



Twin Builder Components: Aircraft Electrical VHDLAMS



ANSYS, Inc.
Southpointe
2600 Ansys Drive
Canonsburg, PA 15317
ansysinfo@ansys.com
<https://www.ansys.com>
(T) 724-746-3304
(F) 724-514-9494

Release 2024 R2
July 2024

ANSYS, Inc. and
ANSYS Europe,
Ltd. are UL
registered ISO
9001:2015 com-
panies.

Copyright and Trademark Information

© 1986-2024 ANSYS, Inc. Unauthorized use, distribution or duplication is prohibited.

ANSYS, Ansys Workbench, AUTODYN, CFX, FLUENT and any and all ANSYS, Inc. brand, product, service and feature names, logos and slogans are registered trademarks or trademarks of ANSYS, Inc. or its subsidiaries located in the United States or other countries. Icem CFD is a trademark used by ANSYS, Inc. under license. All other brand, product, service and feature names or trademarks are the property of their respective owners. FLEXIm and FLEXnet are trademarks of Flexera Software LLC.

Disclaimer Notice

THIS ANSYS SOFTWARE PRODUCT AND PROGRAM DOCUMENTATION INCLUDE TRADE SECRETS AND ARE CONFIDENTIAL AND PROPRIETARY PRODUCTS OF ANSYS, INC., ITS SUBSIDIARIES, OR LICENSORS. The software products and documentation are furnished by ANSYS, Inc., its subsidiaries, or affiliates under a software license agreement that contains provisions concerning non-disclosure, copying, length and nature of use, compliance with exporting laws, warranties, disclaimers, limitations of liability, and remedies, and other provisions. The software products and documentation may be used, disclosed, transferred, or copied only in accordance with the terms and conditions of that software license agreement.

ANSYS, Inc. and ANSYS Europe, Ltd. are UL registered ISO 9001: 2015 companies.

U.S. Government Rights

For U.S. Government users, except as specifically granted by the ANSYS, Inc. software license agreement, the use, duplication, or disclosure by the United States Government is subject to restrictions stated in the ANSYS, Inc. software license agreement and FAR 12.212 (for non-DOD licenses).

Third-Party Software

See the legal information in the product help files for the complete Legal Notice for Ansys proprietary software and third-party software. If you are unable to access the Legal Notice, please contact ANSYS, Inc.

Table of Contents

Table of Contents	Contents-1
1 - Aircraft Electrical VHDL-AMS Library	1-2
Basic	1-3
abc2dq0: abc to dq0 transformation	1-4
dq02abc: dq0 to abc transformation	1-6
e_ac: 1-phase AC voltage source	1-8
e_ac_3phase: 3-phase AC voltage source with R-L impedance	1-10
lowpass_filter: ideal first-order low pass filter	1-13
lowpass_filter_elec: ideal first-order electrical low pass filter	1-15
opamp_ideal: ideal operational amplifier	1-17
pid_lim: PID controller with output limiting	1-19
pwm_b: PWM generator with Boolean output	1-21
pwm_q: PWM generator with quantity output	1-23
ramp: Ramp input	1-25
sum2: Sum block with 2 inputs	1-27
sum3: Sum block with 3 inputs	1-29
thyristor_dynamic: Dynamic thyristor	1-31
thyristor_gto_ideal: Ideal GTO thyristor	1-34
thyristor_ideal: Ideal thyristor	1-36
triangle: Triangle wave generator with frequency and amplitude inputs	1-38
Distribution	1-40
boost: Boost converter (VHDL-AMS)	1-41
buck: Buck converter(VHDL-AMS)	1-44
inverter_dcac: DC/AC inverter(VHDL-AMS)	1-47
rectifier_4pulse: 4 pulse diode rectifier(VHDL-AMS)	1-50
rectifier_4pulse_thyristor: 4 pulse thyristor rectifier(VHDL-AMS)	1-53
rectifier_6pulse: 6 pulse diode rectifier(VHDL-AMS)	1-56
rectifier_6pulse_thyristor: 6 pulse thyristor rectifier(VHDL-AMS)	1-59

rectifier_a2d_ideal: Ideal 3 phase AC/DC rectifier(VHDL-AMS)	1-62
rlc_3phase: 3 phase RL transformation line with shunt capacitance(VHDL-AMS)	1-64
Engine	1-67
combustor: Simple combustor	1-68
compressor: Simple compressor	1-70
fueltank: Simple fuel tank	1-72
gt_engine: Simple gas turbine engine	1-74
inlet: Simple inlet	1-77
nozzle: Simple nozzle	1-79
shaft: Simple shaft	1-81
turbine: Simple turbine (VHDL-AMS)	1-83
Generator	1-85
csd: Constant speed drive (VHDL-AMS)	1-86
gcu: Generator control unit (VHDL-AMS)	1-88
generator_ee: Generator with electrical excitation (VHDL-AMS)	1-91
generator_pm: Generator with permanent magnet (VHDL-AMS)	1-94
idg: Integrated drive generator (VHDL-AMS)	1-97
Load	1-101
battery: Battery with fixed data for battery types (VHDLAMS)	1-102
battery_general: Battery with customer given data	1-104
c_motor_dcac: Controller for 3-phase PMSM with DC input	1-107
c_motor_dcdc: DC motor controller	1-110
cpl_ideal: Constant power load	1-112
fan: Fan	1-114
heater_3phase: 3-phase resistance heater	1-117
heater_dc: DC resistance heater	1-120
lamp_simple: Simple incandescent lamp	1-123
motor_dc: Permanent magnet DC motor	1-125
motor_pm: Permanent magnet synchronous motor	1-127
pump: Pump	1-130

r_thermal: Resistance with thermal effects	1-133
tank_w: Heatable tank with constant level	1-135
Aircraft Electrical System Application Example	1-138
AC 3Phase Voltage Source Example	1-148
Battery General Example	1-151
Battery Example	1-155
Boost Converter Example	1-159
Buck Converter Example	1-163
DC-AC Inverter Example	1-167
Electrical Transformation Line Example	1-169
Generator Electrical Excitation Example	1-174
Generator Permanent Magnet Example	1-178
GT Engine Example	1-182
GT Engine Generator Example	1-186
Heater Example	1-190
Integrated Drive Generator Example	1-194
Lowpass Filter Example	1-198
Motor DC Control Example	1-202
Motor PM Control Example	1-205
Motor PM Speed Control Example	1-208
Operational Amplifier Example	1-213
Pump Example	1-217
PWM Example	1-221
Rectifier 4 Pulse Example	1-223
Rectifier 6 Pulse Example	1-226
Simple Heater Example	1-229
Simple Lamp Example	1-233
Simplified Power System Example	1-235
Sources Example	1-241
Sum Example	1-244

Thyristor Example1-248

1 - Aircraft Electrical VHDL-AMS Library

The components in the Aircraft Electrical VHDL-AMS library are mostly first principle mathematical system-level models. The library has two main objectives:

- Provide reusable and extensible generic components for further customer design.
- Provide demonstrative application examples that use these types of components.

The Aircraft Electrical VHDL-AMS library consists of the following types of components:

- [Basic](#)
- [Distribution](#)
- [Engine](#)
- [Generator](#)
- [Load](#)

Every component in the library has a related demonstrative example to show how the component works. An example to demonstrate the entire aircraft electrical system using the generic components in the library can be found:

- [Aircraft Electrical System example](#)

Basic

The Basic consists of the following types of models:

- [abc2dq0](#)
- [dq02abc](#)
- [e_ac](#)
- [e_ac_3phase](#)
- [lowpass_filter](#)
- [lowpass_filter_elec](#)
- [opamp_ideal](#)
- [pid_lim](#)
- [pwm_b](#)
- [pwm_q](#)
- [ramp](#)
- [sum2](#)
- [sum3](#)
- [thyristor_dynamic](#)
- [thyristor_gto_ideal](#)
- [thyristor_ideal](#)
- [triangle](#)

abc2dq0: abc to dq0 transformation

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

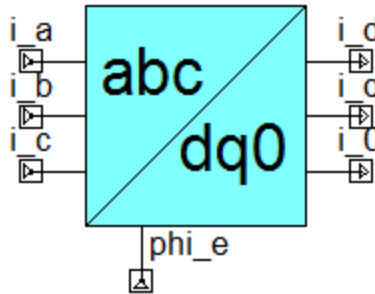


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The abc2dq0 model provides the calculation from i_a , i_b , i_c to i_d , i_q , i_0 transform, with corresponding electrical angle from the motor.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

[Top](#)

Input/Output Quantities

Table 1

Name	Description [Unit]	Direction	Data Type
i_a	Current a input [A]	Input	Real
i_b	Current b input [A]	Input	Real
i_c	Current c input [A]	Input	Real
phi_e	Electrical angle input [rad]	Input	Real
i_d	Current d output [A]	Output	Real
i_q	Current q output [A]	Output	Real
i_0	Current 0 output [A]	Output	Real

[Top](#)

Examples

[Motor PM Speed Control Example](#)

[Top](#)

References

dq02abc: dq0 to abc transformation

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

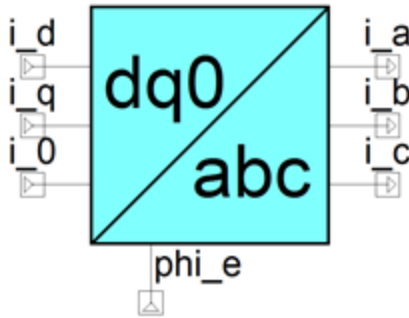


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The dq02abc model provides the calculation from i_d , i_q , i_0 to i_a , i_b , i_c transform, with corresponding electrical angle from the motor.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

[Top](#)

Input/Output Quantities

Table 1

Name	Description [Unit]	Direction	Data Type
i_d	Current d input [A].	Input	Real
i_q	Current q input [A]	Input	Real
i_0	Current 0 input [A]	Input	Real
phi_e	Electrical angle input [rad]	Input	Real
i_a	Current a output [A]	Output	Real
i_b	Current b output [A]	Output	Real
i_c	Current c output [A]	Output	Real

[Top](#)

Examples

[Motor PM Speed Control Example](#)

[Top](#)

References

e_ac: 1-phase AC voltage source

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

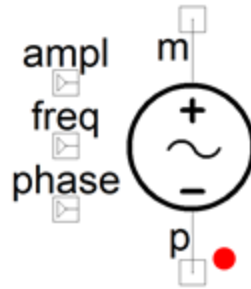


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The e_ac model represents ac voltage source (sine wave).

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p	Positive electrical port	electrical
m	Negative electrical port	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Parameters

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
ampl	Source amplitude [A]	Input	Real
freq	Source frequency [Hz]	Input	Real
phase	Phase [degree]	Input	Real

[Top](#)

Examples

[AC 3Phase Voltage Source Example](#)

[Top](#)

References

e_ac_3phase: 3-phase AC voltage source with R-L impedance

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
---------------------------------------	-----------------------------	-------------------------------------

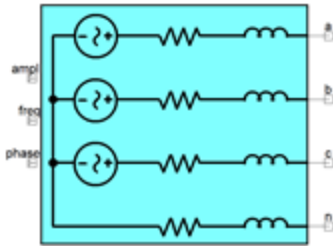


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The e_ac_3phase model represents the 3 phase ac voltage source with symmetrical internal R-L impedances, the three voltage sources are connected in Y to neutral connection to external terminal.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a	Electrical port a	electrical
b	Electrical port b	electrical
c	Electrical port c	electrical
n	Electrical port n	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
r_l	Line resistance	real	0.1 [Ohm]
l_l	Line inductance	real	0.0001 [H]
r_n	Resistance to neutral	real	0.1 [Ohm]
l_n	Inductance to neutral	real	0.0001 [H]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
ampl	Source amplitude [A]	Input	Real
freq	Source frequency [Hz]	Input	Real
phase	Phase [degree]	Input	Real

[Top](#)

Examples

[AC 3Phase Voltage Source Example](#)

[Top](#)

References

lowpass_filter: ideal first-order low pass filter

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

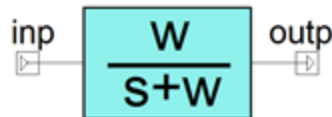


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The lowpass_filter model represents the first order low pass filter behavior based on user defined pole frequency and filter gain.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

Table 1

Name	Description	Data Type	Default Value [Unit]
fp	Pole frequency	real	1.0e6 [Hz]
k	Filter gain	real	1.0

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
inp	Input quantity	Input	Real
outp	Output quantity	Output	Real

[Top](#)

Examples

[Lowpass Filter Example](#)

[Top](#)

References

lowpass_filter_elec: ideal first-order electrical low pass filter

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

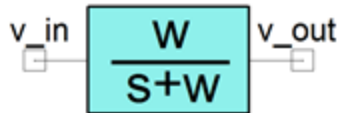


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The electrical low pass filter model represents the first order low pass filter behavior based on user defined pole frequency and filter gain.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

Table 1

Name	Port/Terminal description	Nature/Data type
v_in	Electrical port v_in	electrical
v_out	Electrical port v_out	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Input/Output Quantities

Table 2

Name	Description	Data Type	Default Value [Unit]
fp	Pole frequency.	real	1.0e6 [Hz]
k	Filter gain	real	1.0

[Top](#)

Examples

[Lowpass Filter Example](#)

[Top](#)

References

opamp_ideal: ideal operational amplifier

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

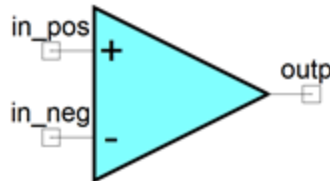


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The opamp_ideal model represents an ideal model for electrical inputs optional amplitude.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

Table 1

Name	Port/Terminal description	Nature/Data type
in_pos	Electrical port in_pos	electrical
in_neg	Electrical port in_neg	electrical
outp	Electrical port outp	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Input/Output Quantities

Table 2

Name	Description	Data Type	Default Value [Unit]
aol	Open loop gain	real	100.0e3
f_0db	The frequency where the product of open loop gain and the feedback factor is equal to 1 (which is 0 dB)	real	1.0e7 [Hz]

[Top](#)

Examples

[Operational Amplifier Example](#)

[Top](#)

References

pid_lim: PID controller with output limiting

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

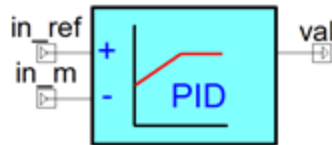


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The pid_lim model represents the behavior of PID controller with limit output, antiwindup is also provided with an adjustable gain.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

Table 1

Name	Description	Data Type	Default Value [Unit]
ts	Sample time	real	0.0 [sec]
kp	Proportional gain	real	1.0
ki	Integral gain	real	1.0
kd	Derivative gain	real	1.0
ll	Lower limit of controller output	real	-1.0e9
ul	Upper limit of controller output	real	1.0e9
yi_init	Initial value of integrator	real	0.0
yd_init	Initial value of differentiator	real	0.0
ka	Antiwindup gain	real	1.0

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
in_ref	Reference input quantity	Input	Real
in_m	Measurement input quantity	Input	Real
val	Controller output	Output	Real

[Top](#)

Examples

[Motor PM Speed Control Example](#)[Top](#)

References

pwm_b: PWM generator with Boolean output

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

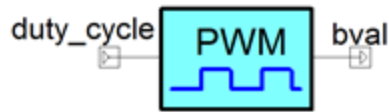


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The pwm_b model represents the simple behavior of PWM signal with boolean output.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

Table 1

Name	Description	Data Type	Default Value [Unit]
freq	PWM frequency	real	1.0 [Hz]
phase	Phase delay	real	0.0 [degree]

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
duty_cycle	Duty cycle	Input	Real
bval	PWM output (signal)	Output	Boolean

[Top](#)

Examples

[PWM Example](#)

[Top](#)

References

pwm_q: PWM generator with quantity output

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

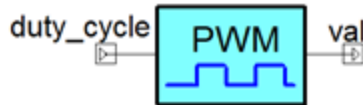


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The pwm_q model represents the simple behavior of PWM signal with quantity output.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

Table 1

Name	Description	Data Type	Default Value [Unit]
freq	PWM frequency	real	1.0 [Hz]
phase	Phase delay	real	0.0 [degree]

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
duty_cycle	Duty cycle	Input	Real
val	PWM output	Output	Real

[Top](#)

Examples

[PWM Example](#)

[Top](#)

References

ramp: Ramp input

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

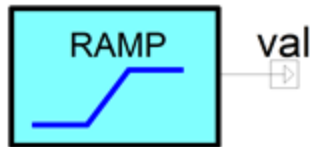


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

This ramp model gives a ramp signal.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

Table 1

Name	Description	Data Type	Default Value [Unit]
start_time	ramp start time	real	0.0 [sec]
offset	offset of the ramp signal	real	0.0
duration	the duration time from offset to offset+amp	real	2.0 [sec]
amp	the amplitude change of the ramp signal	real	1.0

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
val	the output value of ramp signal	Output	Real

[Top](#)

Examples

[Sources Example](#)

[Top](#)

References

sum2: Sum block with 2 inputs

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

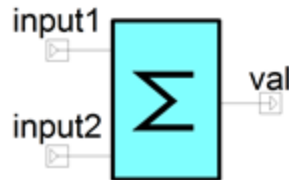


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

This sum2 model provides the ability to add/subtract 2 quantities.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

Table 1

Name	Description	Data Type	Default Value [Unit]
ts	sample time	real	0.0 [sec]
k1	gain for input1	real	1.0
k2	gain for input2	real	1.0

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
input1	the first input to the sum2 block	Input	Real
input2	the second input to the sum2 block	Input	Real
val	the output of the sum2 block	Output	Real

[Top](#)

Examples

[Sum Example](#)

[Top](#)

References

sum3: Sum block with 3 inputs

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

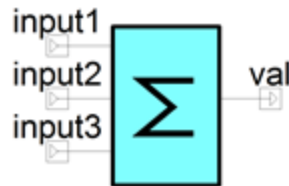


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

This sum3 model provides the ability to add/subtract 3 quantities.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

Table 1

Name	Description	Data Type	Default Value [Unit]
ts	sample time	real	0.0 [sec]
k1	gain for input1	real	1.0
k2	gain for input2	real	1.0
k3	gain for input3	real	1.0

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
input1	the first input to the sum3 block	Input	Real
input2	the second input to the sum3 block	Input	Real
input3	the third input to the sum3 block	Input	Real
val	the output of the sum3 block	Output	Real

[Top](#)

Examples

[Sum Example](#)

[Top](#)

References

thyristor_dynamic: Dynamic thyristor

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

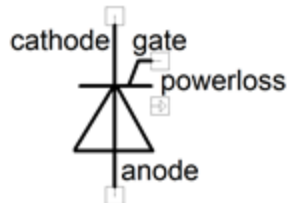


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The thyristor_dynamic model represents the dynamic thyristor model.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
gate	Electrical port gate	electrical
anode	Electrical port anode	electrical
cathode	Electrical port cathode	electrical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
vdrm	forward breakthrough voltage	real	100.0 [V]
vrrm	reverse breakthrough voltage	real	100.0 [V]
idrm	saturation current	real	0.1 [A]
vtm	conducting voltage	real	1.7 [V]
ih	holding current	real	0.006 [A]
itm	conducting current	real	25.0 [A]
vgt	gate trigger voltage]	real	0.7 [V]
igt	gate trigger current	real	0.005 [A]
ton	switch on time	real	0.000001 [sec]
toff	switch off time	real	0.000015 [sec]
vt	voltage equivalent of temperature	real	0.04 [V]
nbv	reverse breakthrough emission coefficient	real	0.74

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
powerloss	power loss in dynamic thyristor model [W]	Output	Real

[Top](#)

Examples

[Thyristor Example](#)

[Top](#)

References

thyristor_gto_ideal: Ideal GTO thyristor

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

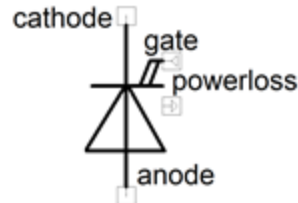


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The thyristor_gto_ideal model represents the ideal thyristor GTO model.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
anode	Electrical port anode	electrical
cathode	Electrical port cathode	electrical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
ron	closed thyristor resistance	real	0.00001 [Ohm]
goff	opened thyristor conductance	real	0.00001 [1/Ohm]
vknee	forward threshold voltage, default by 0.8	real	0.8 [V]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
gate	gate signal	Input	Boolean
powerloss	power loss in ideal GTO thyristor model [W]	Output	Real

[Top](#)

Examples

[Thyristor Example](#)

[Top](#)

References

thyristor_ideal: Ideal thyristor

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

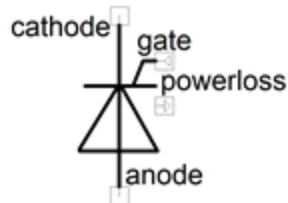


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The thyristor_ideal model represents the ideal thyristor model.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
anode	Electrical port anode	electrical
cathode	Electrical port cathode	electrical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
ron	closed thyristor resistance	real	0.00001 [Ohm]
goff	opened thyristor conductance	real	0.00001 [1/Ohm]
vknee	forward threshold voltage, default is 0.8	real	0.8 [V]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
gate	gate signal	Input	Boolean
powerloss	power loss in ideal thyristor model [W]	Output	Real

[Top](#)

Examples

[Thyristor Example](#)

[Top](#)

References

triangle: Triangle wave generator with frequency and amplitude inputs

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
---------------------------------------	-----------------------------	-------------------------------------

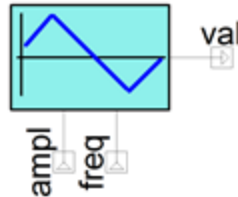


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

This triangle model provides triangular wave with changeable frequency and amplitude in the simulation.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

Table 1

Name	Description	Data Type	Default Value [Unit]
off	offset of the triangle signal	real	0.0
tdelay	time delay of the triangle signal	real	0.0
phase	phase of the triangle signal	real	0.0 [degree]

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
ampl	amplitude of the triangle signal	Input	Real
freq	frequency of the triangle signal	Input	Real
val	output of triangle signal	Output	Real

[Top](#)

Examples

[Sources Example](#)

[Top](#)

References

Distribution

The Distribution consists of the following types of models:

- [boost](#)
- [buck](#)
- [inverter_dcac](#)
- [rectifier_4pulse](#)
- [rectifier_4pulse_thyristor](#)
- [rectifier_6pulse](#)
- [rectifier_6pulse_thyristor](#)
- [rectifier_a2d_ideal](#)
- [rlc_3phase](#)

boost: Boost converter (VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

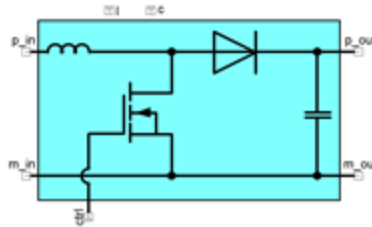


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The boost component represents the behavior of the boost converter; the output voltage across the p_out and m_out terminals is controlled by the control signal to the mosfet.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p_in	Electrical port p_in	electrical
m_in	Electrical port m_in	electrical
p_out	Electrical port p_out	electrical
m_out	Electrical port m_out	electrical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
use_v0	determine if use initial voltage or not	boolean	false
v0	initial voltage	real	0.0 [V]
use_i0	determine if use initial current or not	boolean	false
mos_vf	mosfet forward voltage (equiv)	real	0.8 [V]
mos_rr	mosfet reverse resistance	real	100000.0 [Ohm]
mos_isat	mosfet saturation current (exponent)	real	1.0e-12 [A]
mos_vt	mosfet threshold voltage (exponent)	real	0.035 [V]
diode_rb	diode bulk resistance (equiv)	real	0.001 [Ohm]
diode_vf	diode forward voltage (equiv)	real	0.8 [V]
diode_rr	diode reverse resistance	real	100000.0 [Ohm]
diode_isat	diode saturation current (exponent)	real	1.0e-12 [A]
diode_vt	diode threshold voltage (exponent)	real	0.035 [V]
mos_rb	mosfet bulk resistance (equiv)	real	0.001 [Ohm]
i_0	initial current	real	0.0 [A]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
c	value of capacitance [F]	Input	Real
l	value of inductance [H]	Input	Real
ctrl	control signal to the mosfet	Input	Real

[Top](#)

Examples

[Boost Converter Example](#)

[Top](#)

References

buck: Buck converter(VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

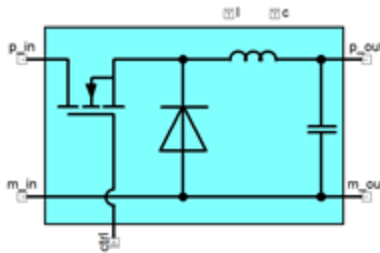


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The buck component represents the behavior of the buck converter; the output voltage across the p_out and m_out terminals is controlled by the control signal to the mosfet.Â

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p_in	Electrical port p_in	electrical
m_in	Electrical port m_in	electrical
p_out	Electrical port p_out	electrical
m_out	Electrical port m_out	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
use_v0	determine if use initial voltage or not	boolean	false
v0	initial voltage	real	0.0 [V]
use_i0	determine if use initial current or not	boolean	false
i0	initial current	real	0.0 [A]
mos_rb	mosfet bulk resistance (equiv)	real	0.001 [Ohm]
mos_vf	mosfet forward voltage (equiv)	real	0.8 [V]
mos_rr	mosfet reverse resistance	real	100000.0 [Ohm]
mos_isat	mosfet saturation current (exponent)	real	1.0e-12 [A]
mos_vt	mosfet threshold voltage (exponent)	real	0.035 [V]
diode_rb	diode bulk resistance (equiv)	real	0.001 [Ohm]
diode_vf	diode forward voltage (equiv)	real	0.8 [V]
diode_rr	diode reverse resistance	real	100000.0 [Ohm]
diode_isat	diode saturation current (exponent)	real	1.0e-12 [A]
diode_vt	diode threshold voltage (exponent)	real	0.035 [V]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
c	value of capacitance [F]	Input	Real
l	value of inductance [H]	Input	Real
ctrl	Control signal to the mosfet	Input	Real

[Top](#)

Examples

[Buck Converter Example](#)

[Top](#)

References

inverter_dcac: DC/AC inverter(VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

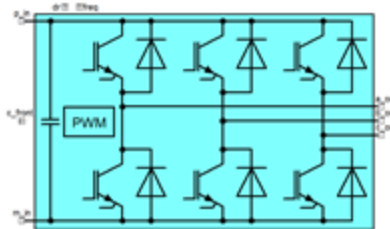


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The inverter_dcac component represents the simple behavior of a dc-ac inverter; frequency and duty ratio are needed for circuit simulation.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p_in	Electrical port p_in	electrical
m_in	Electrical port m_in	electrical
a_out	Electrical port a_out	electrical
b_out	Electrical port b_out	electrical
c_out	Electrical port c_out	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
igbt_rb	IGBT bulk resistance (equiv)	real	0.001 [Ohm]
igbt_vf	IGBT forward voltage (equiv)	real	0.8 [V]
igbt_rr	IGBT reverse resistance	real	100000.0 [Ohm]
igbt_isat	IGBT saturation current (exponent)	real	1.0e-12 [A]
igbt_vt	IGBT threshold voltage (exponent)	real	0.035 [V]
diode_rb	diode bulk resistance (equiv)	real	0.001 [Ohm]
diode_vf	diode forward voltage (equiv)	real	0.8 [V]
diode_rr	diode reverse resistance	real	100000.0 [Ohm]
diode_isat	diode saturation current (exponent)	real	1.0e-12 [A]
diode_vt	diode threshold voltage (exponent)	real	0.035 [V]
tdelay	Initial delay	real	0.0 [sec]
use_v0_front	Determine if use initial voltage or not for the front capacitance	boolean	false
v0_front	Initial voltage for the front capacitance	real	0.0 [V]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
dr	Duty ratio	Input	Real
freq	Output frequency [Hz]	Input	Real
c_front	Front capacitor value [F]	Input	Real

[Top](#)

Examples

[DC-AC Inverter Example](#)

[Top](#)

References

rectifier_4pulse: 4 pulse diode rectifier(VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

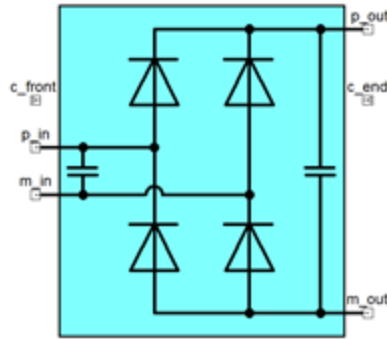


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The rectifier_4pulse component represents the simple behavior of a 4 pulse diode rectifier.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p_in	Electrical port p_in	electrical
m_in	Electrical port m_in	electrical
p_out	Electrical port p_out	electrical
m_out	Electrical port m_out	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
use_v0_front	Determine if use initial voltage or not for the front capacitance	boolean	false
v0_front	Initial voltage for the front capacitance	real	0.0 [V]
use_v0_end	Determine if use initial voltage or not for the end capacitance	boolean	false
v0_end	Initial voltage for the end capacitance	real	0.0 [V]
diode_rb	diode bulk resistance (equiv)	real	0.001 [Ohm]
diode_vf	diode forward voltage (equiv)	real	0.8 [V]
diode_rr	diode reverse resistance	real	100000.0 [Ohm]
diode_isat	diode saturation current (exponent)	real	1.0e-12 [A]
diode_vt	diode threshold voltage (exponent)	real	0.035 [V]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
c_front	Front capacitor value [F]	Input	Real
c_end	End capacitor value [F]	Input	Real

[Top](#)

Examples

[Rectifier 4 Pulse Example](#)

[Top](#)

References

rectifier_4pulse_thyristor: 4 pulse thyristor rectifier(VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

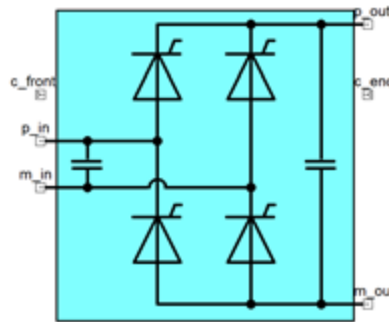


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The rectifier_4pulse_thyristor component represents the simple behavior of a 4 pulse thyristor rectifier, the PWM phase shift is used to control the output DC voltage amplitude, it is limited to the range of $[0,90]$ degree, phase = 0.0 gives the maximum output and phase = 90.0 gives the minimum output. Results may vary with different phase shift cause by circuit components.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p_in	Electrical port p_in	electrical
m_in	Electrical port m_in	electrical
p_out	Electrical port p_out	electrical
m_out	Electrical port m_out	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
use_v0_front	Determine if use initial voltage or not for the front capacitance	boolean	false
v0_front	Initial voltage for the front capacitance	real	0.0 [V]
use_v0_end	Determine if use initial voltage or not for the end capacitance	boolean	false
v0_end	Initial voltage for the end capacitance	real	0.0 [V]
pwm_freq	Inlet AC source frequency	real	5000.0 [Hz]
pwm_phase	PWM signal phase shift, used to control the output DC voltage amplitude	real	0.0 [degree]
thyristor_ron	Closed thyristor resistance	real	0.00001 [Ohm]
thyristor_goff	Opened thyristor conductance	real	0.00001 [1/Ohm]

thyristor_ vknee	Forward threshold voltage, default is 0.8	real	0.8 [V]
---------------------	--	------	---------

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
c_front	Front capacitor value [F]	Input	Real
c_end	End capacitor value [F]	Input	Real

[Top](#)

Examples

[Rectifier 4 Pulse Example](#)[Top](#)

References

rectifier_6pulse: 6 pulse diode rectifier(VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

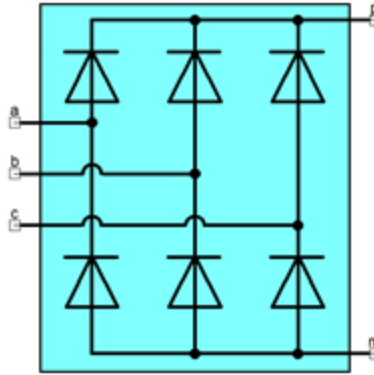


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The rectifier_6pulse component represents the simple behavior of a 6 pulse diode rectifier.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a	Electrical port a	electrical
b	Electrical port b	electrical
c	Electrical port c	electrical
p	Electrical port p	electrical
m	Electrical port m	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
rb	diode bulk resistance, for equivalent behavior	real	0.001 [Ohm]
diode_vf	diode forward voltage, for equivalent behavior	real	0.8 [V]
diode_rr	diode reverse resistance	real	100000.0 [Ohm]
diode_isat	diode saturation current, for exponent behavior	real	1.0e-12 [A]
diode_vt	diode threshold voltage, for exponent behavior	real	0.035 [V]

[Top](#)

Input/Output Quantities

[Top](#)

Examples

[Rectifier 6 Pulse Example](#)

[Top](#)

References

rectifier_6pulse_thyristor: 6 pulse thyristor rectifier(VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
---------------------------------------	-----------------------------	-------------------------------------

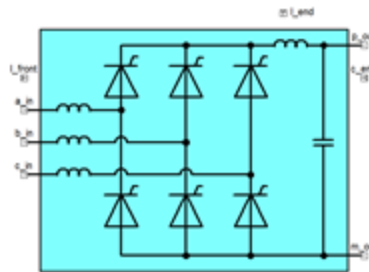


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The rectifier_6pulse_thyristor component represents the simple behavior of a 6 pulse thyristor rectifier, the PWM phase shift is used to control the output DC voltage amplitude, it is limited to the range of $[0,90]$ degree, phase = 0.0 gives the maximum output and phase = 90.0 gives the minimum output. Results may vary with different phase shift cause by circuit components.

[Top](#)

Assumptions and Limitations

The rectifier_6pulse_thyristor component is better to be used with load with a small resistance, otherwise the performance would be affected by the small discharge rate (caused by the large resistive load).

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a_in	Electrical port a_in	electrical
b_in	Electrical port b_in	electrical
c_in	Electrical port c_in	electrical
p_out	Electrical port p_out	electrical
m_out	Electrical port m_out	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
use_i0_front	Determine if use initial voltage or not for the front inductance	boolean	false
i0_front	Initial current for the front inductance	real	0.0 [A]
use_i0_end	Determine if use initial current or not for the end inductance	boolean	false
i0_end	Initial current for the end inductance	real	0.0 [A]
use_v0_end	Determine if use initial voltage or not for the end capacitance	boolean	false
v0_end	Initial voltage for the end capacitance	real	0.0 [V]
pwm_freq	Inlet AC source frequency	real	5000.0 [Hz]
pwm_phase	PWM signal phase shift, used to control the output DC	real	0.0 [degree]

	voltage amplitude		
thyristor_ron	Closed thyristor resistance	real	0.00001 [Ohm]
thyristor_goff	Opened thyristor conductance	real	0.00001 [1/Ohm]
thyristor_vknee	Forward threshold voltage, default is 0.8	real	0.8 [V]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
l_front	Front inductance value [H]	Input	Real
l_end	End inductance value [H]	Input	Real
c_end	End capacitance value [F]	Input	Real

[Top](#)

Examples

[Rectifier 6 Pulse Example](#)

[Top](#)

References

rectifier_a2d_ideal: Ideal 3 phase AC/DC rectifier(VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
---------------------------------------	-----------------------------	-------------------------------------

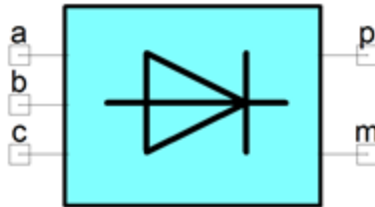


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The rectifier_a2d_ideal component represents the ideal behavior of 3 phase ac-dc rectifier.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a	Electrical port a	electrical
b	Electrical port b	electrical
c	Electrical port c	electrical
p	Electrical port p	electrical
m	Electrical port m	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
ratio	The ratio between DC output voltage and phase input voltage	real	0.581
eff	Power conversion efficiency	real	1.0

[Top](#)

Input/Output Quantities

[Top](#)

Examples

[Simplified Power System Example](#)

[Top](#)

References

rlc_3phase: 3 phase RL transformation line with shunt capacitance(VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
---------------------------------------	-----------------------------	-------------------------------------

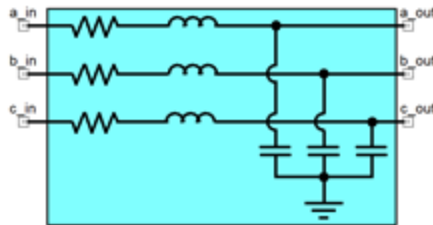


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The rlc_3phase component represents the behavior of the 3 phase RL transformation line with shunt capacitances.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a_in	Electrical port a_in	electrical
b_in	Electrical port b_in	electrical
c_in	Electrical port c_in	electrical
a_out	Electrical port a_out	electrical
b_out	Electrical port b_out	electrical
c_out	Electrical port c_out	electrical

Note: Terminal set to No Action when unconnected. Terminal may remain unconnected without generating an error.

