

1 Introduction

The 1700W GCU has both RS232 and CANbus interfaces that perform essentially the same functions, these being:

- Configuration (of parameters stored in the GCU's non-volatile memory),
- Control (real-time control of the GCU's various features),
- Monitoring (of measured voltages, currents, temperatures, etc), and
- Updating the GCU's firmware.

Once the GCU has been configured, there is no requirement to connect anything to either communications interface – the GCU will operate quite normally with no communications at all.

The RS232 interface operates at 57600 baud, full-duplex, with 8 data bits and no parity (57600 8N1). The RS232 hardware layer is compliant with TIA/EIA-232-F and ITU V.28.

2 Software

A Windows application that provides easy access to most of the 1700W GCU's various features may be downloaded from www.millswoodeng.com.au/resources.html



Figure 1 – 1700W GCU Configuration Utility

Using the configuration utility relieves the user from the burden of writing software in order to configure and control the GCU. There is no need to read any more of this document if the configuration utility is used – the RS232 protocol is provided solely for the purpose of more tightly integrating the GCU with other hardware and software.

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4 Commands

The GCU supports a number of commands via its RS232 interface. The command processor is not case sensitive, but commands must be entered exactly as shown below, with the correct number of digits and no extraneous spaces. A carriage return or linefeed character is required to terminate each command. A confirmation string is issued if the command is successful.

4.1 Status commands

4.1.1 Show settings

Show Displays the GCU's settings and enabled features.

The first packet returned shows the stored configuration settings and is 96 bytes long (including CR & LF), and is formatted as follows:

```
C o n f i g u r a t i o n   s e t t i n g s :   V b = 5 0 . 4 V   I b =
4 . 0 A   P p = 0 1 . 0 S   P s = 2 5 5   T u = 0 8 5 C   S 0 = 2
5 5   C b r p = 0   C a = 0 0 0 0 1 CR LF
```

The second packet returned shows the stored engine starter settings and is 96 bytes long (including CR & LF), and is formatted as follows:

```
E n g i n e   s t a r t e r   s e t t i n g s :   C t = 0 5 . 0 S   C s
= 0 1 5 0 0 R P M   C c l = 5   P c = 0 8   P 0 = 2 0 %   P + = 0
7 5 % / S   H p o = 3   C f = 1 2 8 CR LF
```

The third packet returned shows the enabled features and is 60 bytes long (including CR & LF), and is formatted as follows:

```
E n a b l e d   f e a t u r e s :   M P O : E n a b l e d   B C A : E
n a b l e d   B C B : D i s a b l e d CR LF
```

MPO = Main power output

BCA = Battery charger A

BCB = Battery charger B

4.2 Configuration settings

The following commands store configuration settings in non-volatile memory:

4.2.1 Set Battery charging voltage

Set Vb=XX.X Where XX.X is the nominal (fully charged) battery voltage in Volts.
V_B may be set to any value from 40.0 to 55.0 inclusive.

4.2.2 Set Battery charging current

Set Ib=X.X Where X.X is the maximum battery charging current (for each battery) in Amps.
I_B may be set to any value from 0.5 to 8.0 inclusive.

4.2.3 Set Packet period

Set Pp=XX.X Sets the packet streaming period. XX.X is the desired interval of time between successive transmissions in seconds. Pp may be set to any value from 00.1 to 25.5 inclusive.

4.2.4 Set Packets streamed

Set Ps=XXX Sets which packets types are streamed. XXX is a decimal value ranging from 000 to 255 inclusive. Bits have the following significance:

- Bit 0: Set to stream packet type 0 (voltages)
- Bit 1: Set to stream packet type 1 (currents)
- Bit 2: Set to stream packet type 2 (battery statuses)
- Bit 3: Set to stream packet type 3 (temperatures)
- Bit 4: Set to stream packet type 4 (miscellaneous data)
- Bits 5 to 7: Irrelevant

4.2.5 Set Temperature limit

Set Tu=XXX Where XXX is the upper temperature limit in degrees Celsius. Tu may be set to any value from 000 to 255 inclusive. There is approximately 10% hysteresis. Setting Tu to 0 forces the GCU into thermal shutdown, and setting Tu to 255 disables thermal shutdown. The main power output and both battery chargers are turned off during thermal shutdown.

