII L1 at the MOSFET switch and compared to a preset reference. The current reference /threshold is factory preset to about 1.5-amps; however, it is user adjustable. The factory preset current reference/threshold setting should never require adjustment if your main lamp is 50-Watts or higher. However, if adjustment becomes necessary or if using low-current main lamps (under 50-Watts), contact equipment manager in COMDT (G-SEC-2A) for guidance and/or documented adjustment procedure.

At night, when main lamp current loss is detected, the SACII L1 automatically activates and sends an "F" pulse signal to the Main Light's lampchanger in an attempt to advance it to the next lamp position. When the last lamp in the lampchanger (position six) fails, SACII L1 will send and continue to apply the "F" pulse signal to the lampchanger for about 100 seconds more until the SACII's internal watchdog timer times out. The SACII L1 will then switch over to auxiliary mode of operation, securing power to the Main Light at the power port (TB2-1 & 2), and sending a ground (from TB1-10) to emergency light flasher's appropriate "S" terminal turning the emergency light on. A logic "low" at TB1-9 indicates that the light signal system has switched over to and is now operating in the auxiliary mode (emergency mode). The Type L photoresistor connected to SACII L1 which previously controlled the normal on/off operation of the Main Light will now control the emergency light's on/off (night/day) operation by toggling the logic status at TB1-10 between logic "low" (on) and "float" (off). Ensure that there is ***no*** other photoresistor installed anywhere in the system, especially at the emergency light's flasher. In the auxiliary mode when the emergency light is on, the emergency light's flasher provides lamp current sensing and lampchanging.

Rotation Detection.

While the SACII L1 continuously monitors main lamp current, it also continuously monitors lantern rotation, if desired. The rotation detector installed inside the rotating beacon's housing supplies timer-resetting ground pulses to the SACII L1's ROTATION input terminal, TB1-4. The small blue jumper wire connected between TB1-2 and TB1-3 must be removed from SACII L1 in order to enable its rotation detection circuitry. This jumper wire is required for special applications only; e.g., flashing main light. With the blue jumper wire removed, as long as the SACII L1 receives a ground pulse from the rotation detector at least once about every 100

seconds, the light circuits will remain in the primary mode (Main Light not failed). If the lantern motor fails and the beacon stops rotating, the rotation detector ceases to send timer-resetting ground pulses to the SACII L1. After about 100 seconds the SACII will time out, switch the light signal system to auxiliary mode of operation, secure power to the Main Light, and apply a ground to emergency light flasher's appropriate "S" terminal to activate the emergency light. The SACII's ROTATION input can also detect over-speed conditions. If for whatever reason the beacon starts to rotate at a higher-than-normal RPM corresponding to more than one ground pulse every two seconds into TB1-4, the SACII will time out and switch the light signal system to auxiliary mode after 100 seconds. Emergency light's rotation (if a rotating beacon), however, is not monitored.

SOUND SIGNAL SYTEM

The sound signal system is hooked up in a manner similar to the light signal system. SACII S1 directly controls the Main Sound signal's on/off operation. The Main Sound signal is indirectly controlled via SACII S1's CONTROL terminal (TB1-5) by either a fog detector or remotely by the LEACMS; however, if an LEACMS is installed, it will normally be configured to keep the Main Sound signal always controlled on (free-running). If fog detector control is desired (in lieu of LEACMS) a contact closure to ground (provided by the fog detector) supplied to SACII S1's CONTROL terminal (TB1-5) commands the sound signal off under normal visibility conditions. By the same token, under low visibility conditions the fog detector's contact closure opens, thus removing ground from TB1-5 and thereby commanding the sound signal on.

Sound signal monitoring is provided by the Sound Signal Current Detector (SSCD). The SSCD directly senses the actual 390-Hz audio signal going to the drivers (horns) of the FA-232/02. If the Main Sound signal is operating normally the SSCD provides a timer-resetting ground pulse to SACII S1's ROTATION input terminal (TB1-4) during a sound blast. Yes, you read that correctly, the ***ROTATION*** input! This operation is similar to the way a rotation detector provides timer-resetting ground pulses to the SACII L1 in the Main Light circuit. Likewise, the small blue jumper wire connected between TB1-2 and TB1-3 must be removed from SACII S1 in order to enable sound signal monitoring. When the Main Sound signal fails and the SSCDs cease to provide timer-resetting ground pulses to TB1-4, the SACII S1 will time out after about 100 seconds, switch over to auxiliary mode of operation, and indirectly, via the SSR, activate the emergency sound signal. The normal on/off operation of the emergency sound signal is now controlled by the same fog detector or LEACMS that originally controlled the Main Sound signal's on/off operation before its failure.

In the primary mode, the SACII S1's internal watchdog timer is activated and starts timing out immediately after each sound blast but resets automatically at the start of the blast as long as the FA-232/02 is operating normally. One SSCD is required for each FA-232 driver present; i.e., the FA-232/02 will require two SSCDs connected in series: one side of the series string is connected to ground at TB1-2 of SACII S1 and the other side is connected to the ROTATION input (TB1-4). Since the SSCD is a non-polarized device, the two SSCDs can be connected up together without regard to the individual wire's polarity (such as plus or minus). In this way, ***both*** sound signal drivers that make up an FA-232/02 must be blasting normally and at the same time in order for the timer-resetting ground pulse to make its way through each SSCD and reach SACII S1 at TB1-4. No connections are made to SACII S1's TB2-3 terminal.

Since the Main Sound signal's 12-VDC operating current is not monitored, SACII S1's factory preset 1.5-amp current threshold must be lowered to decrease the risk of false triggering. This is especially important if the Main Sound signal is a single FA-232 or a single SA-850, both of which draw maximum currents too close to the 1.5-amp preset threshold for comfort. Contact equipment manager in COMDT (G-SEC-2A) for instructions.

LOW ENERGY ACMS INTERFACE

The SACII L1 provides Main Light signal status to the LEACMS. The LEACMS continuously monitors the light system's mode of operation, primary (normal) or auxiliary (failed), and if in primary mode, whether the Main Light is on or off (at TB1-8).

Similarly, SACII S1 provides Main Sound signal status to the LEACMS. The LEACMS also has the capability to remotely command the sound signal on and off (both main and emergency signals).

LEACMS has the capability to remotely perform an audio/visual system reset by providing a momentary ground to SACII L1's and SACII S1's input RESET terminals (TB1-6) via the ARM.

Also, as discussed earlier, the SDB provides main battery bank status to the LEACMS. The low battery voltage alarm conditions are LOW ALARM (at 11.5-VDC) and TRANSFER ALARM (at 11.0-VDC).

RACON

The SDB provides power to the free-running RACON on circuit #4. The Seabeacon 2 RACON is monitored by the LEACMS but not controlled.

Theory of Operation - Category II Solar Powered Lighthouse System (Regulated)

The Category II solar powered lighthouse system is essentially identical to the Category I system described in the preceding discussion but without the requirement for remote aid monitoring and control, i.e., **no LEACMS**. Otherwise, the entire Category I discussion applies.

Refer to the standard Office of Civil Engineering lighthouse drawing 140412 Rev. B, 3 sheets, CATEGORY II SOLAR POWERED LIGHTHOUSE SYSTEM (REGULATED).

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