

## 5. OPERATIONAL DEMOS

### 5.1 Control of LAB-VOLT's 8540 dynamometer based on Mitsubishi's A-700 inverter

In this subsection, user is presented with a SIMULINK-based model to perform basic control over LAB-VOLT's 8540 dynamometer through the serial interface. In this demo, the dynamometer will be operated in torque mode with speed limit. This means that the dynamometer will follow the torque reference as long as the speed limit is not surpassed. If the speed limit is reached the torque reference will be automatically limited so the speed limit is respected. Worth noting that while operating the dynamometer in torque mode, the speed needs to be limited to avoid the risk of over-speed (which would be the case if the torque developed by the dynamometer surpasses that from friction and the load at its shaft).

Since the user may be interested in monitoring and getting an insight into the serial communication protocol between OPAL-RT's simulator and Mitsubishi's A-700, some of the signals involved in the serial communication protocol are brought into the user's control.

#### **Procedure:**

- 1.- Connect the OPAL-RT simulator to the OP8660 as shown in section 3.1.
- 2.- Connect the OPAL-RT simulator with the host computer as shown in section 3.2.
- 3.- Perform the control connections between OPAL-RT's hardware and LAB-VOLT's 8540 dynamometer as shown in section 3.3 (i.e. serial asynchronous link (3.3.1) and ABZ encoder link (3.3.2)).
- 4.- Turn-on the 8540 dynamometer and, through its touch-panel, enable its "Computer-Based control", as depicted in Figure 5.1. In this operating mode user can monitor the state of the dynamometer: torque, speed (frequency), current and voltage.

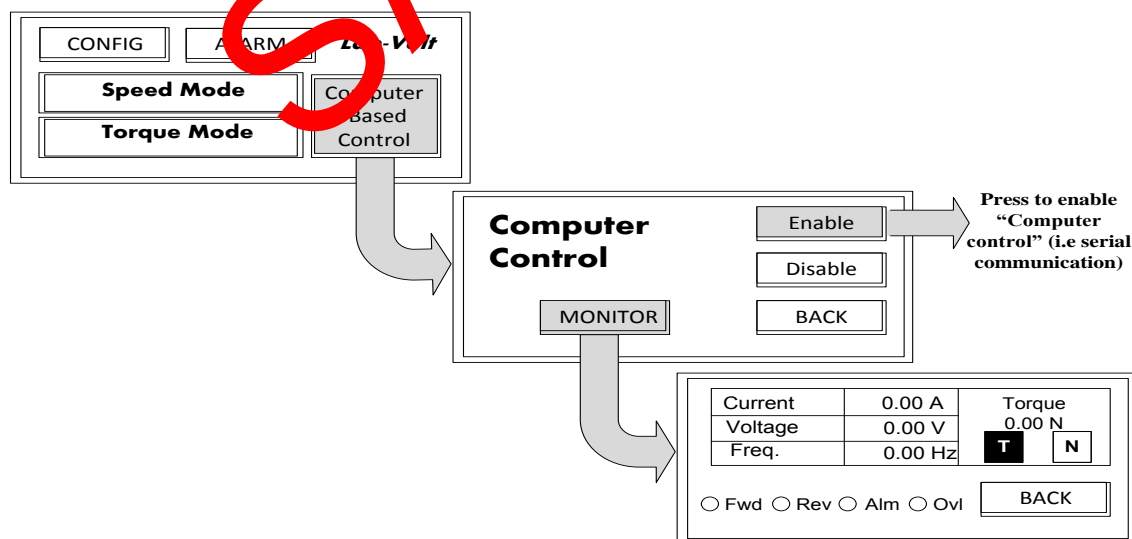


Figure 5.1 Dynamometer touch-screen interface: enabling the "Computer Based Control"

5.-Following the parameters from the *PCC* presented in Table 5.1, create an RT-LAB project and load/run the model “*Dynamometer\_A700\_v2\_1.mdl*”.