4.2.6 Set Initial state

Set S0=XXX Sets the GCU's initial state. S0 defines how the GCU's outputs and features are configured immediately after power-up or reset. XXX is a decimal value ranging from 000 to 255 inclusive. Bits have the following significance:

- Bit 0: Main power output (1 = enabled)
- Bit 2: Battery charger A (1 = enabled)
- Bit 3: Battery charger B (1 = enabled)
- Bit 6: Keep fans on (1 = enabled)
- Bits 1, 4, 5 and 7: Irrelevant

4.2.7 Set CAN Baudrate

Set Cbrp=X Sets the CAN Baudrate according to the following formula:

$$\text{Baudrate (kb/s)} = \frac{1000}{X + 1}$$

Values for X other than 0 (1Mb/s), 1 (500kb/s), 3 (250kb/s) and 7 (125kb/s) have not been tested.

4.2.8 Set CAN address

Set Ca=XXXXX Sets the 16-bit CAN address. XXXXX may be set to any value from 00000 to 65535 inclusive. See the CAN protocol document for further information.

4.3 Engine starter settings

The following commands store engine starter settings in non-volatile memory:

4.3.1 Set Cranking timeout

Set Ct=XX.X Sets the maximum cranking time for the engine starter. XX.X is the time limit in seconds, and may be set to any value from 01.0 to 25.0 inclusive.

4.3.2 Set Cranking speed

Set Cs=XXX Sets the speed at which the engine will be cranked (turned over). XXX is the BLDC rotational speed in RPM x 100, and may be set to any value from 001 to 255 inclusive (corresponding to BLDC speeds of 100 to 25500 RPM).

4.3.3 Set Cranking current limit

Set Ccl=X Sets the maximum current that may be drawn when starting the engine. The value of X is given by the following table:

X	Current limit
0	20 Amps
1	23 Amps
2	27 Amps
3	30 Amps
4	33 Amps
5	67 Amps
6	100 Amps
7	133 Amps
8	167 Amps
9	200 Amps

4.3.4 Set Pole count

Set Pc=XX Sets the number of poles in the BLDC motor. This value is used to calculate the mechanical RPM of the BLDC motor from its electrical RPM, and may be set to any even number from 2 to 32 inclusive.

4.3.5 Set Initial PWM duty cycle

Set P0=XX Sets the initial PWM duty cycle applied to the BLDC motor when starting the engine. XX is a percentage and may be set to any value from 10 to 50 inclusive.

4.3.6 Set PWM ramp rate

Set P+=XXX Sets the rate of increase in PWM duty cycle applied to the BLDC motor when starting the engine. XXX is the percentage change per second, and may be set to any value from 10 to 250 inclusive.

4.3.7 Set Hall sensor phase offset

Set Hpo=X Sets the angular offset applied to the Hall sensors. This parameter is used to compensate for positional error in the location of the Hall sensors. The value of X is given by the following table:

X	Offset
0	-180 degrees
1	-120 degrees
2	-60 degrees
3	0 degrees
4	+60 degrees
5	+120 degrees
6	+180 degrees

4.3.8 Set Control flags

Set Cf=XXX Sets flags that control the behaviour of the engine starter. XXX is a decimal value ranging from 000 to 255 inclusive. Bits have the following significance:

Bit 7: Direction of rotation
Bit 6: Crank from compression
Bit 5: Ignore Hall sensor errors
Bits 0 to 4: Irrelevant

4.4 Control commands

The following commands perform actions (but do not store anything in non-volatile memory):

4.4.1 Main power output

Enable MPO Enables the main power output.

Disable MPO Disables the main power output.

4.4.2 Battery charger A

Enable BCA Enables battery charger A.

Disable BCA Disables battery charger A.

4.4.3 Battery charger B

Enable BCB Enables battery charger B.

Disable BCB Disables battery charger B.

An "Enabled features" packet is returned on receipt of a valid "Enable" or "Disable" command.

4.4.4 Engine starter module

Start Starts cranking the engine.

Stop Stops cranking the engine. This command is included for safety reasons only (the engine starter automatically disengages when it detects that the engine has started).

4.4.5 Reset

Reset Restarts the GCU. Outputs are set to their power-up states (as defined by the "Set S0" command), and the battery statuses Eba and Ebb are re-initialised to zero (see packet type 2 below).

5 Monitoring

The GCU measures and reports a number of quantities via its RS232 interface. The measured data is formatted into a human-readable plain text packets that are streamed regularly at a user-defined rate (configured by the Set P_P command). Packet streams may be turned on and off individually using the Set P_S command.

Measurements are fixed width, i.e. leading zeros are always included. Measurements are separated from each other by pairs of spaces, and packets are terminated by both carriage returns and linefeeds.

