

Ripple Generator 2550

**Programmable Ripple Voltage
Generation for DC Supplies**

Instruction Manual

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Introduction

The Ripple Generator Model 2550

Ripple Generator 2550 is an electronic device capable of superimposing AC voltage waveforms onto the output of a DC supply. This combined AC plus DC waveform can then power a Device Under Test (DUT) to test the DUT for immunity to “noise” on its power supply. The Ripple Generator is able to generate programmable AC waveforms up to 50V amplitude (maximum voltage is limited to one quarter of the DC input supply voltage) and 25 kHz, on top of a DC supply of up to 500V at 40A.

To add voltage waveforms to a DC supply, the Ripple Generator uses internal power electronics to internally store the energy required for the AC waveform. This means only a single DC supply is required to generate the combined output waveform. The DC supply must be capable of sourcing the entire required RMS current to the load. An external AC/DC adapter is provided to power the internal electronics, but does not supply energy to the output.

Component List

The Ripple Generator Model 2550 kit contains the following components:

- P/N 2550-1: Ripple Generator control unit. 2U rackmount enclosure.
- P/N 2550-2-Country: AC/DC power supply, 24V DC output with AC cord
- P/N 2550-3PR: Input+ Terminal, ITT Snaplock, Red Pin
- P/N 2550-3PBK: Input– Terminal, ITT Snaplock, Black Pin
- P/N 2550-3SR: Output+ Terminal, ITT Snaplock, Red Socket
- P/N 2550-3SBK: Output- Terminal, ITT Snaplock, Black Socket
- P/N 2550-4: CD containing ECM Configuration Tool Software
- P/N 2550-5: Instruction Manual (this document)

Snaplock connectors are available from ITT Interconnect Solutions, USA at (714) 557-4700.

Specifications and Limitations

Following is a list of environmental, electrical, and physical specifications for the Ripple Generator 2550 kit.

Table 1: Ambient Environmental Specification

Parameter	Specification
Location	Indoor use only.
Operating Temperature	Operating: 5 to 40 °C Storage: 0 to 50°C
Humidity	0-95% Relative Humidity. Non-condensing.
Altitude	Up to 2000m. For de-rating at high altitude contact ECM.
Cooling	Internal fans with front intake and rear exhaust. See section “Location and Mounting” for cooling installation requirements.

Table 2: Electrical Specification

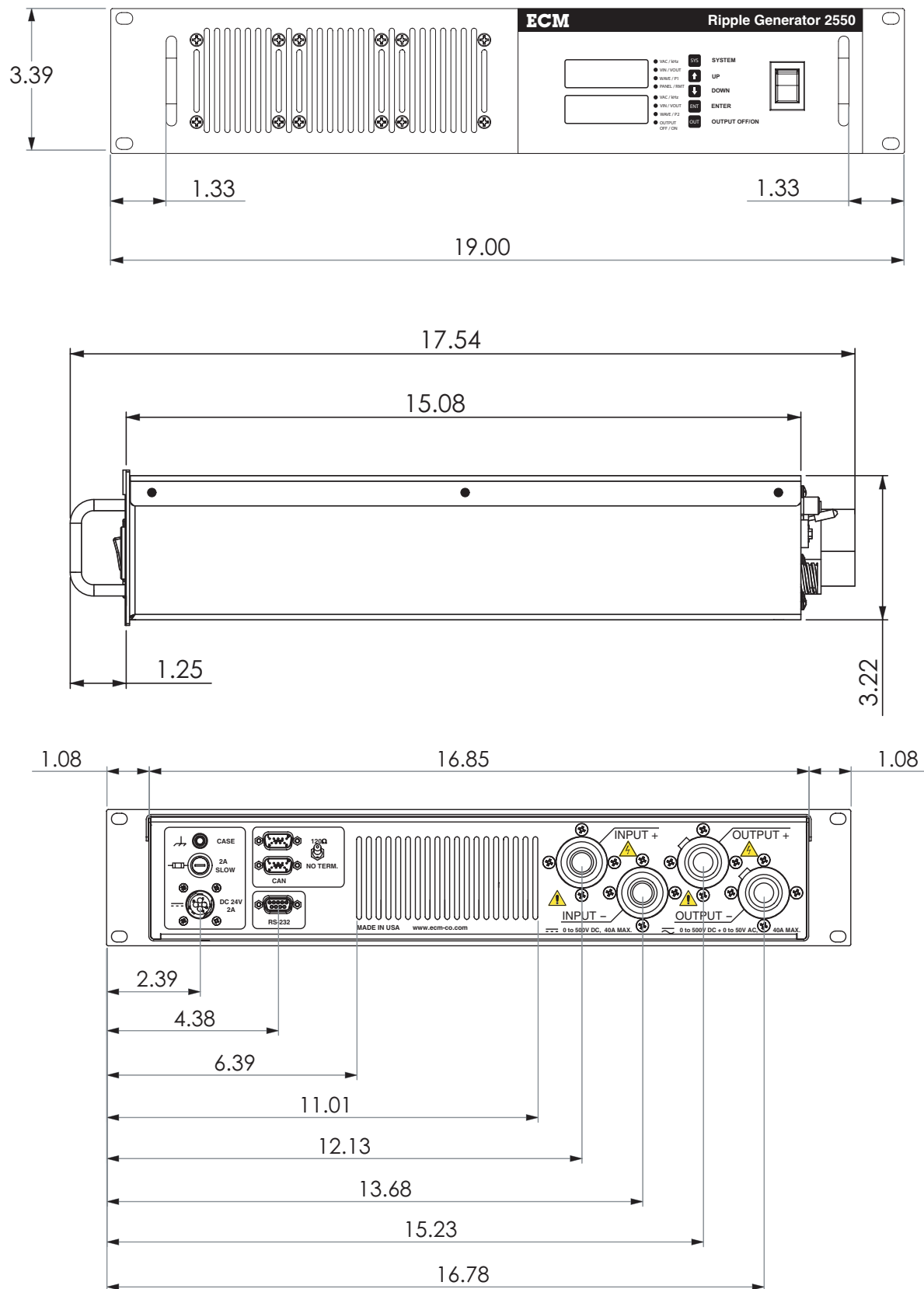
Parameter	Specification
Electronics Power Supply	
Voltage	24V DC nominal
Current	2A maximum
Fuse	Size: 3AG Rating: 2A Type: Slow-Blow
Connector	AMP CPC 4 pin, Term. 1: 24V DC, Term. 4: GND
Input Supply	
Voltage	0-500V DC 2000V maximum transient overvoltage (as measured at input to Ripple Generator)
Current	40A RMS maximum 50A peak maximum
Output	
Voltage	DC: Input Voltage - ~2V drop AC: 0-50V (amplitude), limited to $\frac{1}{4}$ x Input Voltage
Current	See Input Supply
Frequency	0, 1-25kHz
Waveform	Sinusoidal, others available upon request

