GENCON™ Communicator Mk 3 (COMM3)

Enoch H Wexler*

October 12, 2020

Contents

*emc.consultants@gmail.com

1 General

COMM3 is a control and monitoring hub for power plants that employ multiple "all-in-one" GENCON genset controllers. COMM3 software is based on the real-time branch of the Linux operating system. The features described herein correspond to COMM3 software version 0.75. The 7" touchscreen mimics the front panel of the selected GENCON controller, which is B2 in the following snapshot:

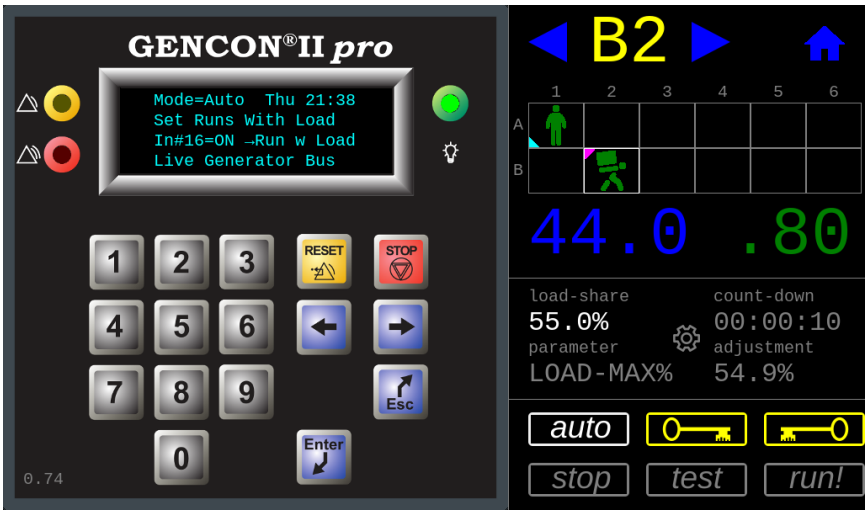


Figure 1: Blue homepage: GENCON mimic

COMM3 expands and improves on the following GENCON functions:

1. Load sharing
2. Event logging
3. Data scope
4. Gensets management
5. Communication:
   - Intranet: Modbus/TCP slave
   - Internet: MQTT/TCP client

2 Load-sharing

Logically interconnects two GENCON networks, alone capable of controlling 8 gensets max only, to form an integral 14 gensets max load-sharing system.

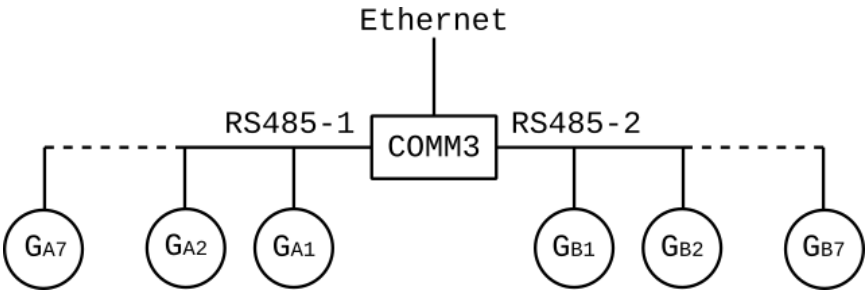


Figure 2: Max load-sharing system block diagram

Network A (RS485-1) has a **virtual** genset representative of network B (RS485-2) in its ID No 8 slot, and vice versa. This means that if any genset in network B is the bus master[1], its network representative in network A is network A bus master. This is demonstrated in the following snapshot: Genset A1 display is replicated on screen. The magenta colored corner indicates that genset B2 is the bus master:

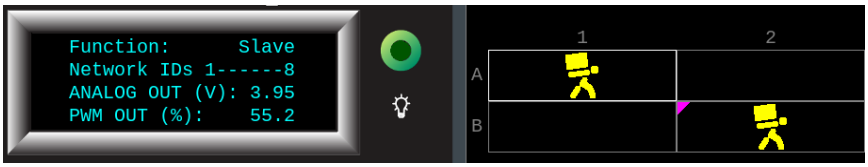


Figure 3: Bus extension demonstrated

3 Event-logging

COMM3 maintains a logbook of the last 100 genset events.