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
r	Line resistance	real	0.1 [Ohm]
l	Line inductance	real	2.4e-5 [H]
c	Shunt capacitance	real	2.0e-9 [F]
use_i0	Determine if use initial current or not for the line inductance	boolean	false
i0	Initial current for the line inductance	real	0.0 [A]
use_v0	Determine if use initial voltage or not for the shunt capacitance	boolean	false
v0	Initial voltage for the shunt capacitance	real	0.0 [V]

[Top](#)

Input/Output Quantities

[Top](#)

Examples

[Simplified Power System Example](#)

[Top](#)

References

Engine

The Engine consists of the following types of models:

- [combustor](#)
- [compressor](#)
- [fuel tank](#)
- [gt_engine](#)
- [inlet](#)
- [nozzle](#)
- [shaft](#)
- [turbine](#)

combustor: Simple combustor

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

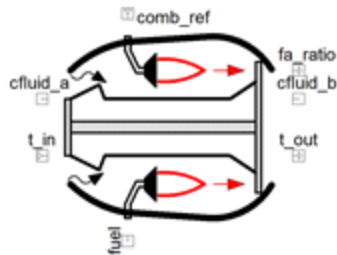


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The combustor component describes the behavior of the combustor in GT Engine Example.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
cfluid_a	fluidic terminal	compressible_fluidic
cfluid_b	fluidic terminal	compressible_fluidic
fuel	fluidic terminal	compressible_fluidic

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
eff	combustor pressure loss efficiency	real	0.95

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
comb_ref	combustor input temperature from controller [K]	Input	Real
t_in	combustor inlet temperature [K]	Input	Real
fa_ratio	fuel air ratio	Output	Real
t_out	combustor outlet temperature [K]	Output	Real

[Top](#)

Examples

[GT Engine Example](#)

[Top](#)

References

compressor: Simple compressor

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

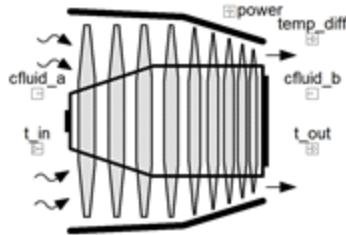


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The compressor model represents the behavior of compressor in GT Engine Example.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
cfluid_a	compressible_fluidic port cfluid_a	compressible_fluidic
cfluid_b	compressible_fluidic port cfluid_b	compressible_fluidic

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
pressureRatio	outlet pressure / inlet pressure of compressor	real	8.0
eta_comp	isentropic efficiency of compressor	real	0.85

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
t_in	compressor inlet temperature [K]	Input	Real
temp_diff	compressor temperature difference [K]	Output	Real
power	power consumption of the compressor[W]	Output	Real
t_out	compressor outlet temperature [K]	Output	Real

[Top](#)

Examples

[GT Engine Example](#)

[Top](#)

References

fueltank: Simple fuel tank

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--



Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The fuel tank model is a tank model to represent the fuel change and the fuel remain in the tank.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
engine_conn	compressible_fluidic port engine_conn	engine connection

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
fuel_remain0	initial fuel level in the tank	real	1.0
rho	gasoline density	real	719.0 [kg/m ³]
v	total volume of the fuel tank	real	0.015 [m ³]
fuel_limit_low	fuel level lower limitation	real	0.1
fuel_limit_high	fuel level upper limitation	real	1.1

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
fuel_remain	percentage fuel remain in the tank	Output	Real
fuel_rate	fuel consumption rate [kg/s]	Output	Real

[Top](#)

Examples

[GT Engine Example](#)

[Top](#)

References

gt_engine: Simple gas turbine engine

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

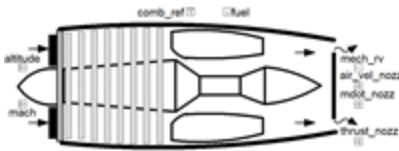


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The gt_engine component describes the behavior of gt_engine in GT Engine Generator Generator Example.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
fuel	fuel connection	compressible_fluidic
mech_rv	mechanical rotational port	rotational_v

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
gamma_inlet	specific heats ratio in inlet	real	1.4
t_amb0	ambient air temperature at sea level	real	288.15 [K]
p_amb0	ambient air pressure at sea level	real	101325.0 [Pa]
eta_comp	isentropic efficiency of compressor	real	0.85
pr_comp	outlet pressure / inlet pressure of compressor	real	8.0
eta_comb	combustor pressure loss efficiency	real	0.95
eta_t_turb	turbine efficiency	real	0.87
eta_m_turb	mechanical efficiency of the turbine shafts	real	0.98
area_nozz	nozzle area	real	0.3 [m ²]
inertia_shaft	shaft inertia	real	1.0 [kg * m ²]
omega0_shaft	initial rotational velocity of shaft	real	0.0 [rad/sec]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
altitude	flight altitude [m]	Input	Real
mach	mach number	Input	Real
comb_ref	combustor reference temperature from controller [K]	Input	Real
air_vel_nozz	nozzle output gas velocity [m/s]	Output	Real
mdot_nozz	nozzle output mass flow rate [kg/s]	Output	Real
thrust_nozz	nozzle thrust [N]	Output	Real

[Top](#)

Examples

[GT Engine Generator Example](#)

[Top](#)

References

inlet: Simple inlet

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

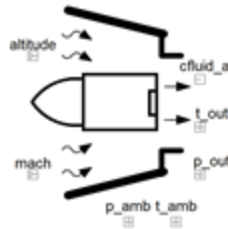


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The inlet component describes the behavior of the inlet in GT Engine Example.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
cfluid_a	compressible_fluidic port cfluid_a	compressible_fluidic

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
t_amb0	ambient air temperature at sea level	real	288.15 [K]
p_amb0	ambient air pressure at sea level	real	101325.0 [Pa]
gamma	ratio of specific heats	real	1.4

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
altitude	flight altitude [m]	Input	Real
mach	mach number	Input	Real
t_out	output temperature for inlet [K]	Output	Real
p_out	output pressure for inlet [Pa]	Output	Real
p_amb	ambient pressure [Pa]	Output	Real
t_amb	ambine temperature [K]	Output	Real

[Top](#)

Examples

[GT Engine Example](#)[Top](#)

References

nozzle: Simple nozzle

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

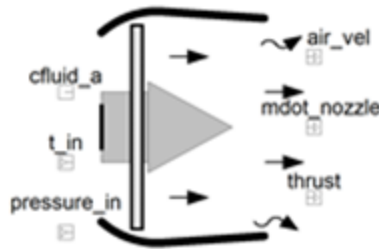


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The nozzle component describes the behavior of nozzle in GT Engine Example.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
cfluid_a	fluidic terminal	compressible_fluidic

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
area	nozzle area	real	0.3 [m ²]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
pressure_in	pressure input from inlet	Input	Real
t_in	nozzle inlet temperature [K]	Input	Real
air_vel	nozzle output gas velocity [m/s]	Output	Real
mdot_nozzle	nozzle output mass flow rate [kg/s]	Output	Real
thrust	nozzle thrust [N]	Output	Real

[Top](#)

Examples

[GT Engine Example](#)

[Top](#)

References

shaft: Simple shaft

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

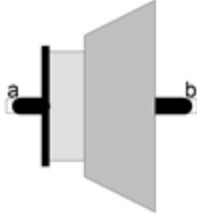


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The shaft component describes the behavior of shaft in GT Engine Example.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a	rotational_velocity port a	rotational_velocity
b	rotational_velocity port b	rotational_velocity

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
inertia	shaft inertia [kg * m ²]	real	1.0
omega0	initial rotational speed [rad/s]	real	0.0

[Top](#)

Input/Output Quantities

[Top](#)

Examples

[GT Engine Example](#)

[Top](#)

References

turbine: Simple turbine (VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

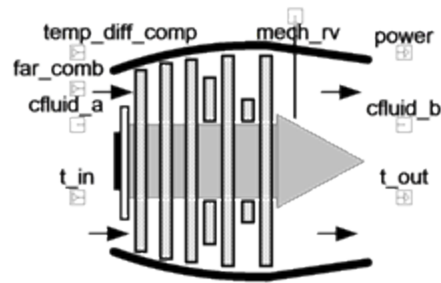


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The turbine component describes the behavior of the turbine in GT Engine Example.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
cfluid_a	compressible_fluidic	-
cfluid_b	compressible_fluidic	-
mech_rv	rotational_velocity	-

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
eta_t	turbine efficiency	real	0.87
eta_m	mechanical efficiency of the turbine shaft	real	0.78

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
temp_diff_comp	compressor temperature difference, $t_{in} - t_{out}$	Input	Real
far_comb	fuel air ratio from combustor	Input	Real
t_in	turbine inlet temperature [K]	Input	Real
power	turbine power [W]	Output	Real
t_out	turbine outlet temperature [K]	Output	Real

[Top](#)

Examples

[GT Engine Example](#)

[Top](#)

References

Generator

The Generator consists of the following types of models:

- [csd](#)
- [gcu](#)
- [generator_ee](#)
- [generator_pm](#)
- [idg](#)

csd: Constant speed drive (VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

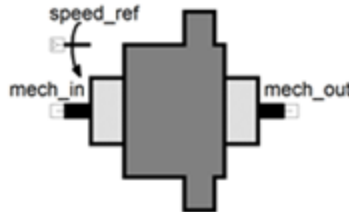


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The csd model describes the behavior of constant speed drive.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
mech_in	rotational_velocity	mechanical
mech_out	rotational_velocity	mechanical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
eta	constant speed drive convert efficiency	real	1.0

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
speed_ref	demand output rotational speed [rpm], it should be positive	Input	Real

[Top](#)

Examples

[Integrated Drive Generator Example](#)

[Top](#)

References

gcu: Generator control unit (VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

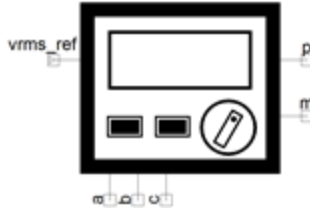


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

This model represents the behavior of the generator control unit for standard sine wave generator. The inputs are the measurements from 3 phase voltages and the reference V_{rms} value, the output is the exciter generator field voltage, a PID controller is used as the control algorithm.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a	Electrical port a	electrical
b	Electrical port b	electrical
c	Electrical port c	electrical
p	electrical port for the exciter generator field voltage	electrical
m	electrical port for the exciter generator field voltage	electrical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
ts	sample time	real	0.0 [sec]
kp	proportional gain	real	1.0
ki	integral gain	real	0.01
kd	derivative gain	real	0.0
ll	lower limit of controller output	real	-1.0e9
ul	upper limit of controller output	real	1.0e9
yi_init	initial value of integrator	real	0.0
yd_init	initial value of differentiator	real	0.0
ka	antiwindup gain	real	1.0

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
vrms_ref	voltage rms reference	Input	Real

[Top](#)

Examples

[Integrated Drive Generator Example](#)

[Top](#)

References

generator_ee: Generator with electrical excitation (VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
---------------------------------------	-----------------------------	-------------------------------------

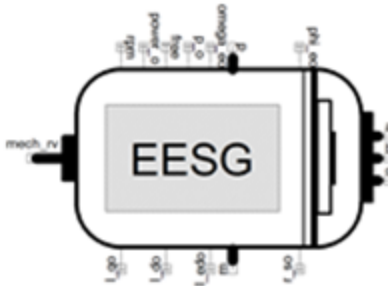


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The generator_3phase model represents the dynamic behavior of 3 phase generator with electrical excitation.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a	Electrical port a	electrical
b	Electrical port b	electrical
c	Electrical port c	electrical
p	Electrical port p	electrical
m	Electrical port m	electrical
mech_rv	rotational_velocity port mech_rv	mechanical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
l_d	inductance of stator, d axis	real	0.042 [H]
l_q	inductance of stator, q axis	real	0.042 [H]
l_e	excitation inductance	real	0.05 [H]
r_s	stator resistance	real	0.4 [Ohm]
r_e	excitation resistance	real	1.0 [Ohm]
l_ed	mutual inductance stator exciter d-axis	real	0.035 [H]
pole	numbers of pole, twice the number of pole pairs	real	4.0
inertia	rotor inertia	real	0.075 [kg*m ²]
phi_0	initial rotor angle	real	0.0 [rad]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
phi_eo	generator electrical angle [rad]	Output	Real
omega_eo	generator electrical rotational speed [rad/s]	Output	Real
p_o	pole	Output	Real
l_do	l_do [H]	Output	Real
l_qo	l_qo [H]	Output	Real
l_edo	l_edo [H]	Output	Real
r_so	r_so [Ohm]	Output	Real
power_o	generator power [W]	Output	Real
rpm	generator revolution per minute	Output	Real
free	signal to stop the generator	Input	Boolean

[Top](#)

Examples

[Generator Electrical Excitation Example](#)

[Top](#)

References

generator_pm: Generator with permanent magnet (VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
---------------------------------------	-----------------------------	-------------------------------------

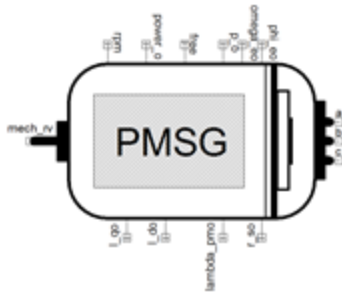


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The generator_3phase model represents the dynamic behavior of 3 phase permanent magnet generator.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a	Electrical port a	electrical
b	Electrical port b	electrical
c	Electrical port c	electrical
mech_rv	rotational_velocity port mech_rv	mechanical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
l_d	inductance of stator, d axis	real	0.042 [H]
l_q	inductance of stator, q axis	real	0.042 [H]
lambda_pm	mutual flux linkage	real	0.875 [kg*m ² /s ² *A]
r_s	stator resistance	real	0.4 [Ohm]
p	numbers of poles, twice the number of pole pairs	real	4.0
inertia	rotor inertia	real	0.075 [kg*m ²]
phi_0	initial rotor angle	real	0.0 [rad]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
phi_eo	the value of generator electrical angle, equal to the product of rotor angle and number of pole pair [rad]	Output	Real
omega_eo	the value of generator electrical rotational speed, equal	Output	Real

	to the product of rotor rotational speed and number of pole pair [rad/sec]		
p_o	the value of number of poles, twice the number of pole pairs	Output	Real
l_do	the value of inductance of stator, d axis [H]	Output	Real
l_qo	the value of inductance of stator, q axis [H]	Output	Real
lambda_pmo	the value of mutual flux linkage [kg*m ² /s ² *A]	Output	Real
r_so	the value of stator resistance [Ohm]	Output	Real
power_o	the value of generator power [W]	Output	Real
rpm	the value of revolution per minute of the generator [rev/min]	Output	Real
free	signal to stop the generator	Input	Boolean

[Top](#)

Examples

[Generator Permanent Magnet Example](#)

[Top](#)

References

idg: Integrated drive generator (VHDL-AMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

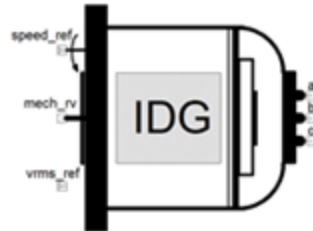


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

This idg model represents the behavior of the integrated drive generator, it includes the csd, generator_ee and gcu in the library.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a	Electrical port a	electrical
b	Electrical port b	electrical
c	Electrical port c	electrical
mech_rv	rotational_v port mech_rv	mechanical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
ts	sample time	real	0.0 [sec]
kp	proportional gain	real	1.0
ki	integral gain	real	0.01
kd	derivative gain	real	0.0
ll	lower limit of controller output	real	-1.0e9
ul	upper limit of controller output	real	1.0e9
yi_init	initial value of integrator	real	0.0
yd_init	initial value of differentiator	real	0.0
ka	antiwindup gain	real	1.0
eta_csd	constant speed drive convert efficiency	real	1.0
l_d	inductance of stator, d axis	real	0.042 [H]
l_q	inductance of stator, q axis	real	0.042 [H]
l_e	excitation inductance	real	0.05 [H]
r_s	stator resistance	real	0.4 [Ohm]
r_e	excitation resistance	real	1.0 [Ohm]
l_ed	mutual inductance stator exciter d-axis	real	0.035 [H]
pole	numbers of pole, twice the number of pole pairs	real	4.0
inertia	rotor inertia	real	0.075 [kg*m ²]
phi_0	initial rotor angle	real	0.0 [rad]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
vrms_ref	voltage rms reference	Input	Real
speed_ref	demand output rotational speed [rpm]	Input	Real

[Top](#)

Examples

[Electrical Transformation Line Example](#)

[Top](#)

References

Load

The Load consists of the following types of models:

- [battery](#)
- [battery_general](#)
- [c_motor_dcac](#)
- [c_motor_dcdc](#)
- [cpl_ideal](#)
- [fan](#)
- [heater_3phase](#)
- [heater_dc](#)
- [lamp_simple](#)
- [motor_dc](#)
- [motor_pm](#)
- [pump](#)
- [r_thermal](#)
- [tank_w](#)

battery: Battery with fixed data for battery types (VHDLAMS)

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

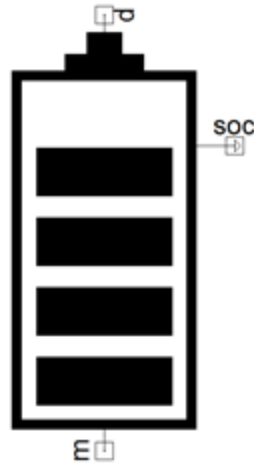


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The battery model represents the dynamic behavior of battery model with fixed data.

[Top](#)

Assumptions and Limitations

The battery soc cannot be under 0.0.

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p	Electrical port p	electrical
m	Electrical port m	electrical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
tc	battery dynamics time constant	real	10.0 [sec]
soc0	initial soc	real	0.8

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
soc	state of charge	Output	Real

[Top](#)

Examples

[Battery Example](#)

[Top](#)

References

O. Tremblay and L.-A. Dessaint, "Experimental Validation of a Battery Dynamic Model for EV Applications", World Electric Vehicle Journal.

battery_general: Battery with customer given data

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

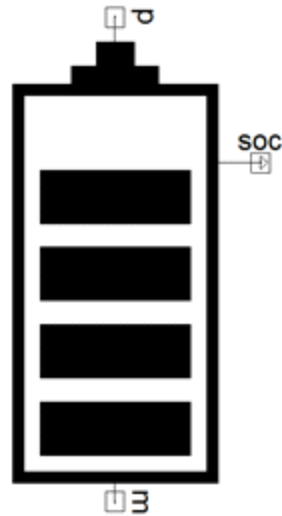


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The battery_general model represents the dynamic behavior of battery model with customer-provided data.

[Top](#)

Assumptions and Limitations

The battery soc cannot be under 0.0.

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p	Electrical port p	electrical
m	Electrical port m	electrical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
tc	battery dynamics time constant	real	10.0 [sec]
v_nom	battery nominal voltage	real	1.2 [V]
qRated	battery rated capacity	real	6.5 [Ah]
v_full	fully charged voltage	real	1.4 [V]
i_nom	nominal discharge current	real	1.3 [A]
r_batt	battery internal resistance	real	0.0046 [Ohm]
q_nom	battery capacity at nominal voltage	real	5.2 [Ah]
v_exp	exponential zone voltage	real	1.25 [V]
q_exp	exponential zone charge	real	1.3 [Ah]
soc0	initial soc	real	0.8

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
soc	state of charge	Output	Real

[Top](#)

Examples

[Battery General Example](#)

[Top](#)

References

O. Tremblay and L.-A. Dessaint and A.-I. Dekkiche "A Generic Battery Model for the Dynamic Simulation of Hybrid Electric Vehicles".

c_motor_dcac: Controller for 3-phase PMSM with DC input

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

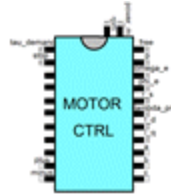


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The model represents torque current control behavior of the 3 phase permanent magnet synchronous motor controller, inputs are connected to DC source, outputs are connected to the 3 phase motor, motor will follow the provided tau_demand command.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
plus	Electrical port plus	electrical
minus	Electrical port minus	electrical
b	Electrical port b	electrical
c	Electrical port c	electrical

[Top](#)

Parameters

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
tau_demand	input demand torque [N * m]	Input	Real
rpm	revolution per minute of the motor [rev/min]	Input	Real
omega_e	motor electrical rotational speed, equal to the product of rotor rotational speed and number of pole pair [rad/sec]	Input	Real
phi_e	motor electrical angle, equal to the product of rotor angle and number of pole pair [rad]	Input	Real
r_s	motor stator resistance [Ohm]	Input	Real
lambda_pm	motor mutual flux linkage [kg*m ² /s ² *A]	Input	Real
l_d	motor inductance of stator, d axis [H]	Input	Real
l_q	motor inductance of stator, q axis [H]	Input	Real
stop	input signal to stop the motor	Input	Boolean
free	output signal (to the motor) to stop the motor	Output	boolean
p	number of poles of the motor, twice the number of pole pairs	Input	Real
power_m	motor power consumption [W]	Input	Real

[Top](#)

Examples

[Motor PM Control Example](#)

[Top](#)

References

c_motor_dcdc: DC motor controller

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

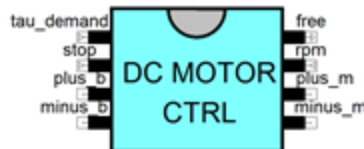


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The c_motor_dcdc model represents control behavior of the DC Motor controller.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
plus_m	Electrical port plus_m	electrical
minus_m	Electrical port minus_m	electrical
plus_b	Electrical port plus_b	electrical
minus_b	Electrical port minus_b	electrical

[Top](#)

Parameters

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
rpm	revolution per minute of motor [rev/min]	Input	Real
stop	input signal to stop the motor	Input	Boolean
free	output signal (to the motor) to stop the motor	Output	Boolean
tau_demand	input demand torque [N * m]	Input	Real

[Top](#)

Examples

[Motor DC Control Example](#)

[Top](#)

References

cpl_ideal: Constant power load

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--



Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The cpl_ideal model represents the ideal behavior of a constant power load(cpl).

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p	Electrical port p	electrical
m	Electrical port m	electrical

[Top](#)

Parameters

[Top](#)

Input/Output Quantities

Table 2

Name	Description	Direction	Data Type [Unit]
power	input power for the ideal cpl	Input	Real [W]

[Top](#)

Examples

[Simplified Power System Example](#)

[Top](#)

References

fan: Fan

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

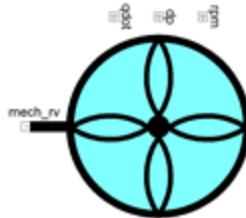


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The fan model represents the behavior of fan in Motor PM Control Example.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
mech_rv	rotational_velocity port mech_rv	mechanical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
coe_f	friction coefficient	real	0.1 [Nm*s/rad]
coe_w	windage coefficient	real	0.1 [Nm*s^2/rad^2]
inertia	fan rotor inertia	real	0.1 [kg*m^2]
phi_0	initial rotor angle	real	0.0 [rad]
fan_freq0	nominal fan frequency	real	50.0 [Hz]
dp_fan0	the pressure increase for zero volume flow rate	real	500.0 [Pa]
q_fan0	the volume flow rate for zero pressure increase	real	2.0 [m^3/sec]
eta_fan	efficiency coefficient from mechanical power to fluid power (air flow)	real	0.5

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
rpm	revolution per minute	Output	Real
dp	fan pressure increase [Pa]	Output	Real
qdot	air volume flow rate [m^3/sec]	Output	Real

[Top](#)

Examples

[Motor PM Control Example](#)

[Top](#)

References

heater_3phase: 3-phase resistance heater

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

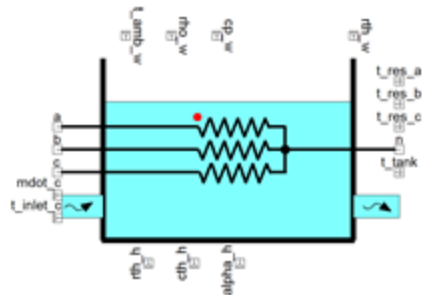


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The heater_3phase represents the behavior of a water tank heater model. Notice that the $t_set + t_deadband$ cannot be greater than 100.0 deg C.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a	Electrical port a	electrical
b	Electrical port b	electrical
c	Electrical port c	electrical
n	Electrical port n	electrical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
r_nom	heater resistance at nominal temperature	real	1.0 [Ohm]
t_nom	nominal temperature for the heater	real	20.0 [deg C]
volume	water volume for the water tank	real	0.01 [m^3]
t_set	temperature set for the water tank	real	50.0 [deg C]
t_deadband	temperature deadband for the water tank	real	5.0 [K]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
rth_h	thermal resistance for the heating resistance [K/W]	Input	Real
cth_h	thermal heat capacitance for the heating resistance [J/C]	Input	Real
alpha_h	resistive temperature coefficient for the heating resistance [Ohm/K]	Input	Real
t_amb_w	ambient temperature [deg C]	Input	Real
rho_w	water density [kg/m ³]	Input	Real
cp_w	water specific heat [J/kg*K]	Input	Real
mdot_c	inlet cooling water mass flow rate. [kg/s]	Input	Real
t_inlet_c	inlet cooling water temperature [deg C]	Input	Real
rth_w	thermal resistance from water tank to ambient [K/W]	Input	Real
t_res_a	heating resistance temperature [deg C]	Output	Real
t_res_b	heating resistance temperature [deg C]	Output	Real
t_res_c	heating resistance temperature [deg C]	Output	Real
t_tank	tank temperature [deg C]	Output	Real

[Top](#)

Examples

[Heater Example](#)

[Top](#)

References

heater_dc: DC resistance heater

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

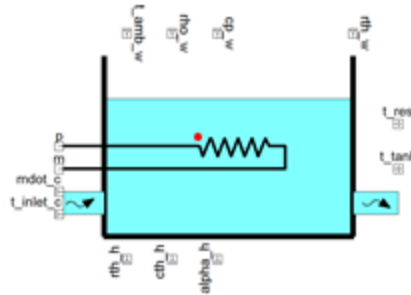


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The heater_dc model represents the behavior of a water tank heater model. Notice that the $t_set + t_deadband$ cannot be greater than 100.0 deg C.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p	Electrical port p	electrical
m	Electrical port m	electrical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
r_nom	heater resistance at nominal temperature	real	1.0 [Ohm]
t_nom	nominal temperature for the heater	real	20.0 [deg C]
volume	water volume for the water tank	real	0.01 [m ³]
t_set	temperature set for the water tank	real	50.0 [deg C]
t_deadband	temperature deadband for the water tank	real	5.0 [K]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
rth_h	thermal resistance for the heating resistance [K/W]	Input	Real
cth_h	thermal heat capacitance for the heating resistance [J/C]	Input	Real
alpha_h	resistive temperature coefficient for the heating resistance [Ohm/K]	Input	Real
t_amb_w	ambient temperature [deg C]	Input	Real
rho_w	water density [kg/m ³]	Input	Real
cp_w	water specific heat [J/kg*K]	Input	Real
mdot_c	inlet cooling water mass flow rate. [kg/s]	Input	Real
t_inlet_c	inlet cooling water temperature [deg C]	Input	Real

rth_w	thermal resistance from water tank to ambient [K/W]	Input	Real
t_res	heating resistance temperature [deg C]	Output	Real
t_tank	tank temperature [deg C]	Output	Real

[Top](#)

Examples

[Heater Example](#)

[Top](#)

References

lamp_simple: Simple incandescent lamp

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--



Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The lamp_simple model gives a simple representation for the incandescent lamp.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p	Electrical port p	electrical
m	Electrical port m	electrical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
t_amb	ambient temperature	real	20.0 [deg C]
t_nom	nominal temperature	real	20.0 [deg C]
r_nom	filament resistance at nominal temperature	real	1.0 [Ohm]
ke	thermal radiation coefficient	real	0.25e-12 [W/K^4]
alpha	resistive temperature coefficient	real	0.045 [Ohm/K]
rth	thermal conduction	real	5000.0 [K/W]
cth	thermal heat capacitance	real	0.2e-3 [J/C]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
h_flow	heat flow from filament [W]	Output	Real

[Top](#)

Examples

[Simple Lamp Example](#)

[Top](#)

References

motor_dc: Permanent magnet DC motor

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

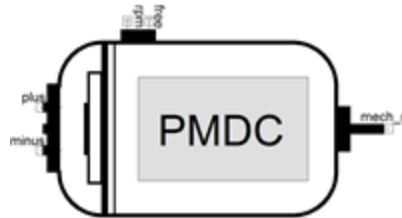


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The motor_dc model simply represents the mathematical modeling of permanent magnet DC motor (PMDC).

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
plus	Electrical port plus	electrical
minus	Electrical port minus	electrical
mech_rv	rotational_velocity port mech_rv	mechanical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
l_a	armature inductance	inductance	0.0095 [L]
r_a	armature/rotor resistance	resistance	1.2 [Ohm]
coe_t	motor torque constant	real	100.0
coe_e	back emf constant	real	100.0
coe_b	viscous damping coefficient	real	0.01
i_a0	initial current	current	0.0 [A]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
rpm	revolution per minute [rev/min]	Input	real
free	motor free signal	Input	boolean

[Top](#)

Examples

[Motor DC Control Example](#)

[Top](#)

References

motor_pm: Permanent magnet synchronous motor

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

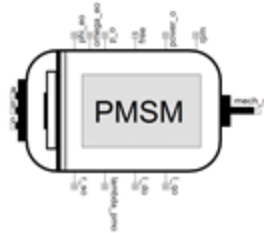


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The motor_pm model represents the dynamic behavior of 3 phase permanent magnet motor.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a	Electrical port a	electrical
b	Electrical port b	electrical
c	Electrical port c	electrical
mech_rv	rotational_velocity port mech_rv	mechanical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
l_d	inductance of stator, d axis	real	0.042 [H]
l_q	inductance of stator, q axis	real	0.042 [H]
lambda_pm	mutual flux linkage	real	0.875 [kg*m ² /s ² *A]
r_s	stator resistance	real	0.4 [Ohm]
p	number of poles, twice the number of pole pairs	real	4.0
inertia	rotor inertia	real	0.075 [kg*m ²]
phi_0	initial rotor angle	real	0.0 [rad]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
phi_eo	the value of motor electrical angle, equal to the product of rotor angle and number of pole pair [rad]	Output	Real
omega_eo	the value of motor electrical rotational speed, equal to the product of rotor rotational speed and number of pole pair [rad/sec]	Output	Real
p_o	the value of number of poles, twice the number of pole pairs	Output	Real
l_do	the value of inductance of stator, d axis [H]	Output	Real
l_qo	the value of inductance of stator, q axis [H]	Output	Real
lambda_pmo	the value of mutual flux linkage [$\text{kg}\cdot\text{m}^2/\text{s}^2\cdot\text{A}$]	Output	Real
r_so	the value of stator resistance [Ohm]	Output	Real
power_o	the value of motor power [W]	Output	Real
rpm	the value of revolution per minute of the motor [rev/min]	Output	Real
free	signal to stop the motor	Input	Boolean

[Top](#)

Examples

[Motor PM Control Example](#)

[Top](#)

References

pump: Pump

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

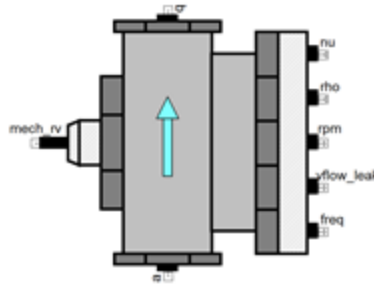


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

This pump model represents a fixed displacement pump model with non-compressible fluid assumed.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
a	fluidic port a	fluidic
b	fluidic port b	fluidic
mech_rv	rotational_velocity port mech_rv	mechanical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
displacement	pump displacement	real	5.0e-6 [m ³ /rad]
eta_v	volumetric efficiency of pump	real	0.9
eta_me	mechanical efficiency of pump	real	0.85
pressure_nom	pump nominal pressure	real	1.0e7 [Pa]
rho_nom	pump nominal fluid density	real	1000.0 [kg/m ³]
omega_nom	pump nominal angular velocity	real	200.0 [rad/s]
nu_nom	pump nominal kinematic viscosity	real	1.0e-6 [m ² /s]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
nu	pump fluid kinematic viscosity [m ² /s]	Input	Real
rho	pump fluid density [kg/m ³]	Input	Real
rpm	pump rpm [rev/min]	Output	Real
vflow_leak	leakage volume flow rate [m ³ /s]	Output	Real
freq	pump frequency [Hz]	Output	Real

[Top](#)

Examples

[Pump Example](#)

[Top](#)

References

r_thermal: Resistance with thermal effects

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

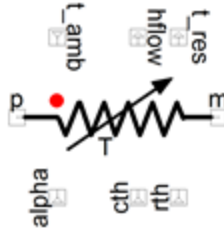


Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The r_thermal model represents the behavior of a resistance value varied with temperature.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

Table 1

Name	Port/Terminal description	Nature/Data type
p	Electrical port p	electrical
m	Electrical port m	electrical

[Top](#)

Parameters

Table 2

Name	Description	Data Type	Default Value [Unit]
t_nom	nominal temperature	real	20.0 [deg C]
r_nom	resistance at nominal temperature	real	1.0 [Ohm]

[Top](#)

Input/Output Quantities

Table 3

Name	Description [Unit]	Direction	Data Type
t_amb	ambient temperature [deg C]	Input	Real
alpha	resistive temperature coefficient [Ohm/K]	Input	Real
rth	thermal conduction [K/W]	Input	Real
cth	thermal heat capacitance [J/C]	Input	Real
hflow	outlet heat flow [W], output is positive	Input	Real
t_res	resistance temperature [deg C]	Output	Real

[Top](#)

Examples

[Simple Heater Example](#)

[Top](#)

References

tank_w: Heatable tank with constant level

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--



Figure 1. Component symbol

- [Description](#)
- [Assumptions and Limitations](#)
- [Mathematical Description](#)
- [Netlist Syntax](#)
- [Conservative Pins](#)
- [Parameters](#)
- [Input/Output Quantities](#)
- [Example](#)
- [References](#)

Description

The tank_w model represents the behavior of heatable water tank with constant water level (inlet water flow rate is equal to the outlet water flow rate). The tank will send out a boolean control signal to turn the heater on or off based on set temperature and a deadband temperature range. Notice that the $t_set + t_deadband$ cannot be greater than 100.0 deg C.

[Top](#)

Assumptions and Limitations

[Top](#)

Mathematical Description

[Top](#)

Netlist Syntax

[Top](#)

Conservative Pins

[Top](#)

Parameters

Table 1

Name	Description	Data Type	Default Value [Unit]
volume	water volume	real	0.01 [m ³]
t_nom	nominal temperature	real	20.0 [deg C]
t_set	temperature set for the water tank	real	50.0 [deg C]
t_deadband	temperature deadband for the water tank	real	5.0 [K]

[Top](#)

Input/Output Quantities

Table 2

Name	Description [Unit]	Direction	Data Type
t_amb	ambient temperature [deg C]	Input	Real
rho	water density [kg / m ³]	Input	Real
cp	specific heat [J / kg * K]	Input	Real
mdot	inlet water mass flow rate [kg/s]	Input	Real
t_inlet	inlet water temperature [deg C]	Input	Real
hflow	inlet heat flow [W]	Input	Real
rth_w	thermal resistance from water tank to ambient [K/W]	Input	Real
ctrl	control signal, to turn on (1.0) or off (-1.0) the water heater	Output	Real
t_tank	tank water temperature [deg C]	Output	Real

[Top](#)

Examples

[Simple Heater Example](#)

[Top](#)

References

Aircraft Electrical System Application Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Aircraft Electrical System Application Example** schematic is shown in Figure 1. It contains:

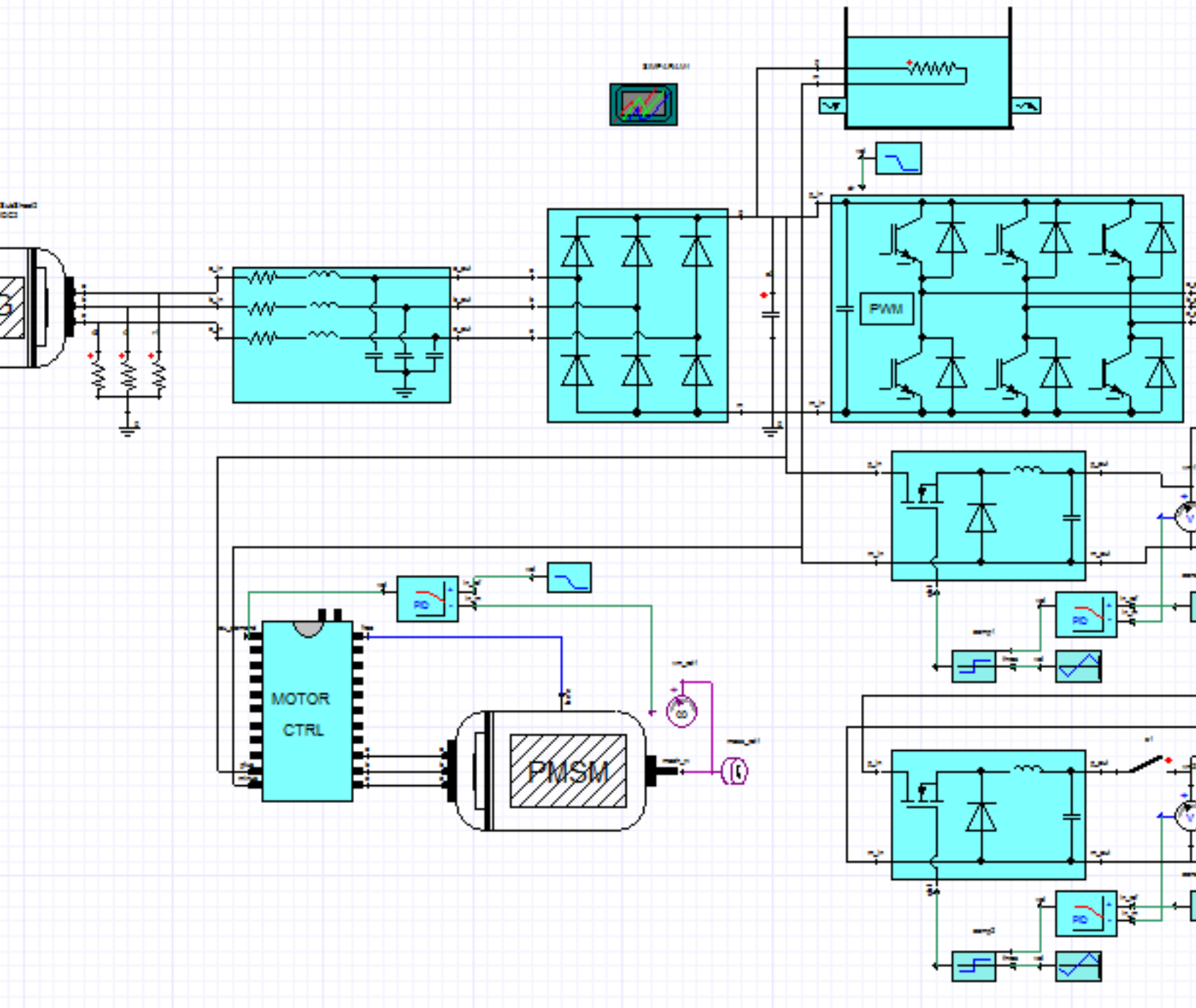


Figure 1. Aircraft Electrical System Application Example Schematic

- Gas turbine engine
- Fuel tank
- Integrated drive generator

- Three phase transmission line
- 6 pulse rectifier
- DC-AC inverter
- Heater
- Buck converter
- Lamp
- PID controller
- DC-AC 3 phase motor controller
- PMSM motor
- Battery

There are two sub-systems in the system:

- **Gas turbine engine sub-system**, shown in Figure 2. It contains inlet, compressor, combustor, turbine, shaft and nozzle models from Aircraft Electrical VHDL-AMS/Engine library.
- **Integrated drive generator sub-system**, shown in Figure 3. It contains constant speed drive, generator control unit and generator with electrical excitation models from Aircraft Electrical VHDL-AMS/Generator library.