**Table 5.1 PCC for the control LAB-VOLT’s 8540 dynamometer based on Mitsubishi’s A-700 inverter**

PARAMETER	VALUE/CONFIGURATION	NOTES
<b>PARAMETER</b>	Dynamometer 8540 control	
(1) Project Name	<i>Dynamometer_A700_v2_1.mdl</i>	Add as existing model →Import
(2) Model Name	Redhat	
(3) Development Settings/Target platform	Hardware synchronized	
(4) Execution/Real-Time Simulation Mode	*.c , *.h , *.mk, *.m, *.mat	Trasf.Time : Before compilation (in ASCII mode)
(6)	<b>Simulation → Build</b>	
(7) Assignation	SM_OP8660	XHP (ON)
	SS_torque_ctrl	XHP (OFF)
(8)	<b>Simulation → Load → Execute</b>	

6.- Figure 5.2 presents the SIMULINK console generated by RT-LAB while executing *Dynamometer\_A700\_v2\_1.mdl*. If necessary, resize the console through *View/Fit System To View*. Follow the onscreen instructions to start the dynamometer (Figure 5.2):

- First, establish a limit for the speed of the dynamometer. The allowed speed range for this demo is [0-1800] [rpm]. A recommended value is 1000[rpm].
- Next, establish a torque reference for the dynamometer. The allowed range for this demo is [0-5] N\*m. A recommended value is 0.7 N.m. Try different torque values close to 0.7 N\*m and see the effect on the dynamometer's speed.
- Start the dynamometer using the Start\_Stop manual switch (value 1).
- Stop the dynamometer using the Start\_Stop manual switch (value 0).

The user console will allow you to monitor the speed and torque of the dynamometer. The speed reading comes directly from the dynamometer’s ABZ encoder connected to the OP8660. On the other hand, the torque reading is monitored through the serial link between the OP5600/OP4500/OP7000 simulator and dynamometer’s A-700 inverter.

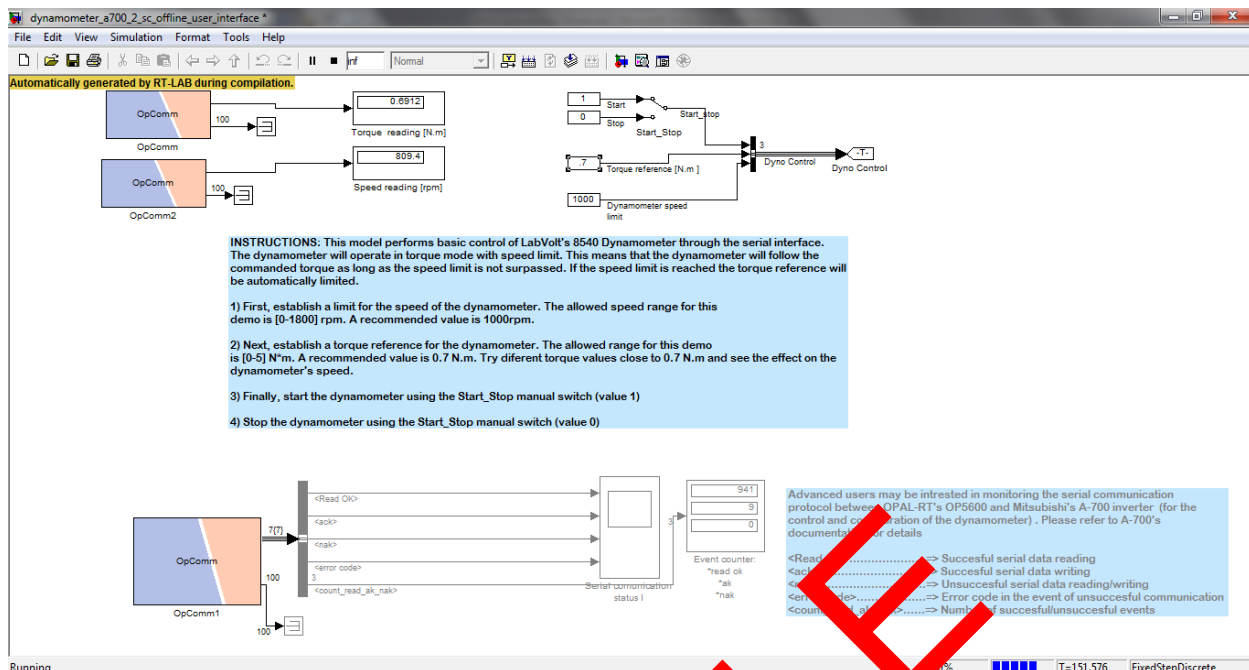


Figure 5.2 Console for the “Dynamometer\_A700\_v2\_1.mdl” demo as the model runs and the 8540 operates in torque mode.