5.1 Packet type 0 – Voltage

Packet type 0 is 66 bytes (including CR & LF), and is formatted as follows:

```
V b a = 5 0 . 4 V   V b b = 5 0 . 4 V   V m = 5 5 . 0 V   V g = 1 1
0 . 5 V   V u = 0 6 0 . 0 V   V h v = 1 0 9 . 0 V CR LF
```

Vba = Battery A voltage

Vbb = Battery B voltage

Vm = Main power output voltage

Vg = Generator (BLDC motor) voltage

Vu = Umbilical input voltage

Vhv = Internal HV bus voltage

Vg is a DC value. Generator voltage is measured after the active rectification process.

5.2 Packet type 1 – Current

Packet type 1 is 63 bytes (including CR & LF), and is formatted as follows:

```
I b a = 0 7 . 9 A   I b b = 0 3 . 5 A   I m a = 0 4 . 1 A   I m b =
0 4 . 3 A   I g = 1 5 . 3 A   I c = 1 7 0 A CR LF
```

Iba = Battery A current

Ibb = Battery B current

Ima = Main power output current, A-side

Imb = Main power output current, B-side

Ig = Generator (BLDC motor) current

Ic = Cranking current

5.3 Packet type 2 – Battery status

Packet type 2 is 30 bytes (including CR & LF), and is formatted as follows:

```
E b a = + 0 0 0 0 0 m A H   E b b = + 0 0 0 0 0 m A H CR LF
```

Eba = Battery A energy

Ebb = Battery B energy

Eb is similar to a fuel gauge, except that it represents the change in energy stored (since power-up), rather than the total amount of energy stored. A positive value means that the battery has had a net gain in energy since power-up (i.e. it has been charged).

5.4 Packet type 3 – Temperature

Packet type 3 is 51 bytes (including CR & LF), and is formatted as follows:

T	=	+	0	3	1	C		T	b	a	=	+	0	1	9	C		T	b	b	=	+	0	2	2	C		T	g	=	+	0	0
1	C		T	e	=	+	1	0	0	C	CR	LF																					

T = Internal GCU temperature
Tba = Battery A temperature
Tbb = Battery B temperature
Tg = Generator (BLDC motor) temperature
Te = Engine starter module temperature

For external temperature sensing the GCU will generally return a value of -128C if no temperature sensing device is present. In the case of the engine starter module not being fitted the corresponding value is indeterminate.

5.5 Packet type 4 – Miscellaneous

Packet type 4 is 56 bytes (including CR & LF), and is formatted as follows:

S	g	=	0	9	5	4	0	R	P	M		R	0	=	0	0	0		R	1	=	0	0	0		R	2	=	0	0	0
R	3	=	1	2	8		P	W	M	=	3	4	.	6	%	CR	LF														

Sg = Generator (BLDC motor) speed
R0 = Flag register 0 – Bit 5: Thermal shutdown flag (1 = shutdown)
 Bit 6: Start button pressed flag (1 = pressed)
 Bit 7: Arm input active flag (1 = active)
R2 = Flag register 2 – Bit 0: Main power output (1 = enabled)
 Bit 2: Battery charger A (1 = enabled)
 Bit 3: Battery charger B (1 = enabled)
R3 = Flag register 3 – Bit 0: Hall sensor 1 state
 Bit 1: Hall sensor 2 state
 Bit 2: Hall sensor 3 state
 Bit 3: Cranking flag (1 = cranking)
 Bit 4: Engine running flag (1 = engine running)
 Bit 5: Locked rotor flag (1 = rotor locked)
 Bit 6: Driver fault flag (1 = fault detected)
 Bit 7: Engine starter ready flag (1 = ready)

PWM = Engine starter PWM duty cycle during cranking.

Sg is only valid if Hall sensors are fitted to the BLDC motor and connected, and the number of poles has been correctly specified.

6 Document version history

6.1 0.9 -> 1.0

- Initial release.

6.2 1.0 -> 1.1

- Updated product name from 1600W GCU to 1700W GCU.
- Set Initial states updated to allow configuration of battery chargers and main power output at power-up.
- Packet type 1 updated to allow for currents greater than 9.9 Amps.

6.3 1.1 -> 1.2

- Engine starter PWM duty cycle added to packet type 4.

6.4 1.2 -> 1.3

- Engine starter PWM duty cycle field modified to improve resolution.
- Cranking current field modified to improve range.
- Engine starter parameters P0 and P+ added.
- Setting of cranking current limit changed.
- Explanation of flag register 3 added.

6.5 1.3 -> 1.4

- Reporting of engine starter settings modified.
- Crank from compression parameter added.

6.6 1.4 -> 1.5

- Hall sensor phase offset parameter added.
- Ignore Hall sensor errors added to Control flags.