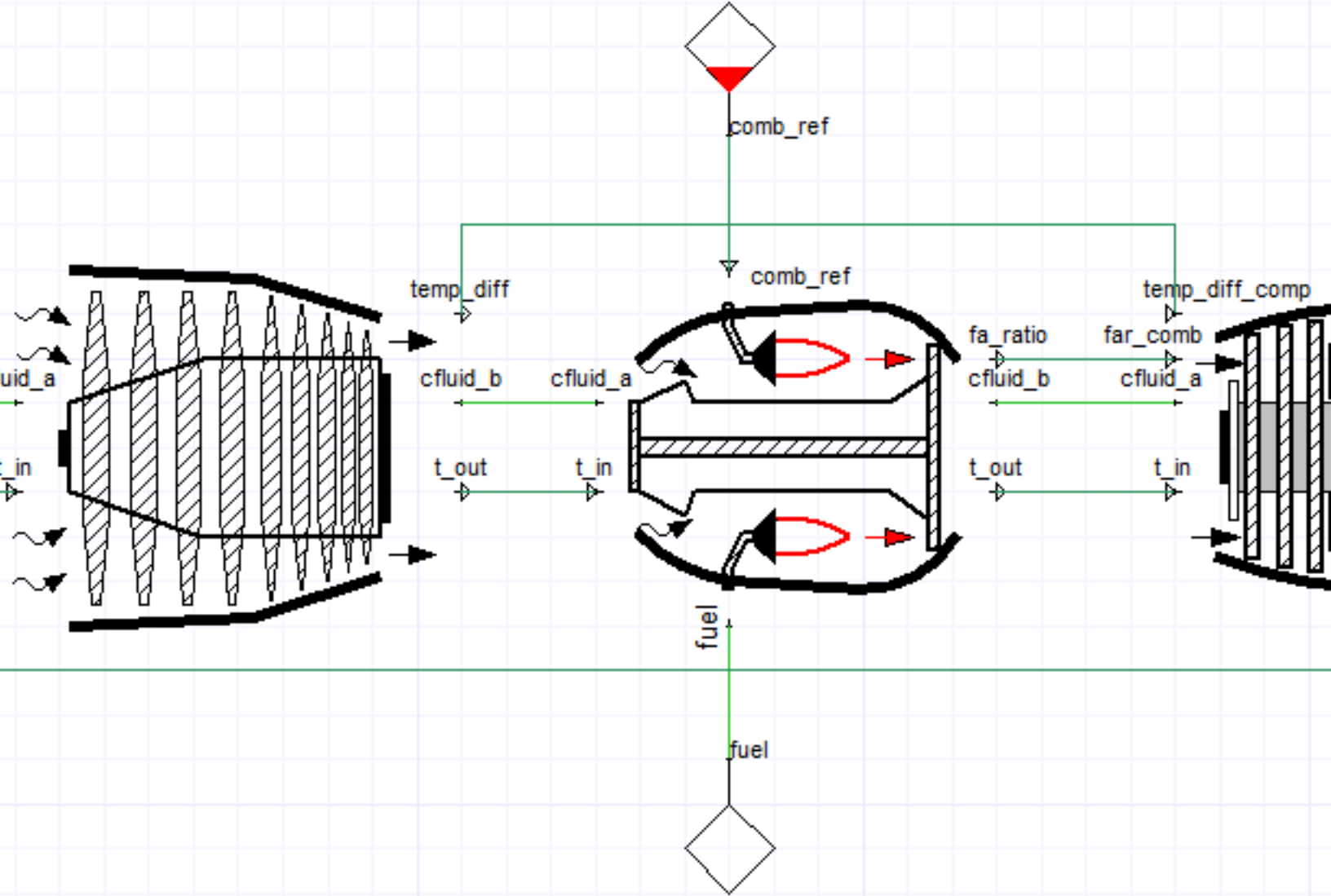


Figure 2. Gas Turbine Engine Sub-System Schematic

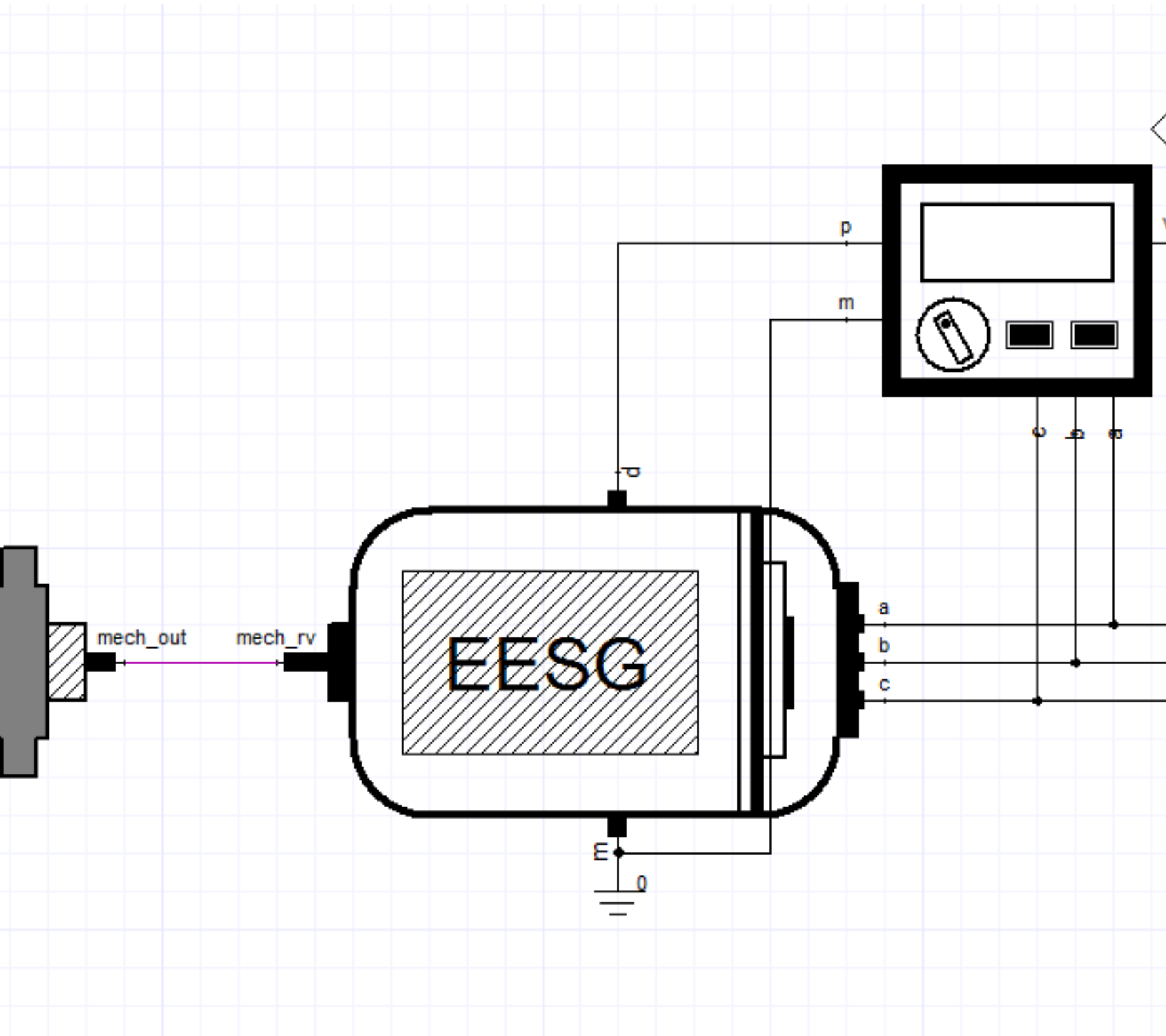


Figure 3. Integrated Drive Generator Sub-System Schematic

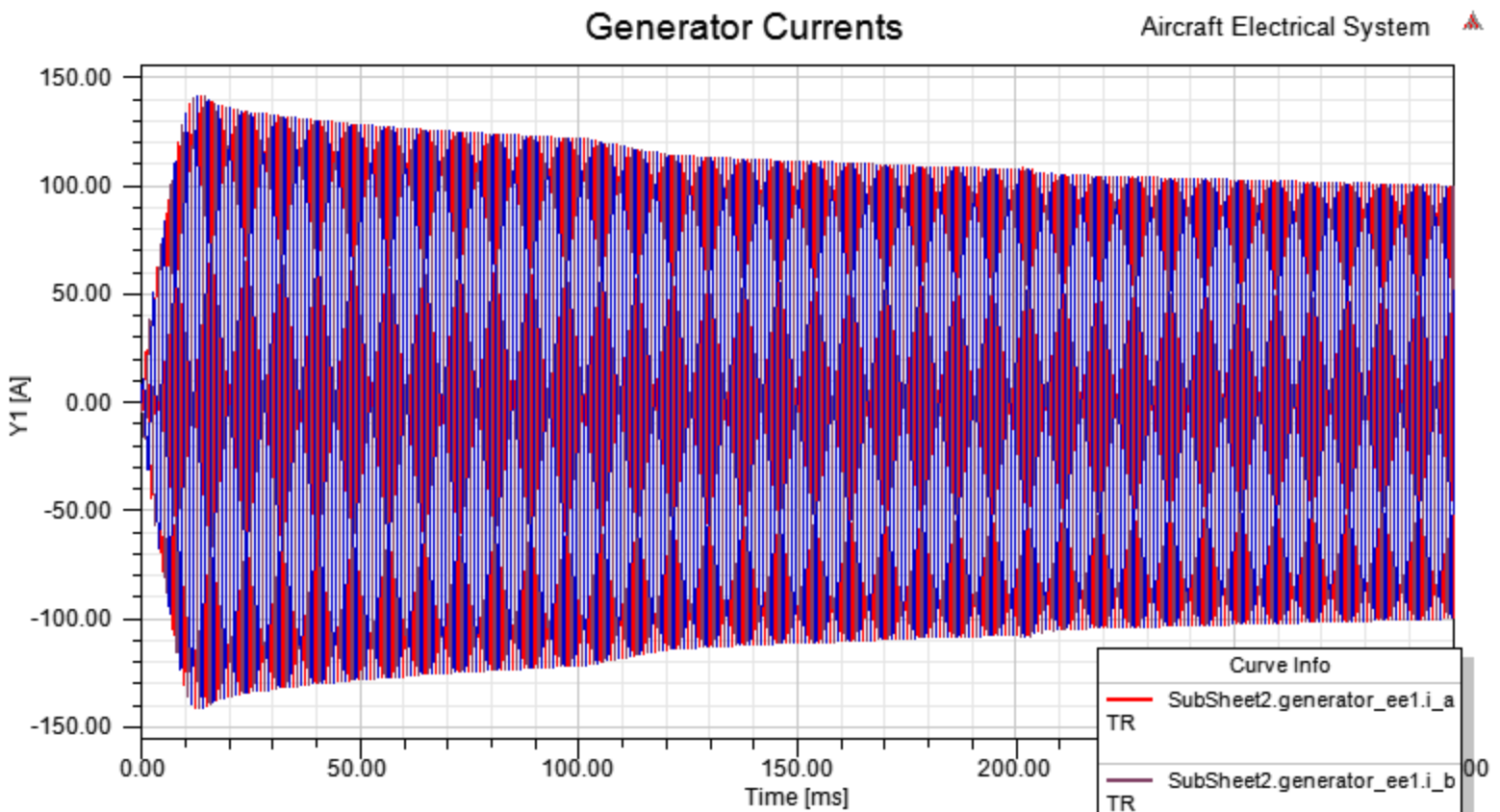
There are five control loops in the system load side:

- The ramp change of the PWM duty ratio input of the DC-AC inverter. At 0.1 sec, the duty ratio decreases from 1 to 0.5 within 0.02 sec.
- The PI control to maintain the output voltage of buck converter 1, which is the source of lamp 1 and buck converter 2. The output voltage is kept at 220 V.
- The PI control to maintain the output voltage of buck converter 2, which is the source of lamp 2 and the battery pack. The output voltage is kept at 65 V.
- The on/off control on the switch at the output of buck converter 2. The switch is turn off at 0.2 sec.
- The motor speed control through the DC-AC 3 phase motor controller. The speed reference is changed from 1 rad/sec to 2 rad/sec at 0.15 sec within 0.01 sec.

[Top](#)

Simulation Results

The integrated drive generator output currents are shown in Figure 4.



The DC-AC inverter output currents are shown in Figure 5.

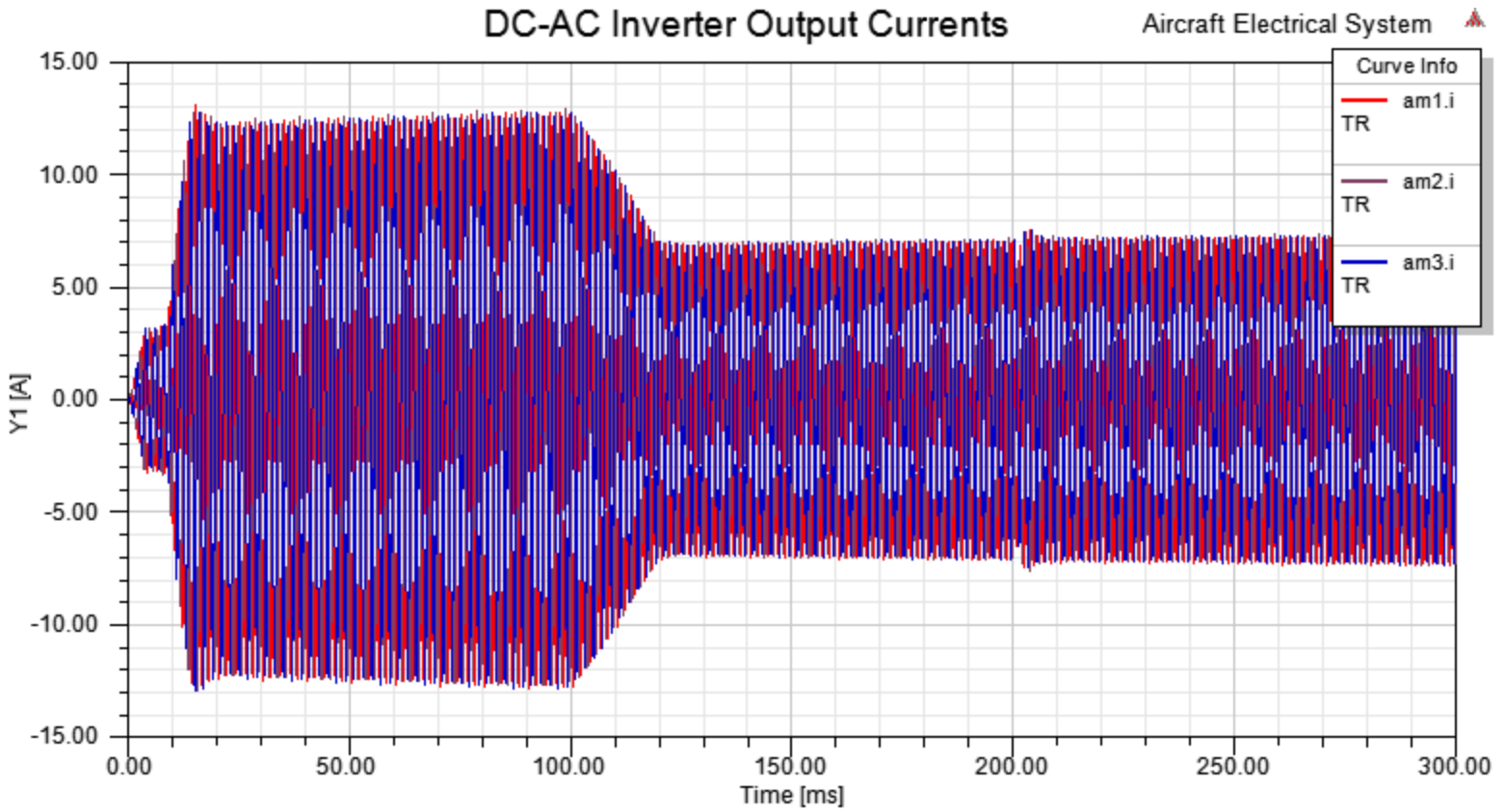
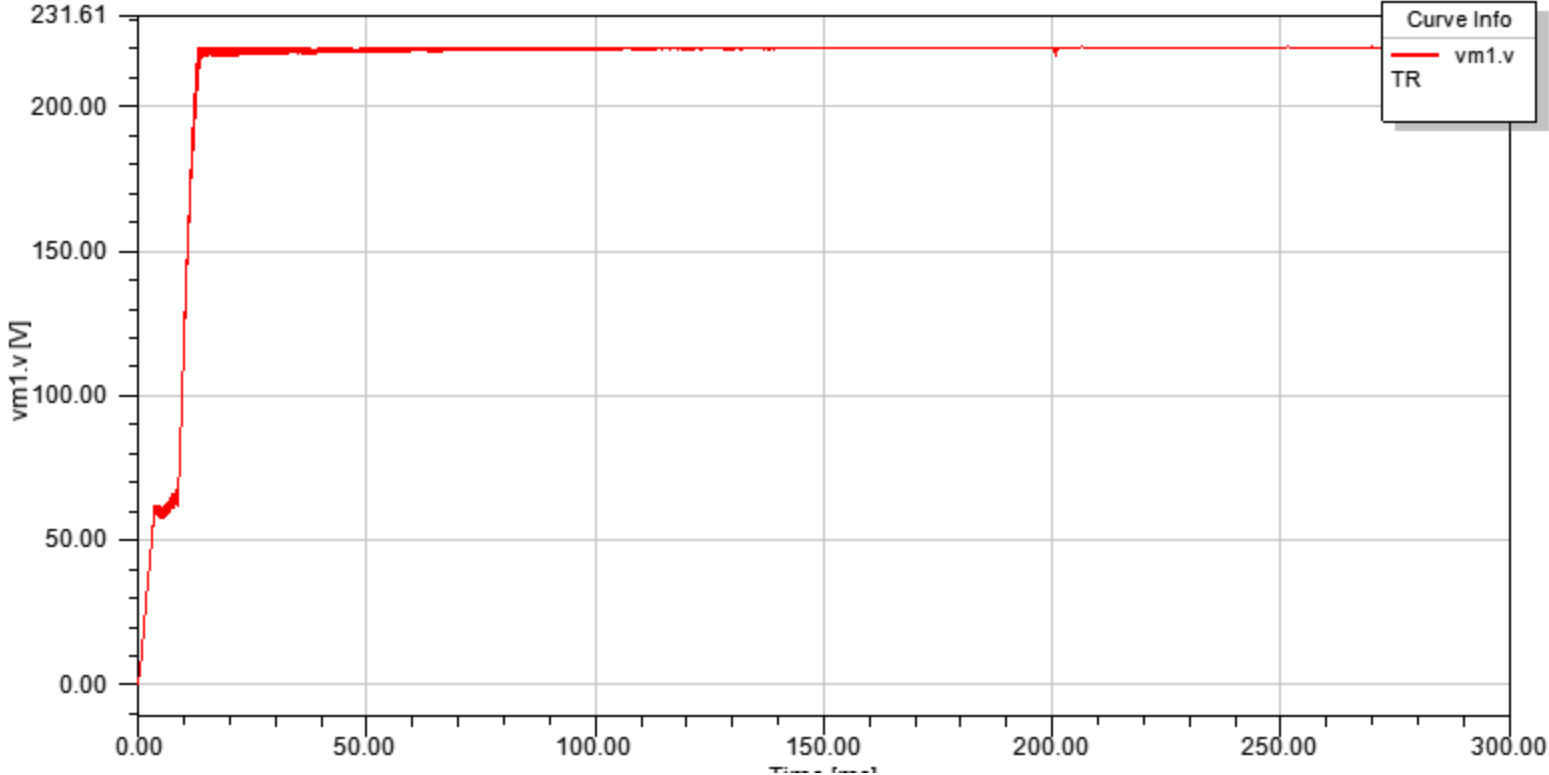


Figure 5. DC-AC Inverter Output Currents

The buck converter output voltages are shown in Figure 6. Please note that from 0.2 sec, the switch is turned off, so the vm2.V mostly depends on the battery pack voltage.

Buck Converter 1 Output Voltage

Aircraft Electrical System 



Buck Converter 2 Output Voltage

Aircraft Electrical System 

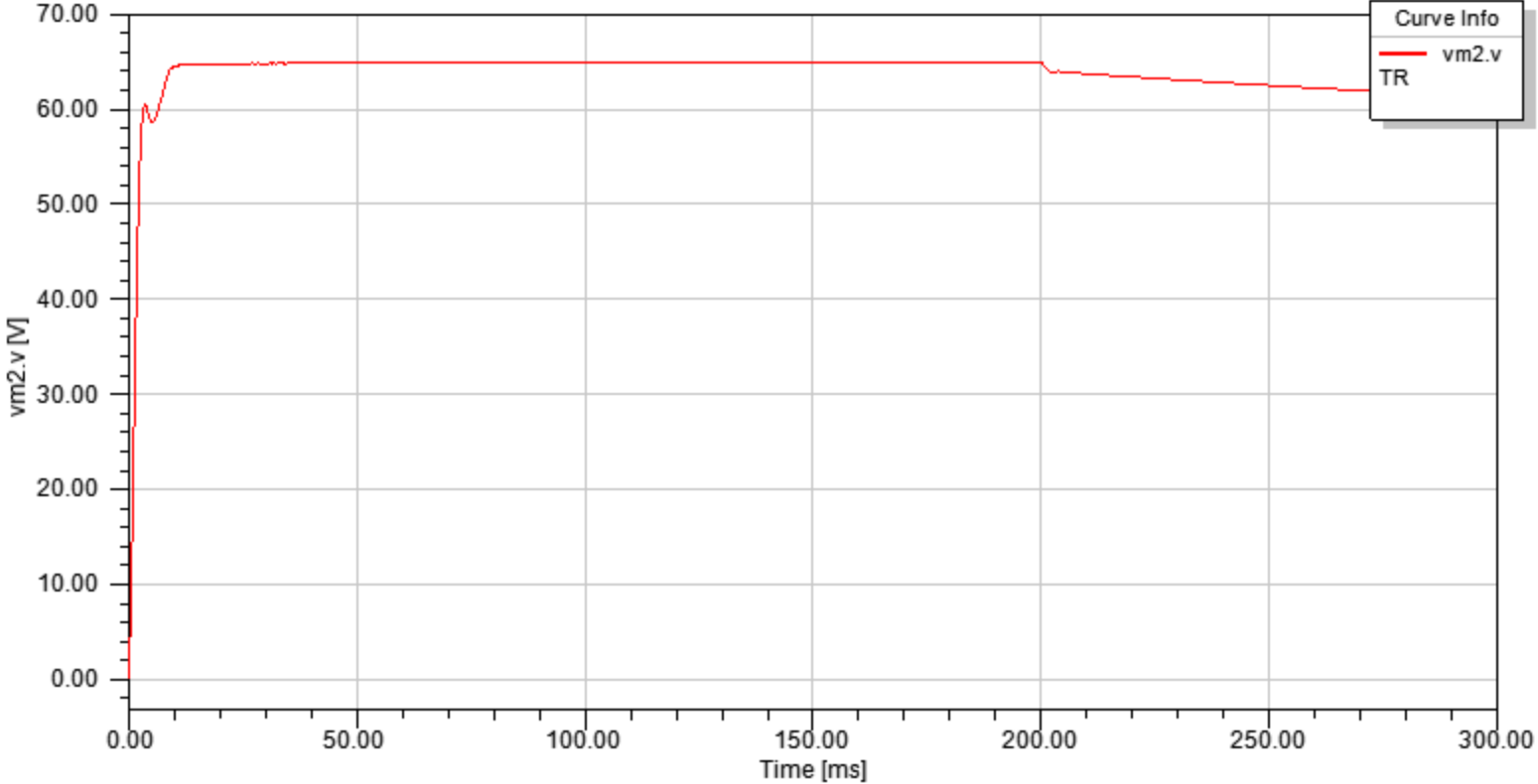


Figure 6. Buck Converter Output Voltages

The PMSM motor speed and speed reference are shown in Figure 7.

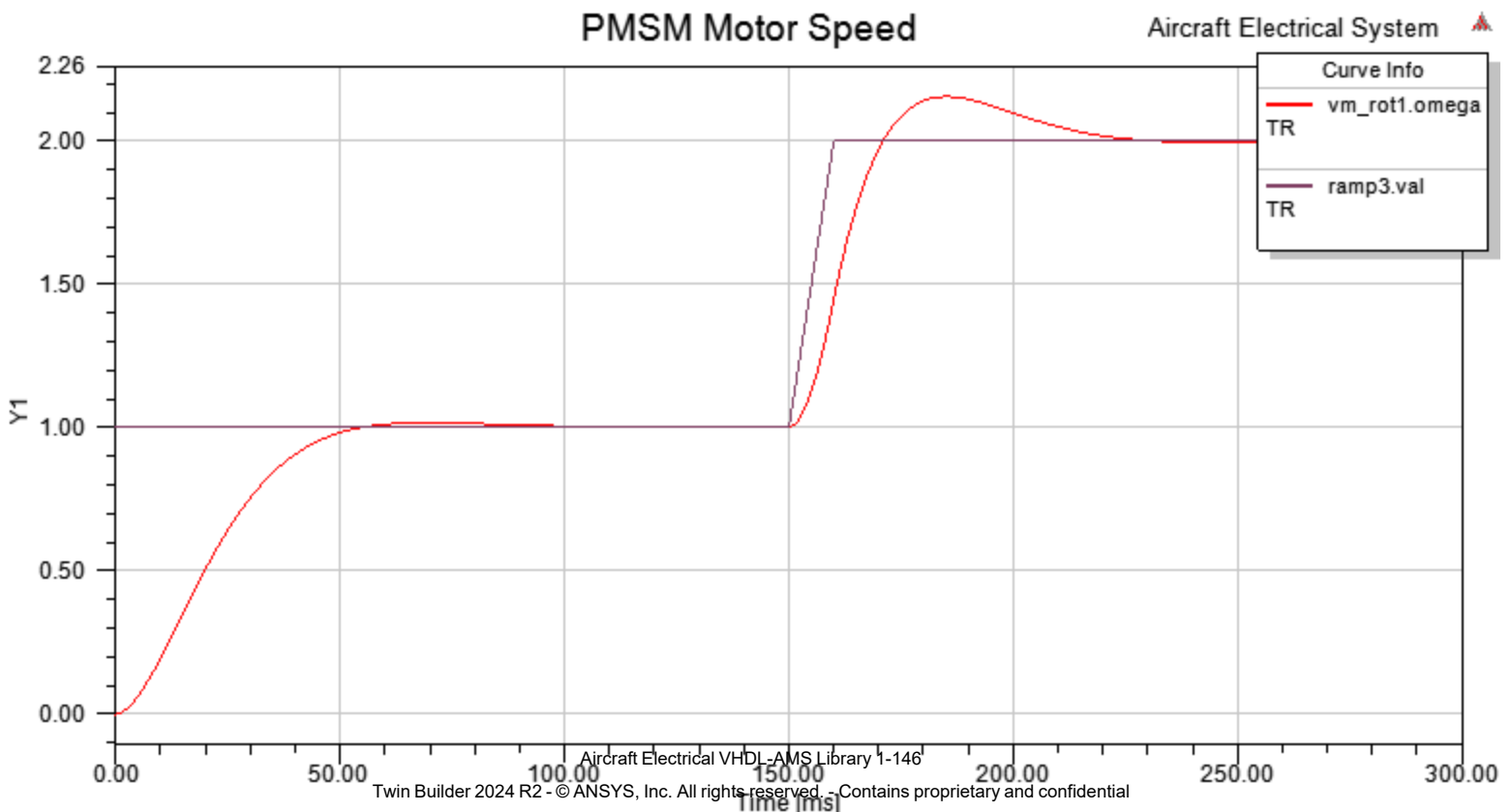
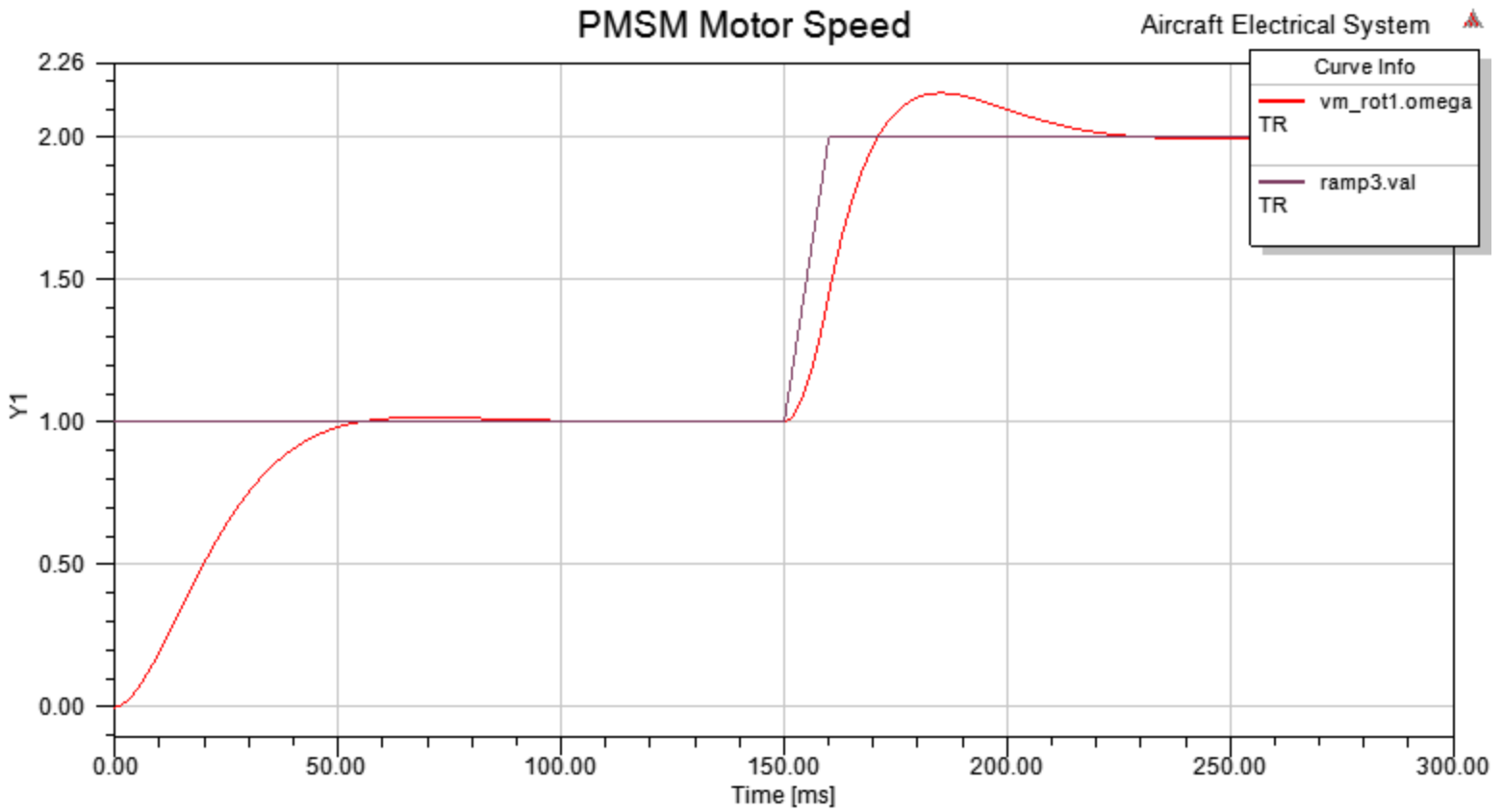


Figure 7. PMSM Motor Speed and Speed Reference

Example Path: <Installation Folder>\AnsysEM\v242\Win64\Examples\Twin Builder\Applications\Aircraft Electrical\Aircraft Electrical System.aedt

[Top](#)

AC 3Phase Voltage Source Example

Library: Aircraft Electrical
VHDL-AMS

Modeling Language:
VHDL-AMS

Version Number: Twin Builder
2024.2

Description

The **AC 3Phase voltage source** schematic is shown in Figure 1.

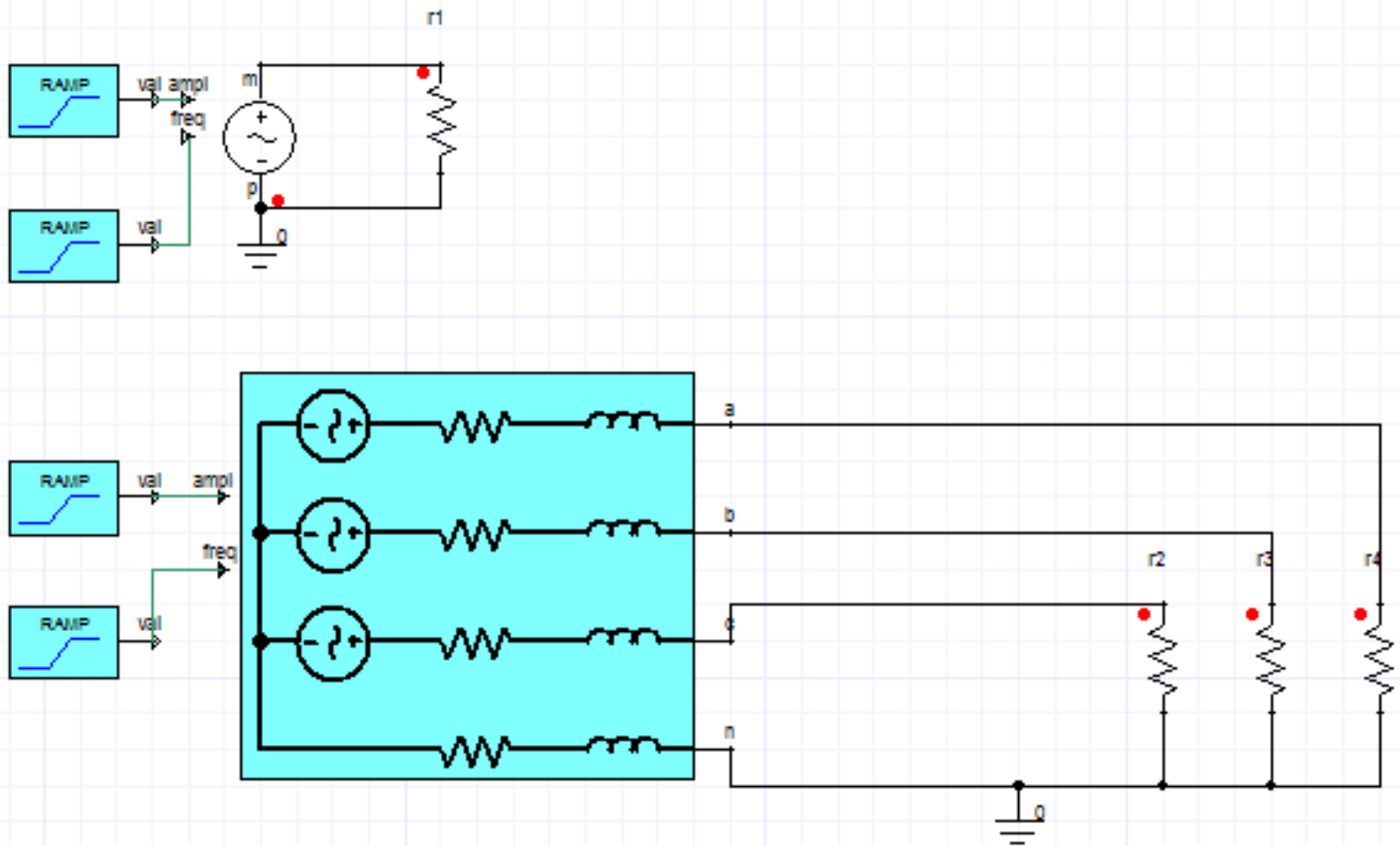


Figure 1. AC 3Phase Voltage Source Example Schematic

The system contains the `e_ac`, `e_ac_3phase` and `ramp` models from the Aircraft Electrical VHDL-AMS library.

Ramp changes are used to drive the amplitude and frequency changes of the AC sources.

- at 1 sec, the amplitude of `e_ac` is changed from 1 A to 2 A within 1 sec.
- at 3 sec, the frequency of `e_ac` is changed from 10 Hz to 20 Hz within 0.0001 sec.

- at 1 sec, the amplitude of e_ac_3phase is changed from 1 A to 2 A within 1 sec.
- at 3 sec, the frequency of e_ac_3phase is changed from 10 Hz to 20 Hz within 0.0001 sec.

[Top](#)

Simulation Results

The load current and voltage of e_ac are shown in Figure 2.

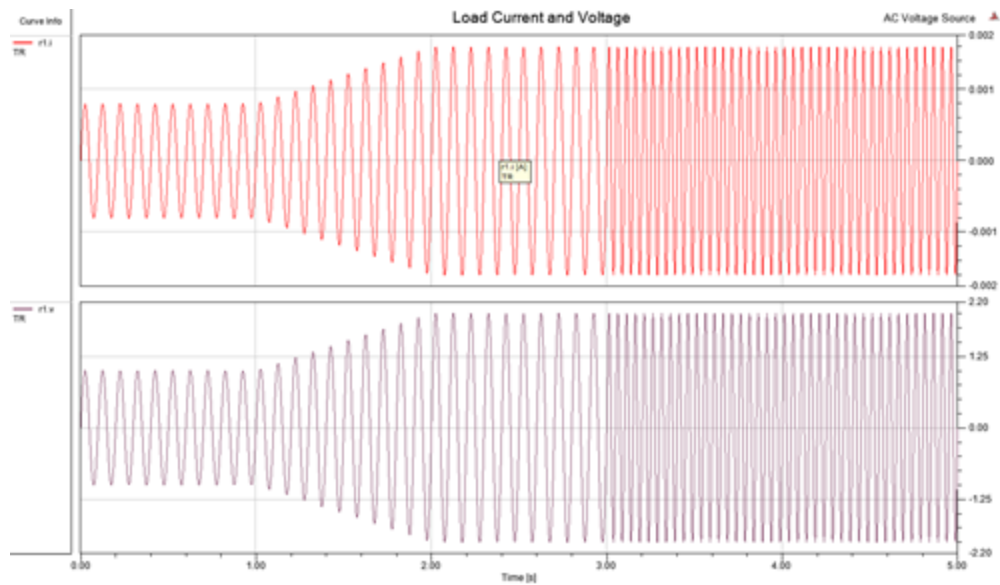


Figure 2. Load Current and Voltage

The load voltages for e_ac_3phase are shown in Figure 3.

