

## **EMCP 4.4 Simulator Manual**

**Author: Lucas Tolbert  
CIC Engineering  
345 Center Street  
East Peoria, IL**

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## Overview

This document will detail the features and operation of the EMCP 4.4 simulator. The EMCP 4.4 simulator was designed to provide a way to demonstrate some of the capabilities of Caterpillar's EMCP 4.4 control.

Each simulator comes with a set of prints that details the wiring and circuitry inside the simulator. The simulator manual document will describe the functionality of the simulator and will reference the internal wiring. This document is not intended to convey complete details regarding the internal wiring of the simulator. Complete details are shown in the electrical schematics.

The simulator can be configured via the UP/DOWN and ENTER/ESC toggle switches and the simulator's LCD display.

The simulator produces a 3-phase waveform to simulate the generator's output voltage. These waveforms are connected to the EMCP's generator and bus voltage input pins. There is a built in phase-shift circuit that allows the generator waveforms to be phase-shifted prior to being connected to the bus voltage input pins. A separate set of 3-phase waveforms are generated to simulate the current phases.

The simulator has the required wiring for the EMCP control to seize the dead bus using the dead bus arbitration sequence. Toggle switches are provided that allow the user to manually control the DBA pins to demonstrate various stages of the DBA process.

The simulator generates an engine speed sensor. The simulator will begin ramping the engine speed when a start initiate command is issued. The RPM will ramp until 1800 RPM is reached.

The simulator has switches to allow the user to control some of the EMCP digital inputs. The simulator has LEDs used to indicate the state of some of the EMCP digital outputs.

The simulator has connectors for the user to connect devices to the CAN1, CAN2, RS485 MODBUS, RS485 annunciator, and the Ethernet communication ports of the EMCP.

The simulator can also parallel with other simulators. This can be used to demonstrate the operation of the sync overview screen on the EMCP.

## **Simulator Power**

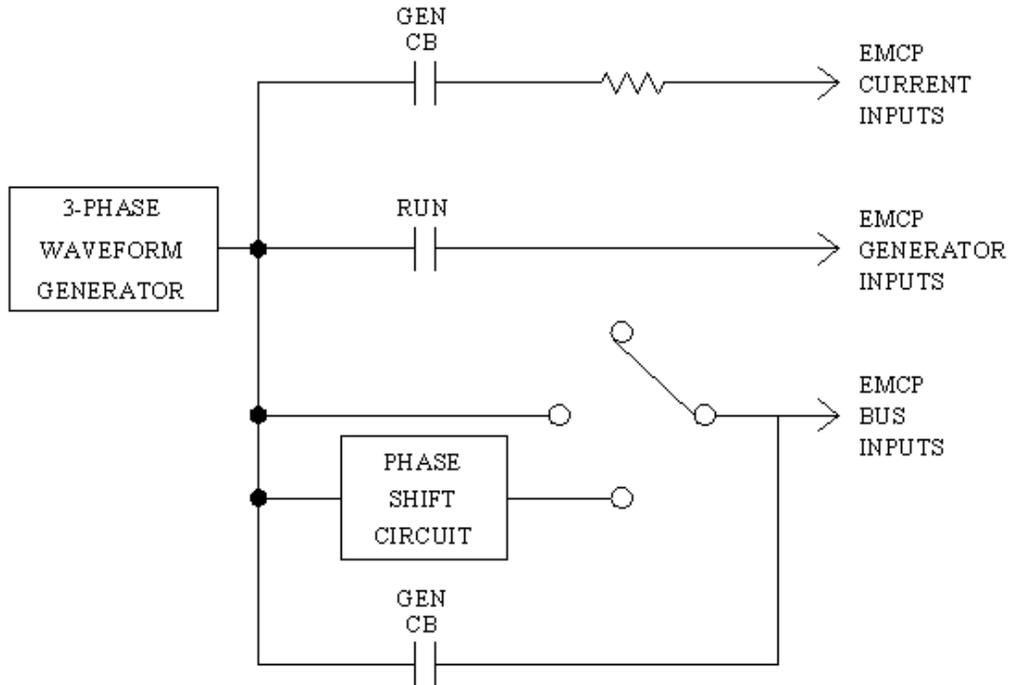
The simulator's incoming power can range from 120VAC to 240VAC at 50 or 60Hz. Power is connected through an AC inlet located on the top right of the simulator front panel. Power can be switched on and off using the toggle switch located to the left of the AC inlet. The incoming power has a 6A breaker in series with the power switch.