## 5.2 Control of LAB-VOLT’s 8857 inverter

In this subsection, user is presented with a SIMULINK-based model to perform basic control over LAB-VOLT’s 8857 inverter. A simple DC-AC scheme is implemented to feed a three-phase RL load as shown in Figure 5.3. Apart from verifying the correct operation of LAB-VOLT’s 8857 inverter and the control pulses generated by the OPAL-RT simulator, user will be able to make a side-by-side comparison between the actual waveforms generated by the hardware and those generated by the real-time simulation of the circuit of interest (using both SimPowerSystems and RT-LAB inverter blocks).

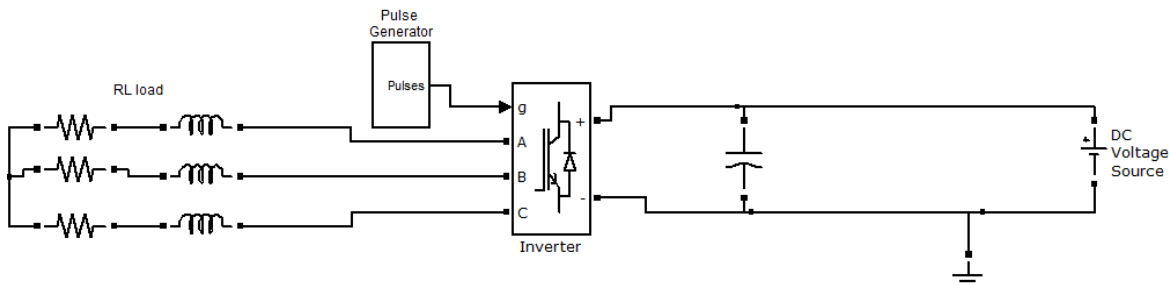


Figure 5.3 Three-phase circuit to verify the operation of LAB-VOLT’s 8857 inverter and the corresponding OPAL-RT control modules.

### Procedure:

- 1.- Connect the simulator to the OP8660 as shown in section 3.1.

- 2.- Connect the simulator with the host computer as shown in section 3.2.
- 3.- Perform the control connections between OPAL-RT's OP8660 and LAB-VOLT's 8857 inverter as shown in section 3.4. Additionally, perform the power connections depicted in Figure 5.4 between OP8660's voltage and current channels and LAB-VOLT's hardware. Actual numbering and labeling of the jacks in the different hardware modules correspond to those depicted in Figure 5.4, except for the resistor module 8509 where no jack numbering is provided so the employed convention is graphically introduced.