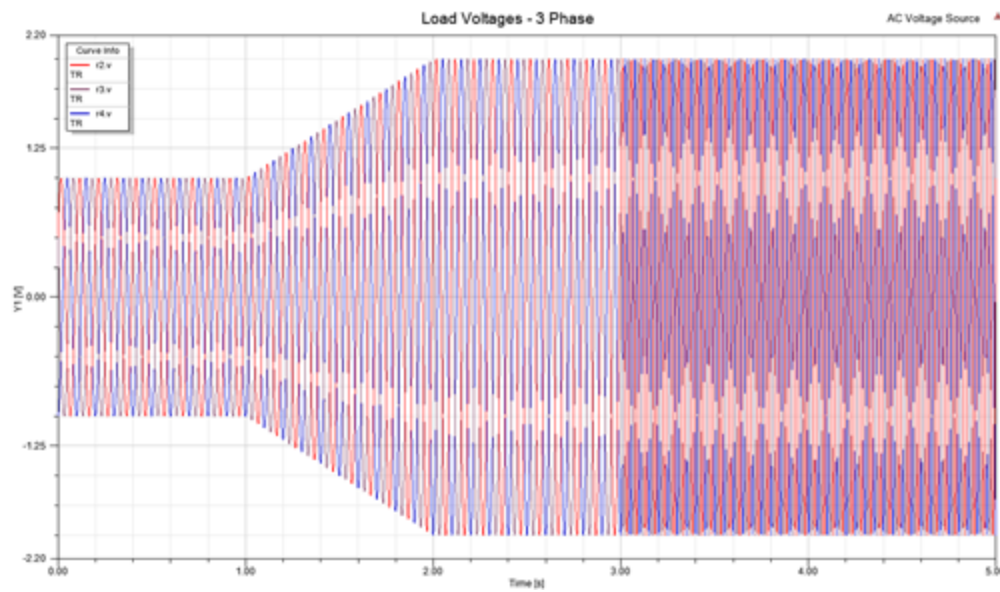


Figure 3. Load Voltages - 3 Phase

[Top](#)

Battery General Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Battery General Example** schematic is shown in Figure 1.

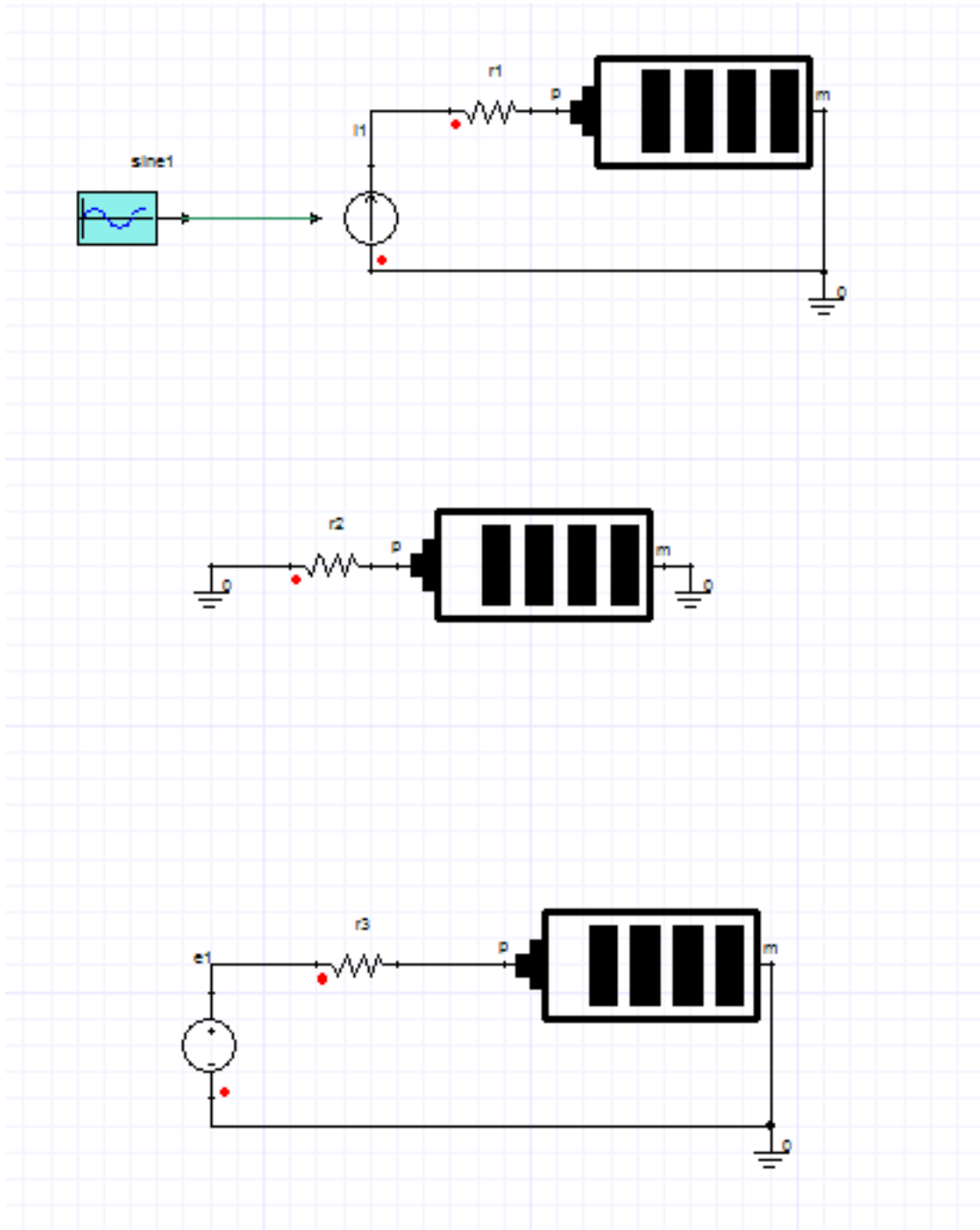


Figure 1. Battery General Example Schematic

The example contains the ramp and battery_general models from the Aircraft Electrical VHDL-AMS library.

Three example circuits are used to demonstrate the performance of the battery_general model:

- battery_general with sinusoidal current source of amplitude as 0.1 A.

- battery_general discharges with a resistive load.
- battery_general with voltage source.

[Top](#)

Simulation Results

The battery SOC of the battery_general with sinusoidal current source example is shown in Figure 2.

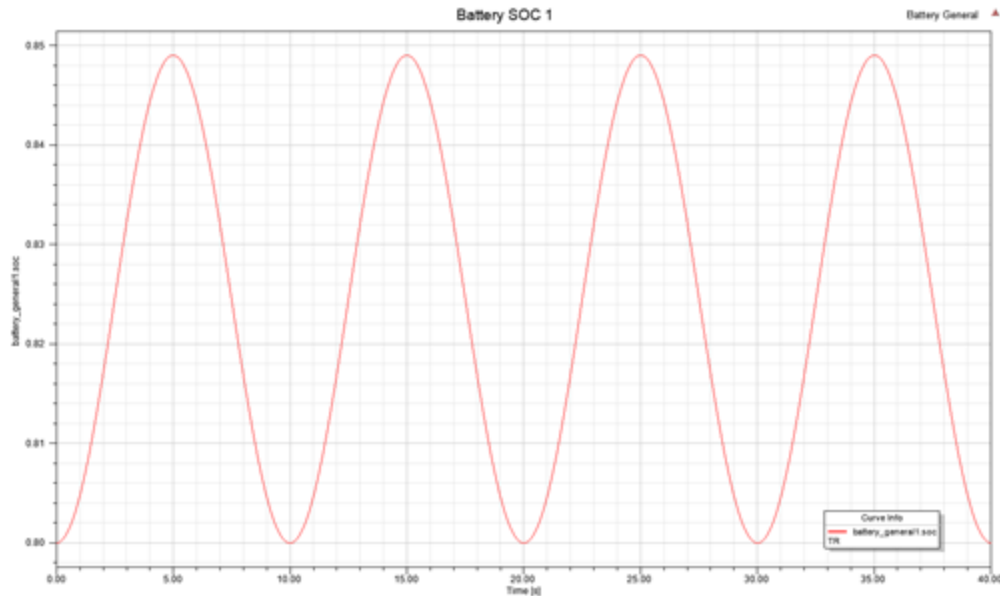


Figure 2. Battery SOC of the Battery_General with Sinusoidal Current Source Example

The battery SOC of the battery_general with resistive load example is shown in Figure 3.

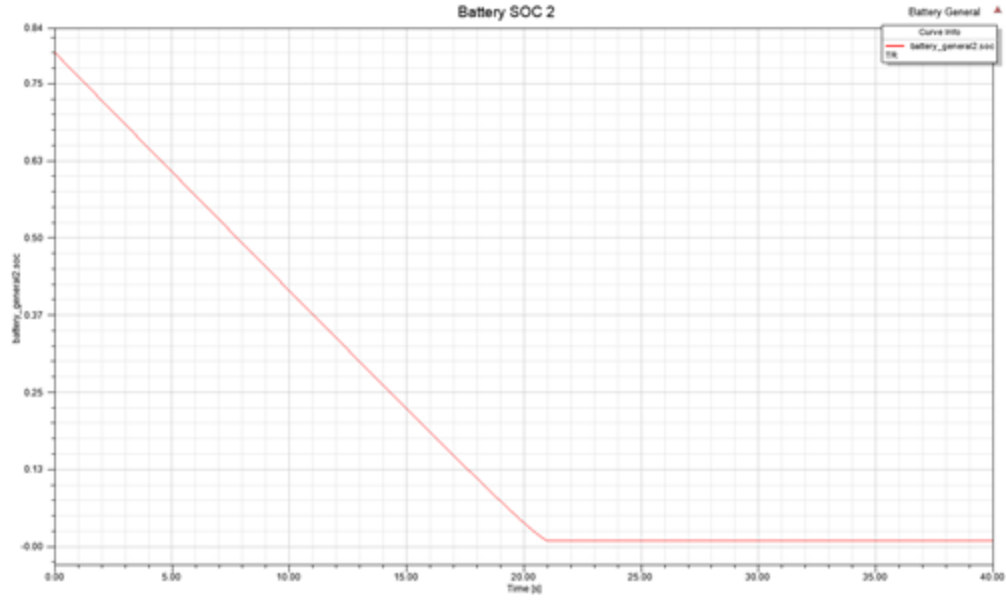


Figure 3. Battery SOC of the Battery_General with Resistive Load Example

The battery SOC of the battery_general with voltage source example is shown in Figure 4.

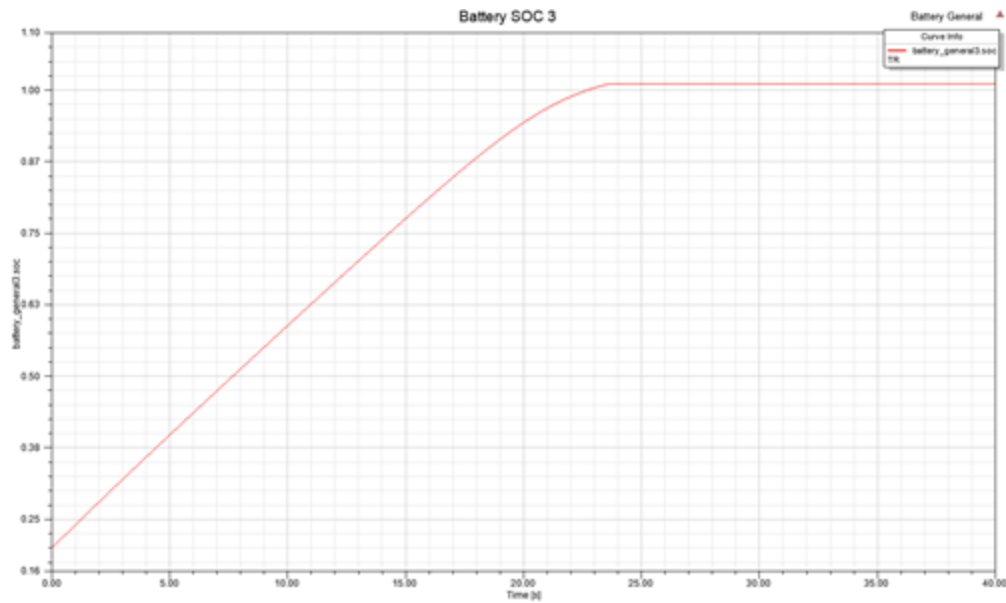


Figure 4. Battery SOC of the Battery_General with Voltage Source Example

[Top](#)

Battery Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Battery Example** schematic is shown in Figure 1.

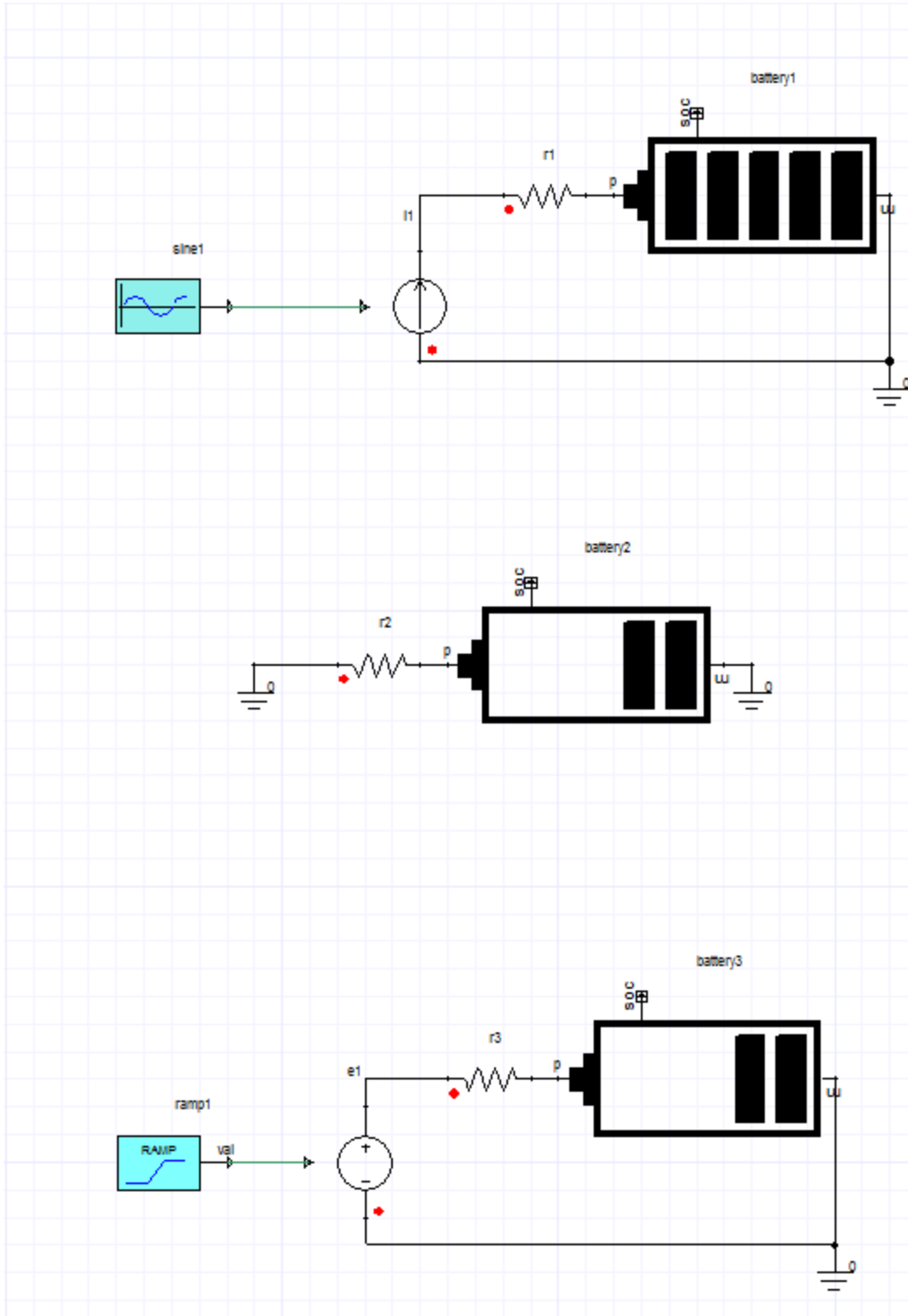


Figure 1. Battery Example Schematic

The example contains the ramp and battery models from the Aircraft Electrical VHDL-AMS library.

Three example circuits are used to demonstrate the performance of the battery model:

- Battery with sinusoidal current source of amplitude as 0.1 A.
- Battery discharges with a resistive load.
- Battery with ramp change voltage source, the voltage source changes at 20.0 sec, from 13 V to 11 V, within 2.0 sec.

[Top](#)

Simulation Results

The battery SOC of the battery with sinusoidal current source example is shown in Figure 2.

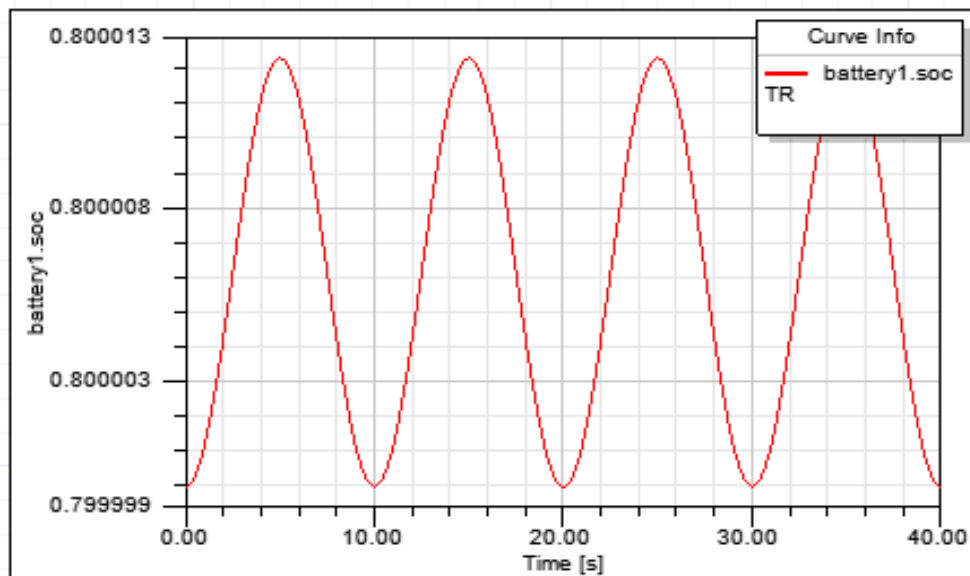


Figure 2. Battery SOC of the Battery with Sinusoidal Current Source Example

The battery SOC of the battery with resistive load example is shown in Figure 3.

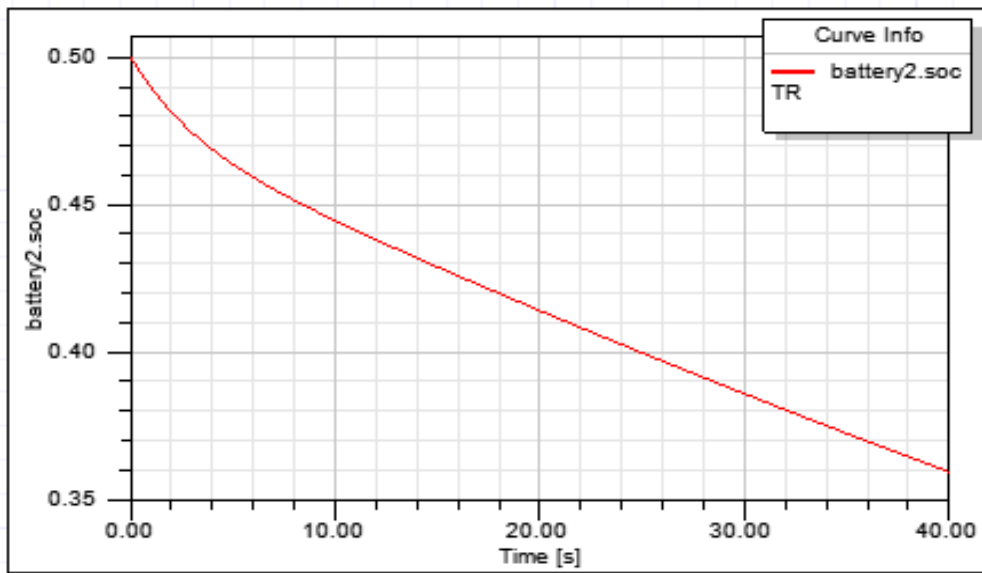


Figure 3. Battery SOC of the Battery with Resistive Load Example

The battery SOC of the battery with ramp change voltage source example is shown in Figure 4.

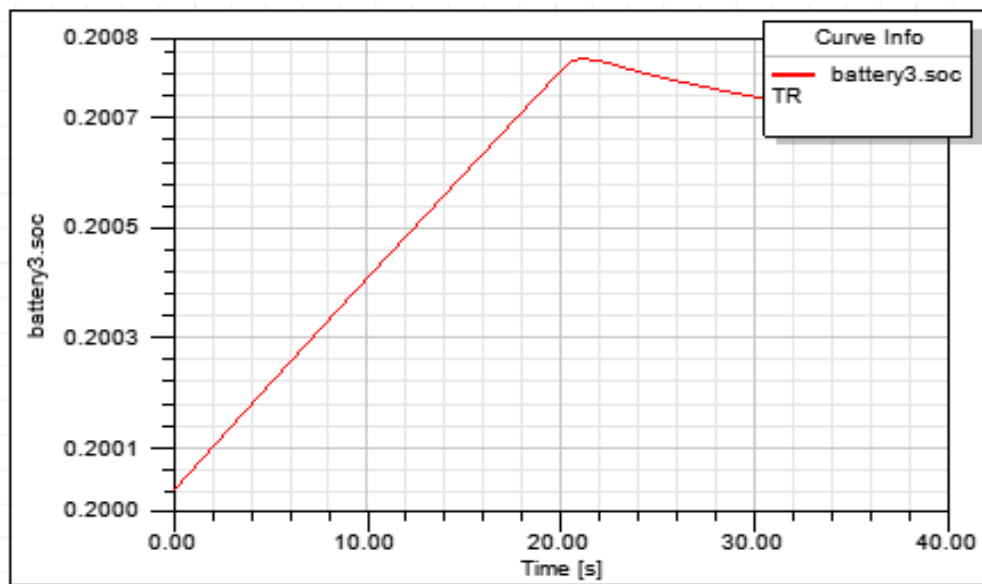


Figure 4. Battery SOC of the Battery with Ramp Change Voltage Source Example

[Top](#)

Boost Converter Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Boost Converter Example** schematic is shown in Figure 1.

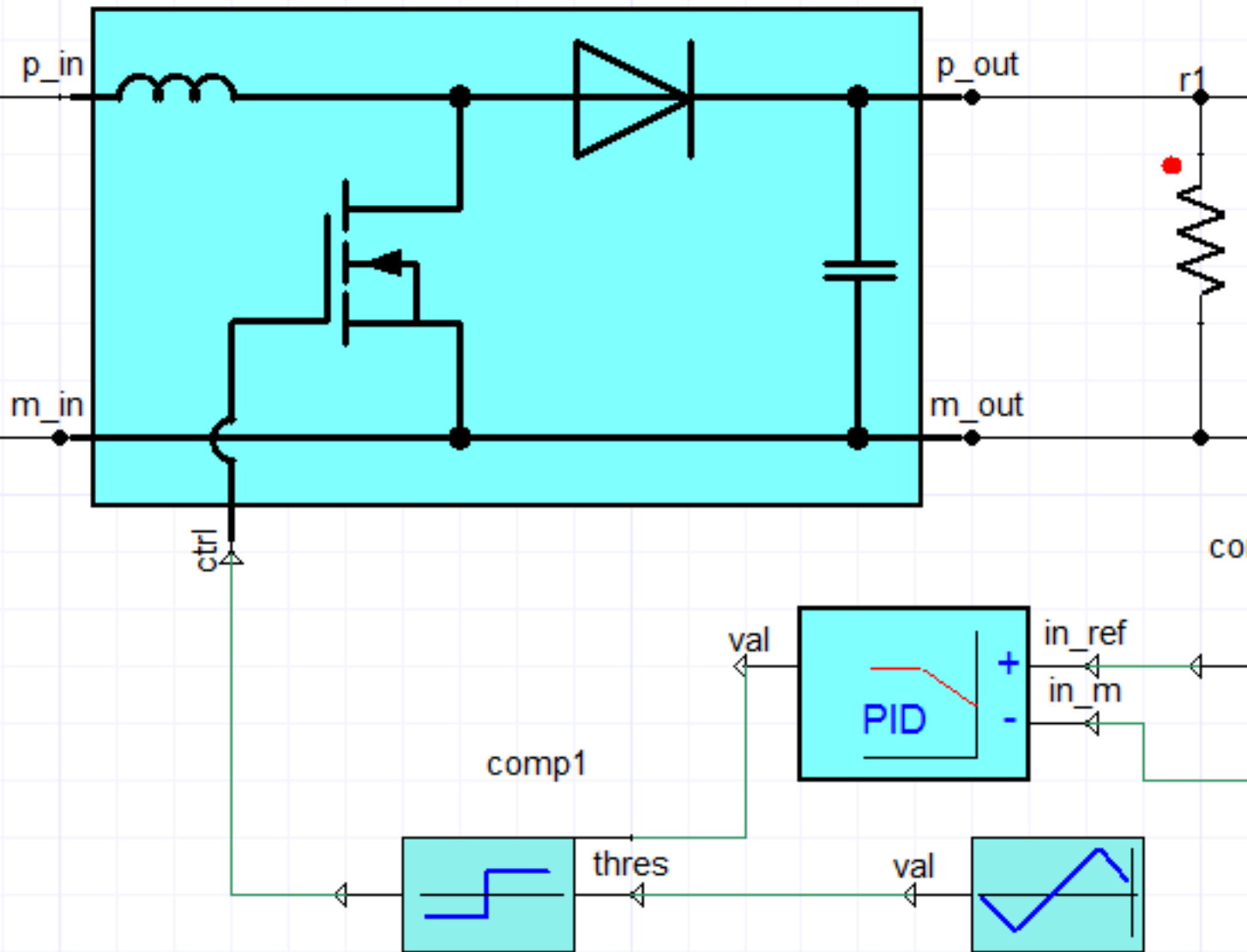


Figure 1. Boost Converter Example Schematic

The system contains the boost converter, pid_lim and triangle models from the Aircraft Electrical VHDL-AMS library. It uses a PI control to control the output voltage of the boost converter. The reference input to the PI controller is 20.0 V.

[Top](#)

Simulation Results

The comparison of the input and output voltages of the boost converter example is shown in Figure 2.

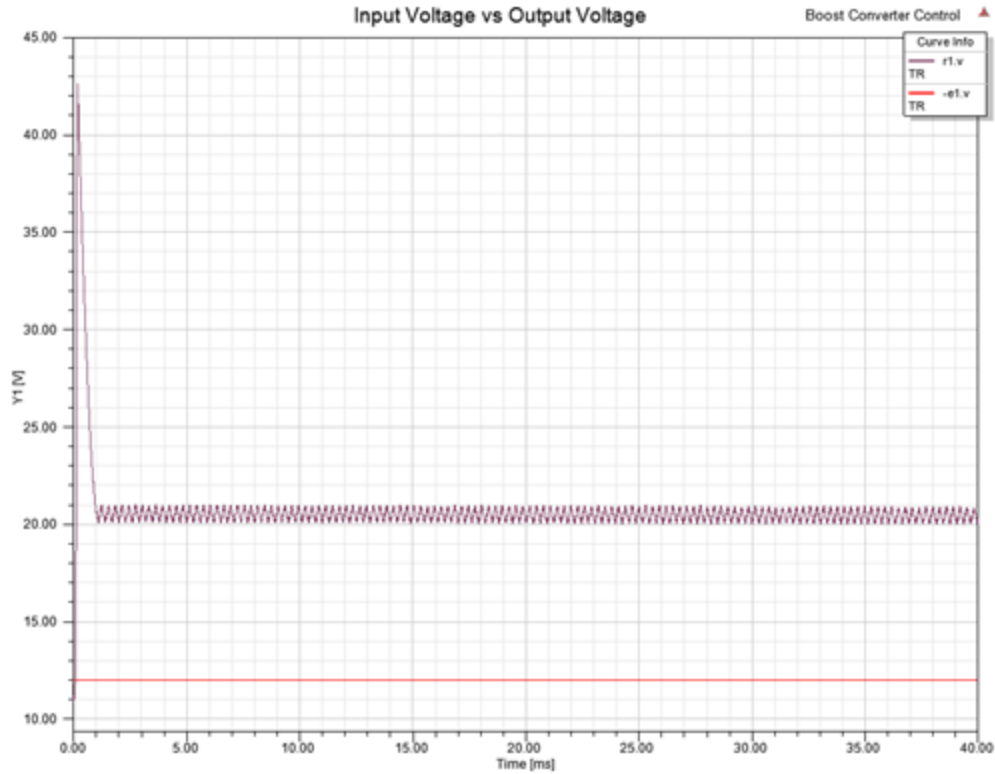


Figure 2. Input Voltage vs. Output Voltage

The control signals are shown in Figure 3.

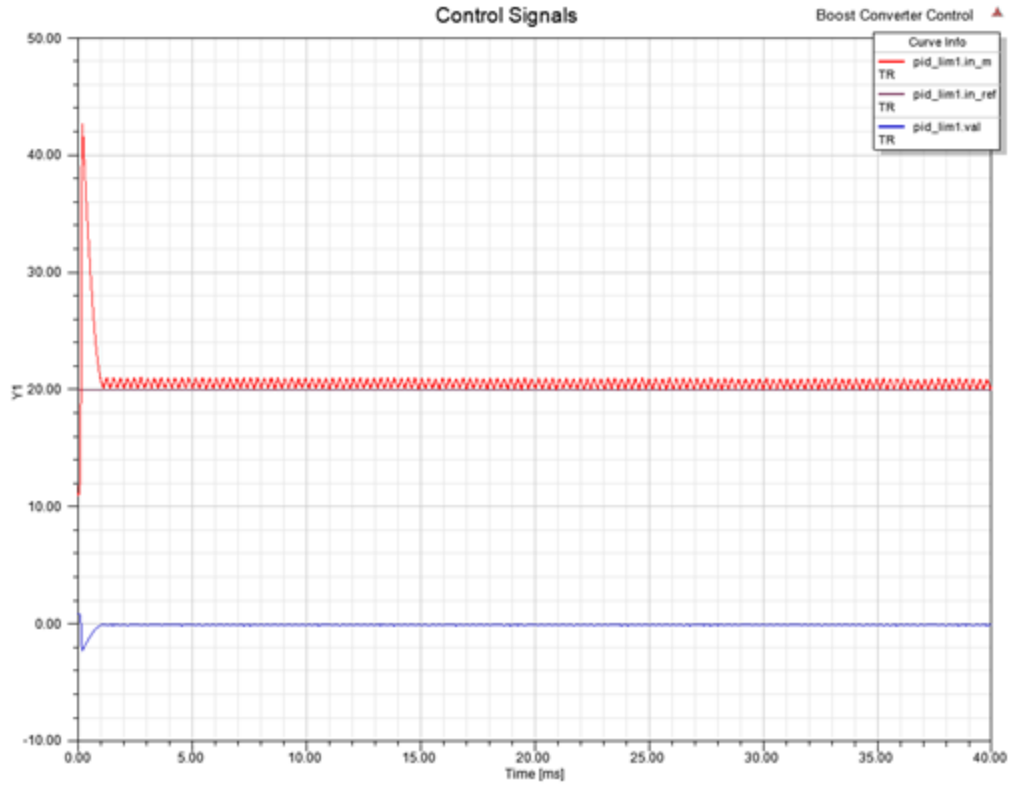


Figure 3. Control Signals

[Top](#)

Buck Converter Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Buck Converter Example** schematic is shown in Figure 1.

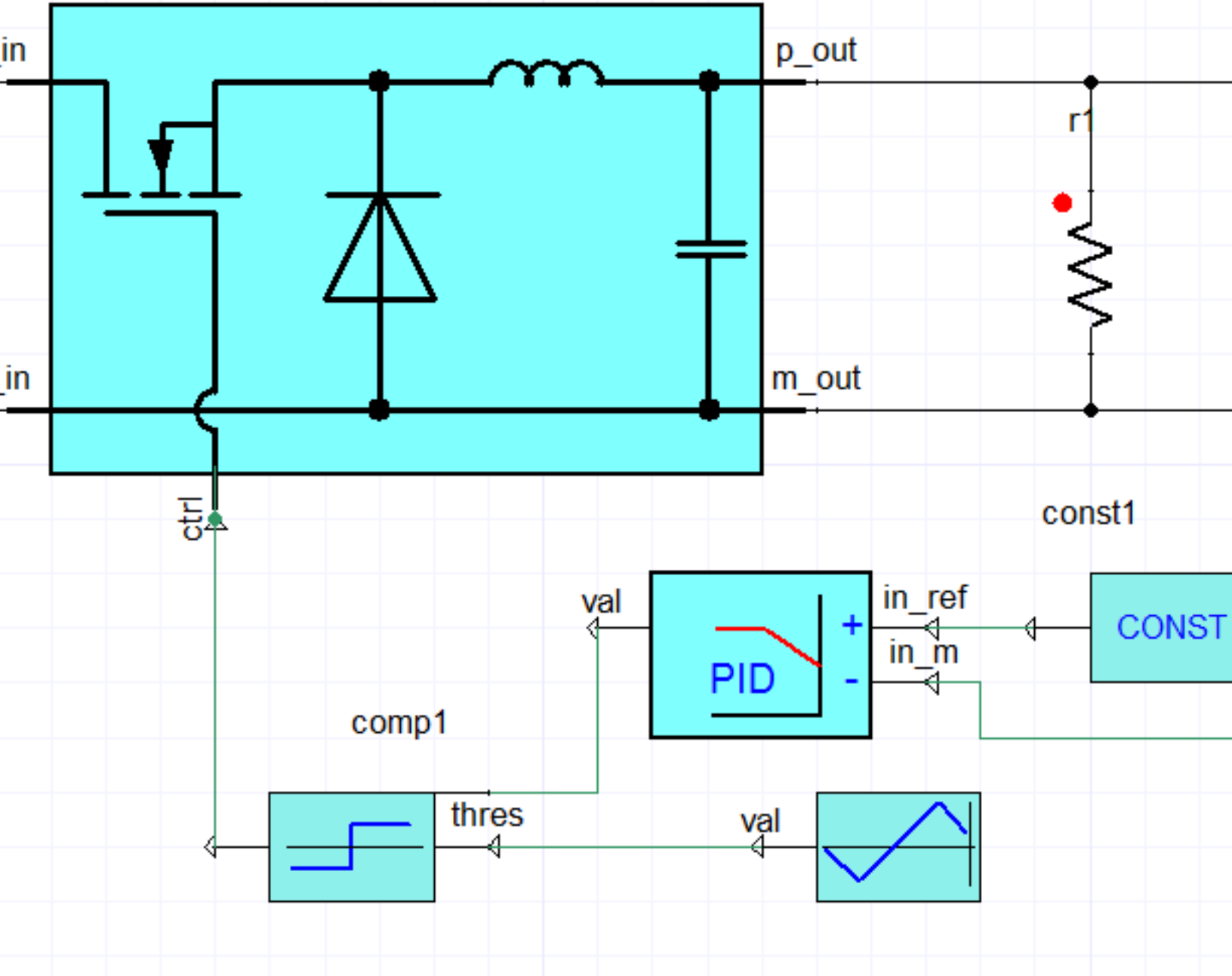


Figure 1. Buck Converter Example Schematic

The system contains the buck converter, pid_lim and triangle models from the Aircraft Electrical VHDL-AMS library. It uses a PI control to control the output voltage of the buck converter. The reference input to the PI controller is 8.0 V.

[Top](#)

Simulation Results

The comparison of the input and output voltages of the buck converter example is shown in Figure 2.

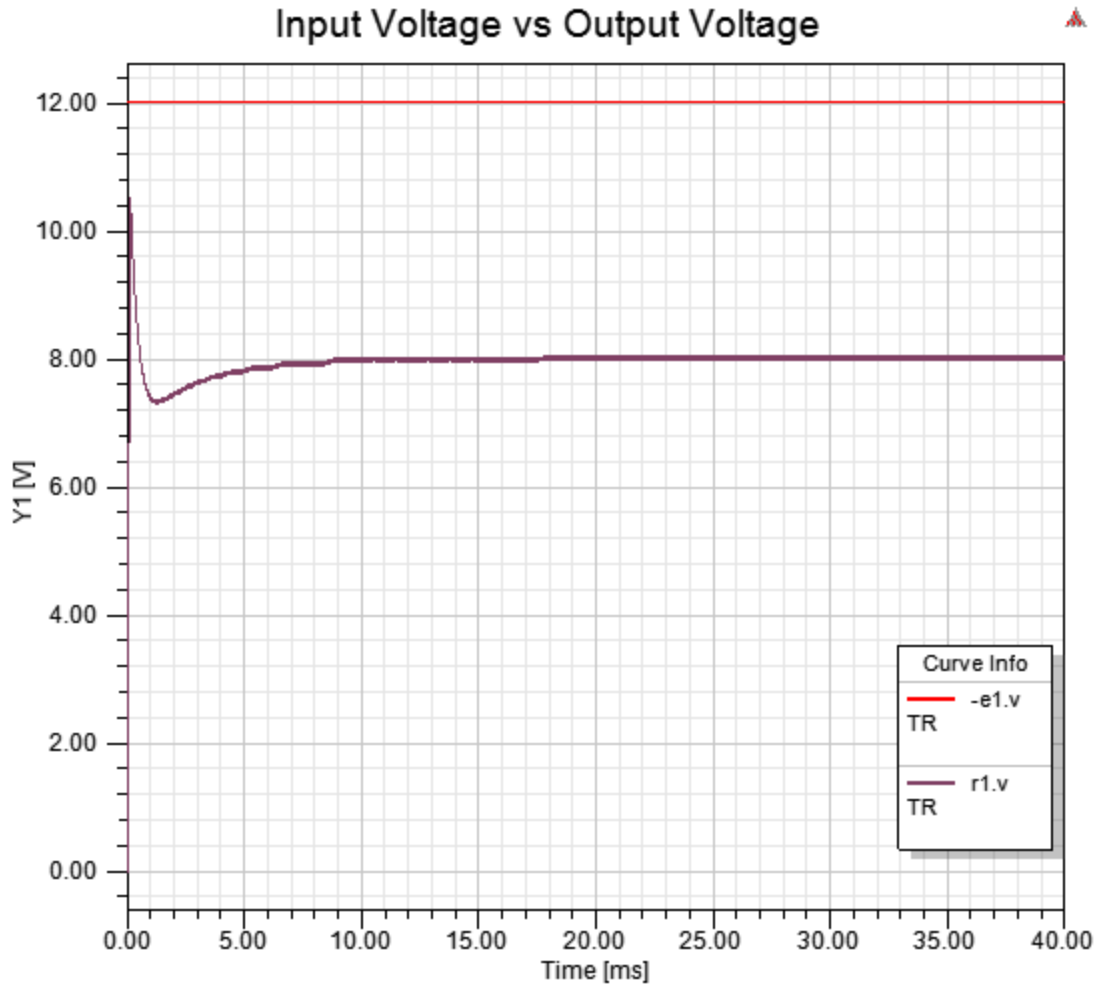


Figure 2. Input Voltage vs. Output Voltage

The control signals are shown in Figure 3.