[1]GENCON load-sharing basics: During load-sharing one genset, and one genset only, sets the bus frequency and the bus voltage at fixed levels. This genset is called the bus "master". In other words, the GENCON controller of this bus master holds its SYSTEM / ANALOG-OUT and PWM-OUT control outputs at fixed levels. During load-sharing the GENCON controllers that serve the other "slave" gensets constantly regulate their power output to match the load of their master (in proportion to their rating).

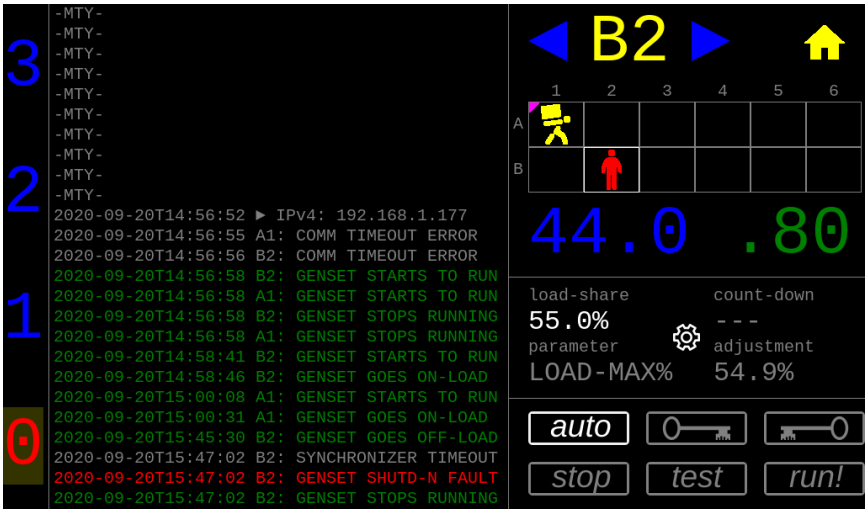


Figure 4: Yellow homepage: New alarms enter the red page #0:

Logged events are called up through the top-right home button. The events are grouped into 4 pages, 25 entries each, where the "live" page 0 displays the most recent events as they enter. Repeated events, such as failed IoT BROKER connections, are logged once only. During COMM3 software set-up the text messages which describe GENCON events can be customized as per each GENCON use.

4 Data-scope

Genset measurements are organized in any desired column order with horizontal scrolling, through selected tab points, making room for all. The measurement color depends on its value exceeding or falling below a set of programmable thresholds. Here is a snapshot:

5 Gensets-management

Using GENCON load-sharing configurations COMM3 engages gensets according to the common bus load, and alternates their activity in a way that balances out their individual run-time count. Here is a short demo:

Sorry, Your browser does not support the video tag.

LOAD-MNGMT ("management") is applied to load-sharing gensets with controllers in configuration #3 and #6 only. Detecting a different con-