A 24VDC power supply is used to provide power for the simulator I/O and the EMCP control. This power supply also powers any devices attached to the communication ports. The 24VDC power supply has a 6A breaker in series with the output.

There is a 9VDC power supply that is used to power the internal electronics of the simulator.

There is a +5VDC and -5VDC power supply used to provide power for the 3-phase current and voltage waveforms.

## 3-Phase Voltage



**Figure 1**

Figure 1 shows a simplified schematic of the 3-phase wiring. The RUN contact and GEN CB contact are relays. The 3-phase waveform generator is the large PCB in the simulator. The phase shift circuit is a RC circuit.

The simulator PCB generates a set of 3-phase voltage waveforms. These waveforms are approximately 70 volts RMS. The amplitude for each phase can be digitally controlled using the simulator LCD interface. See the simulator configuration section later in the manual for details on how to use the setup interface.

The phase shift circuit has 3 possible operating states. The operating state is selected using the VOLTAGE switch located in the lower right above the paralleling connectors. The up position disables the phase shift circuit and connects the bus voltage inputs to the generated 3-phase waveform. The center position opens the phase shift circuit so no voltage is applied to the bus voltage inputs. The down position applies a phase shift of approximately 7 degrees using a RC circuit. The RC circuit will reduce the amplitude of the 3-phase voltage waveform slightly so a small difference in amplitude will be seen between the generator voltage inputs and the bus voltage inputs.

The RUN relay contact will close when the engine speed sensor is above 400 RPM. The GEN CB relay contact will close when the simulator receives a breaker close request. A

LED is provided on the front panel that illuminates when the GEN CB is closed. The GEN CB relay contact will open when the simulator receives a breaker open request

### **3-Phase Current**

The simulator PCB generates a second set of 3-phase waveforms. These waveforms are approximately 3.5 volts peak. These waveforms are connected to a 2-ohm resistor and return to common through the EMCP current inputs. Current does not flow until the GEN CB relay closes. See the Figure 1 for additional details.

The front panel of the simulator has a LOAD CURRENT ADJUST potentiometer that is used to vary the amount of current being generated by varying the amplitude of the waveforms. The waveforms have been adjusted such that the waveforms are sinusoidal until the LOAD CURRENT ADJUST is set too high.

Once the potentiometer is adjusted high enough; the current waveforms will begin to clip. This was done to allow for higher current readings while reducing the total amount of heat generated. Once the current waveforms begin clipping the power factor displayed by the EMCP control will no longer match the setting of the simulator.

### **Engine Speed Sensor**

The engine speed sensor is simulated by generating a square wave and then passing it through an isolation transformer. The engine speed begins ramping from 0 to 1800 RPM at the rate configured in the simulator configuration. The rate is specified in the number of seconds it should take the simulator to ramp from 0 to 1800 RPM.

The engine speed sensor begins ramping up when the DISCRETE OUTPUT 10 signal goes high. The engine speed sensor begins ramping down when the DISCRETE OUTPUT 10 signal goes low.

The current engine speed sensor rate is used to drive the RUN relay. The RUN relay connects the generator output voltage to the EMCP generator voltage input pins. The RUN relay turns on when the engine speed sensor reaches 400 RPM as the sensor ramps up. The RUN relay turns off when the engine speed sensor falls below 400 RPM.

### **EMCP Digital Inputs**

There are 4 switches wired to the EMCP digital inputs. These switches are wired to be active low and are active when switched up (towards the descriptive text).