Table 3: Remote Interface Specification

Parameter	Specification
Front Panel	
Accuracy	±1% of full scale reading + 1 digit
CAN	
Physical Standard	CAN 2.0B, High Speed (ISO 11898)
Application Layer	CANopen
Baud Rate	500kHz (default)
Galvanic Isolation	200V DC (Ground shared with RS-232)
Configuration	ECM Configuration Tool via CANopen protocol
Line Termination	121 ohm selectable via rear panel switch
Pinout (DB9 Female on back panel)	Term. 2: CAN_L Term. 3: Ground Term. 7: CAN_H Others: Not Connected
RS-232	
Baud Rate	NOT IMPLEMENTED
Galvanic Isolation	200V DC (Ground shared with CAN)
Pinout (DB9 Male on back panel)	2 – RXD 3 – TXD 5 – Ground Others Not Connected

Table 4: Physical Characteristics

Parameter	Specification
Chassis	19 in. Rackmount. 2U
Width	19.0 in.
Depth	18.8 in.
Height	3.5 in.
Weight	20 lbm



**Figure 1: Dimensional Drawings
(Not to scale. All dimensions in inches.)**

Important Safety Information

Before installing the Ripple Generator, read this instruction manual fully and ensure the unit is configured correctly for your application.

Due to the hazardous voltages which are present when operating the Ripple Generator, only qualified personnel should install or operate. There are no serviceable parts inside the Ripple Generator. Do not open it. **If you don't know how to handle dangerous high voltages, don't use the Ripple Generator or you might kill or hurt yourself or others.**

Under normal operation, no hazardous voltage is present to the operator of the Ripple Generator. However, the end-user's specific implementation can present hazardous voltages which can result in shock or electrocution. Specifically cables and exposed terminals become hazardous (i.e. live) if not properly terminated to either the Ripple Generator, or to end-user equipment.

The customer and operator assume full responsibility for proper connection, shielding, and labeling of wiring. Before handling any potentially hazardous connection, it is recommended to ensure all components have been electrically turned off and discharged. Capacitors internal to the Ripple Generator, as well as in end-user equipment can, retain charge which could result in injury if not properly discharged before handling.

Engine Control and Monitoring (ECM) and its subsidiary sales organizations take no responsibility for improper use of equipment which results in death, bodily harm, damage, or loss of equipment.

IMPORTANT SAFETY SYMBOLS



WARNING
Risk of Electrical Shock



CAUTION - Risk of Danger
Refer to Accompanying Documents



Direct Current (DC)



Both Direct and
Alternating Current



On (Supply)



Off (Supply)



Fuse



Chassis Ground

Installation and Hardware Setup

Location and Mounting

Acceptable ambient conditions for the Ripple Generator are listed in Table 1. To reduce the potential of electrical shock install the Ripple Generator in a humidity-controlled indoor area. This unit contains no internal user-serviceable components. Service is to be performed only by ECM.

The Ripple Generator is a standard 2U, 19” rackmount enclosure. Support for the unit in an equipment rack can be provided by slides along the sides of the rack and four mounting holes on the front panel. Dimensions for installation into an equipment rack are given in Figure 1. Support for the unit must not be provided solely by the front panel mounting screws.

To provide adequate ventilation for cooling of the unit, a minimum of 4” of clearance should be provided in both the front and rear of the enclosure, free of obstruction from other equipment and wiring. Failure to provide sufficient air-flow to the unit will result in reduced load capacity and increased chance of internal over-heating.

Low Voltage and Communications Connections

To power the internal electronics and display, the Ripple Generator uses an external 24V AC/DC power supply. This power supply plugs into a standard wall AC receptacle, and connects to the Ripple Generator with a 4-pin AMP CPC locking connector. Ensure that the 4-pin connector is fully engaged and the locking ring is tight before using the Ripple Generator. The 24V supply is protected with a fuse on the rear panel of the unit. Location of the connections on the rear panel can be found in Figure 4.

A post is provided on the rear panel of the Ripple Generator for grounding. This post should be attached directly to Earth. A ground fault circuit interrupter is recommended to prevent electrical shock in the event of connection of the case to a high voltage source.

Remote communication with the Ripple Generator can be done with either Controller Area Network (CAN) or with RS-232 serial interfaces. See Table 3 for connector wiring pinout. The CAN software interface protocol is described in section “CAN Communication Protocol”. A locking toggle switch on the rear panel allows a CAN termination resistor (121 Ohm) to be optionally placed on the CAN bus. If sufficient line termination is provided externally, the internal line termination can be disabled.

Input Supply and Output Load Connection

Wiring for the input supply and load connections is made through four ITT Snaplock connectors on the rear panel of the unit, as shown in Figure 4.

The input supply to the Ripple Generator can be either a regulated DC source, or a chemical battery. Depending on the type of source, different connection details must be adhered to. To prevent damage to the Ripple Generator when a regulated DC source is used, ensure that the voltage and current limits of the regulated DC source are set below the maximum rating of the Ripple Generator (see Table 2). Due to the high frequency current fluctuations when the Ripple Generator is in operation, a capacitor on the output of the DC source should be added as shown in Figure 2. This capacitor must be rated for the DC voltage, ripple current seen in operation, and the maximum V/sec that occurs when the DC source is turned on and off. A recommended part is Illinois Capacitor PHC series film capacitor, with a minimum 10uF, 600V rating.