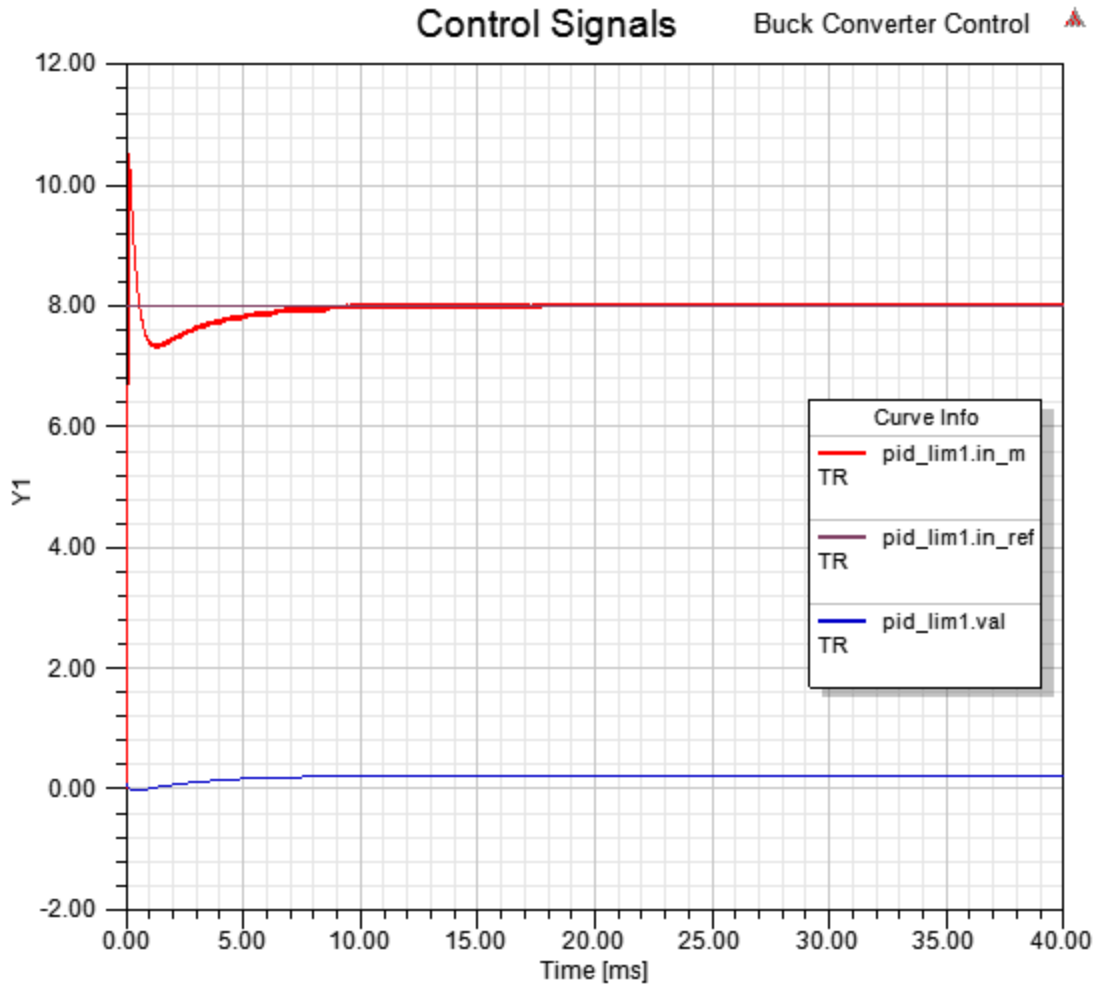


Figure 3. Control Signals

[Top](#)

DC-AC Inverter Example

Library: Aircraft Electrical
VHDL-AMS

Modeling Language:
VHDL-AMS

Version Number: Twin Builder
2024.2

Description

The **DC-AC Inverter Example** schematic is shown in Figure 1.

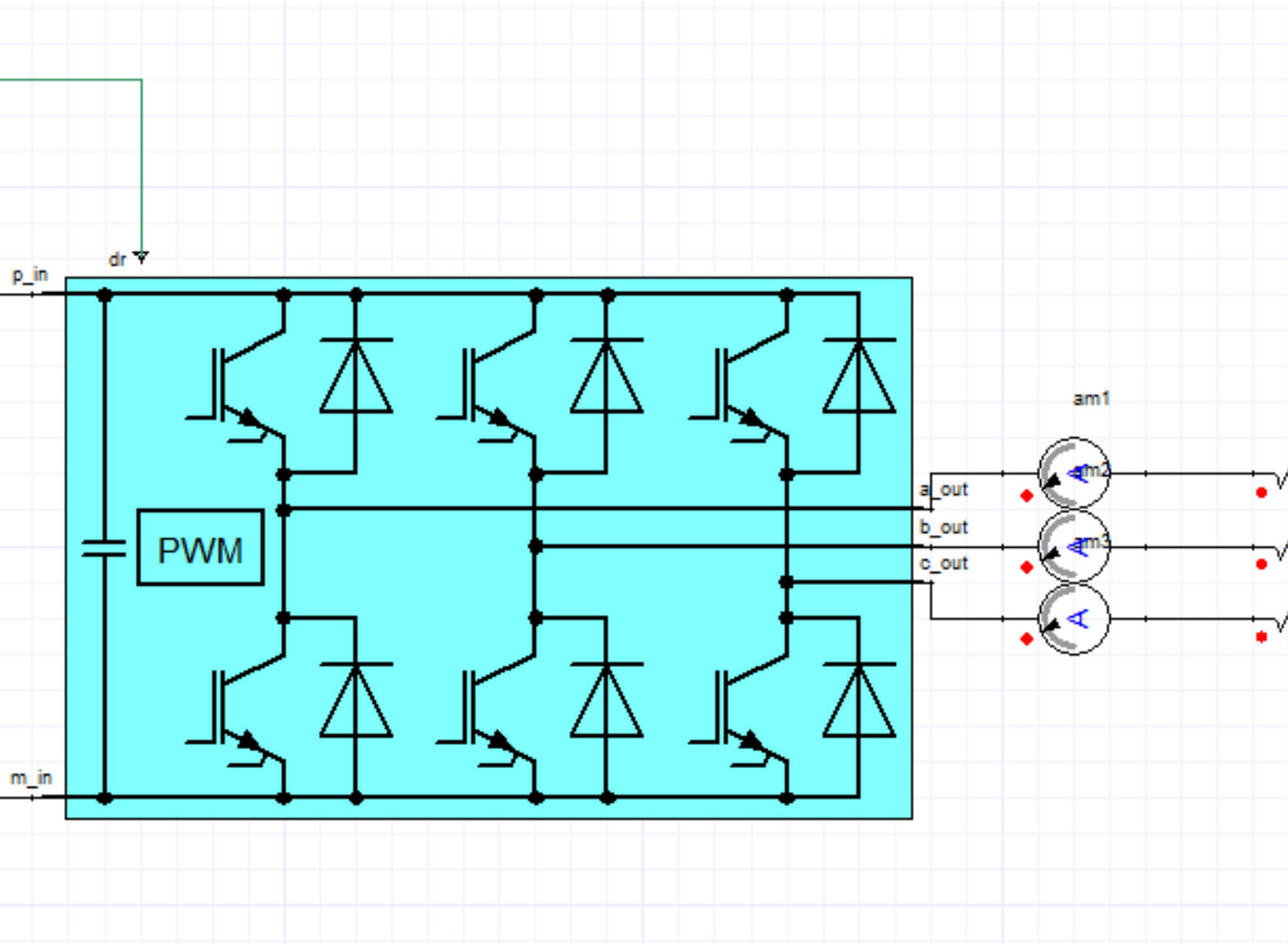


Figure 1. DC-AC Inverter Example Schematic

The system contains the inverter_dcac and ramp models from the Aircraft Electrical VHDL-AMS library. The inverter_dcac model converts the DC source into three phase AC source by user given PWM frequency and duty ratio. A ramp change on the input duty ratio is introduced at 0.2 sec, from 1.0 to 0.5 within 0.05 sec, to show the performance of the system.

[Top](#)

Simulation Results

The load currents of the DC-AC inverter example are shown in Figure 2.

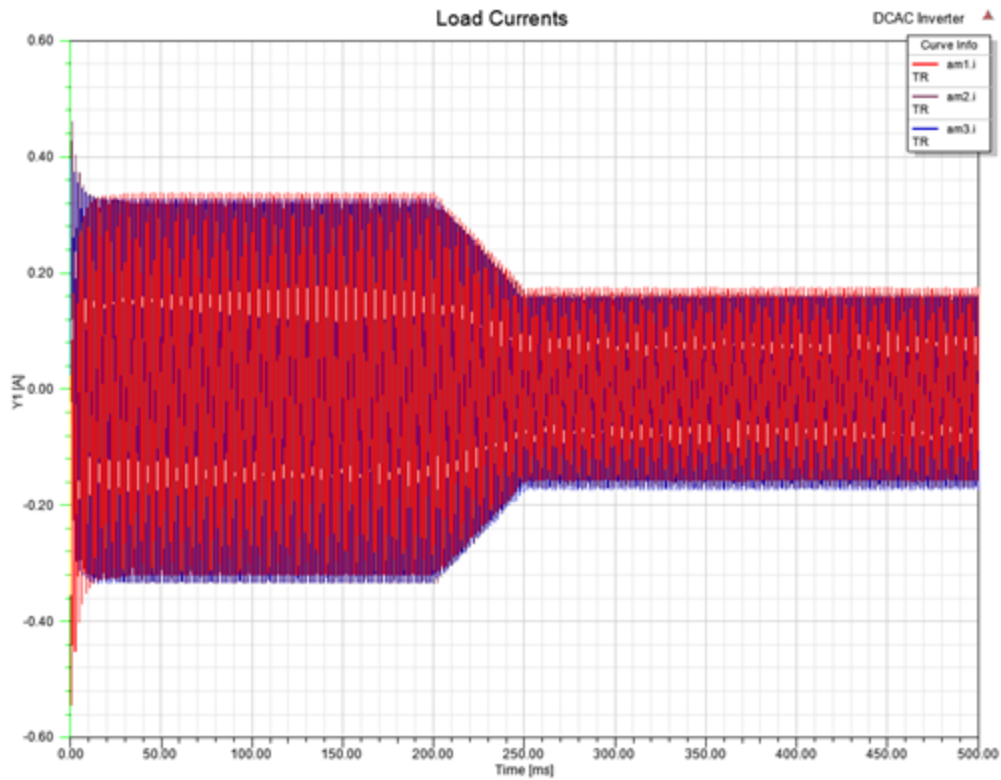


Figure 2. Load Currents

[Top](#)

Electrical Transformation Line Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Electrical Transformation Line Example** schematic is shown in Figure 1.

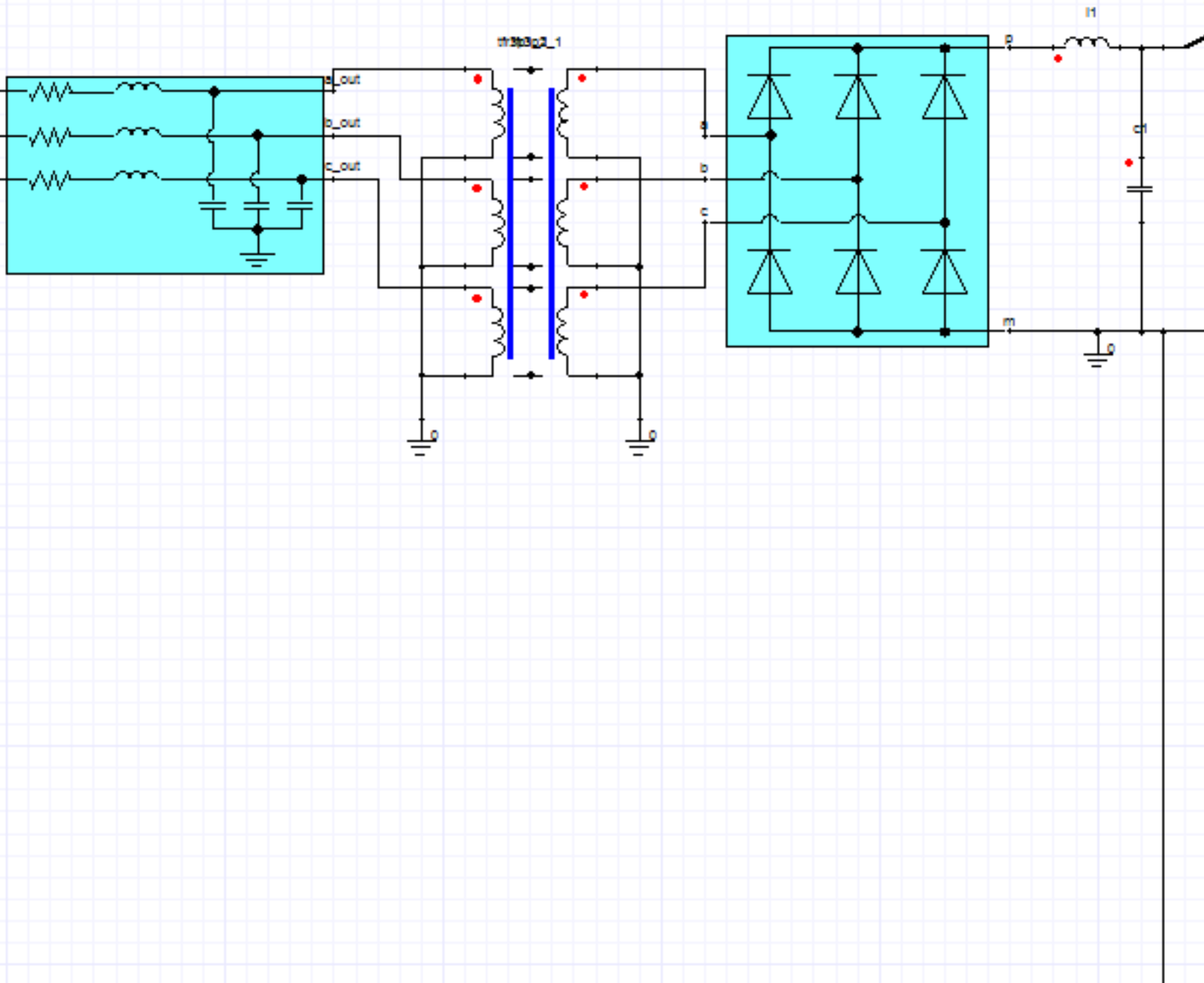


Figure 1. Electrical Transformation Line Example Schematic

The system contains the `idg`, `rlc_3phase`, `rectifier_6pulse`, `heater_dc`, `lamp_simple` and battery models from the Aircraft Electrical VHDL-AMS library.

The `speed_ref` and the `vrms_ref` inputs of the integrated drive generator (IDG) are fixed at 12000 rpm and 100 V respectively. The IDG is drive by a torque source of 10 Nm.

The switch is on for 0.1 sec and then turned off. For the first 0.1 sec, the generator is heating the `heater_dc`, lighting the `lamp_simple` and charging the battery pack. From 0.1 sec to the end of the simulation, the batteries starts to discharge and keep the heater and lamp working.

[Top](#)

Simulation Results

The generator output currents are shown in Figure 2.

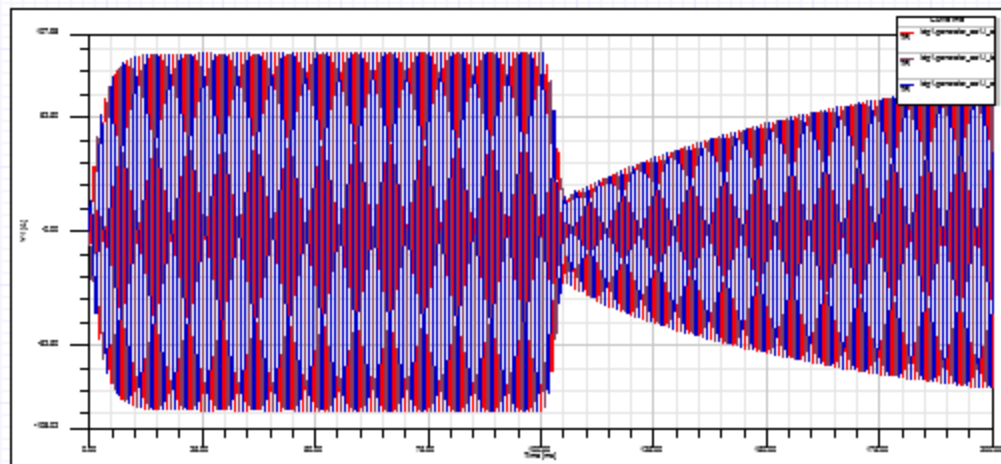


Figure 2. Generator Output Currents

The battery state of charge (SOC) is shown in Figure 3.

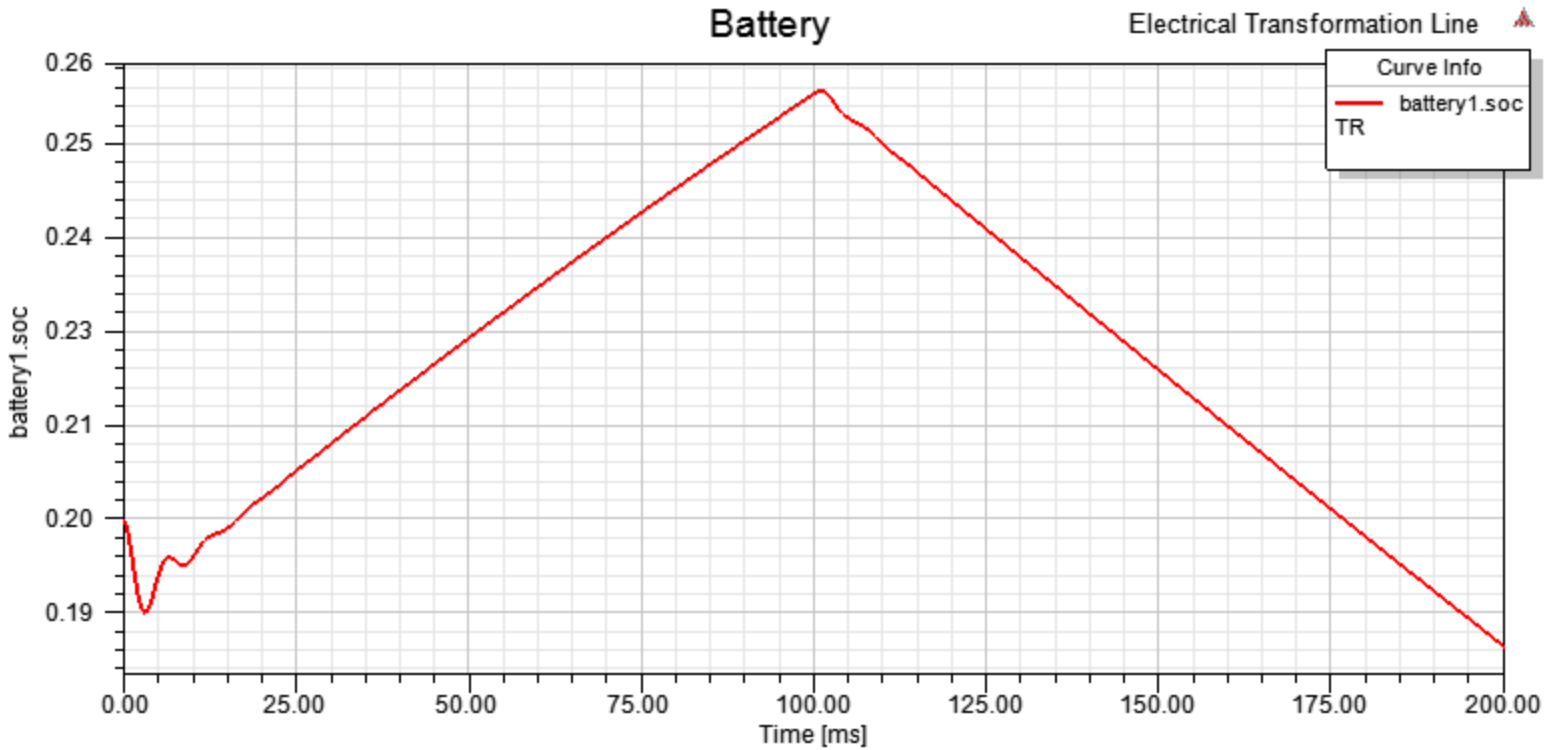


Figure 3: Battery SOC

The temperature of the heat tank is shown in Figure 4.

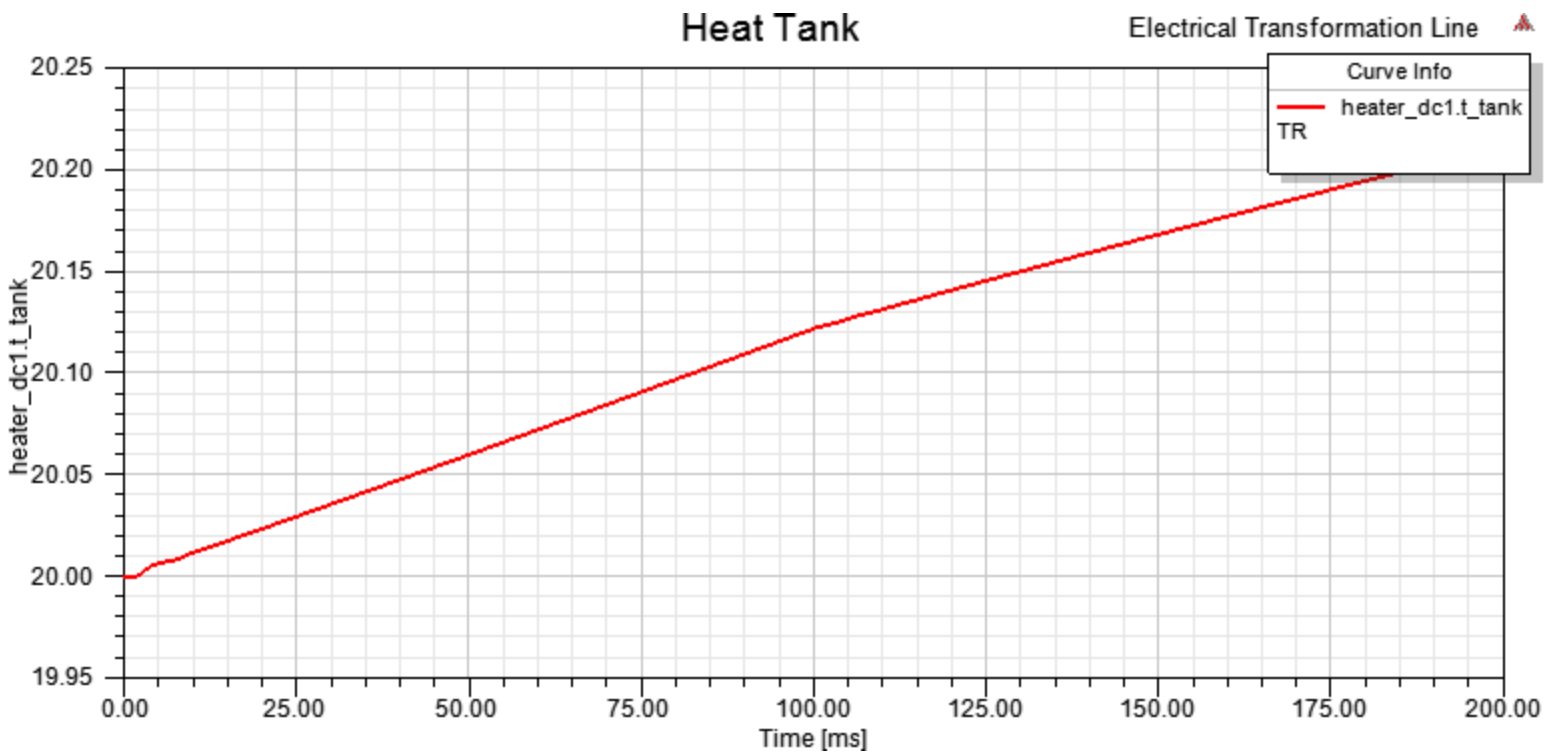


Figure 4: Heat Tank Temperature

The H flow and the filament temperature are shown in Figure 5.

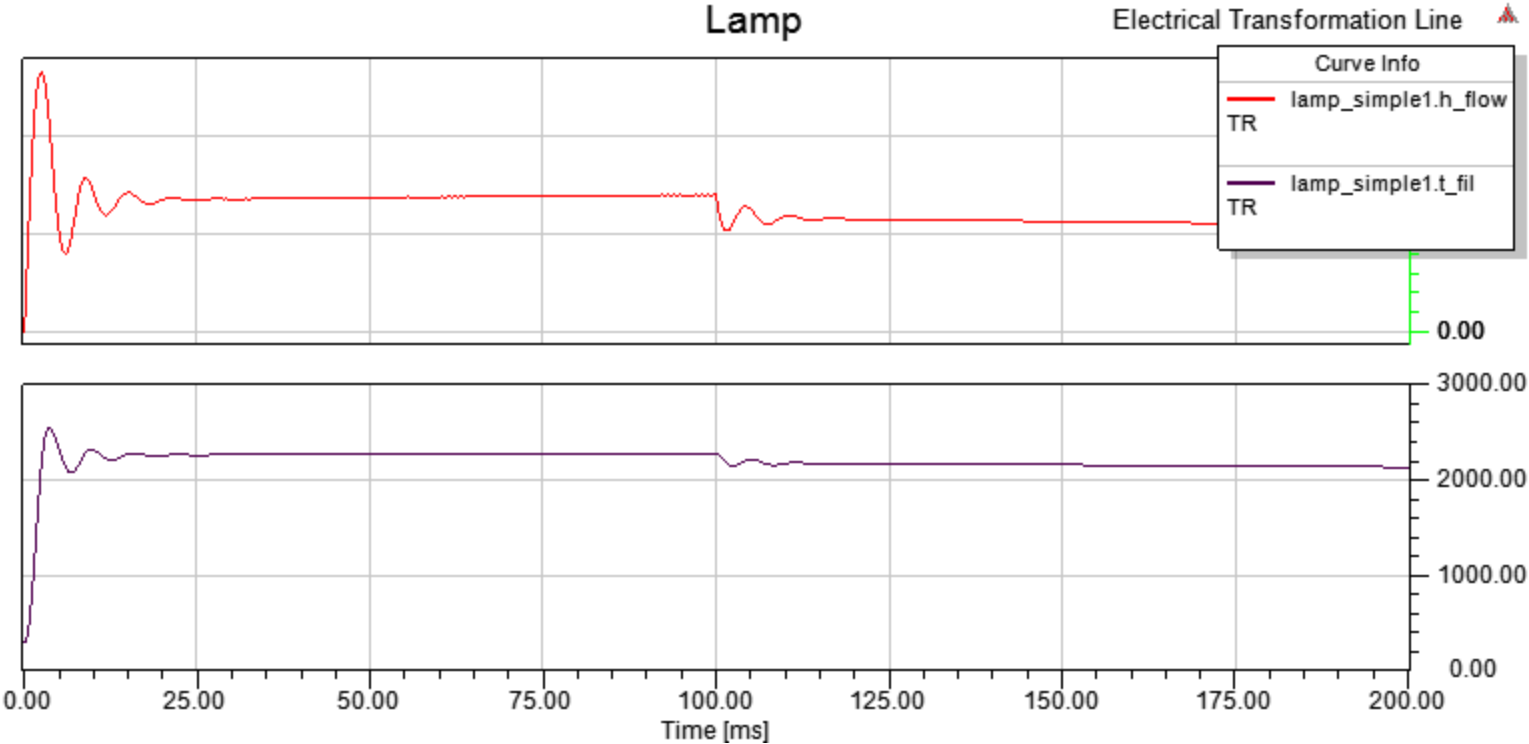


Figure 5: Lamp

[Top](#)

Generator Electrical Excitation Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Generator Electrical Excitation Example** schematic is shown in Figure 1.

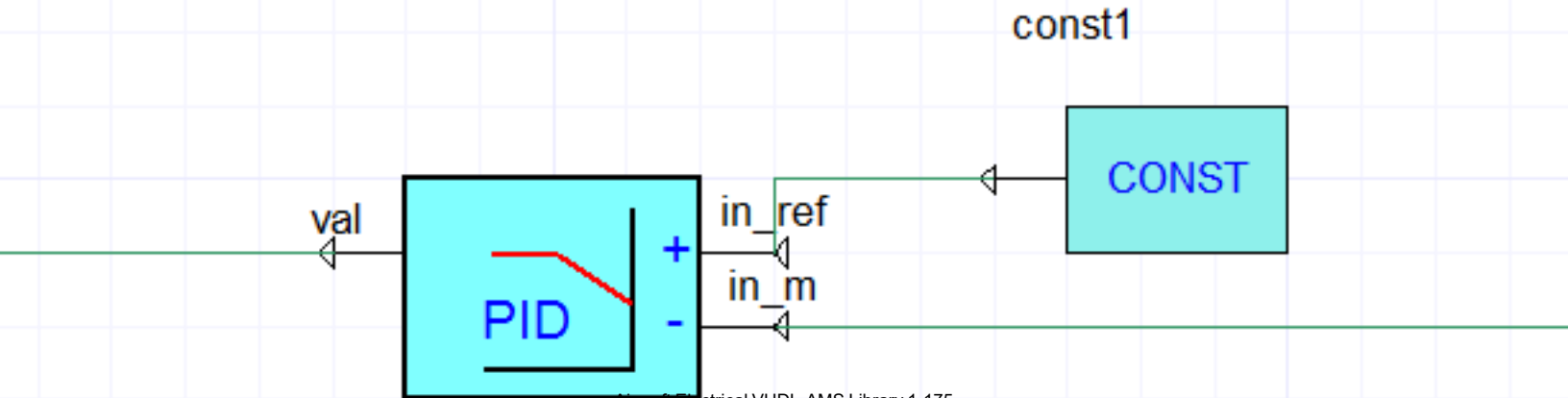
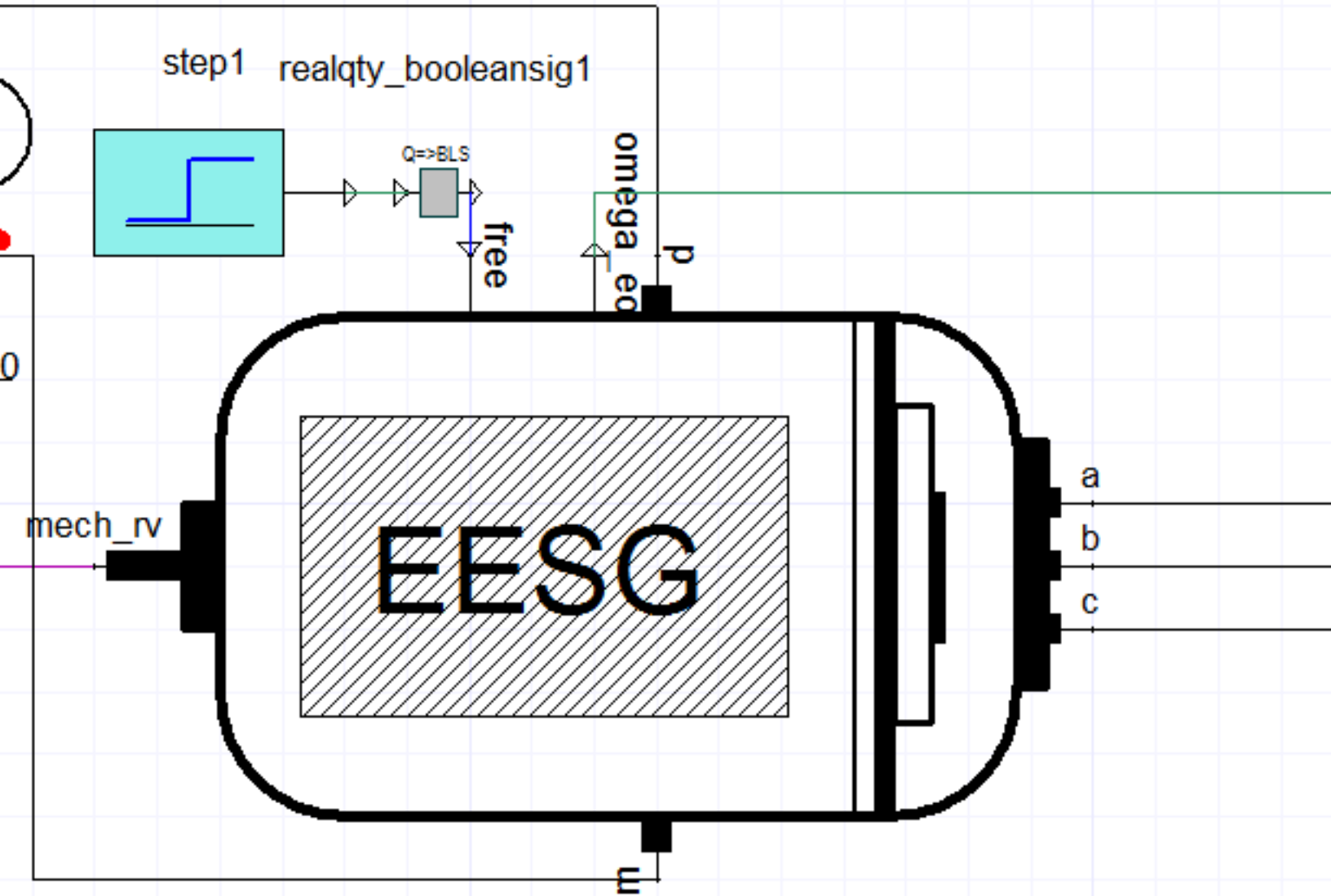


Figure 1. Generator Electrical Excitation Example Schematic

The system contains the pid_lim and generator_ee models from the Aircraft Electrical VHDL-AMS library.

There are two step changes in the system to show the system performance:

- The field voltage of the generator_ee is changed at 2.0 sec, from 10.0 V to 5.0 V.
- The free signal port value is changed at 4.0 sec, from False to True, which means the generator is shut down from 4.0 sec.

A PI control is used to make the generator electrical rotational speed follow the given reference of 100. The control input is the driving torque of the torque source.

[Top](#)

Simulation Results

The generator output currents are shown in Figure 2. The current amplitudes are changing following the field voltage changes, and it goes to zero after the generator is turned off (free signal becomes True).

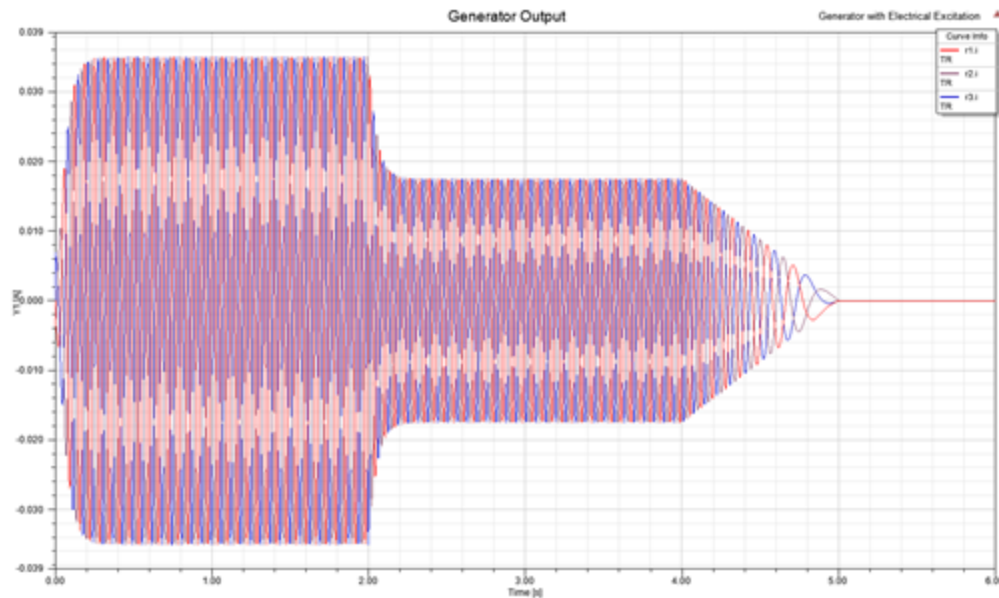


Figure 2. Generator Output Currents

The generator electrical rotational speed is shown in Figure 3. The omega_eo keeps the same when the field voltage changes, due to the PI control.

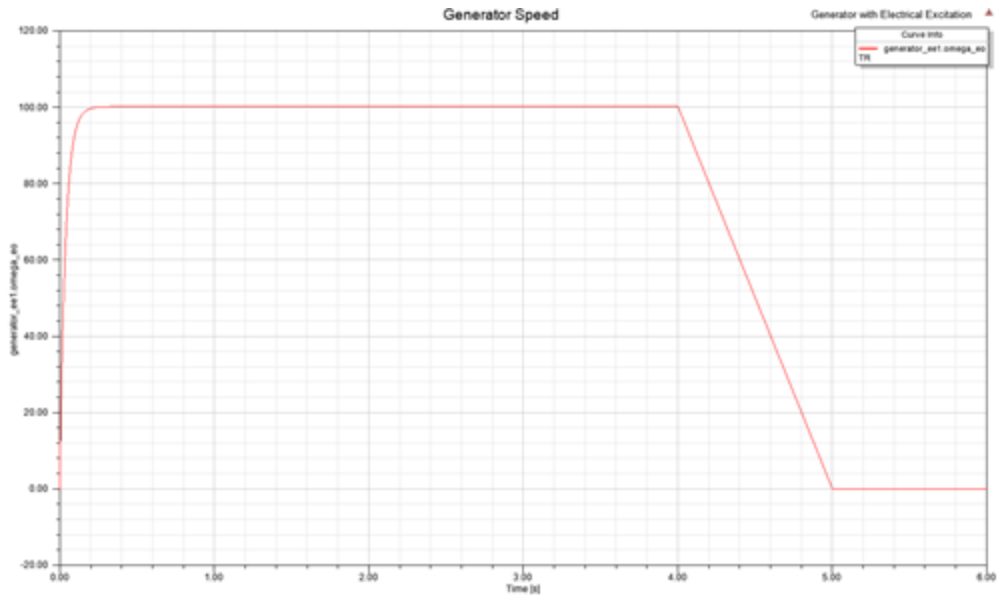


Figure 3: Generator Electrical Rational Speed

The power consumed by the generator is shown in Figure 4. It is negative because the generator is generating energy.