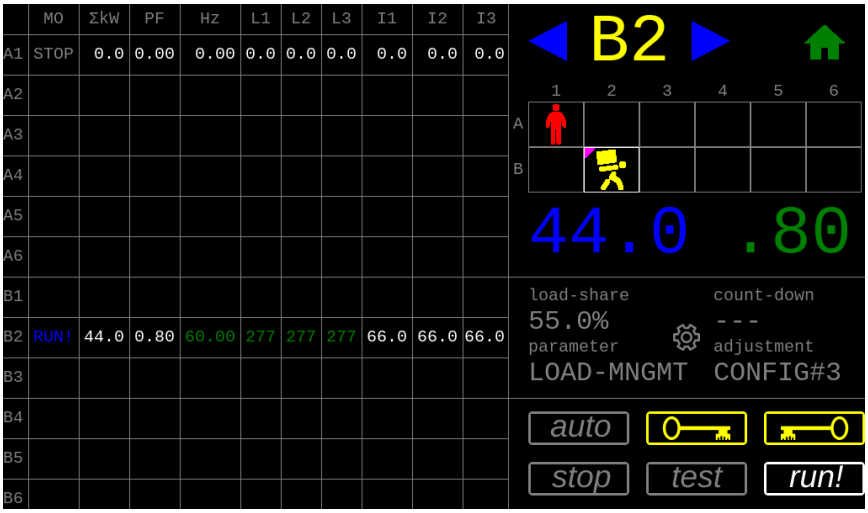


Figure 5: Green homepage: GENCON measurements to compare

figuration would disable the management system with a message identifying the conflicting controller. Note that the load-sharing config#6 can also handle Automatic Mains Failure Standby with soft return to the mains and on demand Peak Shaving. Starting and stopping the gensets with appropriate {*Standby On*} and {*Standby Off*} delays is the responsibility of the participating controllers – via a common In#16 wiring in the config#3 case, or by detecting mains failure, in the config#6 case. Management is performed by toggling in **auto** the Mode of Operation between **STBY** to **AUTO**.

Only when the two touchscreen "skeleton-keys" are gold colored can the on-screen viewed genset be stopped, its alarms reset and its operating mode (*auto* .. *run!*) changed. Also, the management parameters cannot be adjusted unless both keys are gold colored. If you leave the screen untouched for 5 minutes the keys would turn gray and your privileges revoked. Using a genset rotary mode switch, which is customarily wired to the I/O board inputs #01 RUN WITH LOAD, #02 TEST W/O LOAD and #03 SLEEP, would override and toggle the touchscreen *auto*, *stop*, *test* and *run!* buttons.

6 Adjustable-parameters

To adjust the parameters you need to touch the "skeleton keys" first to turn their color gold.

COMM3 has 5 push-buttons on the front panel right side. Their function,

from top to bottom, is as follows:

1. Set GENCON clock. Your time zone is a **setup** option.
2. Select previous parameter.
3. Select next parameter.
4. Increment the parameter value with keystroke-rate dependent step[2].
5. Decrement the parameter value with keystroke-rate dependent step.

7 Backup

When you gray the touchscreen "skeleton-keys" the management parameters and the genset operating modes are saved to a µSD file; to be recalled when the system powers up next. **Warning!** This may include an immediate genset start up. If the system setup includes the **Rebase run-time counters** option those counters offset ("base") is saved too.

8 LCD back-light

The LCD screen back-light LEDs automatically turn off to reduce the current draw on the system battery and to extend those back-lights life. See the adjustable parameter #1.

9 "Watching the wheels go round and round", J. Lennon

The cogwheel at the center of the management sub-screen should never stop "revolving". If it stops for more than a second the system should restart automatically.

[2]Slow down your keystrokes for finer adjustment steps. Press and hold a timer key for a second+ and the setting would "jump" to the next sixth or tenth full-range stop.

Table 1: Adjustable Parameters

№	Name	Description	Min Value	Max Value
#1	SCREEN•	Backlight turnoff timer	60 sec	1 hour
#2	IoT-BROKER	Remote MQTT server (TCP port 1883)	DISABLED	ENABLED
#3	LOAD-MNGMT	Management logic	DISABLED	CONFIG #3 or #6
#4	LOAD-MAX%	Critically high load before...	50%	110%
#5	LOAD-MAX•	Time-delay count-down before adding a genset	3 sec	1 hour
#6	LOAD-MIN%	Critically low load before...	0	#4 parameter value
#7	LOAD-MIN•	Time-delay count-down before removing a genset	3 sec	1 hour
#8	LOAD-INT•	Initial time-delay before removing any genset	#7 parameter value	1 hour
#9	MNGMT-CT•	Cycle-time to consider run-time count & priority	every 2 minutes	99:59 hours or indefinitely
	PRIORITY-A1	Genset priority: IMM, HIGH, MEDIUM or LOW	IMM	LOW
	...			
	PRIORITY-B7	Genset priority...	IMM	LOW

10 Technology

COMM3 is made of two main components: The Beaglebone Black single board computer ("BBB" SBC) that is plugged into Chipsee, a 1024x600 pixel 7" capacitive touch, LCD expansion board ("BBB-EXP7H-Capacitive"), its cape. The operating system is a special Linux compilation ("Buildroot") of the Beagleboard 4.14-rt branch, a TI real-time Linux software repository. The project software is mainly written in C and Python. The software is provided on a replaceable µSD card.