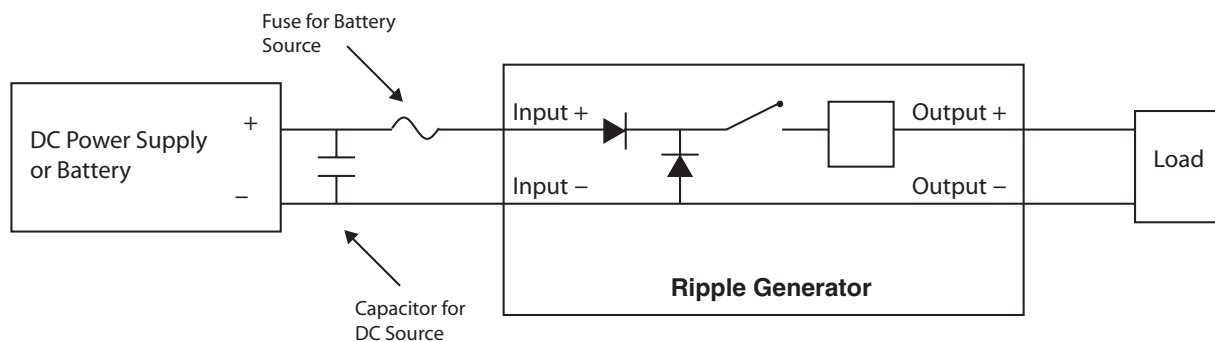


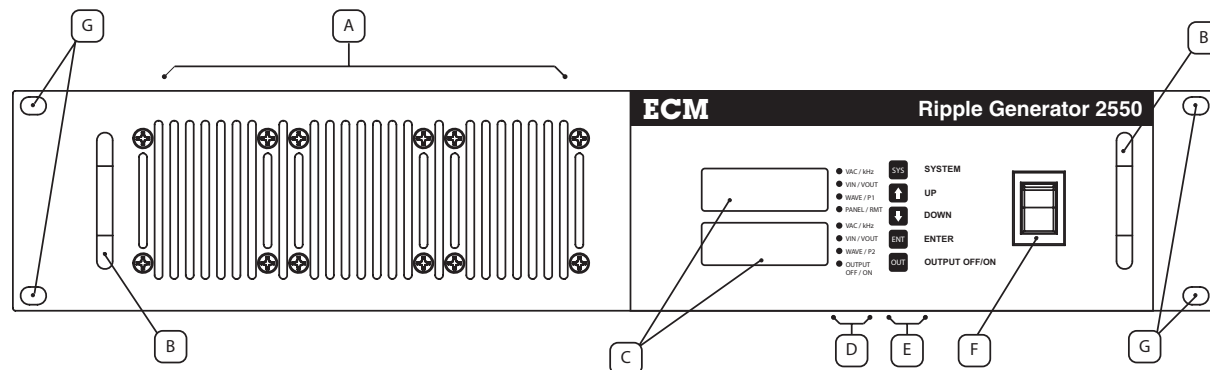
Figure 2: Connection to DC Input Supply

Using a battery as an input source to the Ripple Generator requires a fuse or other current limiting device to be installed in series as shown in Figure 2.

Connection to the load is through the “Output +” and “Output –” connectors on the back of the Ripple Generator. For protection of the unit and the input source, a reverse polarity diode and free wheeling diode are installed internally in the Ripple Generator as shown in Figure 2.

Replacement ITT Snaplock Input and Output connectors can be purchased through ITT Interconnect Solutions, USA at (714) 557-4700.

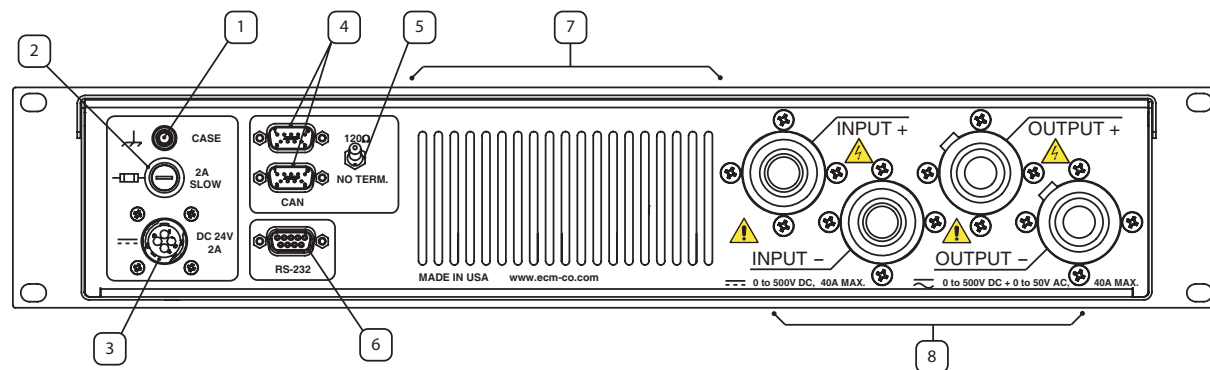
Connections and Controls



NOTES:

- | | |
|--|---------------------------------|
| A COOLING FAN AIR INTAKE | E BUTTONS (5) |
| B CARRYING HANDLES (2) | F POWER SWITCH |
| C NUMERIC DISPLAYS (2) | G MOUNTING HOLES (4), 2U |
| D DUAL COLOR LED INDICATORS (8) | |

Figure 3: Ripple Generator Front Panel Controls



NOTES:

- | | |
|---------------------------------------|--|
| 1 CHASSIS GROUND TERMINAL | 5 CAN TERMINATION SELECTOR SWITCH |
| 2 3AG FUSE, 2A SLOW BLOW | 6 RS-232, D-SUB 9 PIN FEMALE |
| 3 24V DC SUPPLY. AMP CPC 4 PIN | 7 COOLING AIR EXHAUST VENT |
| 4 CAN, D-SUB 9 PIN MALE (2) | 8 SNAPLOCK CONNECTORS |

Figure 4: Ripple Generator Rear Panel Connections

How to Use

Overview

Locations of the front panel controls are shown in Figure 3. Using the front panel rocker switch, turn on the Ripple Generator. The display should become active and run through a power-up sequence. Once fully powered on, the upper and lower displays will show their pre-programmed parameters. The default parameters displayed are the desired AC voltage amplitude (VAC) on the upper display, and the frequency of the AC voltage waveform (FREQ) on the lower display. The default power-up state is: output disabled.