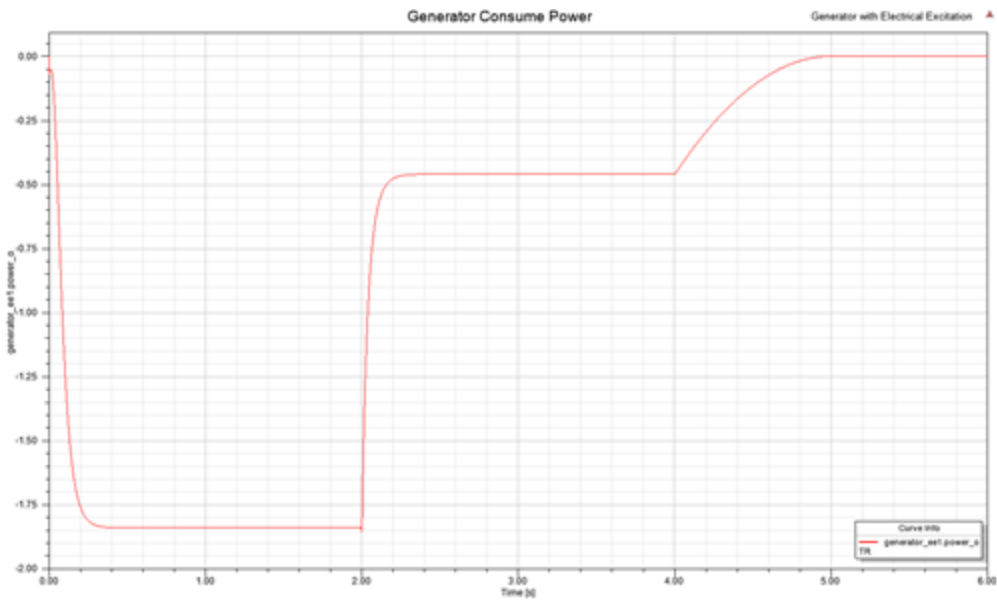


Figure 4: Generator Consume Power

[Top](#)

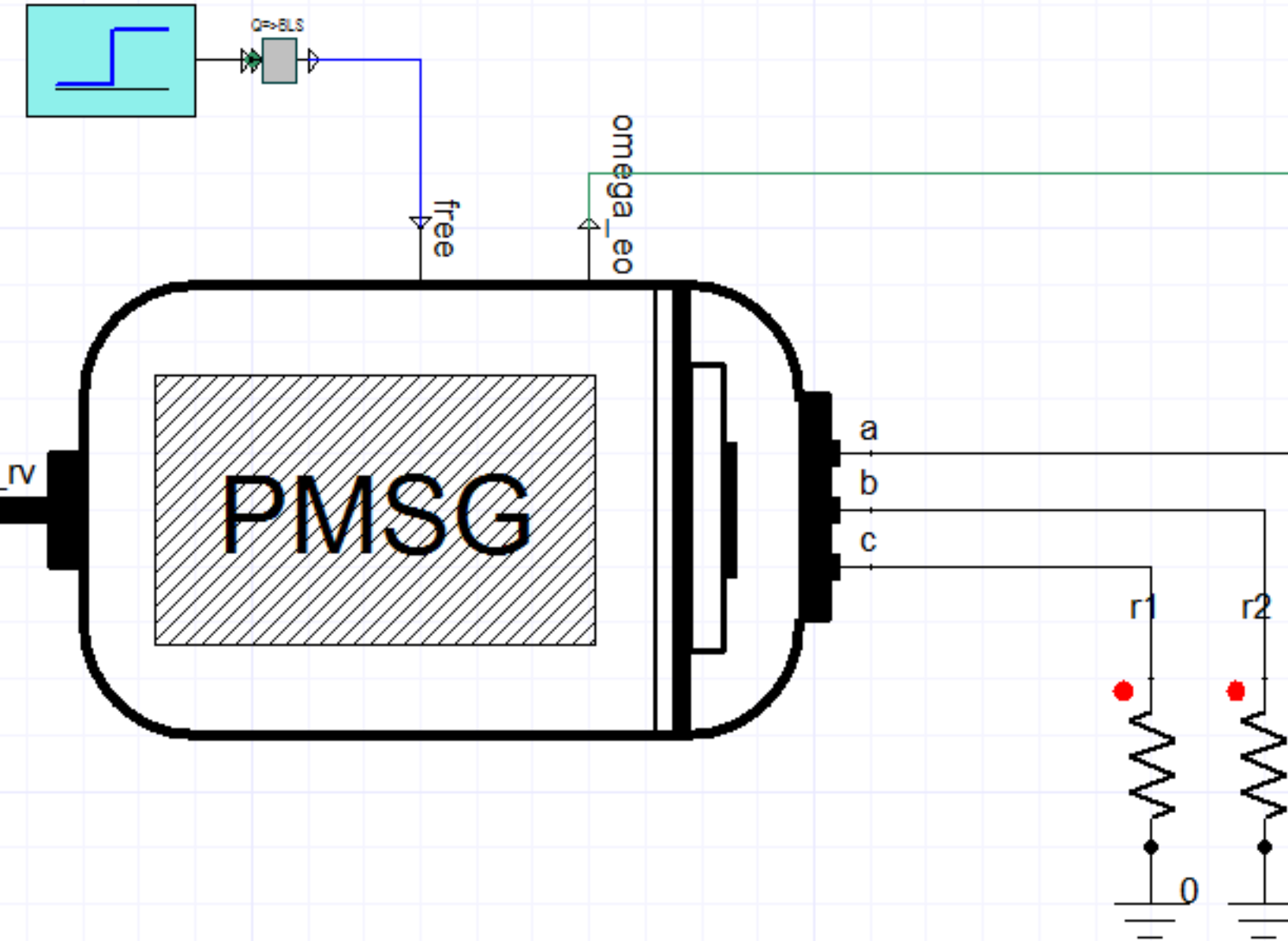
Generator Permanent Magnet Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

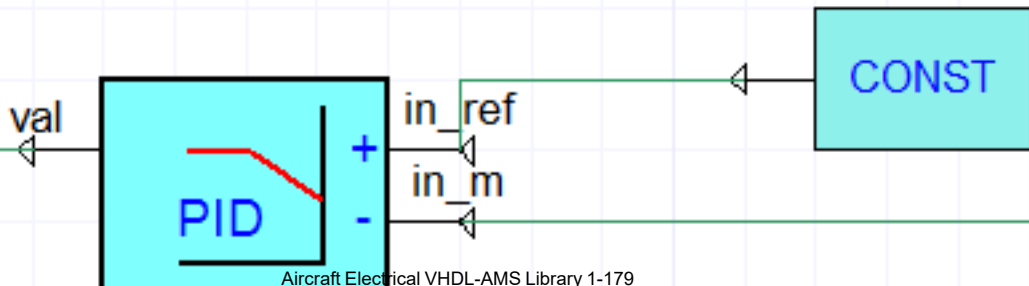
Description

The **Generator Permanent Magnet Example** schematic is shown in Figure 1.

step1 realqty_booleansig1



const1



Aircraft Electrical VHDL-AMS Library 1-179

Figure 1. Generator Permanent Magnet Example Schematic

The system contains the pid_lim and generator_pm models from the Aircraft Electrical VHDL-AMS library.

There is one step change in the system to show the system performance: the free signal port value is changed at 1.0 sec, from False to True, which means the generator is shut down from 1.0 sec.

A PI control is used to make the generator electrical rotational speed follow the given reference of 100. The control input is the driving torque of the torque source.

[Top](#)

Simulation Results

The generator output currents are shown in Figure 2. The current amplitudes are kept the same until 1.0 sec, and it goes to zero after the generator is turned off (free signal becomes True).

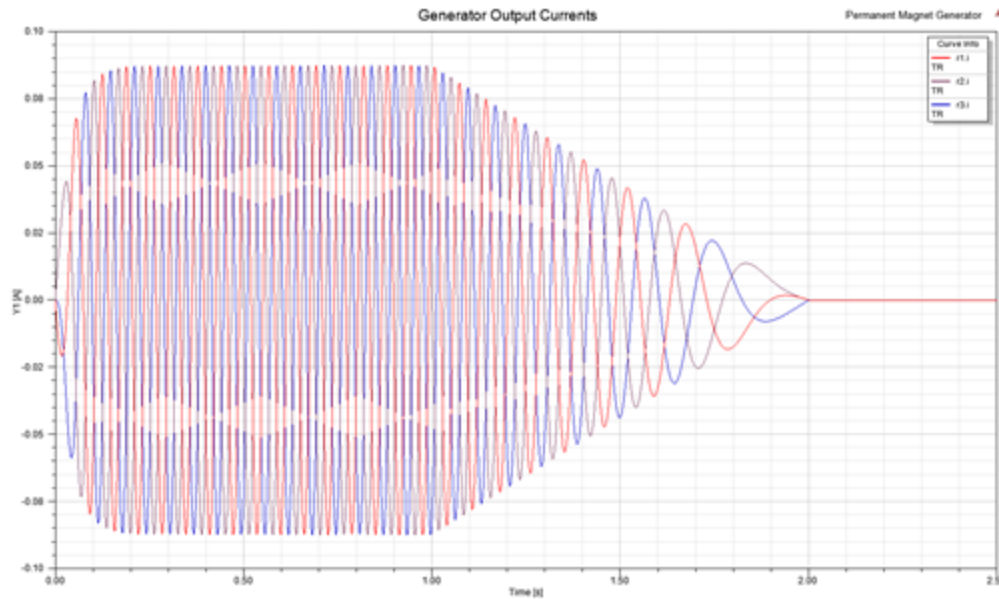


Figure 2. Generator Output Currents

The generator electrical rotational speed is shown in Figure 3. The omega_eo keeps the same until 1.0 sec, due to the PI control.

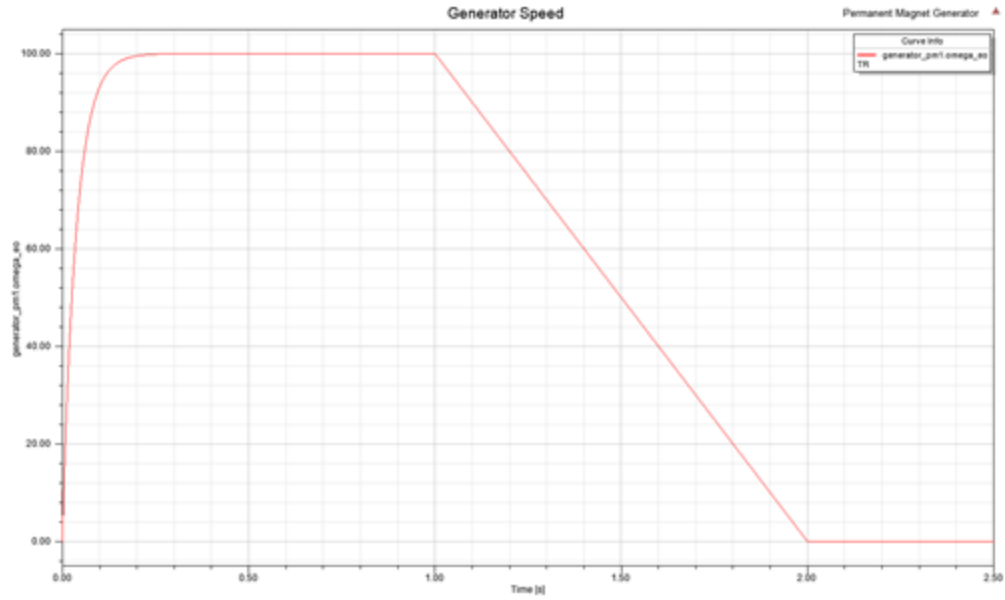


Figure 3: Generator Electrical Rational Speed

The power consumed by the generator is shown in Figure 4. It is negative because the generator is generating energy.

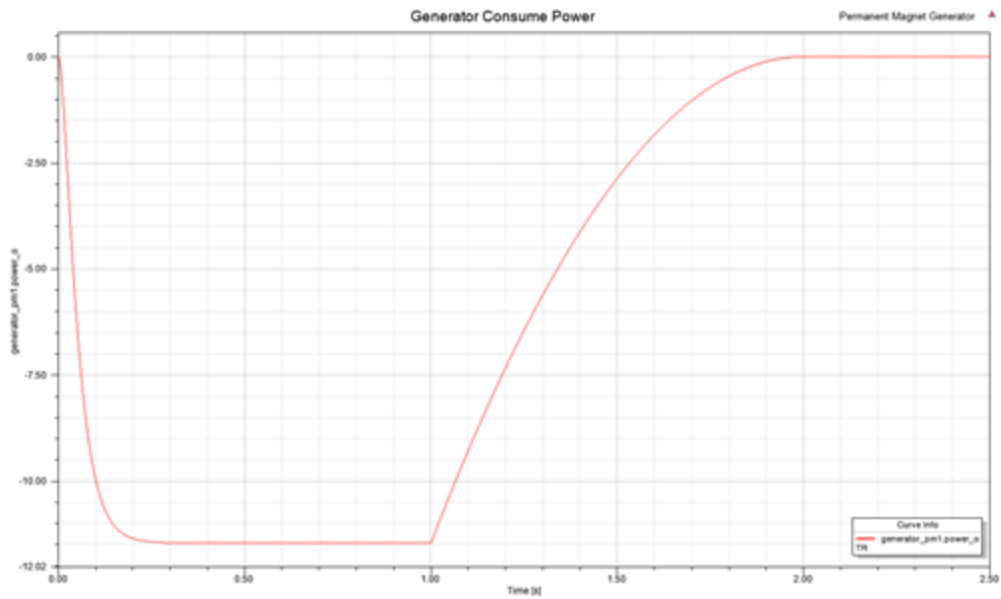


Figure 4: Generator Consume Power

[Top](#)

GT Engine Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **GT Engine Example** schematic is shown in Figure 1.

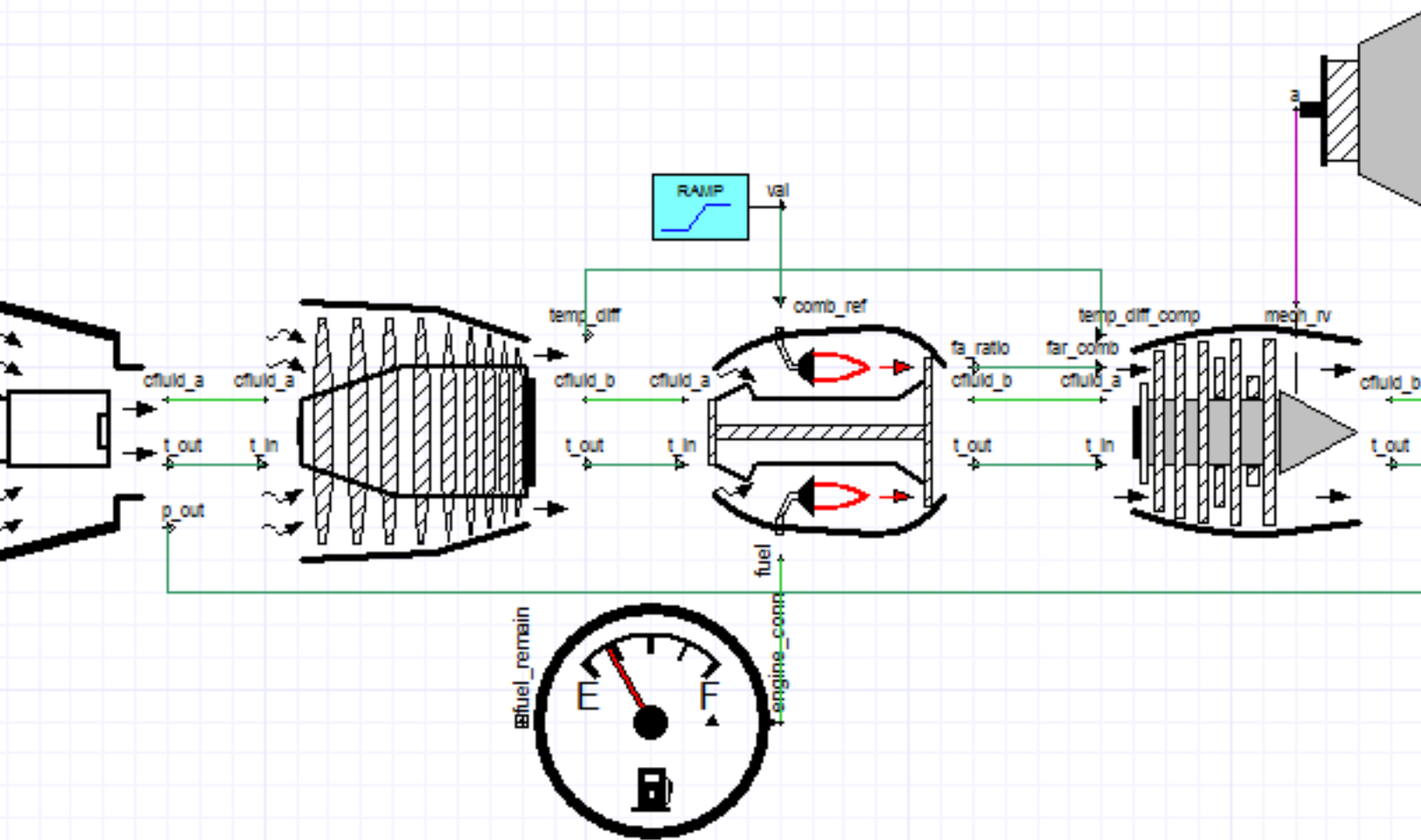


Figure 1. GT Engine Example Schematic

The system contains the ramp, inlet, compressor, combustor, fuel tank, turbine, shaft and nozzle models from the Aircraft Electrical VHDL-AMS library.

There are two ramp changes involved to show the system dynamics:

- The altitude input of the inlet changes at 1500.0 sec, from 5000 m to 20000 m, within 200.0 sec.
- The combustor input temperature reference changes at 500.0 sec, from 1000.0 K to 1500.0 K, within 500.0 sec.

[Top](#)

Simulation Results

The rotational speed of the mass model is shown in Figure 2.

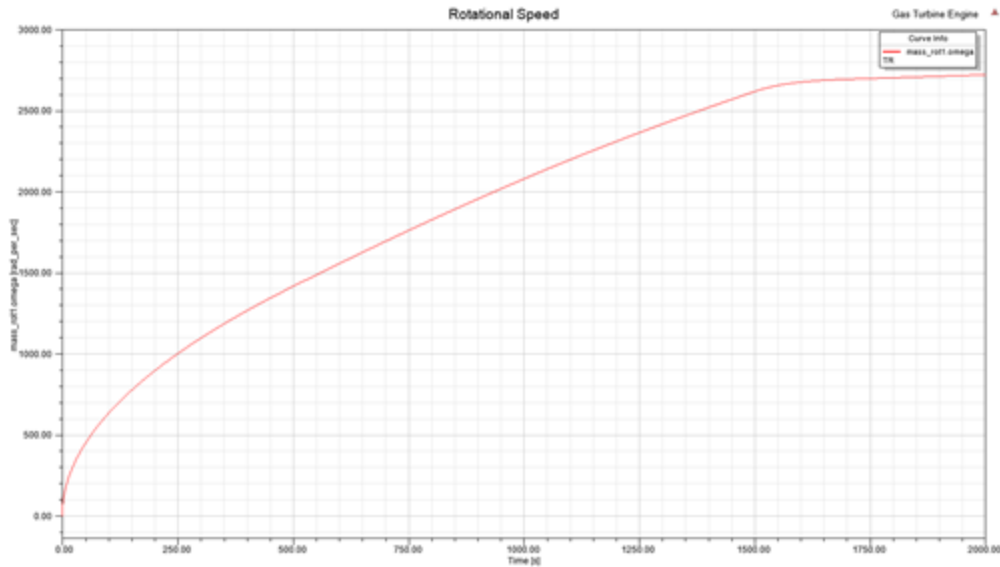


Figure 2. Mass Rotational Speed

The percentage of remind fuel in the tank and the fuel consumption rate are shown in Figure 3.

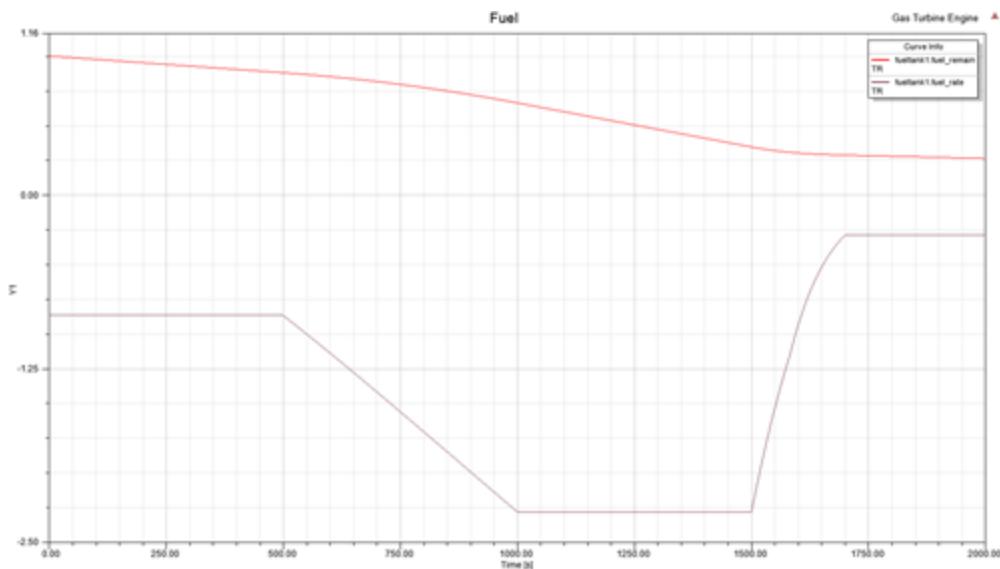


Figure 3: Fuel

The compressor power is shown in Figure 4.



Figure 4: Compressor Power

The fuel "air ratio in the combustor is shown in Figure 5.

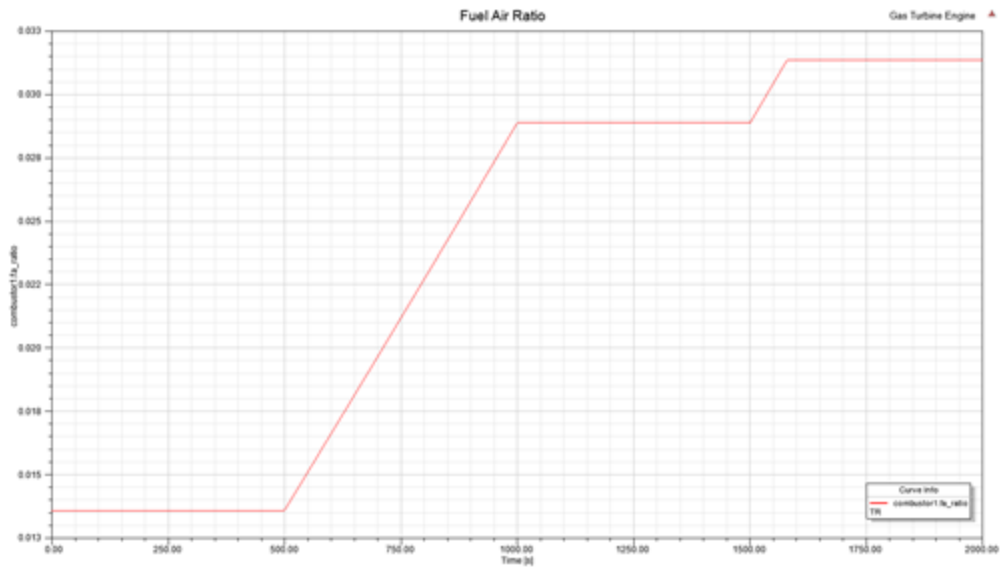


Figure 5: Fuel Air Ratio

The air velocity out of nozzle, mass flow rate out of nozzle and the thrust are shown in Figure 6.

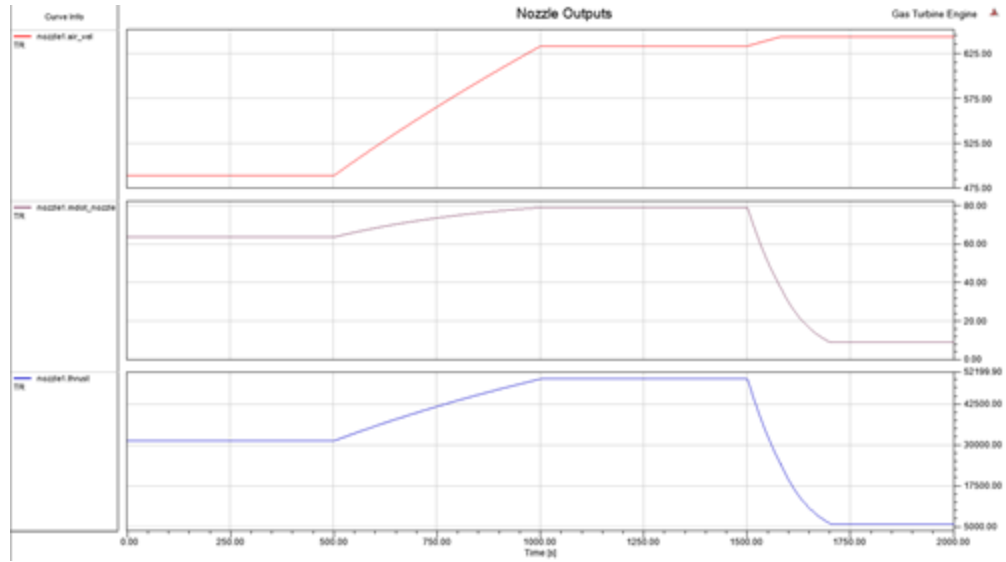


Figure 6: Nozzle Outputs

[Top](#)

GT Engine Generator Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **GT Engine Generator Example** schematic is shown in Figure 1.

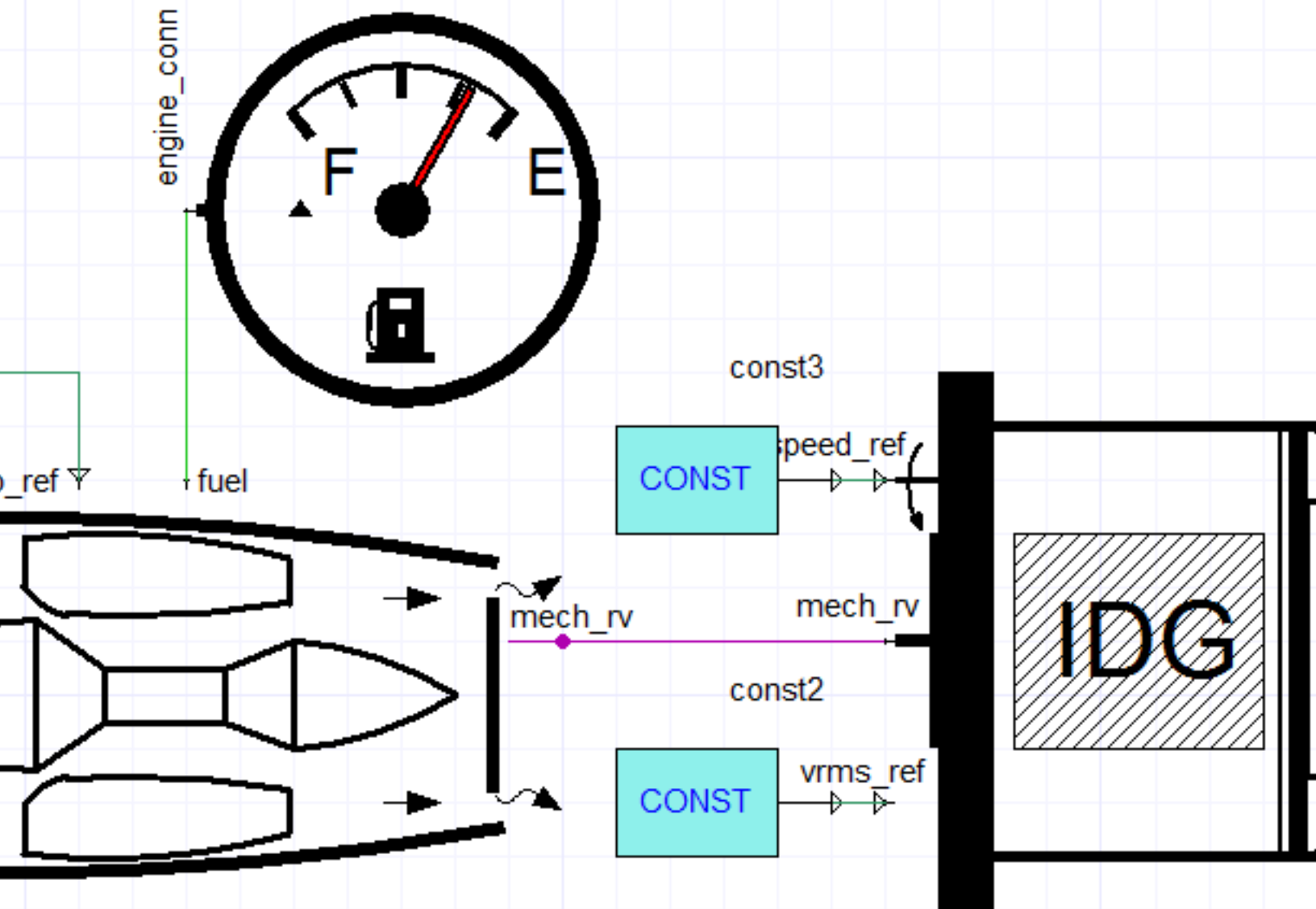


Figure 1. GT Engine Generator Example Schematic

The system contains the ramp, gt_engine, fueltank and the idg models from the Aircraft Electrical VHDL-AMS library.

There are two ramp changes are involved to show the system dynamics:

- The altitude input of the inlet changes at 0.5 sec, from 15000 m to 10000 m, within 0.2 sec.
- The combustor input temperature reference changes at 0.1 sec, from 1000.0 K to 2500.0 K, within 0.2 sec.

The vrms_ref input to the integrated drive generator (IDG) is 20.0.

[Top](#)

Simulation Results

The generator output voltage RMS is shown in Figure 2.

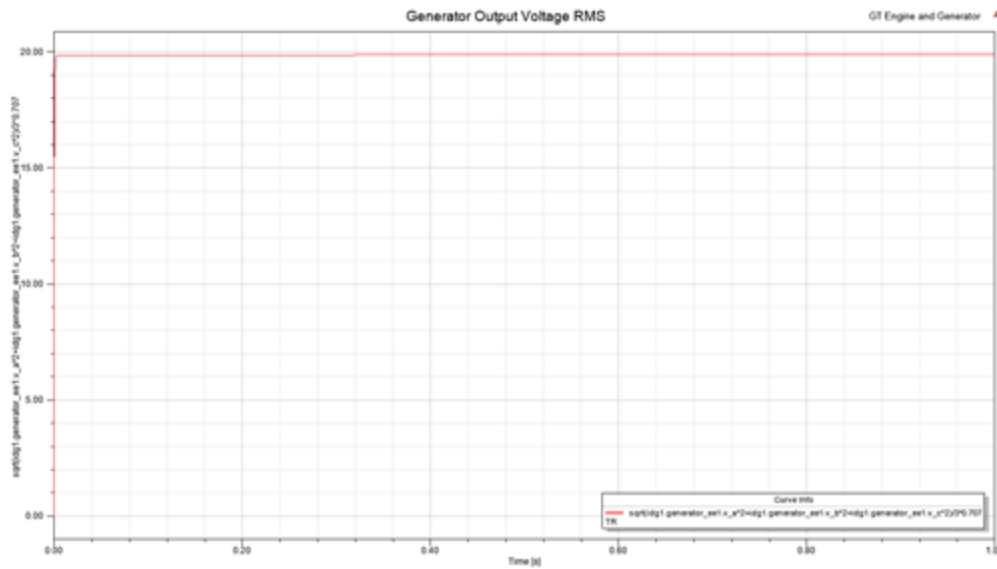


Figure 2. Generator Output Voltage RMS

The percentage of remind fuel in the tank and the fuel consumption rate are shown in Figure 3.

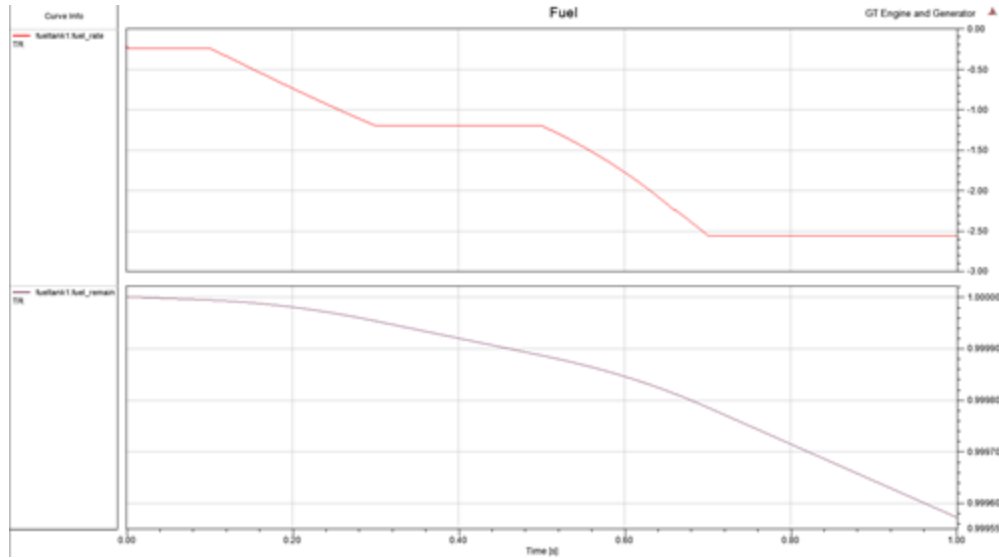


Figure 3: Fuel

The air velocity out of nozzle, mass flow rate out of nozzle and the thrust are shown in Figure 4.

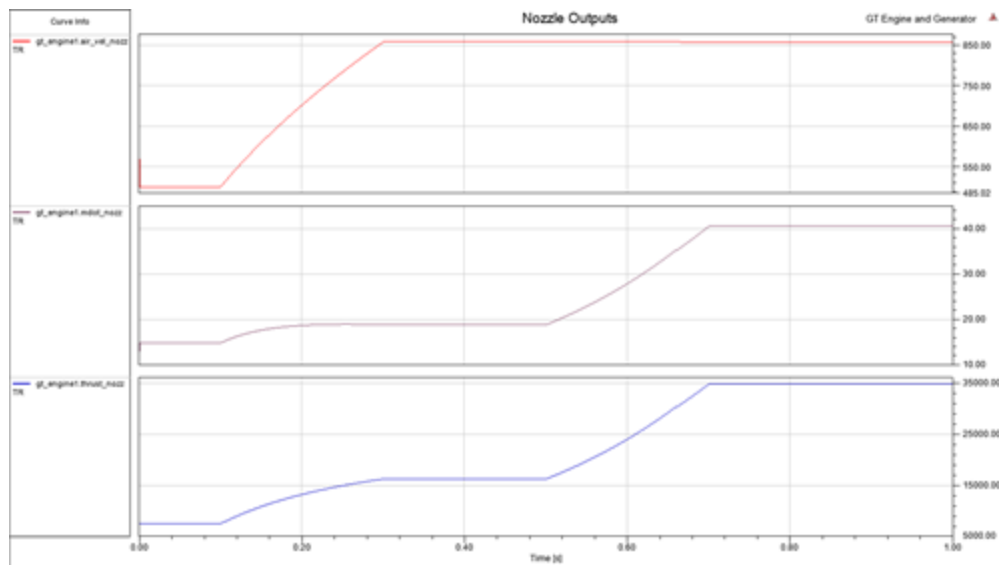


Figure 4: Nozzle Outputs

Top

Heater Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Heater Example** schematic is shown in Figure 1.