The E-STOP switch is connected to the DEDICATED DISCRETE INPUT #1 on the EMCP. The REMOTE INITIATE switch is connected to the DEDICATED DISCRETE INPUT #2 on the EMCP.

The DIGITAL INPUT 1 switch is connected to the PROGRAMMABLE DISCRETE INPUT #1. The DIGITAL INPUT 2 switch is connected to the PROGRAMMABLE DISCRETE INPUT #2.

The GEN BREAKER MANUAL CLOSE switch is connected to the DEDICATED ISOLATED DISCRETE INPUT #4 on the EMCP. The GEN BREAKER MANUAL OPEN switch is connected to DEDICATED ISOLATED DISCRETE INPUT #3 on the EMCP. This switch is a 3-position momentary toggle switch.

The generator circuit breaker monitoring inputs are wired to the relay being used to simulate the generator circuit breaker.

## **EMCP Digital Outputs**

There are 4 LEDs wired to the EMCP's DISCRETE OUTPUTS. These LED's are wired to output #1 through #4.

DISCRETE OUTPUT #10 is used by the simulator's internal logic to begin simulating the start of a generator by ramping the engine speed sensor. This output should be configured in the EMCP to turn on with the FUEL CONTROL RELAY STATUS.

DEDICATED DISCRETE OUTPUT #2 and #3 are used by the simulator's internal logic to control the GEN CB relay. DEDICATED DISCRETE OUTPUT #2 is used by the simulator to open the GEN CB relay. DEDICATED DISCRETE OUTPUT #3 is used by the simulator to close the GEN CB relay.

## **EMCP Analog Inputs**

The EMCP ANALOG INPUT 1 is wired to simulate the jacket water temperature sensor. This input is tied to a 47-ohm resistor.

The EMCP ANALOG INPUT 2 is wired to simulate the engine oil pressure sensor. This input is tied to a 10-ohm resistor when the engine is not running and a 100-ohm resistor when the engine is running.

The EMCP ANALOG INPUT 3 is wired to a potentiometer on the front panel. The potentiometer is connected to the EMCP +5V sensor power supply. A tip jack is provided on the front panel to allow for easy voltage measurements of the analog signal.

## **EMCP Analog Outputs**

The EMCP ANALOG OUTPUT 1 is wired to the front panel and tip jacks have been provided. These jacks allow for easy measurement of the analog output signal.

## **EMCP PWM Outputs**

The EMCP PWM OUTPUT 1 is wired to the front panel and tip jacks have been provided. These jacks allow for easy measurement of the PWM output signal.

## **EMCP HWDBA Control**

The simulator has been designed to allow for demonstration of the hard-wired dead bus arbitration process.

A relay is wired to function as the DBA relay for the pre and post arbitration inputs. This relay is driven by the EMCP HWDBA #5 pin. It is wired to allow the EMCP to detect the voltage difference on the pre-arbitration and post-arbitration inputs.

The REQUEST switch is used to control the state of the REQUEST line. The center position of the switch allows the REQUEST line to float and lets the EMCP drive the REQUEST line. The down position pulls the REQUEST line to the switch reference in order to simulate another EMCP control driving the REQUEST line. The up position places the REQUEST line in parallel mode. Additional details about paralleling will be described in a later section.

The CAPTURE switch functionality is identical to the REQUEST switch but controls the CAPTURE line.

## **EMCP Communication**

There are several connectors in the lower left of the front panel that allows access to the various communication ports supported by the EMCP.

The CAN 1 CONNECTOR allows access to the CAN 1 communication port of the EMCP. The connector is wired to match the standard service port wiring. +24VDC power is supplied through pins A and B. An internal 120-ohm termination resistor is installed inside the simulator.

There are 2 connectors provided for access to the CAN2 communication port. These connectors are wired in parallel. The 2 connectors have been provided so that auxiliary devices such as a DIO module can be connected to the simulator using one of the connectors and a computer can be connected to the other connector. The connectors are wired to match the standard service port wiring. +24VDC power is supplied through pins A and B. An internal 120-ohm termination resistor is installed inside the simulator.