Using the Ripple Generator for the first time, or with a new DUT, the AC voltage amplitude (VAC) should be started at a low value (the default value of 5V is generally a good starting point). The frequency of the output voltage waveform (FREQ) has a default value of 20kHz. See Section entitled “Front Panel Display” below for instructions on how to change the parameter values using the front panel interface, and Section “CAN Communication Protocol” for interfacing remotely with the CAN bus.

To enable the output, press the front panel button labeled “OUT,” or issue the required CAN commands if in remote operation. The dual color LED labeled OUTPUT should change from red to green as the output changes state. If the displays show error codes (see Section “Front Panel Display”) or fails to change to green, turn all power off and check the device wiring to ensure proper connection.

With the output enabled, the commanded waveform will be present on the output and be supplied to the DUT. Changing parameter FREQ will cause the frequency of the output voltage to change, and changing parameter VAC will cause the amplitude of the voltage waveform to change. Increasing VAC will increase the AC voltage amplitude up to a maximum of one quarter of the DC input supply voltage. The maximum AC voltage will also be limited by the current waveform to the load. When the minimum of the current waveform reaches zero, the voltage amplitude will inherently be limited independently of the VAC parameter. In this case, increasing the VAC parameter further will have no effect.

Front Panel Controls

The front panel controls consist of one rocker switch and five buttons as shown in Figure 3. The rocker switch is used to toggle the power from the 24V supply to the Ripple Generator. Of the five buttons, four of them (SYS, \uparrow , \downarrow , and ENT) are used for navigation of parameter selection and system menus. These functions are explained in the next sections. The final button (OUT) is used to enable and disable the high voltage output.

Front Panel Display

The front panel display has two modes of operation: RUN (when measurements or error codes are displayed) and SYS (where the instrument is set up). Pressing the SYS key toggles between SYS and RUN modes.

When in RUN mode, the parameter being displayed is indicated by a set of dual color LEDs to the right of the each display. Each LED can be red or green and corresponds to the red and green text label beside it. Three LEDs for each display are used to indicate which of six parameters are currently displayed. Five parameters (VAC, kHz, VIN, VOUT, and WAVE) are fixed and repeated for both top and bottom display. Two parameters (P1 for top, P2 for bottom) are programmable from the list of parameters shown in Table 6. The ↑ and ↓ keys scrolls through the six parameters to display, and the ENT key toggles between the top or bottom display.

The fourth LED on each display is used as a status indicator. On the top display, it indicates if the unit has control via the front panel (PANEL) or if it is set up to be controlled remotely (RMT) via either CAN or RS232. On the bottom display, it indicates whether the high voltage output is turned OFF or ON.

In RUN mode, two things other than data can be displayed:

1. “ERR” and “####” where “####” is an error code. See Appendix B.
2. “----” which means that the unit has an internal problem, consult ECM.

When in SYS mode, configuration options for the device will be shown. Pressing the ↑ and ↓ keys will scroll through the setup options, see Table 5. Pressing the ENT key will select the displayed setup option and allow for programming.

Table 5: Menu Tree for Ripple Generator 2550

Setup Option	Level 1	Function
VAC		Set the AC voltage of the noise ripple. Allowable range: 0.00 to 50.00 amplitude. [5.00V] Note: Max. limited to ¼ VIN
FREQ		Set the frequency of the noise ripple in kHz. Allowable values: 0, 1.000 to 25.000 kHz. [20.000 kHz]
WAVE		Set the wave type of the noise ripple [SIN]
P1P2	P1 (upper display) P2 (lower display)	Program upper display parameter P1 [TEMP] Program upper display parameter P2 [TFET]
CONF	LEdS NID RMOT	Set display intensity [3333] Set Node ID for CAN communication in hexadecimal [10] Select or release remote control mode [OFF]

All entries must be followed by pressing the ENT key. Default values given within square parentheses.

SYS Setup Options

◆ VAC

This setting is the AC voltage amplitude of the noise ripple. So if it is set at 10V, then the output will go up 10V and down 10V from the DC input voltage. Valid range is from 0.00V to 50.00V, however the maximum value is limited to one quarter of the input voltage. An error will be reported if an invalid value is entered or if the unit has been configured for remote control. This setting applies to all wave types selectable in the “WAVE” setup option. The input style for this setting is described in Appendix A.

◆ FREQ

This setting is the frequency of the voltage ripple that is applied to the output. An error will be reported if an invalid value is entered or if the unit has been configured for remote control. This setting applies to all wave types selectable in the “WAVE” setup option. The input style for this setting is described in Appendix A.

◆ WAVE

The shape of the noise ripple is configurable in this menu item. You can disable noise ripple or select from five available choices, 3 predefined waves, and 2 user-defined waves. All waves are periodic. The wave options are:

- OFF No noise is applied to the output. Voltage in is voltage out.
(NOT YET IMPLEMENTED)
- SIN A sine wave noise ripple is applied.
- TRI A triangle wave noise ripple is applied. (NOT YET IMPLEMENTED)
- SQR A square wave noise ripple is applied. (NOT YET IMPLEMENTED)
- USR1 The user-defined noise ripple is applied. (NOT YET IMPLEMENTED)
- USR2 The user-defined noise ripple is applied. (NOT YET IMPLEMENTED)

USR1 and USR2 are two periodic waves that are available for user to define. The values to form this waveform can only be configured through CAN or RS232.

◆ P1P2

There are two display parameters for the front panel that are user configurable, P1 (on the top display) and P2 (on the bottom display). Each parameter is independently configurable in the “P1P2” menu item. The available parameters for P1 and P2 are in Table 6.