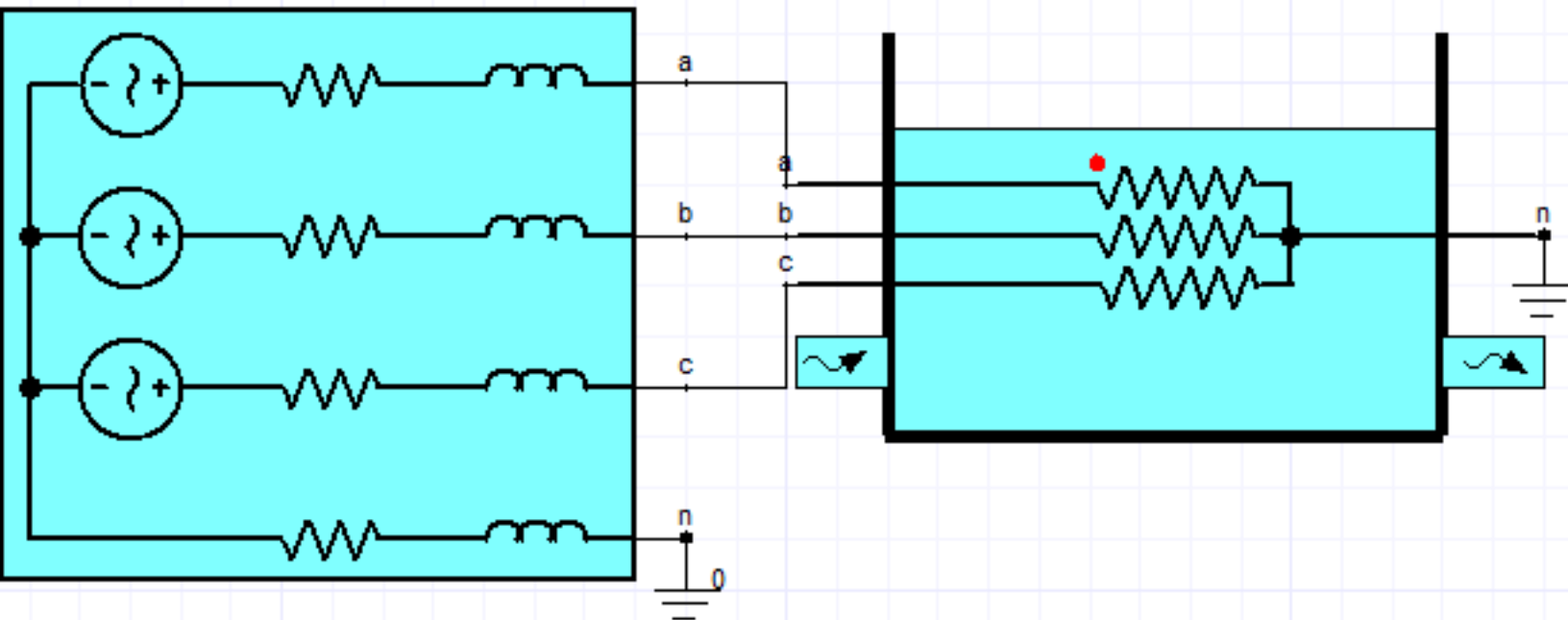
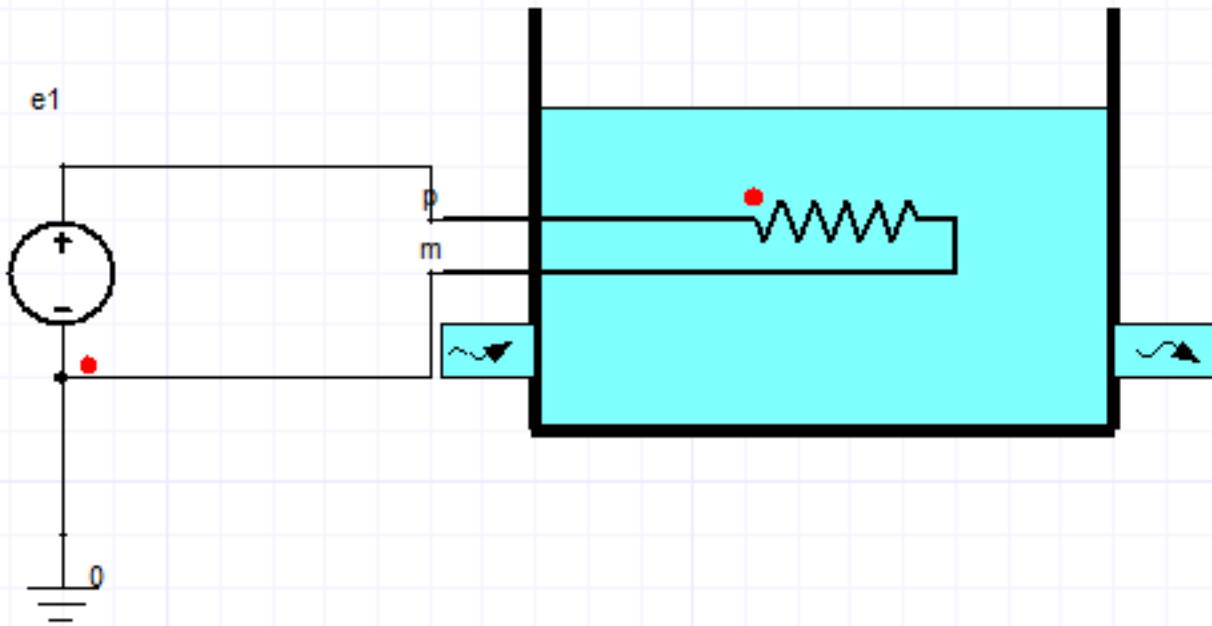


Figure 1. Heater Example Schematic

The example contains the e_ac_3phase, heater_dc and heater_3phase models from the Aircraft Electrical VHDL-AMS library.

In the example, the heaters are heated by voltage sources. The $t_set = 50$ degree C and $t_deadband = 5$ degree C are set for the heaters, which means the heater will start to heat the water tank when tank temperature is lower than $t_set - t_deadband = 45$ degree C, and the heater will stop heating the water tank when the tank temperature reaches 55 degree C.

[Top](#)

Simulation Results

The heater DC performance is shown in Figure 2.

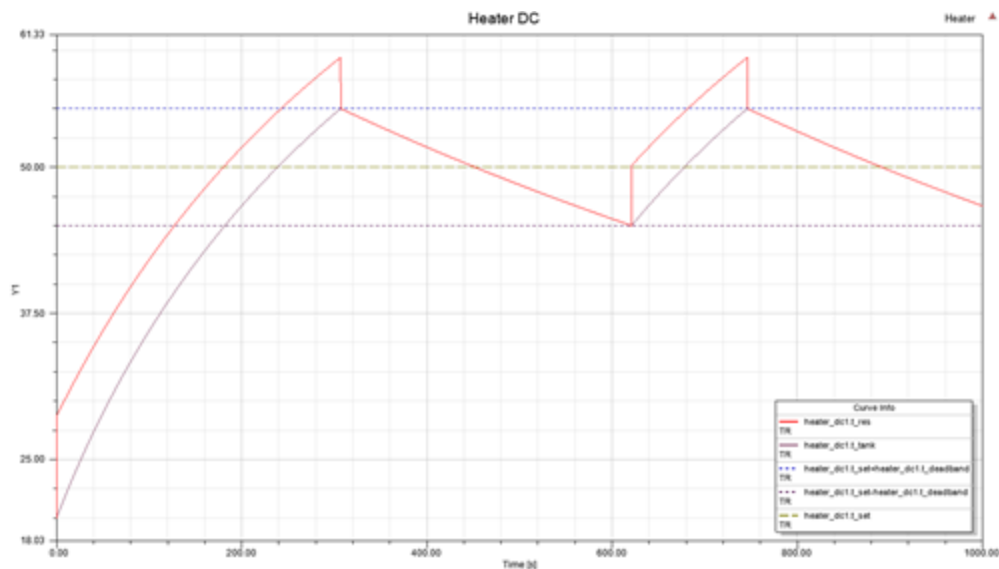


Figure 2. Heater DC

The heater 3phase performance is shown in Figure 3.

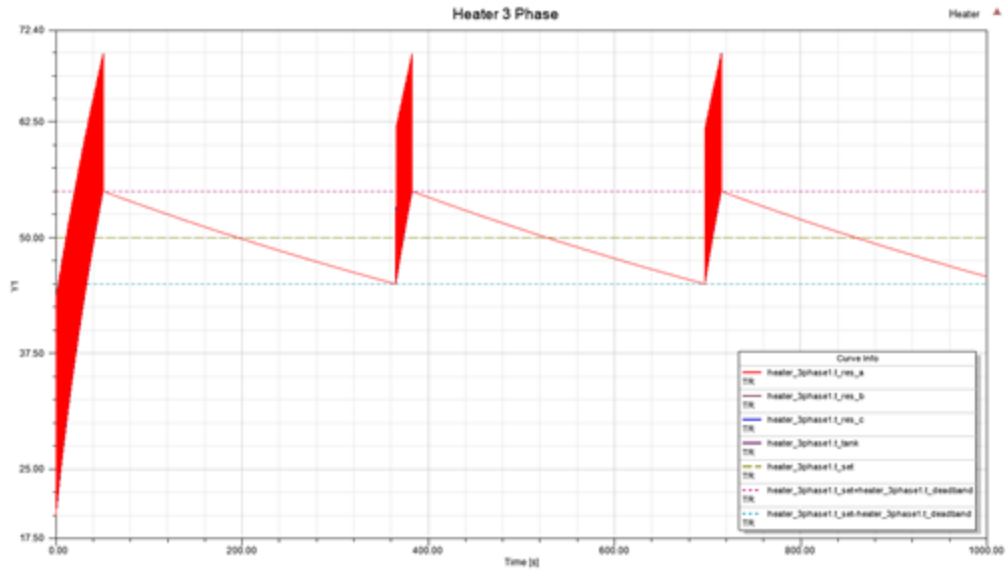


Figure 3: Heater 3Phase

Top

Integrated Drive Generator Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Integrated Drive Generator Example** schematic is shown in Figure 1.

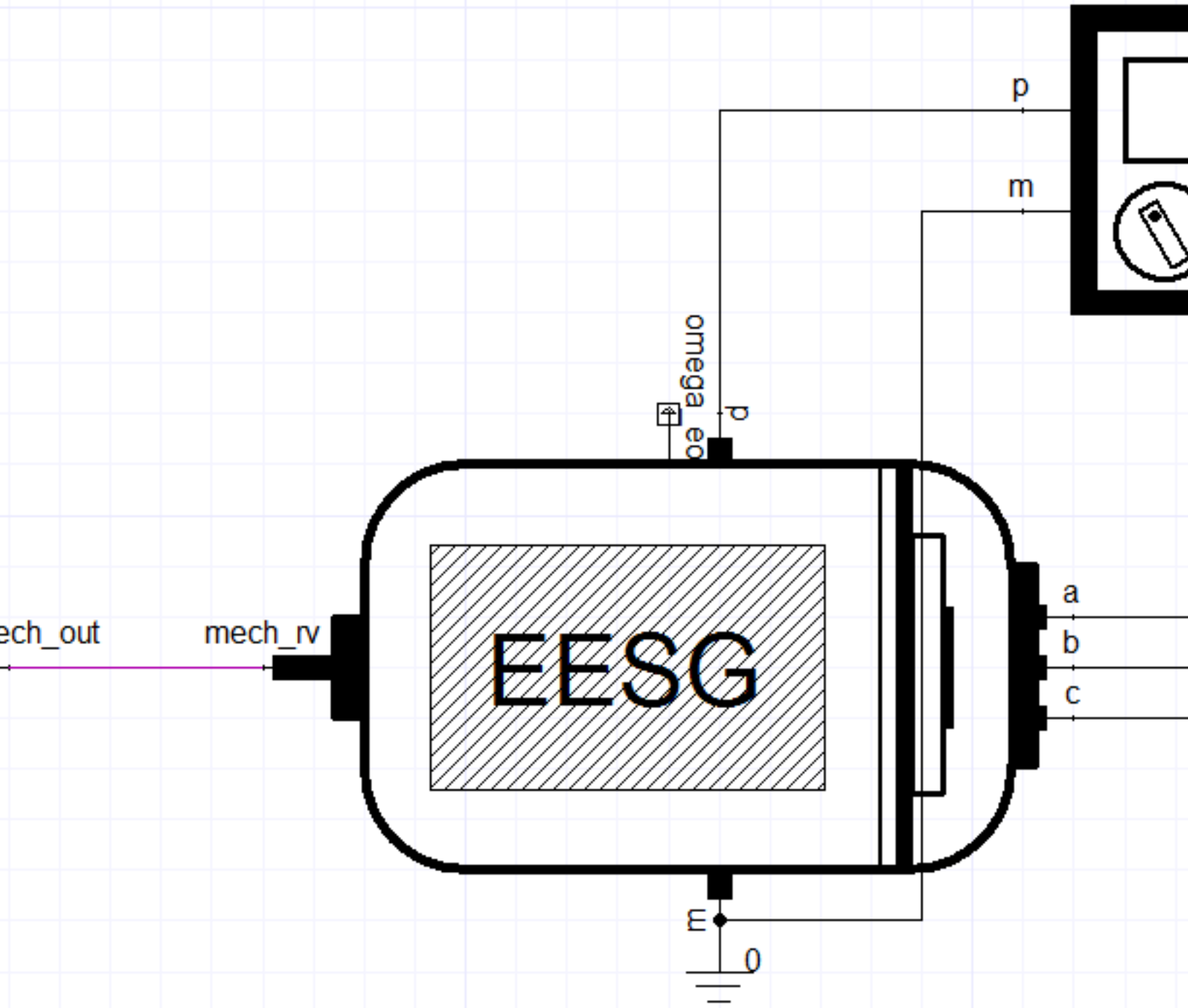


Figure 1. Integrated Drive Generator Example Schematic

The system contains the `csd`, `gcu`, and `generator_ee` models from the Aircraft Electrical VHDL-AMS library.

The speed reference input of the constant speed drive (`csd`) is set to 12000 rpm and the `csd` is driven by a constant torque source of 100 Nm.

The `vrms_ref` input to the integrated drive generator (IDG) is 1000.0.

[Top](#)

Simulation Results

The generator output voltages are shown in Figure 2.

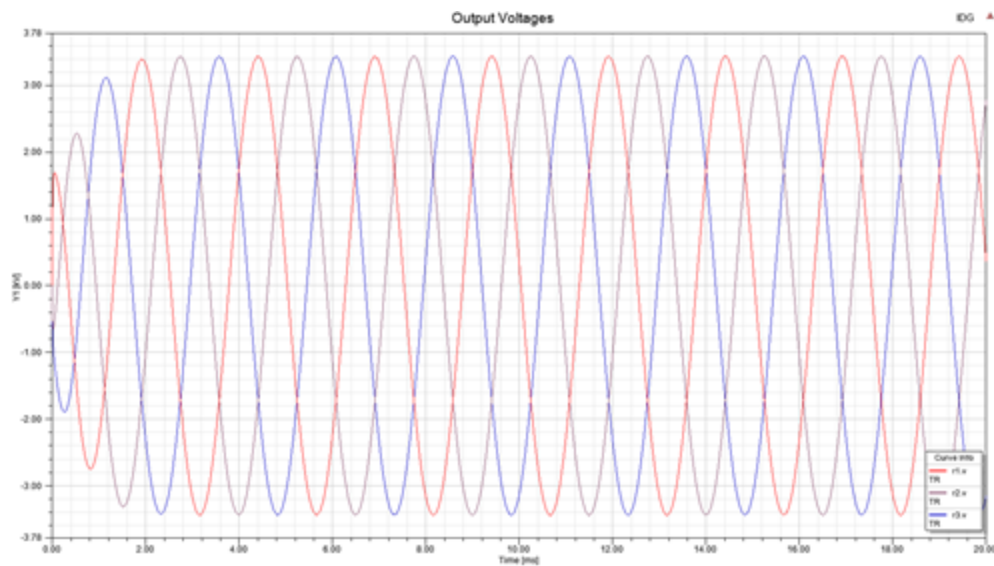


Figure 2. Output Voltages

The generator output voltage RMS is shown in Figure 3.

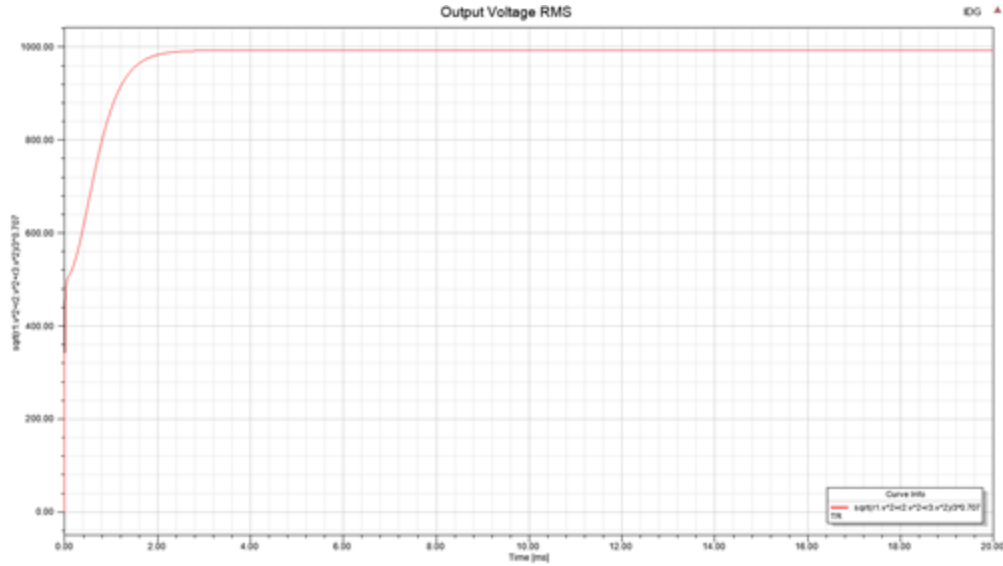


Figure 3. Output Voltage RMS

The control field voltage of the generator control unit (GCU) is shown in Figure 4.

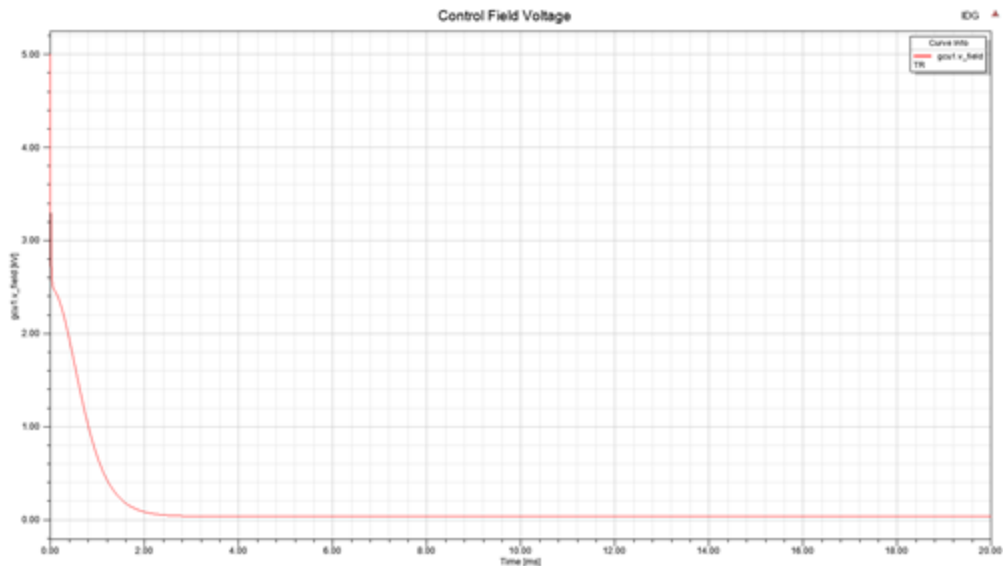


Figure 4. Control Field Voltage

[Top](#)

Lowpass Filter Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Lowpass Filter Example** schematic is shown in Figure 1.

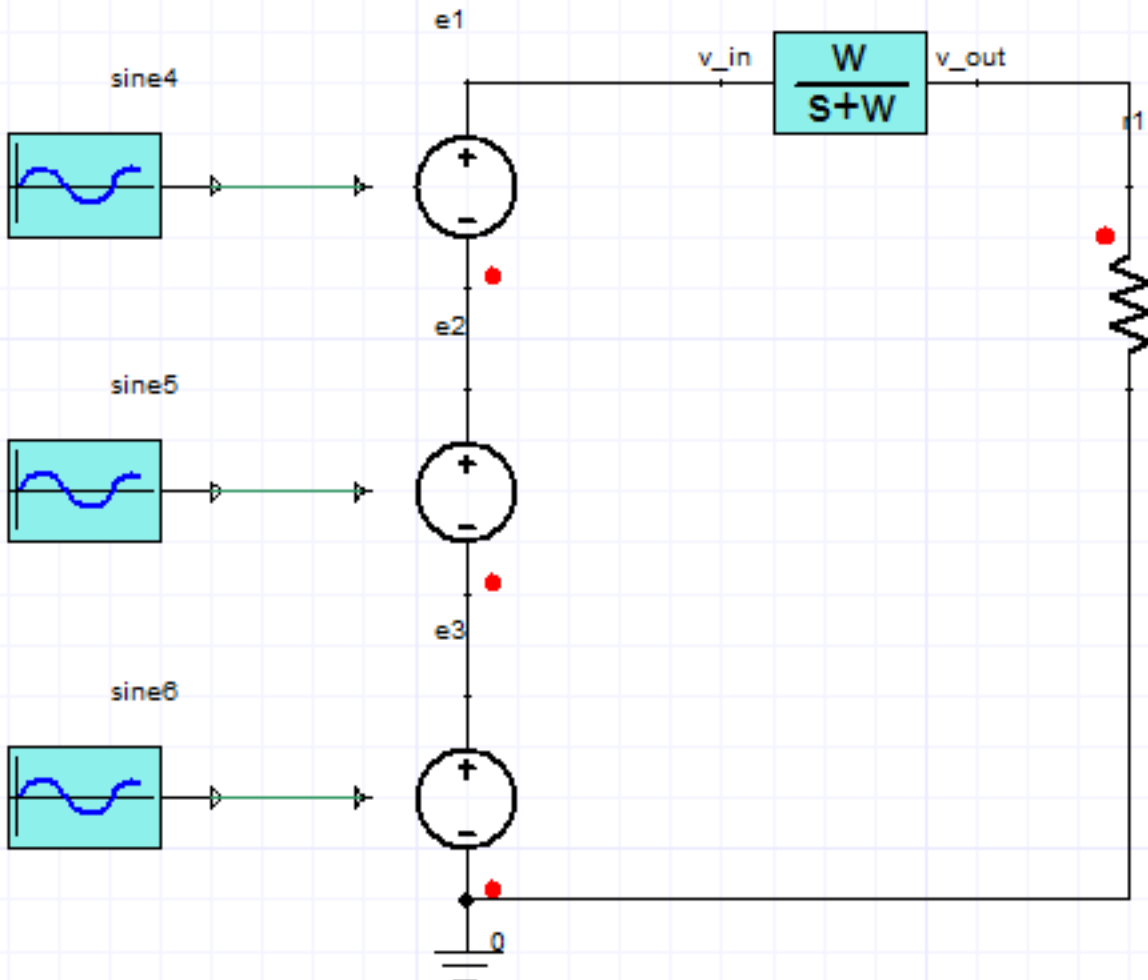
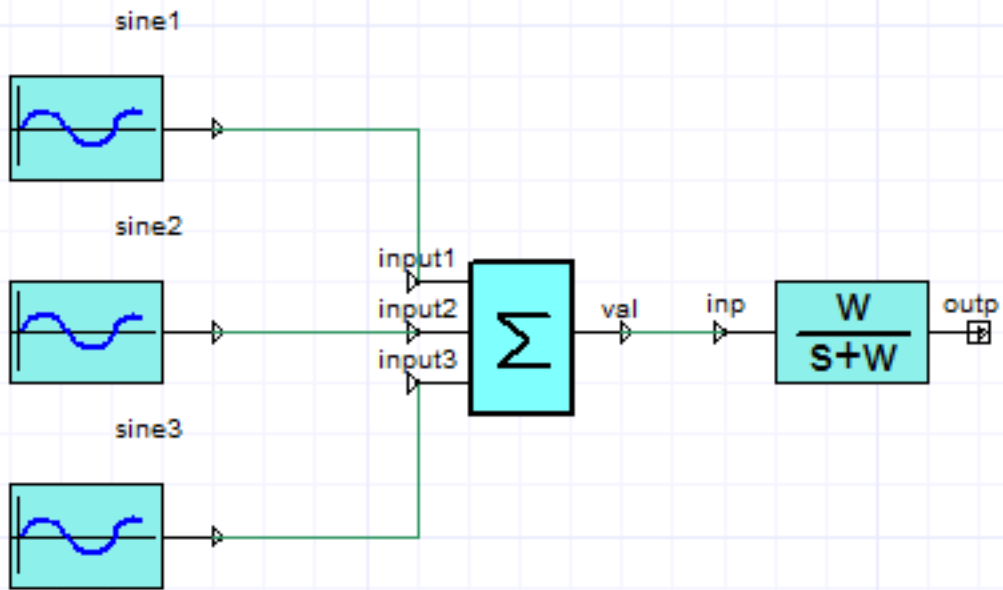


Figure 1. Lowpass Filter Example Schematic

The system contains the sum3, lowpass_filter and lowpass_filter_elec models from the Aircraft Electrical VHDL-AMS library.

Multi-frequency AC signals are used to test the performance of first order low pass filters.

[Top](#)

Simulation Results

The input and output of lowpass_filter model is shown in Figure 2.

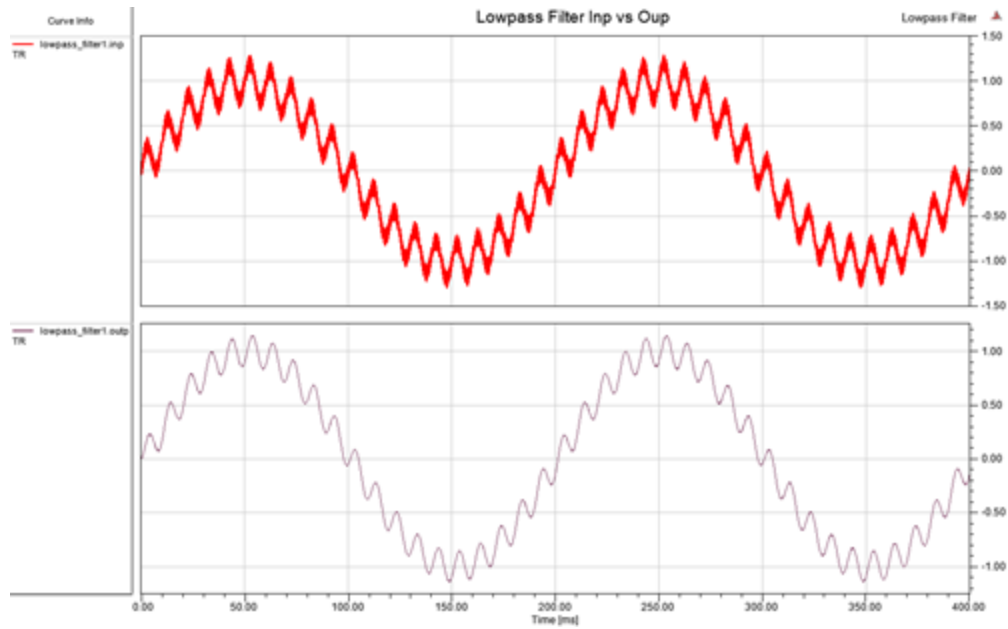


Figure 2. Lowpass Filter Inp vs Oup

The input and output voltages of lowpass_filter_elec are shown in Figure 3.

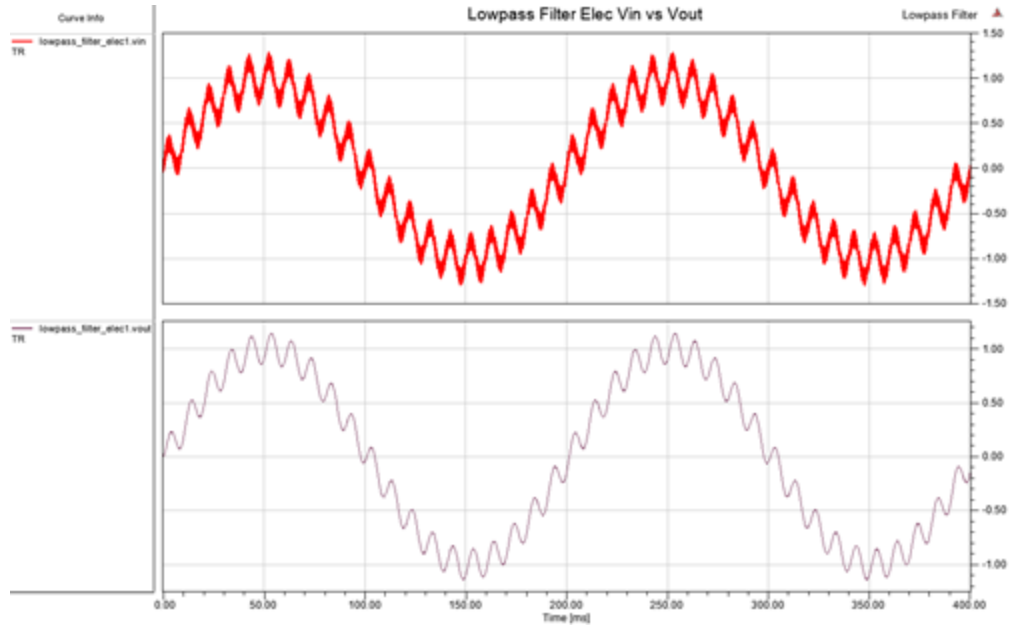


Figure 3. Lowpass Filter Elec Vin vs Vout

[Top](#)

Motor DC Control Example

Library: Aircraft Electrical
VHDL-AMS

Modeling Language:
VHDL-AMS

Version Number: Twin Builder
2024.2

Description

The **Motor DC Control Example** schematic is shown in Figure 1.

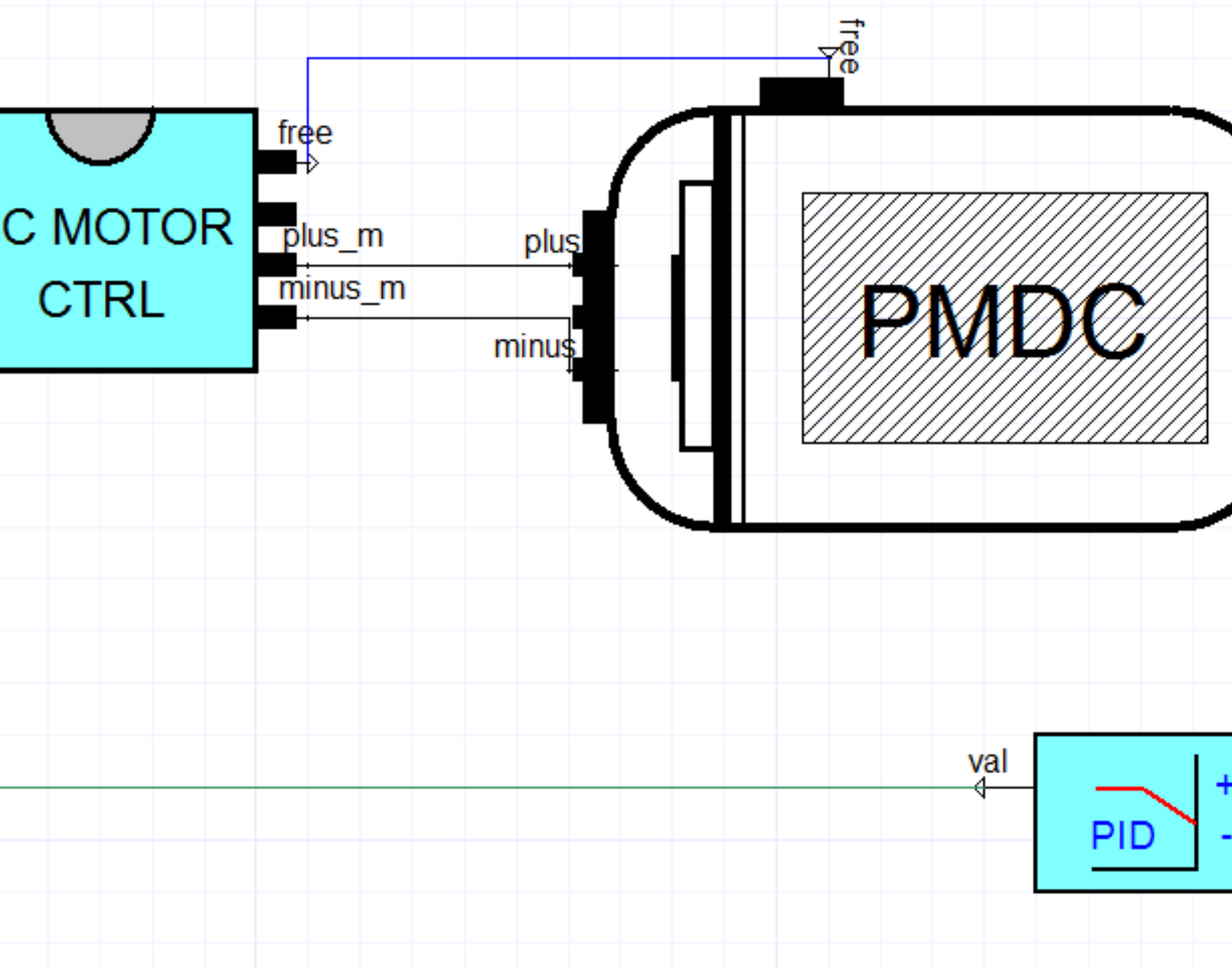


Figure 1. Motor DC Control Example Schematic

The example contains the ramp, c_motor_dcdc, motor_dc and pid_lim models from the Aircraft Electrical VHDL-AMS library.

A PI control is used to keep the rotational speed of the PMDC to track the given reference. The rotational speed reference takes a ramp change starts at 3.0 sec, decrease from 100 to 50 rad/sec, within 0.1 sec.

The stop signal input to the motor controller is kept as False during the simulation.

[Top](#)

Simulation Results

The PMDC output torque and the torque demand input to the motor controller are shown in Figure 2.

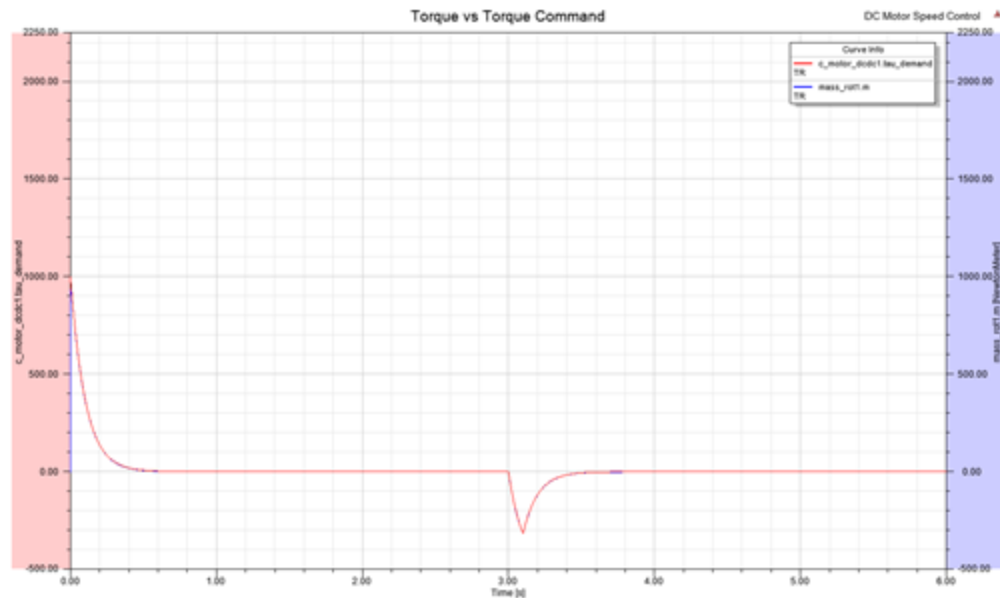


Figure 2. PMDC Output Torque and the Torque Demand Input to the Motor Controller

The rotational speed reference and the motor rotational speed are shown in Figure 3.

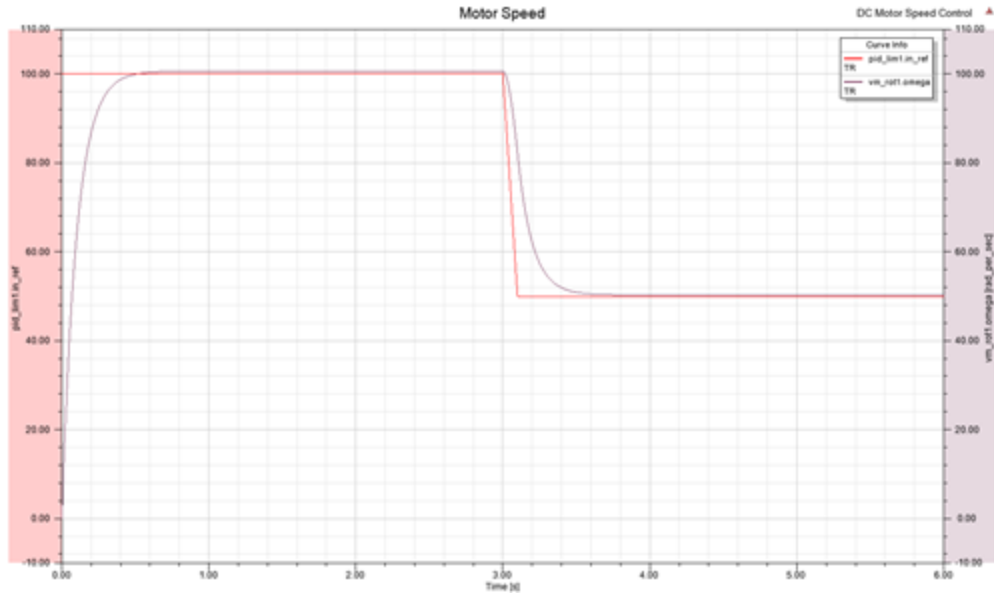


Figure 3. Motor Speed

[Top](#)

Motor PM Control Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Motor PM Control Example** schematic is shown in Figure 1.

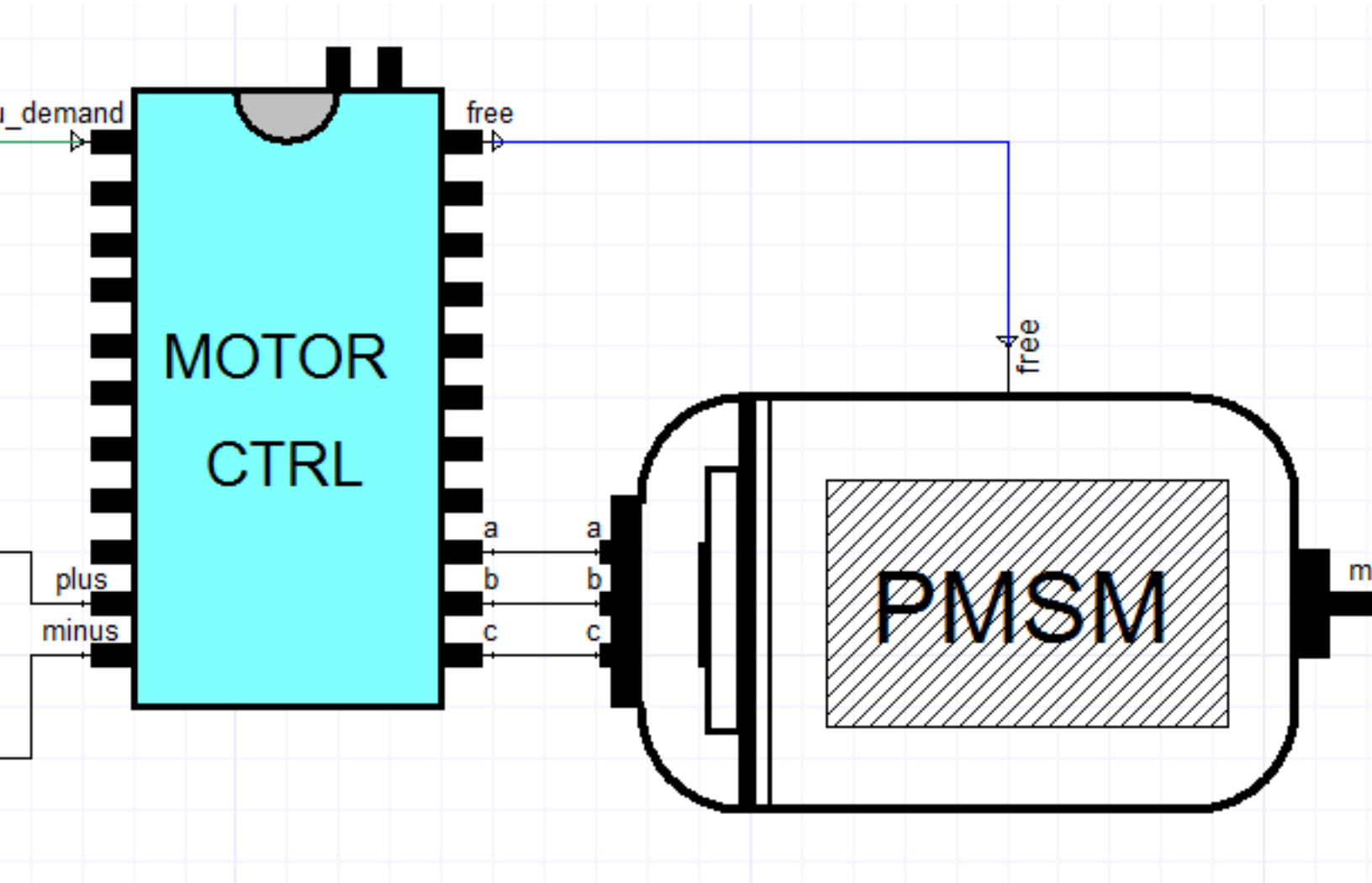


Figure 1. Motor PM Control Example Schematic

The example contains the ramp, c_motor_dcac, motor_pm and fan models from the Aircraft Electrical VHDL-AMS library.