11 GENCON firmware

11.1 General

COMM3 *requires* the following GENCON firmware to operate. This firmware has the following new features:

- Auto/Stby mode switching under COMM3 control.
- A load-sharing #3 configured genset can be started/stopped immediately by In#01 and, following {*Standby On*}/{*Standby Off*} time-delays, by In#16. A genset started by In#16, unlike when starting by In#01, would call up all the other gensets that are in *auto* mode, to run in parallel and share the load. Starting a genset by the touchscreen *run!* button is equivalent to starting it by In#16.

11.2 IOB1 version 3.9R 200830

FIELD	DEMO
63.5V	—-
120V	120V
220V	220V
240V	240V
277V	277V

11.3 IOB2 version 3.9R 200830

FIELD	DEMO
63.5V	—-
120V	120V
220V	220V
240V	240V
277V	277V

11.4 IOB4 version 3.9R 200830

FIELD	DEMO
63.5V	—-
120V	120V
220V	220V
240V	240V
277V	277V

12 COMM2-PRO

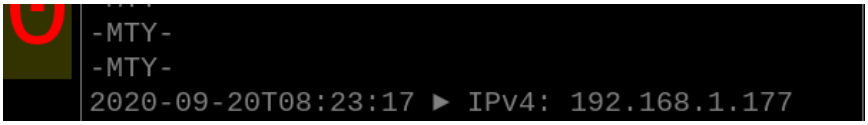
The previous Communicator model is still a useful tool during GENCON based systems service and commissioning. Hence, through this new modbus.146 firmware, it has been brought into compatibility with GENCON firmware V3.9R, the firmware that the COMM3 project requires. Use the Gpanes V145 utility to "Load COMM Firmware". Note that this COMM2-PRO firmware is only available to new or upgraded COMM2-PRO units that have a pre-installed "boofa" bootloader.

13 Modbus/TCP-slave

13.1 General

Modbus/TCP is a protocol suitable for on-site plant monitoring.

The 100 Mbit/s Ethernet interface, port 502, is a high capacity Modbus/TCP server that accepts multiple simultaneous connections. The IPv4 address for the Ethernet interface is allocated when COMM3 powers-up and is reported to the event log. For example:



The server answers queries to unit 1 – the *system overview*, to units 11, 12, etc. – the RS485-1 connected *gensets A1, A2, etc.* and to units 21, 22 etc. – the RS485-2 connected *gensets B1, B2, etc.*

Floating Point analog values in IEEE 754 format (FP) and 32 bit counter values (DWORD) pass in two registers with the more significant register first ("bigendian"). The "Positive Infinity" and "Negative Infinity" floating point special values represent senders over-range and under-range analog values, respectively. When an analog value is not available a floating point qNaN, a "quiet Not a Number", passes. WORD denotes an ordinary Modbus 16 bit value. 2ASC denotes a WORD holding 2 ASCII characters with the MSB first, e.g., 3031_{hex} for "01".

13.2 Unit 1: System Overview

13.2.1 Input registers

Addr	Hex	Type	Description
1, 2	00	FP	Total kW power
3, 4	02	”	Total power factor
5, 6	04	”	Master genset load%

13.3 Unit 11: GENCON A1

13.3.1 Discrete inputs

Addr	Hex	Description of default use
1	00	GENCON relay R#1: trip-coil
2	01	GENCON relay R#2: visual-alarm
3	02	GENCON relay R#3: audible-alarm
4	03	GenSet is the bus master
5	04	GenSet is on full-load
6	05	IOB relay K#1: preheat
7	06	IOB relay K#2: fuel-solenoid
8	07	IOB relay K#3: crank
9	08	IOB relay K#4: air-damper
10	09	IOB relay K#5: lubrication pump
11	0A	IOB relay K#6: gen activity
12	0B	IOB relay K#7: gen breaker
13	0C	IOB relay K#8: mains breaker
14	0D	IOB error