Table 6: Parameter List for the Ripple Generator 2550

Name	Full Parameter Name	Parameter Description	OD Index
VSW	Vsw (V)	Supply voltage to power control circuitry	0x2000
TEMP	Heatsink Temp (°C)	Temperature of IGBT heatsink	0x2001
ERFL	Error bit flags (bits)	Module error flags (unsigned long format)	0x2002
ERCd	ECM CANopen Error Code	ECM CANopen Error Code. See Appendix B.	0x2003
VAC	Vac (V)	Commanded amplitude of AC voltage ripple	0x2004
FREQ	Frequency (kHz)	Commanded frequency of voltage ripple	0x2005
VIN	Vin (V)	Input DC voltage before voltage ripple is added	0x2006
VTOT	Vtotal (V)	Total output voltage, DC & AC component combined	0x2007
WAVE	Wave Type	Index of the selected wave type.	0x2008
TFET	FET Module Temp (°C)	Temperature of MOSFET module	0x2009

Here is an example of setting displayed parameter P2:

1. Press SYS to enter the system setup menu.
2. Press ↓ until “P1P2” is displayed, then press ENT.
3. Press ↓ until “P2” is displayed, then press ENT.
4. Press ↑ and ↓ until the desired parameter is displayed, then press ENT.
5. Press SYS to return to RUN mode.

◆ CONF (Configure) Setup Option

CONF setup appears at the end of the setup menu list. To enter CONF, press SYS and scroll to “CONF”, and then press ENT.

LEdS

The display intensity is programmable. Enter the CONF menu and scroll to “LEdS”. Press “ENT”. Press the ↑ and ↓ keys until the display intensity is suitable, press ENT, and press SYS to return to RUN mode.

NID

This configures the Node ID of the unit under the CANopen protocol used for CAN communication. Enter the CONF menu and scroll to “NID”. Press “ENT”. Press the ↑ and ↓ keys to adjust the Node ID. The values are displayed in hexadecimal. Valid range is 0x01 to 0x7F. See section “CAN Communication Protocol” for further details.

RMOT

The Ripple Generator can be controlled by the front panel or by a remote master communicating over either CAN or RS232. Only one can be selected at a time. For control via the front panel, select “OFF” and remote configurations will be disabled. Select “CAN” or “RS23” for the corresponding remote configurations and the front panel will be disabled from changing any configurations. See the sections “CAN Communication Protocol” and “RS232 Communication Protocol” for further details.

CAN Communication Protocol

The Ripple Generator provides CAN communications based on the CANopen protocol. The basics of the protocol are described in this section. This document assumes the user understands CAN, and only needs to know the details of the CANopen protocol as used in the Ripple Generator.

CANopen Message Types

In CANopen, each device on the CAN bus is identified by a unique number called the Node Id (NID), which ranges from hexadecimal 0x01 to 0x7F. This means that you cannot have more than 127 devices on the bus at a time. The NID is also used to generate the standard 11-bit CANid of the messages transmitted and received by the device. Table 7 contains a list of the CANids reserved each CANopen device. When connecting non-ECM or non-CANopen devices to the same CAN bus, ensure that these CANids are not used.

Table 7: Reserved CANopen CANid Definitions

Message Type	CANid (hex)
NMT	0x00
Emergency	0x80 + NID
TPDO1	0x180 + NID
TPDO2	0x280 + NID
TPDO3	0x380 + NID
TPDO4	0x480 + NID
SDO Tx	0x580 + NID
SDO Rx	0x600 + NID
Heartbeat	0x700 + NI
LSS	0x7E4, 0x7E5

There is a master-slave relationship for all devices on the CAN bus. The Ripple Generator operates as a slave. A slave broadcasts data for the master to receive and also listens for commands from the master. There can be no more than one master on the bus at any time. A master may or may not be assigned a NID. For example, communicating with the devices via software on a computer, such as the ECM Configuration Tool. Software on a computer is not a device, therefore, does not need to be assigned a NID.

◆ Emergency Messages

Broadcast Rate = 0.5sec, DLC = 6.

This message is transmitted by the device and contains all errors codes.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x80 + NID	CO Error		Err Reg	ECM Error		0x00		

CO Error = Error codes defined by CANopen (big endian, LSB first). See Appendix B.

Err Reg = Error register defined by CANopen. See Appendix B.

ECM Error = ECM-specific error codes (big endian, LSB first). See Appendix B.

◆ Heartbeat Message

Broadcast Rate = 0.25sec, DLC = 1.

Transmitted by the device to indicate status and that the device is on, or “alive”.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x700 + NID	State							

State = NMT state, or CANopen state, of the device defined by CANopen.

The NMT states are:

- 0x00 Boot-up
- 0x04 Stopped
- 0x05 Operational
- 0x7F Pre-operational

◆ TPDOs (Transmit Process Data Objects)

A TPDO message consist of two pieces of data, called Process Data Object (PDO), that is transmitted by the Ripple Generator 2550. Each Ripple Generator can transmit up to four TPDOs at a programmable broadcast rate. The data contained in the TPDO is programmable from a list of available parameters (see Table 6). Each TPDO can also be enabled or disabled.

Each PDO is a single precision 32-bit floating point number that conforms to the IEEE-754 Standard, and is transmitted on the CAN bus in big endian format (LSB first).

TPDO1 CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x180 + NID	TPDO1, Parameter A				TPDO1, Parameter B			
TPDO2 CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x280 + NID	TPDO2, Parameter A				TPDO2, Parameter B			
TPDO3 CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x380 + NID	TPDO3, Parameter A				TPDO3, Parameter B			
TPDO4 CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x480 + NID	TPDO4, Parameter A				TPDO4, Parameter B			

◆ SDOs (Service Data Objects)

SDO messages are used to read or write to elements in a table of configuration parameters called the Object Dictionary (OD) stored in the Ripple Generator. They consist of two types: received and transmitted. Received SDOs are messages sent from a master to slave device to command a read or write of parameters. Transmitted SDOs are messages sent by the Ripple Generator in response to a master's commands. Elements in the Object Dictionary are referenced by an Index and Subindex. See later sections for the commands and Object Dictionary locations off configurations for the Ripple Generator.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	cmd	index		subindex	data 3	data 2	data 1	data 0
0x580 + NID	ack	index		subindex	data 3	data 2	data 1	data 0

cmd = master's command for read or write. Typical values are:

0x40 - command a read.

0x23 - command a write of 4 data bytes.

0x27 - command a write of 3 data bytes.

0x2B - command a write of 2 data bytes.

0x2F - command a write of 1 data byte.

ack = slave's acknowledge reply of master's command. Typical values are:

0x43 - read reply containing 4 data bytes.

0x47 - read reply containing 3 data bytes.

0x4B - read reply containing 2 data bytes.