An 8-pin connector has been provided to allow for connection of a RS-485 annunciator. An extension cable has been provided to allow the annunciator to be connected to the simulator.

A RJ45 connector has been provided to allow for connection to the Ethernet communication port.

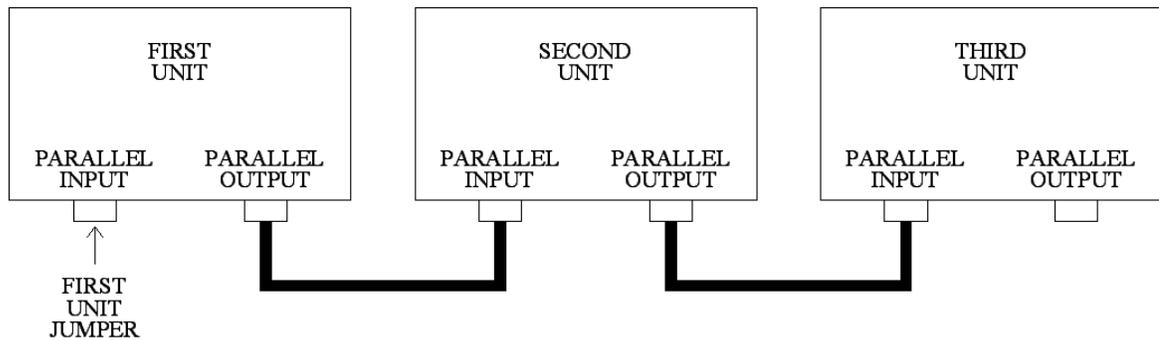
A spring cage terminal strip has been provided for connection to the RS-485 MODBUS communication port.

## EMCP Simulator Paralleling

Up to 3 EMCP simulator units can be paralleled. A diagram of the required cabling is shown in Figure 2.

The followings steps must be done to allow for multiple simulators to be paralleled.

1. The PARALLEL MODE switch, the REQUEST switch, and the CAPTURE switch must be put in the up (PARALLEL) position.
2. The VOLTAGE control switch must be put in the center (OFF) position.
3. 1 simulator unit must be designated the first unit. This unit should have the first-unit jumper plug connected to the PARALLEL INPUT connector. This jumper plug is a 12-pin connector with a jumper from pin 5 to pin 8.
4. A 12-pin parallel cable must be connected from the 1st unit's PARALLEL output connector to the 2<sup>nd</sup> unit's PARALLEL input connector.
5. Any additional units should have a parallel cable connected from the previous unit's PARALLEL OUTPUT connector to their PARALLEL INPUT connector.



**Figure 2**

When multiple simulator units are connected together by the parallel cable the REMOTE INITIATE switch on any unit will cause all the simulators to begin the generator starting sequence.

The GEN TO BUS MAX VOLT DIFFERENCE % THRESH setting should be at the maximum allowable amount. This is required because the bus voltage seen by the units will be lower than the internal generator voltage. Once a unit completes the paralleling sequence that unit will disconnect its internal 3-phase voltage signals from the common bus. This will cause the voltages seen on the SYNC OVERVIEW screen to be different from unit to unit.

The simulator that wins access to the dead bus will continue to drive the bus lines on the parallel cables.

The exact details of how the paralleling functionality was implemented are shown in the electrical schematics and on the paralleling overview page of the schematics.

## **Simulator Configuration**

The simulator has settings that can be configured using the simulator LCD display. There are 2 switches provided that allow for LCD menu navigation. The UP/DOWN switch allows the cursor to be moved or a value to be incremented or decremented. The ENTER/ESC switch has 2 positions. The ENTER switch allows for a menu entry to be selected or a configured value to be saved. The ESC switch allows for a menu or prompt to be exited.

The MAIN MENU is shown at power-up.