Continued on next page

Continued from previous page

Addr	Hex	Description of default use
15	0E	RPM vs frequency error
16	0F	Illegal gen phase order
17	10	GenSet over-voltage
18	11	GenSet under-voltage
19	12	GenSet over frequency
20	13	GenSet under frequency
21	14	GenSet over current
22	15	GenSet reverse power
23	16	GenSet excitation loss
24	17	GenSet high harmonics
25	18	High battery voltage
26	19	Low battery voltage
27	1A	Remote emergency stop
28	1B	Low oil pressure shutdown
29	1C	Low oil pressure warning
30	1D	High water temperature shutdown
31	1E	High water temperature warning
32	1F	Low water temperature
33	20	Low water level
34	21	Low fuel level
35	22	Battery charger fault
36	23	Air damper closed
37	24	Not in auto mode
38	25	External overload
39	26	Generator breaker failure
40	27	Mains breaker failure
41	28	Shutdowns bypass on!
42	29	RPM over-speed
43	2A	Synchronizer timeout
44	2B	RS-485 communication error
45	2C	Unexpected bus volts
46	2D	Immediate shutdown
47	2E	Delayed shutdown
48	2F	Cumulative warning
49	30	Cumulative warning or shutdown
50	31	Unbalanced current
51	32	Engine over crank

Continued on next page

Continued from previous page

Addr	Hex	Description of default use
52	33	Engine slow crank
53	34	GenSet starting failure
54	35	GenSet stopping failure
55	36	IOB2: Sender#1 low OHMs, IOB4: ECU COMM T/O -SHUTDN
56	37	IOB2: Sender#2 low OHMs, IOB4: ECU SHUT DOWN ENGINE
57	38	IOB2: Sender#3 low OHMs, IOB4: ECU RED LAMP
58	39	IOB2: Sender#4 low OHMs, IOB4: ECU AMBER LAMP
59	3A	IOB2: Sender#1 high OHMs, IOB4: ECU PROTECT LAMP
60	3B	IOB2: Sender#2 high OHMs
61	3C	IOB2: Sender#3 high OHMs
62	3D	IOB2: Sender#4 high OHMs
63	3E	IOB2: Sender#1 open circuit
64	3F	IOB2: Sender#2 open circuit
65	40	IOB2: Sender#3 open circuit
66	41	IOB2: Sender#4 open circuit
67	42	AVR control failure
68	43	Governor control failure
69	44	COMM timeout
70	45	Auto mode indicator
71	46	In#15: GenSet breaker aux contact
72	47	In#16: Mains breaker aux contact
73	48	Maintenance is required
74	49	In#01 command (Mode=Auto): Run (with load)
75	4A	In#02 command (Mode=Auto): Test (w/o load)
76	4B	In#03 command (Mode=Auto): Sleep
90	59	No communication
91	5A	Pending shutdown fault
92	5B	Pending warning fault
93	5C	GenSet is running
94	5D	GenSet at standstill
95	5E	GenSet is on load
96	5F	GenSet is off load