0x4F - read reply containing 1 data byte.

0x60 - acknowledge a successful write.

0x80 - error, read/write command aborted.

index = Object Dictionary Index (little endian).

Subindex = Object Dictionary Subindex.

data 0~3 = four available data bytes formatted as little-endian of configurations to write to or configurations read from the slave.

Controlling Ripple Generator via CAN

Note: Remember that the Ripple Generator must be configured for remote control by CAN in order to change any of the following configurations. Otherwise, attempting to write to these configurations will return an error on the SDO reply from the device.

◆ Configure VAC

VAC configuration is stored at OD location 0x5052, 0x00. It is formatted as a 32-bit floating point value, which means the data will have to be converted between floating point and raw hexadecimal (i.e. 21.8 = 0x41AE6666).

To read the current configuration, send the follow message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x40	0x52	0x50	0x00				

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x580 + NID	0x43	0x52	0x50	0x00	data 3	data 2	data 1	data 0

Where data0~3 is the 4 byte hexadecimal representation of the floating point VAC value.

To set a new VAC value, send the follow message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x23	0x52	0x50	0x00	data 3	data 2	data 1	data 0

Where data0~3 is the 4 byte hexadecimal representation of the floating point VAC value.

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x580 + NID	0x60	0x52	0x50	0x00				

◆ Configure Frequency

Frequency configuration is stored at OD location 0x5052, 0x01. The value stored here is an internally used increment or step value used to generate the desire frequency. It is formatted as a 32-bit floating point value, which means the data will have to be converted between floating point and raw hexadecimal (i.e. 21.8 = 0x41AE6666).

The equations to convert between frequency and step value are:

$$\text{StepValue} = \text{Frequency(kHz)} \times 2\pi / 150 \quad \text{Frequency(kHz)} = \text{StepValue} \times 150 / 2\pi$$

To read the current configuration, send the follow message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x40	0x52	0x50	0x01				

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x580 + NID	0x43	0x52	0x50	0x01	data 3	data 2	data 1	data 0

Where data0~3 is the 4 byte hexadecimal representation of the floating point step value.

To set a new frequency value, send the follow message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x23	0x52	0x50	0x01	data 3	data 2	data 1	data 0

Where data0~3 is the 4 byte hexadecimal representation of the floating point step value.

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x580 + NID	0x60	0x52	0x50	0x01				

◆ Configure Wave Type

Wave type configuration is stored at OD location 0x5053, 0x00. The value stored here is a single byte number corresponding to the wave type.

- 0x00 OFF No noise is applied to the output. Voltage in is voltage out.
(NOT IMPLEMENTED)
- 0x01 SIN A sine wave noise ripple is applied.
- 0x02 TRI A triangle wave noise ripple is applied. (NOT IMPLEMENTED)
- 0x03 SQR A square wave noise ripple is applied. (NOT IMPLEMENTED)
- 0x04 USR1 The user-defined noise ripple is applied. (NOT IMPLEMENTED)
- 0x05 USR2 The user-defined noise ripple is applied. (NOT IMPLEMENTED)

To read the current configuration, send the follow message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x40	0x53	0x50	0x00				

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x580 + NID	0x4F	0x53	0x50	0x00	Wave #			

To set a new wave type, send the follow message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x2F	0x53	0x50	0x00	Wave #			

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x580 + NID	0x60	0x53	0x50	0x00				

◆ Set Remote Control

NOT IMPLEMENTED

◆ Enable/Disable High Voltage Output

To enable or disable the high voltage output, use the following OS commands. See Appendix C for details about OS commands.

0x40 Turn on high voltage

0x41 Turn off high voltage

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x2F	0x23	0x10	0x01	OS cmd			

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x580 + NID	0x60	0x23	0x10	0x01				

Setup User-Defined Waveforms

NOT IMPLEMENTED

Other CAN Configurations

◆ Change Node Id

The Node ID (NID) can be programmed from 0x01 to 0x7F (1 to 127). To change the NID, several messages must be sent, followed by a reset of the device.

Start by sending the following message to place the module into pre-operational mode.

CAN id	byte 0	byte 1
0x00	0x80	NID

The next message(s) place the device(s) into LSS (Layer Select Services) configuration mode. If there is only one CANopen device on the CAN bus this process requires only one message. If there are several CANopen devices on the same CAN bus, the specific device must be identified using Product Code, Revision Number and Serial Number.

Multiple Devices on the Bus

CAN id	byte 0	byte 1	byte 2	byte 3	byte 4
0x7E5	0x04	0x00			
0x7E5	0x40	0xC6	0x01	0x00	0x00
0x7E5	0x41	Product Code			
0x7E5	0x42	Revision Number			
0x7E5	0x43	Serial Number			

Single Device on the Bus

CAN id	byte 0	byte 1
0x7E5	0x04	0x01

The device will reply with byte 0 = 0x44 on CAN id 0x7E4 if it enters LSS configuration mode successfully.

The next message sent contains the new NID as an unsigned hexadecimal character.

CAN id	byte 0	byte 1
0x7E5	0x11	new NID

The device will reply with byte 0 = 0x11 and byte 1 = 0x00 on CAN id 0x7E4 indicating a successful NID change.

The last message sent takes the device out of configuration mode.

CAN id	byte 0	byte 1
0x7E5	0x04	0x00

After the NID has been successfully changed, the device enters pre-operational mode and does not broadcast data. The device can be returned to broadcast mode 1 of 2 ways:

1. Power-cycle the device by flipping the switch off and on again.
2. Send a command instructing the device to reset the CAN interface only.

CAN id	byte 0	byte 1
0x00	0x82	NID

◆ TPDO Broadcast Rate

The broadcast rate of TPDOs is programmable from 5ms to 60000ms. The broadcast rate applies to all enabled TPDOs. The configuration for broadcast rate is stored at OD location 0x1800, 0x05. The value stored here is a 16-bit integer number.

To read the current configuration, send the follow message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x40	0x00	0x18	0x05				

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x580 + NID	0x4B	0x00	0x18	0x05	Broadcast Rate			

Where Broadcast Rate is a 16-bit number formatted as little endian.

To set a new broadcast rate, send the follow message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x2B	0x00	0x18	0x05	Broadcast Rate			

Where Broadcast Rate is a 16-bit number formatted as little endian.