One of the methods used to configure the simulator is a series of prompts. This method is used in several places and each of the instances function in a similar manner. The ESC switch will cancel any edits to the current prompt and will return to the previous menu. The ENTER switch will accept any edits to the current prompt and advance to the next prompt. The display will return to the previous menu after the last prompt has been answered.

### **DISPLAY MODE**

This menu entry displays a screen where the current value of the ANALOG INPUT 3 signal is shown. This screen also shows the approximate amount of actual load selected through the LOAD ADJUST CONTROL potentiometer. The screen can be exited using the ESC switch.

### **RPM SETUP/INFO**

This menu entry displays a screen showing details about the engine speed signal generation.

The current engine speed signal ramp time is shown. This number is the amount of time it will take the simulator to ramp from 0 to 1800 RPM.

The ramp rate of the engine speed signal can be configured. Use the UP/DOWN switch to increment and decrement the value.

The screen can be exited using either the ENTER or ESC switch. The ENTER switch will save any changes to the ramp rate. The ESC switch will cancel any changes.

### **LCD SETUP**

This menu entry displays a sequence of prompts that allows the user to configure the LCD contrast and brightness.

### **WAVEFORM FREQUENCY**

This menu entry allows the user to configure the frequency of the 3-phase waveforms.

Use the UP/DOWN switch to increment and decrement the frequency.

The screen can be exited using either the ENTER or ESC switch. The ENTER switch will save any changes to the ramp rate. The ESC switch will cancel any changes.

### **WAVEFORM AMPLITUDE**

This menu entry displays a sequence of prompts that allows the user to configure the amplitude percentage of each phase of the generator voltage signals. The edited value takes effect immediately but edits can still be canceled using the ESC switch. This was done so that phase amplitudes could be tweaked easily.

### **POWER FACTOR**

This menu entry displays a screen that allows the power factor to be configured.

Use the UP/DOWN switch to increment and decrement the power factor percentage.

The screen can be exited using either the ENTER or ESC switch. The ENTER switch will save any changes to the ramp rate. The ESC switch will cancel any changes.

### **ROTATION DIRECTION**

This menu entry displays a screen that allows the rotation direction of the generation 3-phase signals to be selected.

This screen shows the currently selected rotational direction. The UP switch can be used to toggle between the two possibilities: ABC and CBA.

### **DIAGNOSTICS**

This menu entry displays a sub-menu that allows the I/O of the simulator to be viewed.

#### **DIAGNOSTICS->INPUTS**

This menu entry displays a list of the digital inputs for the simulator PCB. The current state of each input is shown. Use the UP/DOWN switch to navigate the list of inputs. Use the ESC switch to return to the previous menu.

#### **DIAGNOSTICS->OUTPUTS**

This menu entry displays a list of the digital outputs for the simulator PCB. The current state of each output is shown. Use the UP/DOWN switch to navigate the list of outputs. Use the ENTER switch to toggle the state of an output. Use the ESC switch to return to the previous menu.

**Note:** while this screen is being shown the automatic processing of the outputs is suspended. When this screen is exited the automatic processing of the outputs will resume.

#### **DIAGNOSTICS->DAC OUTPUTS**

This menu entry displays a list of the analog outputs for the simulator PCB. The 3-phase signals are generated using these analog outputs.

The current raw value of each output is shown. Use the UP/DOWN switch to navigate the list of outputs. Use the ESC switch to return to the previous menu. Use the ENTER switch to begin editing an output.

Once an output is selected for editing the UP/DOWN and ENTER/ESC switches take on a new function. The UP/DOWN switch will increment and decrement the current output's value. The ENTER or ESC switch accept the edit and return to the state where the list can be scrolled.

**Note:** while this screen is being shown the automatic processing of the analog outputs is suspended. When this screen is exited the automatic processing of the outputs will resume.

### **DIAGNOSTICS->ANALOG INPUTS**

This menu entry displays a list of the analog inputs for the simulator PCB. The current raw value of each input is shown. Use the UP/DOWN switch to navigate the list of inputs. Use the ESC switch to return to the previous menu.