13.3.2 Input registers

Addr	Hex	Type	Description of default use
1 .. 10	00	2ASC	Firmware ID string, e.g., "IOB4:. . . "
11, 12	0A	DWORD	GenSet KW Hours count
13, 14	0C	”	GenSet Run-time Minutes
15, 16	0E	FP	IOB2: Sender#1, IOB4: Temperature ℃
17, 18	10	”	IOB2: Sender#2, IOB4: DC mA
19, 20	12	”	IOB2: Sender#3, IOB4: DC Volts
21, 22	14	”	IOB2: Sender#4, IOB4: 13 ECU status bits
23	16	WORD	Engine Cranks count
24	17	”	GenSet Runs count
25	18	”	GenSet OnLoad count
26	19	”	GENCON configuration options
27	1A	”	1^{st} / Latest report code
..	..	”	e.g., report code 5 = STOP BUTTON PRESSED
34	21	”	8^{th} / Oldest report code
35, 36	22	FP	GenSet A Volts (V1)
37, 38	24	”	GenSet B Volts (V2)
39, 40	26	”	GenSet C Volts (V3)
41, 42	28	”	GenSet A Amps (I1)
43, 44	2A	”	GenSet B Amps (I2)
45, 46	2C	”	GenSet C Amps (I3)
47, 48	2E	”	GenSet Frequency Hz (V1)
49, 50	30	”	Bus A Volts (V4)
51, 52	32	”	Bus Frequency Hz (V4)
53, 54	34	”	GenSet KW (active power)
55, 56	36	”	Genset KVAR (reactive power)
57, 58	38	”	GenSet KVA (apparent power)
59, 60	3A	”	Engine speed RPM
61, 62	3C	”	Battery volts
63, 64	3E	”	GenSet KVA rating
65, 66	40	”	GenSet KW rating
IOB4			Cummins PGI ECU default selection
67, 68	42	FP	Coolant Temp ℃ (SPN 110)
69, 70	44	”	Fuel Temp 1 ℃ (SPN 174)
71, 72	46	”	Oil Temp 1 ℃ (SPN 175)
73, 74	48	”	Exhaust Gas ℃ (SPN 173)
75, 76	4A	”	Coolant Press kPa (SPN 109)
77, 78	4C	”	Oil Press kPa (SPN 100)

Continued on next page

Continued from previous page

Addr	Hex	Type	Description of default use
79, 80	4E	”	Fuel Delivery kPa (SPN 94)
81, 82	50	”	Barometric kPa (SPN 108)
IOB4		ECU	Active Diagnostic Trouble Codes (DM1)
83	52	WORD	Number of active DTCs
84	53	”	Lamps (LSB), Flash (MSB)
85, 86	54	DWORD	DTC_1 (SPN,FMI,CM,OC)
..		”	
119, 120	76	”	DTC_{18}
IOB4		ECU	Previously Active Diagnostic Trouble Codes (DM2)
121	78	WORD	Number of active DTCs
122	79	”	Lamps (LSB), Flash (MSB)
123, 124	7A	DWORD	DTC_1 (SPN,FMI,CM,OC)
..		”	
157, 158	9C	”	DTC_{18}

- IOB4: 13 ECU status bits

bit	ECU status
#0..7	Active Diagnostics Lamps (DM1)
#8	Active Power Down
#9	Engine Power Down
#10	ECU Communication Timeout
#11	Engine Start-up Suspended

- GENCON Configuration Options

bit	Option
#0	Generic Configuration
#1	Paralleling System
#2	Mains Standby ATS
#3	Cogeneration Mode
#4	System Auto Start
#5	Load-Sharing AMF
#6	Comm Timeout Enable
#7	1

13.4 ModScan32 sample screenshot

ModScan32 is a popular test software for Modbus slave devices. A free demo is available from: `https://www.win-tech.com/html/demos.htm`