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x580 + NID	0x60	0x00	0x18	0x05				

There is a minimum broadcast rate that is dependent on the number of devices transmitting on the CAN bus and how many TPDOs have been enabled for each module. If the broadcast rate is set too fast, the CAN bus will be overloaded, and communication will be unstable. The formula for calculating the minimum broadcast rate is as follows:

$$\text{Minimum Broadcast Rate (ms)} > \text{Total number of TPDOs for all devices} \times 0.3125$$

Example: There are 8 devices on the CAN bus.

NID 0x01 has 3 TPDOs enabled

NID 0x02 has 1 TPDOs enabled

NID 0x03 has 4 TPDOs enabled

NID 0x04 has 2 TPDOs enabled

NID 0x05 has 4 TPDOs enabled

NID 0x06 has 4 TPDOs enabled

NID 0x07 has 4 TPDOs enabled

NID 0x08 has 4 TPDOs enabled

Minimum Broadcast Rate (ms) = (3 + 1 + 4 + 2 + 4 + 4 + 4 + 4) x 0.3125 = 8.125ms. Since the broadcast rate is valid only in increments of 1ms, round 8.125ms up to the next integer value, 9ms. Therefore no device can have a TPDO broadcast rate less than 9ms.

◆ TPDO Enable/Disable

Each TPDO each can be individually enabled or disabled from transmitting. The OD Index of the TPDO enable/disable configurations for each TPDO are located in table below. This OD location also configures the CAN ID from which the TPDOs will be sent. Below lists the default value.

TPDO	Config OD	CAN ID
TPDO1	0x1800	0x180 + NID
TPDO2	0x1801	0x280 + NID
TPDO3	0x1802	0x380 + NID
TPDO4	0x1803	0x480 + NID

To enable/disable a TPDO, perform a SDO write as follows:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x2F	0x180n		0x01	CAN ID		0x00	en/dis

Where 0x180n correspond to the configurations OD location for the particular TPDO listed in the table above, CAN ID is the CAN ID from which the TPDO is sent (defaults listed above), and en/dis is either set to 0x40 (enable) or 0xC0 (disable). 0x180n and CAN ID are formatted as little endian.

If the CAN ID is to be left as-is when configuring TPDO enable/disable, the default value can be written if the configuration is always set at default. Alternatively, read the current configuration, modify the list byte, and write it back.

◆ TPDO Mapping

The two PDOs transmitted on each TPDO are configurable by the user. This is called TPDO mapping. The PDO parameter is said to be mapped to the TPDO to be transmitted.

The OD Index of the TPDO Mapping configurations for each TPDO are listed below.

TPDO	Config OD
TPDO1	0x1A00
TPDO2	0x1A01
TPDO3	0x1A02
TPDO4	0x1A03

TPDO mapping is a 4 step process:

1. Write a 0 to subindex 0x00 of the above listed TPDO Mapping configurations location.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x2F	0x1A0n		0x00	0x00			

2. Enter the OD index of the 1st PDO (see Table 6 for a list of parameters) at subindex 0x01.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x23	0x1A0n		0x01	0x20	0x00	PDO OD Index	

3. Enter the OD index of the 2nd PDO (see Table 6 for a list of parameters) at subindex 0x02.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x23	0x1A0n		0x02	0x20	0x00	PDO OD Index	

4. Write a 2 to subindex 0x00.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x2F	0x1A0n		0x00	0x02			

Where 0x1A0n correspond to the TPDO Mapping configurations OD location for the particular TPDO listed in the table above, and PDO OD Index is the index of the PDO parameter in Table 6. Both values are formatted as little endian.

◆ Factory Reset

To reset all user-configurable parameters to factory defaults, use the OS command 0xDF. See Appendix C for details about OS commands.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x2F	0x23	0x10	0x01	0xDF			

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x580 + NID	0x60	0x23	0x10	0x01				

RS232 Communication Protocol

NOT IMPLEMENTED

Appendices

Appendix A: Entering Decimal Numbers

There are times when a decimal number must be entered in the system setup menu. With the limited number of display characters and buttons, this can be tricky. The procedure for entering a decimal number is explained in this section.

Each character position can be scrolled up and down to display the following characters:

‘-’ ‘0’ ‘1’ ‘2’ ‘3’ ‘4’ ‘5’ ‘6’ ‘7’ ‘8’ ‘9’ ‘0.’ ‘1.’ ‘2.’ ‘3.’ ‘4.’ ‘5.’ ‘6.’ ‘7.’ ‘8.’ ‘9.’

(Note that there are two sets of 0 to 9 digits with decimal point and without.)

After a character is selected for position, press ENT to move to the next position. The display will expect a certain number of digits after a decimal point depending on the parameter being set. When that is reached, the value will be saved, and the display will return to the menu. If the number to be entered is longer than the number of available character positions, the display will shift to the left each time ENT is pressed until the expected number of digits is reached.

If the number you wish to enter is a negative number, you must select the negative symbol ‘-’ in the first character position. This is the only position that the negative symbol can be selected. Then select the number in the next position starting with the most significant digit. For example, you will enter the thousands, then hundreds, then tens place, etc. When the one’s position is reached, select the decimal point version of the number. Continue to enter digits after the decimal point in the same manner.

For any valid number, only one decimal point can be entered. If a decimal point is already selected, any character positions to the right of the decimal point will only allow the non-decimal-point version of a number can be selected. If a decimal point is to the right of your current character position (i.e. from the existing configured value) and you select a decimal-point number, the digits to the right will be cleared.

If a mistake is made, you cannot return to previous character positions to correct it. You can press SYS to exit the setup menu. The value will not be saved, and you can return to the menu item to start over. If you continue to press ENT to complete the entered number, the incorrect value will be saved. This can be detrimental depending on the parameter being configured, especially if the mistake is in the placement of the decimal point.