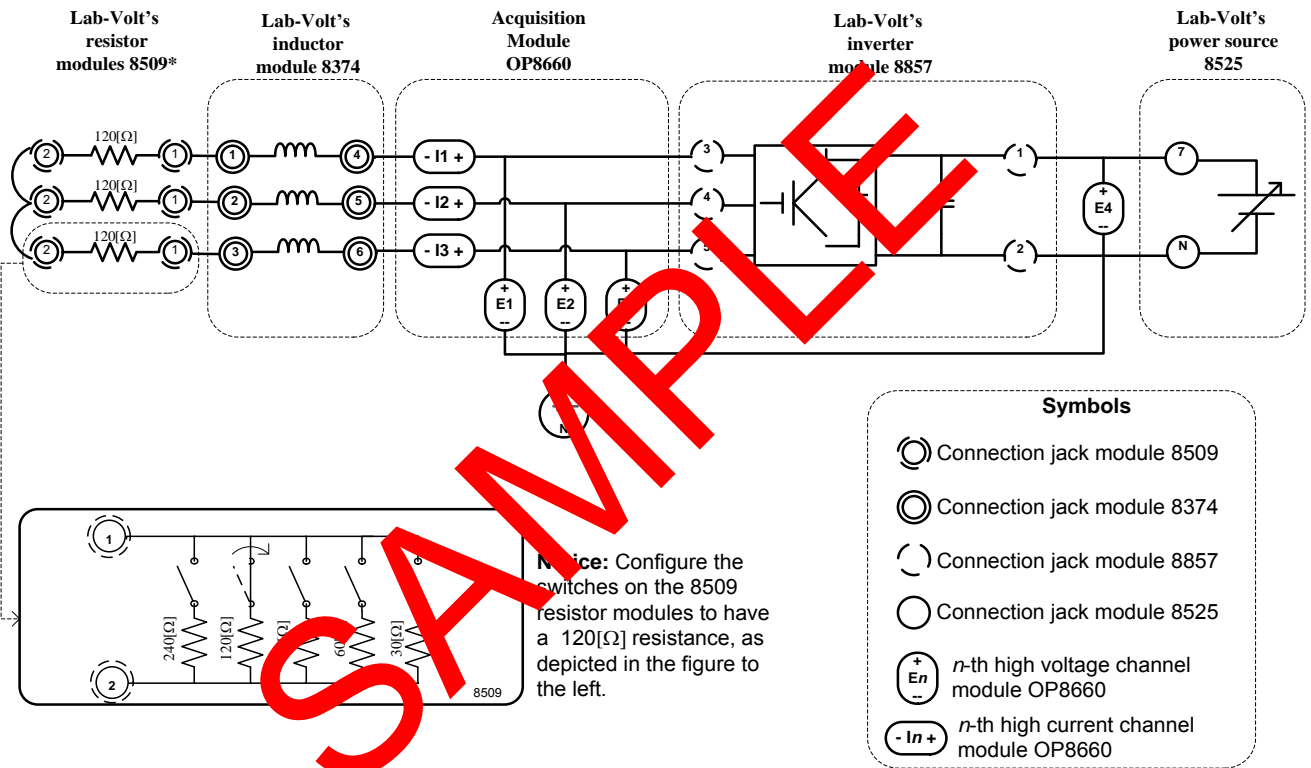


Figure 5.4 Connections between OP8660's voltage and current channels and LAB-VOLT's hardware

- 4.- Make sure the selected inverter is fed through its 24 [V] AC input, as shown in section 3.4.2. (the same control pulses are sent to both inverters, so user can choose any one of them). Turn ON the selected inverter. Turn ON the 8525 power source: use 8525's voltmeter and variable voltage knob to establish a DC voltage level between 40 and 50[V] DC. Make sure the voltmeter's selection knob is set to *DC 7-N*.
- 5.-Following the parameters from the *PCC* presented in Table 5.2, create an RT-LAB project and load/run the model "*INVERTER\_8857\_v2\_1.mdl*".

**Table 5.2 PCC for the control LAB-VOLT's 8540 dynamometer based on Mitsubishi's A-700 inverter**

PARAMETER	VALUE/CONFIGURATION	NOTES
(1) Project Name	Inverter 8857 control	
(2) Model Name	<i>INVERTER_8857_v2_1.mdl</i>	Add as existing model →Import
(3) Development Settings/Target platform	Redhat	
(4) Execution/Real-Time Simulation Mode	Hardware synchronized	
(5) Files	*.c , *.h , *.mk, *.m, *.mat	Trans Time : Before compilation (in ASCII mode)
<b>(6) Simulation → Build</b>		
(7) Assigination	SM_OP8660	XHP (ON)
	SS_Calib	YHP (OFF)
<b>(8) Simulation → Load → Execute</b>		

6.- Figure 5.5 presents the SIMULINK console generated by RT-LAB while executing “*INVERTER\_8857\_v2\_1.mdl*. If necessary, resize the console through *View/Fit System To View*. The console will allow user to enable the operation of the selected inverter, modify the frequency of the modulation carrier and monitor the current/voltage waveforms through the RL load. As indicated at the beginning of this section, a comparison is performed between the simulation output waveforms (using both SimPowerSystems and RT-LAB inverter blocks) and the actual waveforms of LAB-VOLT's 8857 inverter. Figure 5.6 presents a detailed view of the console's scope. User is encouraged to compare the generated waveforms, where:

- $I_a/V_a_{mat}$  => simulation waveform obtained using SimPowerSystems' universal IGBT bridge block (yellow trace)
- $I_a/V_a_{opal}$  => simulation waveform obtained using RT-LAB's 2-level TSB block (magenta trace)
- $I_a/V_a_{meas}$  => actual waveform measured by OPAL-RT's OP8660 acquisition module (cyan trace).

It is worth noting from Figure 5.6, the close proximity between the measured current waveforms and those obtained by simulation through RT-LAB's 2-level TSB block.