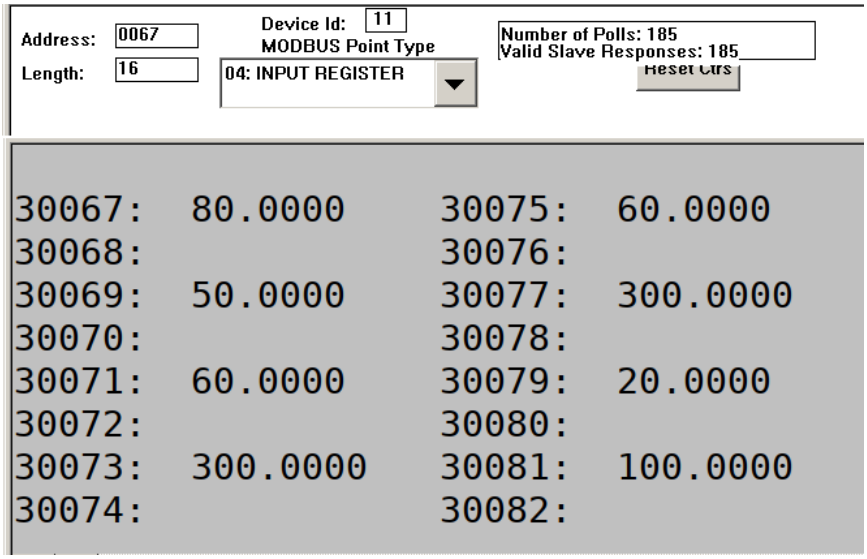


Figure 6: CANbus retrieved J1939 ECU measurements

13.5 Connecting to Microsoft Excel

This Microsoft Excel Spreadsheet, via an underlying VBA script (macro), connects to the COMM3 Modbus/TCP server port 502 and updates every 2 seconds. The script requires the OstroSoft Winsock Component software library to be preinstalled. Download oswinsck.exe. *emc.verizon.net* is the fully qualified domain name of the COMM3 server on our local network.

14 MQTT/TCP-client

14.1 General

MQTT/TCP is a protocol suitable for off-site plant monitoring through an intermediary Internet "broker" server.

14.2 Dashboards demo

COMM3 was tested with Thingsboard, a popular open-source Internet of Things (IoT) platform. Here are a few browser snapshots:

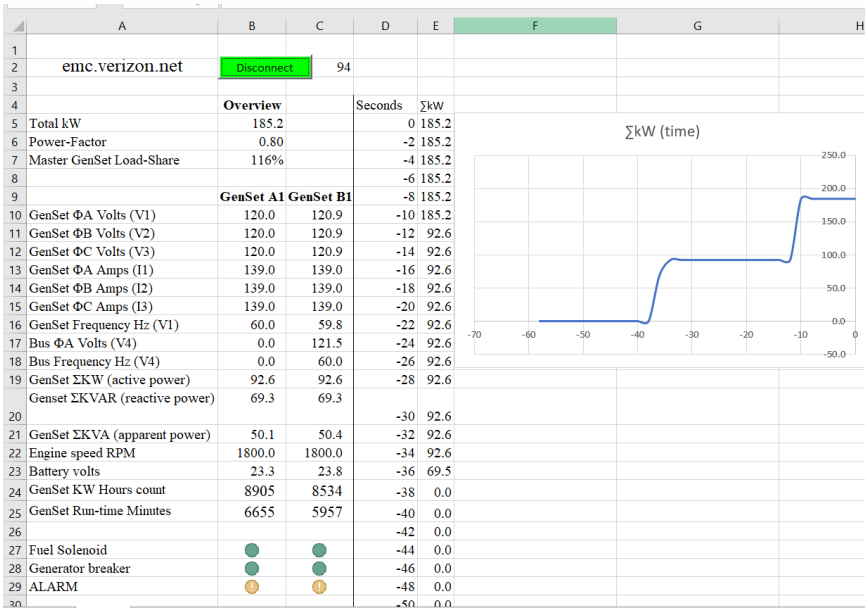


Figure 7: Excel 2019 running example

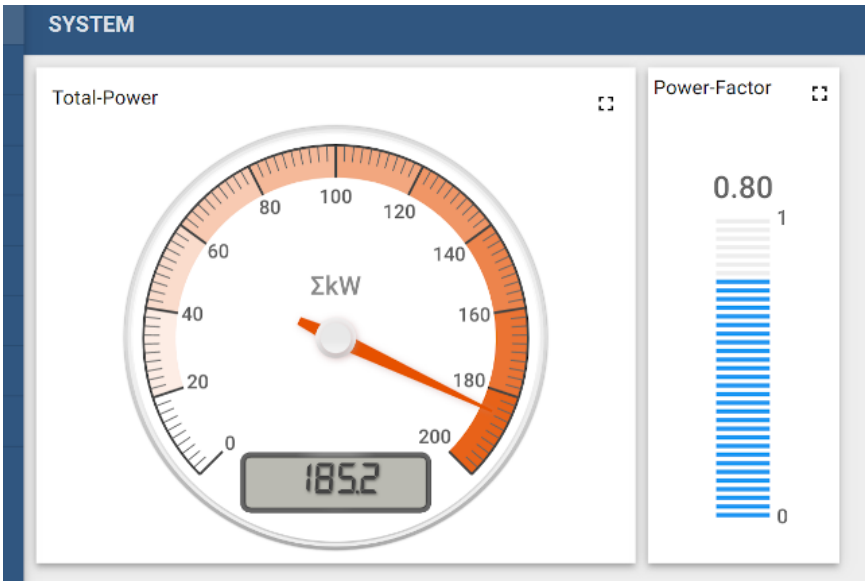


Figure 8: System Dashboard

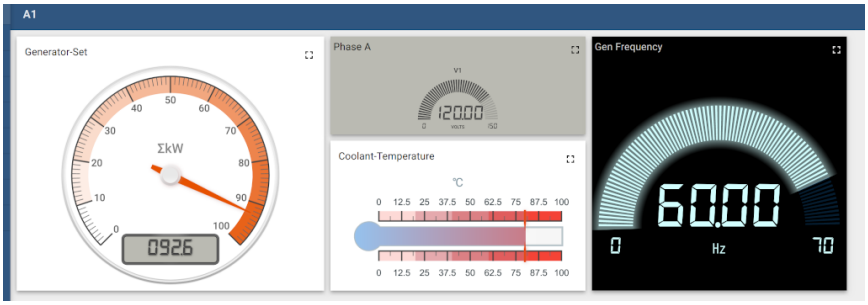


Figure 9: Genset A1

14.3 Implementation

COMM3 publishes JSON formatted strings to the server (broker) as soon as the information enters. Examples:

14.3.1 Client attributes (sent once):

```
{device":"COMM3-001","version":"0.61","manage":true,"mirror":true,"netA":6,"netB":6}
```

14.3.2 Telemetry from genset A1

```
{"id":"A1","f1":60.0,"bat":23.4,"i2":139.0,"f4":0.0,"KVA":100.0,"i1":139.0,"i3":139.0,
"v4":0.0,"KW":80.0,"v12":208,"v1":120.0,"v2":120.0,"v3":120.0,"pf":0.80,"kw":92.6,"rpm
```

14.3.3 Event from genset A1

```
{"id":"A1","log":"error","event":"GENSET SHUTD-N FAULT"}
```

15 Installation

15.1 General

COMM3 can be installed on the electric control panel door if provided with precise (CNC prepared) rectangular cutout that fits its 7" touch-screen, with 4 mounting holes, 5 switch access holes and a small opening to show its LEDs activity. Use plastic spacers, screws and nuts. [COMM3 PCB mounting holes are isolated.] Bond the electric control panel ground with COMM3 DC supply negative.

COMM3 requires a good quality 2A 5Vdc power supply. This DC supply should be provided through a Center-Positive 5.5mm/2.1mm Barrel Plug.

15.2 RS485 ports

Activity of the RS485 ports is indicated by the two blue-1 and green-2 front panel LEDs where a slow blinking rate indicates having no communication. The RS485 ports are expected to be installed at the end of their respective RS485 cables and they already have 120Ω termination resistors. Also note that these RS485 ports, which are not isolated, are not recommended for long distance communication. It is also advised to switch off the 120Ω termination of the GENCON controllers.

Connector ***P12*** definition:

Pin Number	Definition
1	GND
2	CAN0_L
3	CAN0_H
4	RS485_2+
5	RS485_2-
6	RS485_1+
7	RS485_1-
8	RS232_0_TXD
9	RS232_0_RXD
10	RS232_1_TXD
11	RS232_1_RXD
12	+5V

Figure 10: 2.54mm/0.1" pitch, 12 position, pluggable terminal block

15.3 COMM3 DIY instructions

For self-assembly and set-up instructions contact Energy Measurement & Control (USA).