Appendix B: Error Codes

Table B.1: Generic CANopen Error Codes

CO ERROR CODE	DESCRIPTION OF ERRORS
0x0000 - 00FF	No error or error reset
0x1000 - 10FF	Generic
0x2000 - 20FF	Current
0x2100 - 21FF	Current - Device inputs
0x2200 - 22FF	Current - Inside the module
0x3000 - 30FF	Voltage
0x3100 - 31FF	Voltage - Main voltage
0x3200 - 32FF	Voltage - Inside the module
0x3300 - 33FF	Voltage - Output
0x4000 - 40FF	Temperature
0x4100 - 41FF	Temperature - Ambient
0x4200 - 42FF	Temperature - Device
0x5000 - 50FF	Device Hardware
0x6000 - 60FF	Device Software
0x6100 - 61FF	Device Software - Internal
0x6200 - 62FF	Device Software - User
0x6300 - 63FF	Device Software - Data set
0x7000 - 70FF	Additional Modules
0x8000 - 80FF	Monitoring
0x8100 - 81FF	Monitoring - Communication
0x8110	Monitoring - CAN Overrun (objects lost)
0x8120	Monitoring - CAN in error passive mode
0x8130	Monitoring - Node Guarding or Heartbeat Error
0x8140	Monitoring - Recovering from bus off
0x8150	Monitoring - Transmit COB ID collision
0x8200 - 82FF	Protocol
0x8210	Protocol - PDO not processed due to length error
0x8220	Protocol - PDO length exceeded
0x9000 - 90FF	External
0xF000 - F0FF	Additional functions
0xFF00 - FFFF	Device specific
ERROR REGISTER	
BIT	DESCRIPTION
0	Generic Error
1	Current
2	Voltage
3	Temperature
4	Communication Error
5	Device profile defined error
6	Reserved (always 0)
7	Manufacturer Specific Error

Table B.2: ECM Error Codes

ECM ERROR CODE	DESCRIPTION OF ERRORS
0x0000	All OK
0x0071	IGBT Error
0x0072	Top FET Error
0x0073	Bottom FET Error
0x0074	FET Module Overheated
0x0075	IGBT Overheat
0x00A1	Invalid software state
0x00B1	CAN overrun
0x00B2	CAN passive mode
0x00B3	CAN heartbeat error
0x00B4	CAN recover bus off
0x00B5	CAN Tx CanId collision
0x00B6	Serial overrun
0x00B7	Can overrun Lss
0x00B8	Can overrun Sdo
0x00B9	Can overrun Rx
0x00BA	Can overrun ECT5
0x00FF	Module powering down within 500ms

Appendix C: OS Commands

CANopen allows for an addition set of operational commands for the device defined by the manufacturer. These are called OS commands. OS commands are sent as an SDO write message to OD location 0x1023, 0x01.

To activate an OS command, send the following message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x2F	0x23	0x10	0x01	OS cmd			

The reply from the Ripple Generator 2550 indicating a successful write:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x580 + NID	0x60	0x23	0x10	0x01				

Depending on the function of the OS commands, the action may not be instantaneous and may take some time to complete. A OS command status register will indicate the status of the OS command, which can be retrieved by requesting an SDO read of the OD location 0x1023, 0x02. Send the following message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x40	0x23	0x10	0x02				

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x580 + NID	0x60	0x23	0x10	0x02	Status			

Where status can be one of the following values:

- 0x00 Last command completed. No error occurred. No reply.
- 0x01 Last command completed. No error occurred. The reply can now be read.
- 0x02 Last command completed. Error occurred. No reply.
- 0x03 Last command completed. Error occurred. The reply can now be read.
- 0x04 - FE Reserved
- 0xFF Command is executing.

Depending on the function of the OS command, the device may return a OS command reply, usually indicating a successful operation or details of its failure. If the OS status indicates a reply is ready, you can read it by requesting an SDO read of OD location 0x1023, 0x03. Send the following message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + NID	0x40	0x23	0x10	0x03				

The reply from the Ripple Generator 2550:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x580 + NID	0x60	0x23	0x10	0x03	Reply			

Below is a list of OS commands for the Ripple Generator 2550, along with the OS replies for each, if any.

Command	Value	Description	Reply
ResetTPDOs	0x1F	Set all TPDOs as delivered from factory.	None
DisableTPDOCOBReset	0x22	Do not allow CAN id's to be set by CANopen spec. This affects TPDO's 1-4, Heartbeat, Error messages.	None
EnableTPDOCOBReset	0x23	CAN id's set by CANopen spec based on module's NID.	None
HVOutTurnOn	0x40	Turn on high voltage output (Only applicable in Remote mode).	None
HVOutTurnOff	0x41	Turn off high voltage output(Only applicable in Remote mode).	None
defFactoryReset	0xDF	Set all EE values to std configuration.	None

Warranty and Disclaimers

WARRANTY

The products described in this manual, are warranted to be free from defects in material and workmanship for a period of 365 days from the date of shipment to the buyer. Within the 365 day warranty period, we shall at our option repair such items or reimburse the customer the original price of such items which are returned to us with shipping charges prepaid and which are determined by us to be defective. This warranty does not apply to any item which has been subjected to misuse, negligence or accident; or misapplied; or modified; or improperly installed.

This warranty comprises the sole and entire warranty pertaining to the items provided hereunder. Seller makes no other warranty, guarantee, or representation of any kind whatsoever. All other warranties, including but not limited to merchantability and fitness for purpose, whether express, implied, or arising by operation of law, trade usage, or course of dealing are hereby disclaimed.

The warranty is void if Ripple Generator is opened or serviced by persons other than ECM qualified technicians.

LIMITATION OF REMEDY

Seller's liability arising from or in any way connected with the items sold and/or services provided shall be limited exclusively to repair or replacement of the items sold or refund of the purchase price paid by buyer, at seller's sole option. In no event shall seller be liable for any accidental, incidental, consequential or special damages of any kind or nature whatsoever, including but not limited to injury or death, or lost profits arising from or in any way connected with items sold and/or services provided to buyer, whether alleged to arise from breach of contract, express or implied warranty, or in tort, including without limitation, negligence, failure to warn or strict liability. In no event shall the company's liability to buyer arising out of or relating to the sale of any product or service exceed the purchase price paid by buyer to the company for such product or service.

PRODUCT CHANGES

We reserve the right to discontinue a particular product or to make technical design changes at any time without notice.

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Los Altos, CA 94023-0040 • USA • (408) 734-3433 • Fax: (408) 734-3432 • www.ecm-co.com