Two ramp changes are used to demonstrate the performance of this motor control example:

- The DC voltage source takes a ramp change at 1.0 sec, from 330 V to 350 V, within 0.1 sec.
- The torque demand input to the motor controller (c_motor_dcac) takes a ramp change at 2.0 sec, from 100 Nm to 200 Nm, within 0.1 sec.

The stop signal input to the motor controller is kept as False during the simulation.

[Top](#)

Simulation Results

The PMSM output torque and the torque demand input to the motor controller are shown in Figure 2.

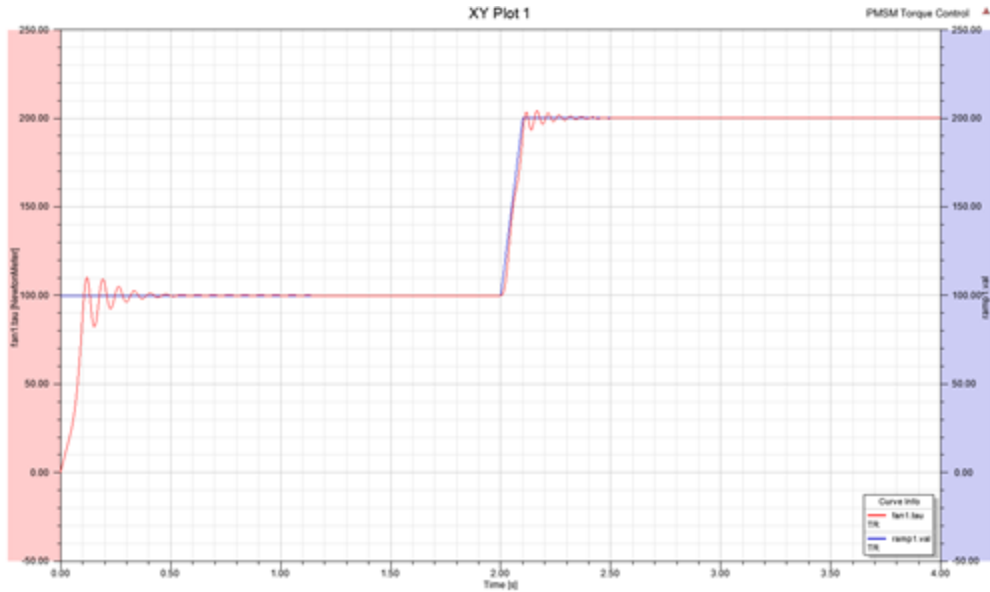


Figure 2. PMSM Output Torque and the Torque Demand Input to the Motor Controller

The fan dynamics are shown in Figure 3.

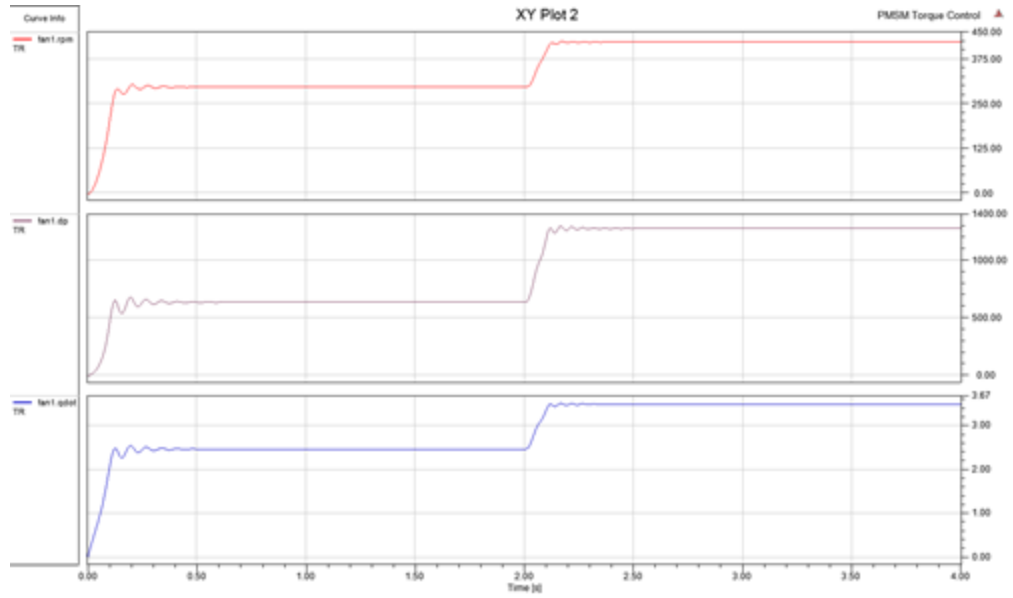


Figure 3: Fan Dynamics

[Top](#)

Motor PM Speed Control Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Motor PM Speed Control Example** schematic is shown in Figure 1.

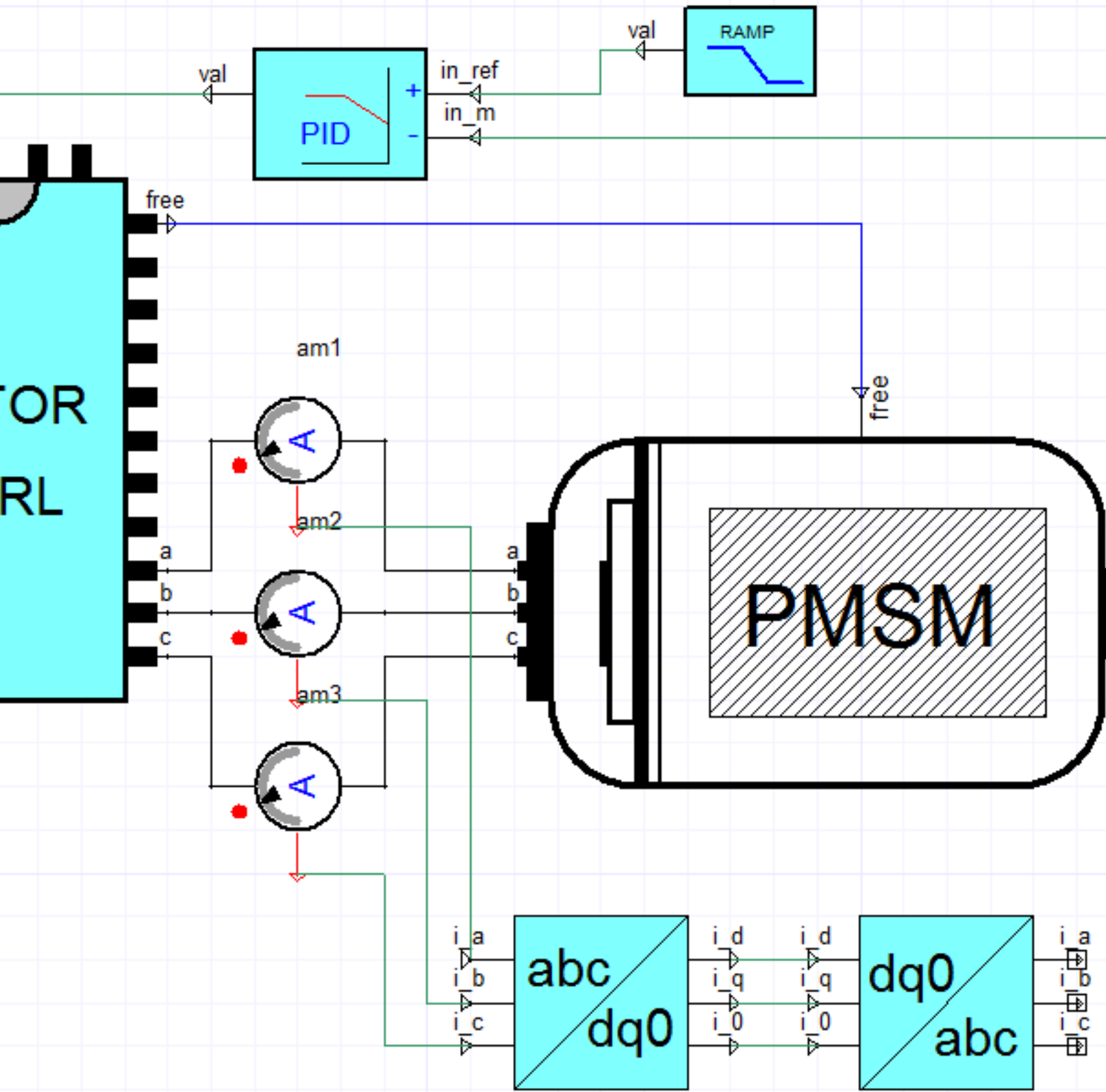


Figure 1. Motor PM Speed Control Example Schematic

The system contains the `c_motor_dcac`, `pid_lim`, `motor_pm`, `ramp`, `abc2dq0` and `dq02abc` models from the Aircraft Electrical VHDL-AMS library.

A PI control is used to make the motor rotational speed track the input reference. The ramp change of the speed reference input starts at 5 sec, it increases from 10 to 20 within 0.1 sec.

The demonstration of the usage of `abc2dq0` and `dq02abc` blocks is also included.

[Top](#)

Simulation Results

The motor speed and reference is shown in Figure 2.

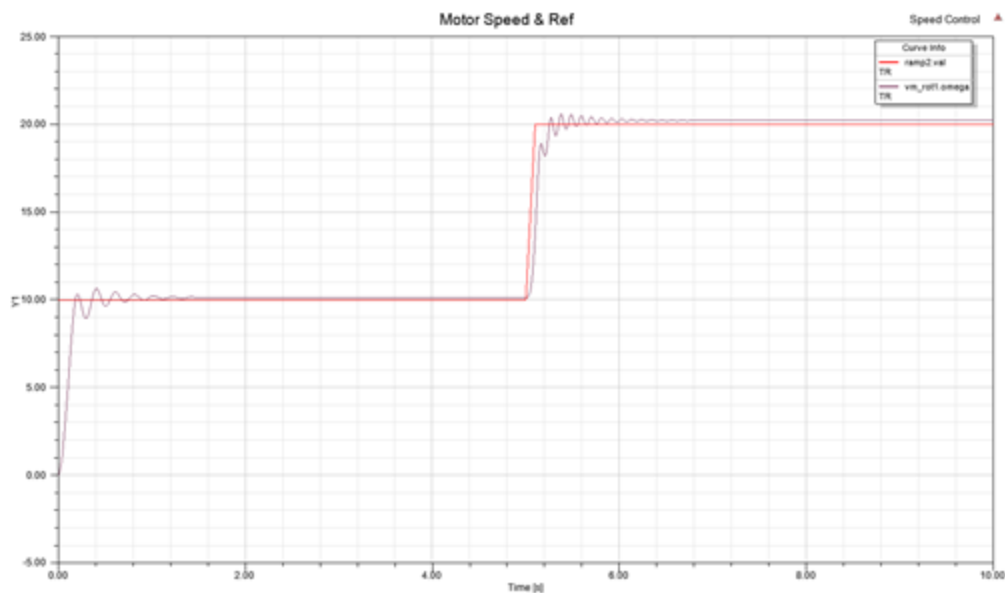


Figure 2. Motor Speed & Ref

The controller output torque demand and the mass torque are shown in Figure 3.

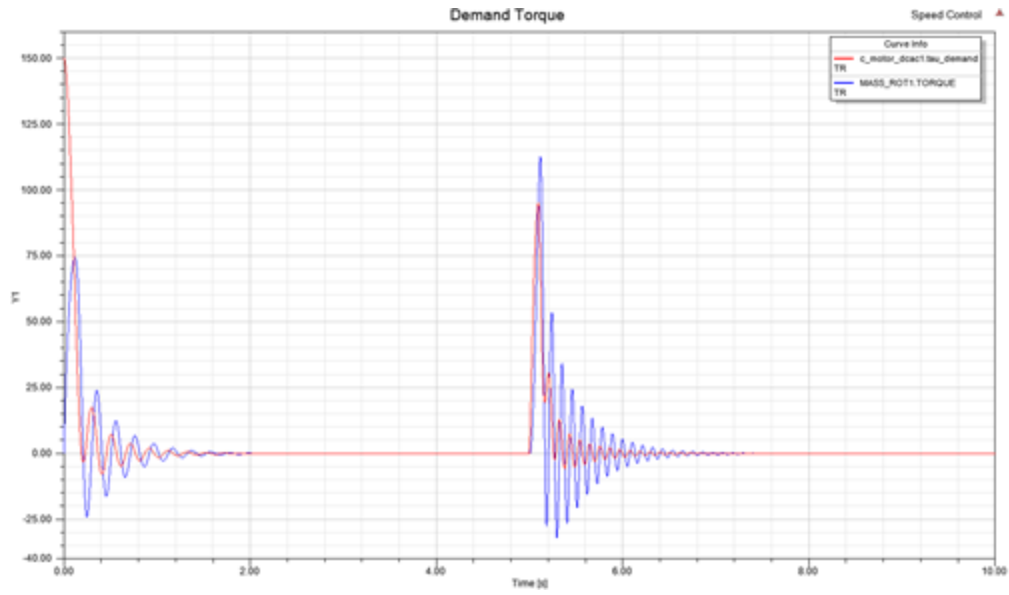


Figure 3: Demand Torque

The results for the abc2dq0 and dq02abc blocks are shown in Figure 4 and Figure 5.

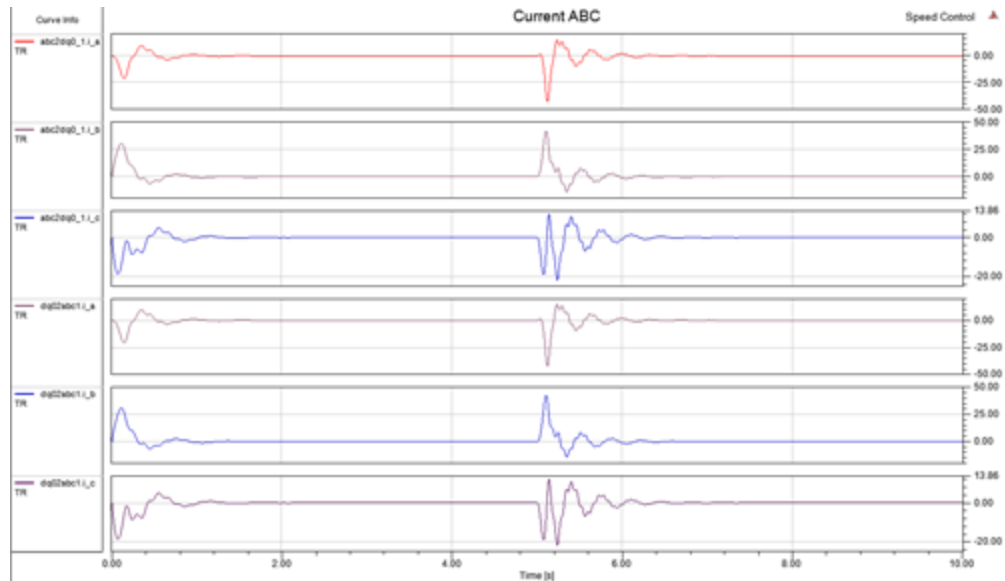


Figure 4: Current ABC

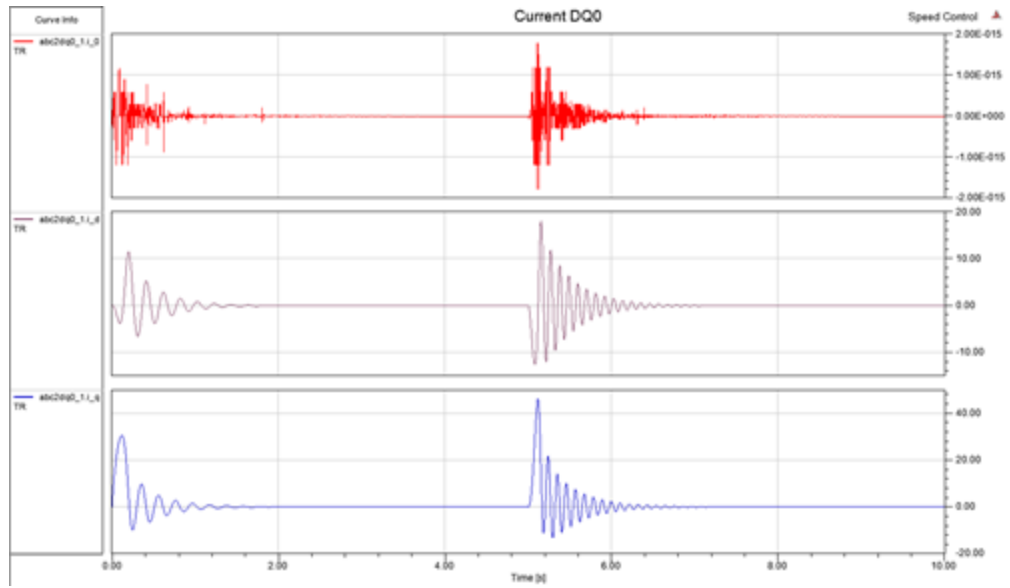


Figure 5: Current DQ0

[Top](#)

Operational Amplifier Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Operational Amplifier Example** schematic is shown in Figure 1.

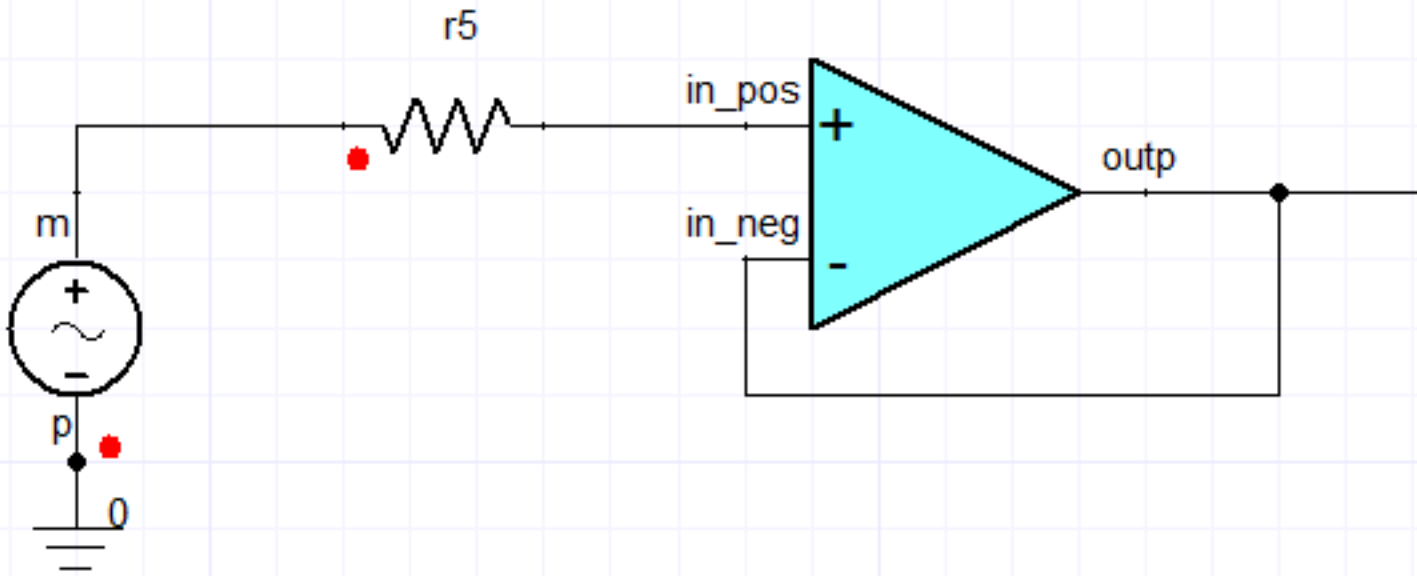
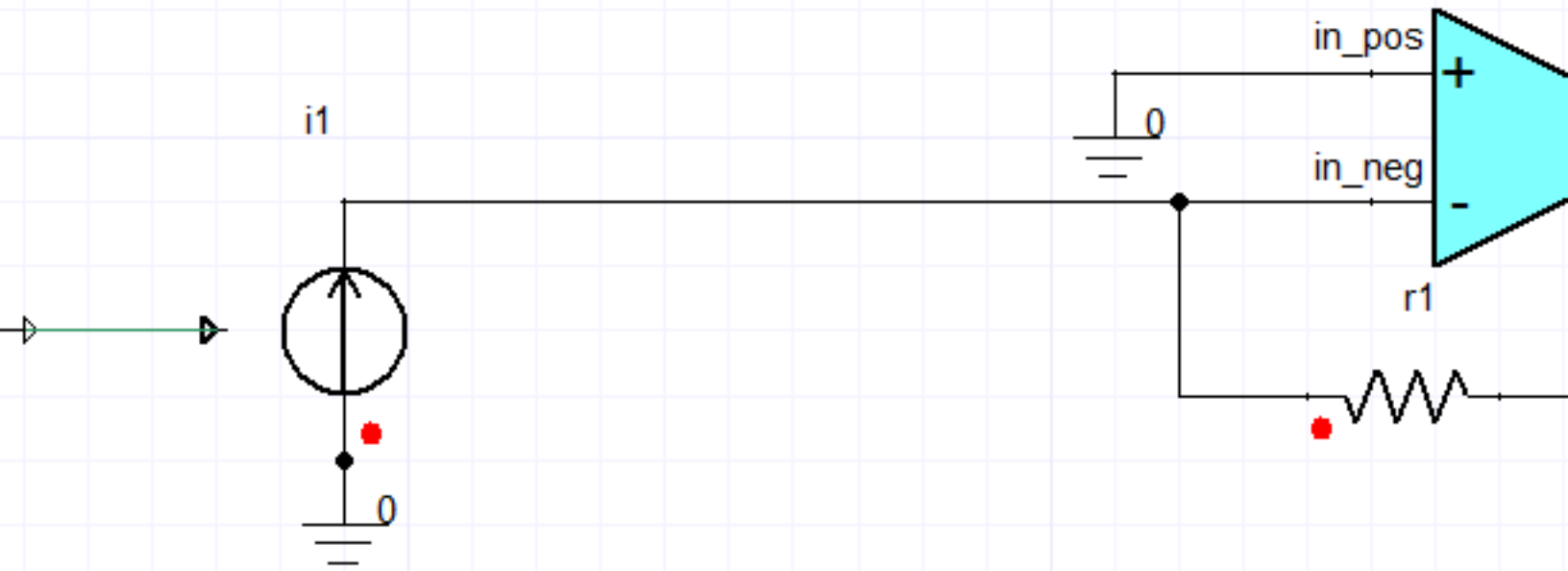


Figure 1. Operational Amplifier Example Schematic

The system contains the e_ac and opamp_ideal models from the Aircraft Electrical VHDL-AMS library.

Two demonstrative examples are shown in this example project:

- current to voltage converter
- voltage follower (c_motor_dcac) takes a ramp change at 2.0 sec, from 100 Nm to 200 Nm, within 0.1 sec.

[Top](#)

Simulation Results

The source current and output voltage are shown in Figure 2.

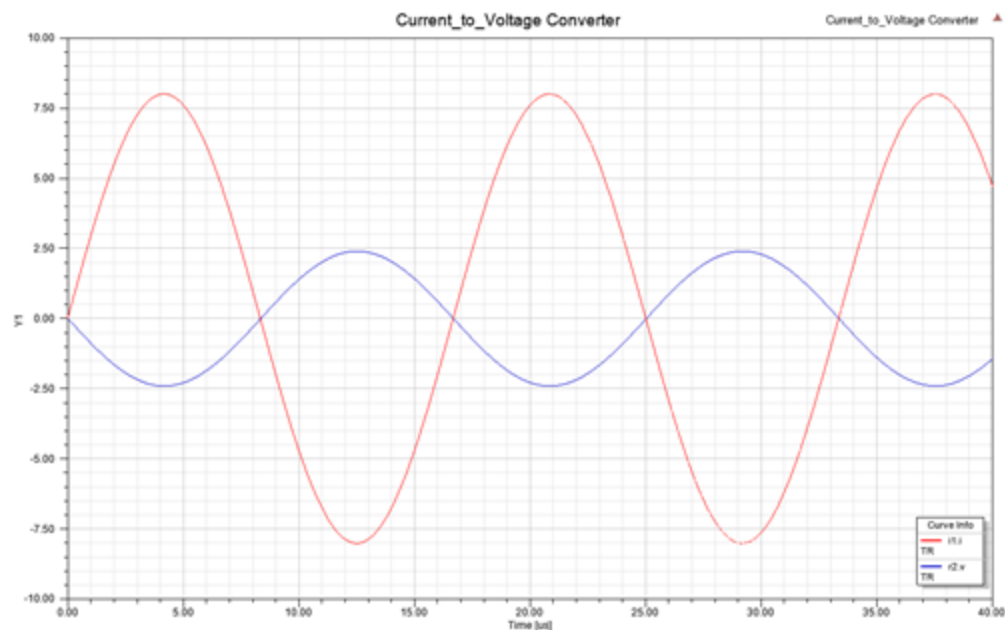


Figure 2. Current to Voltage Converter

The source voltage and output voltage are shown in Figure 3.

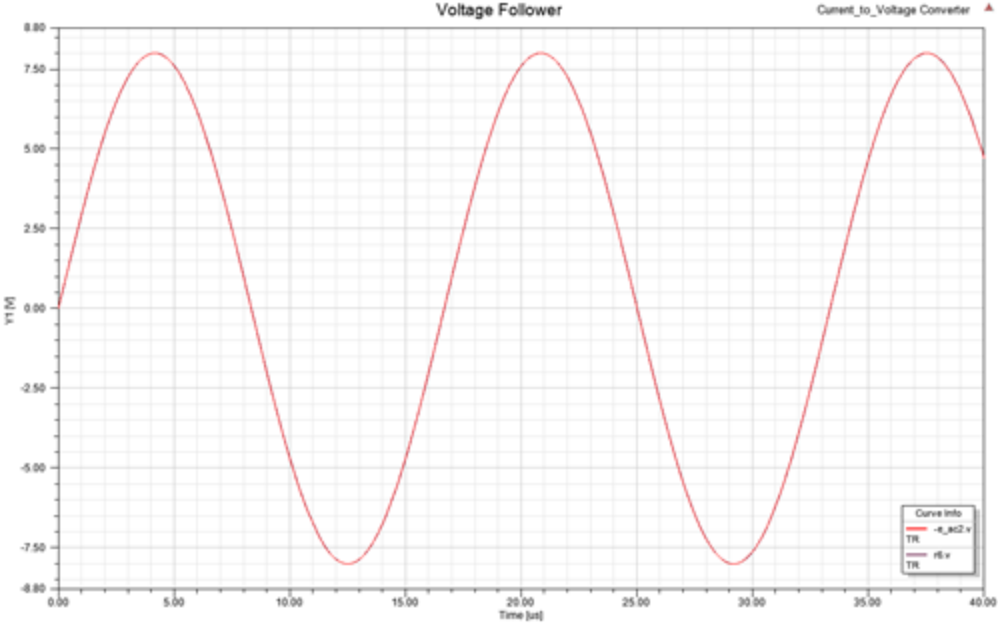


Figure 3: Voltage Follower

[Top](#)

Pump Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Pump Example** schematic is shown in Figure 1.

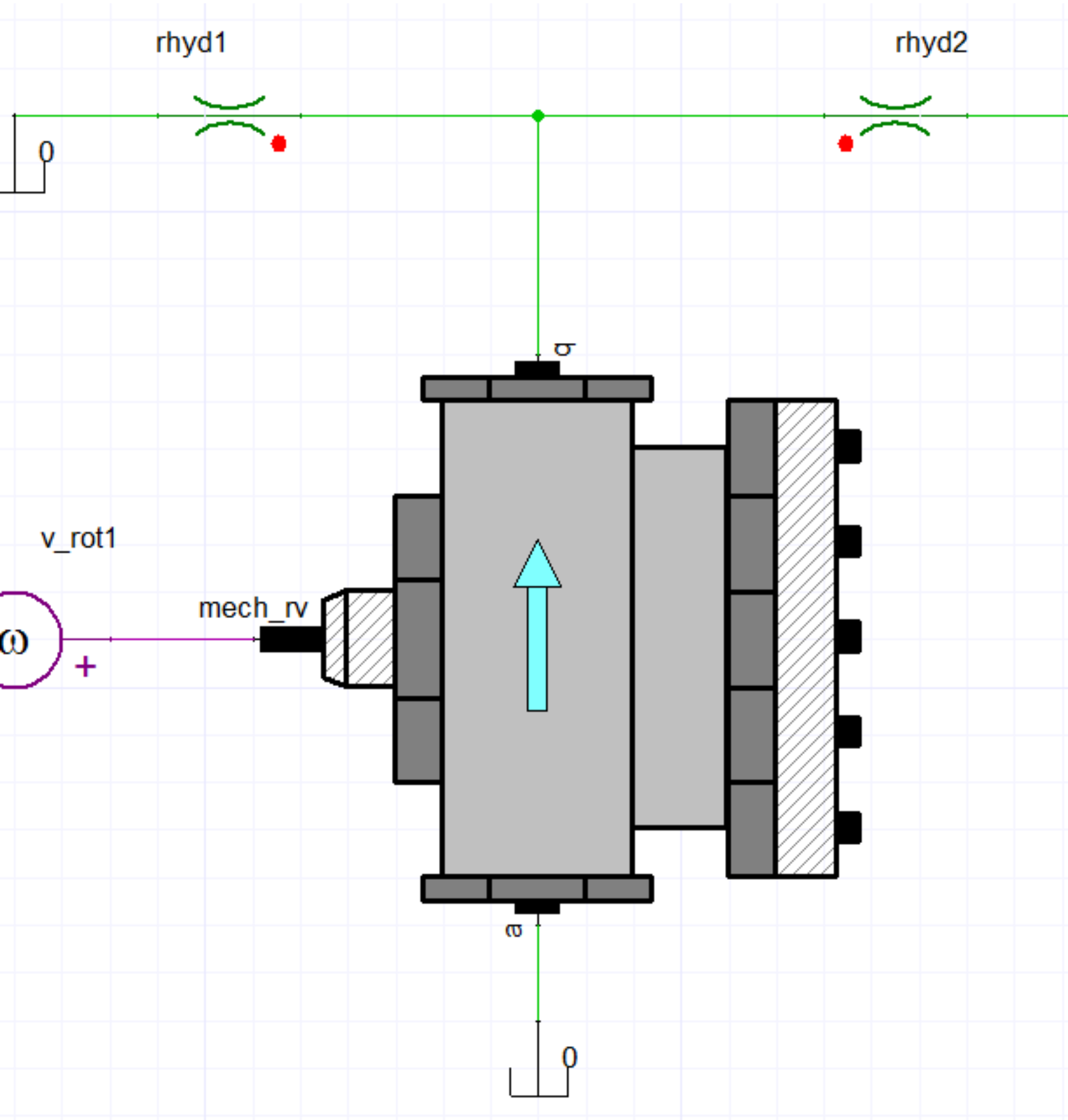


Figure 1. Pump Example Schematic

The example contains the pump model from the Aircraft Electrical VHDL-AMS library.

In the example, the pump model is driven by the angular velocity source, and the fluidic flow is distributed to two linear orifices which have different hydraulic conductance values.

[Top](#)

Simulation Results

The rotational speed of the pump is shown in Figure 2.

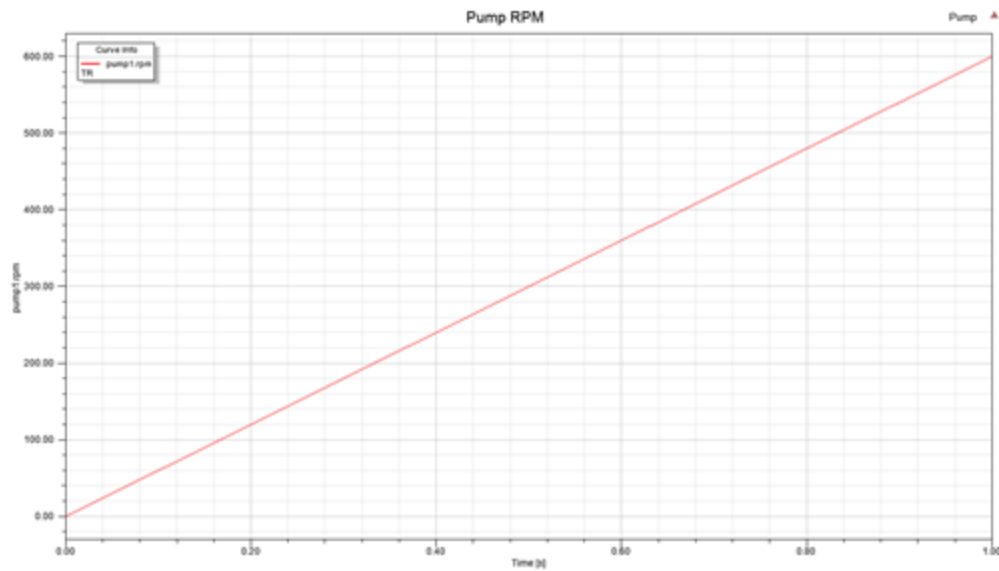


Figure 2. Pump RPM

The leaked volume flow rate of the pump is shown in Figure 3.

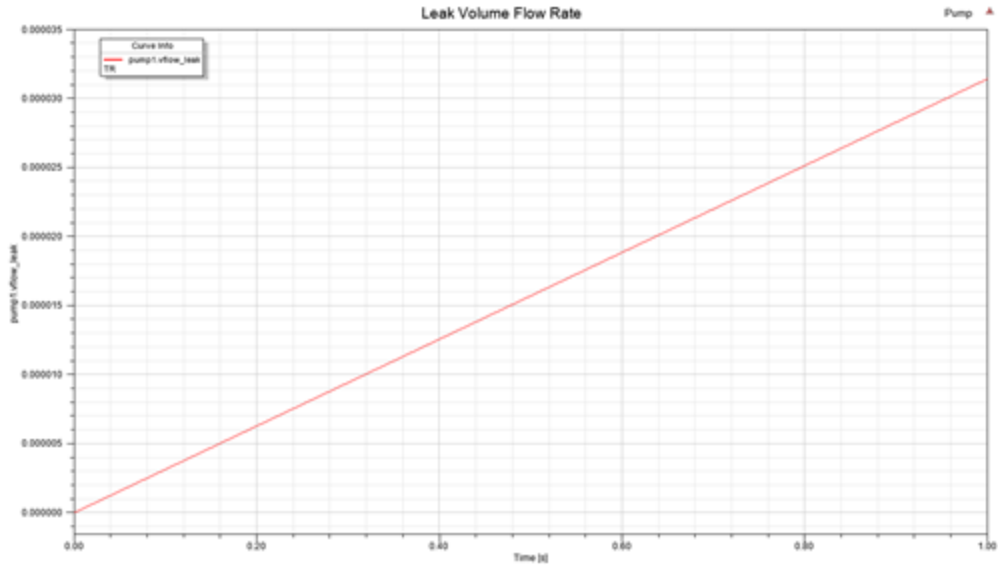


Figure 3: Leak Volume Flow Rate

The volume flow rates are shown in Figure 4.

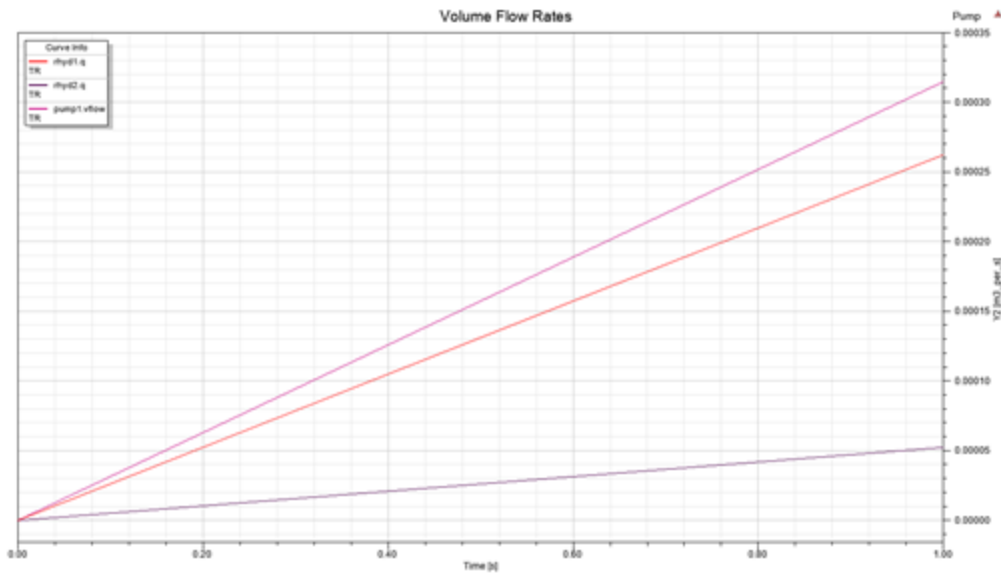


Figure 4: Volume Flow Rates

[Top](#)

PWM Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **PWM Example** schematic is shown in Figure 1.

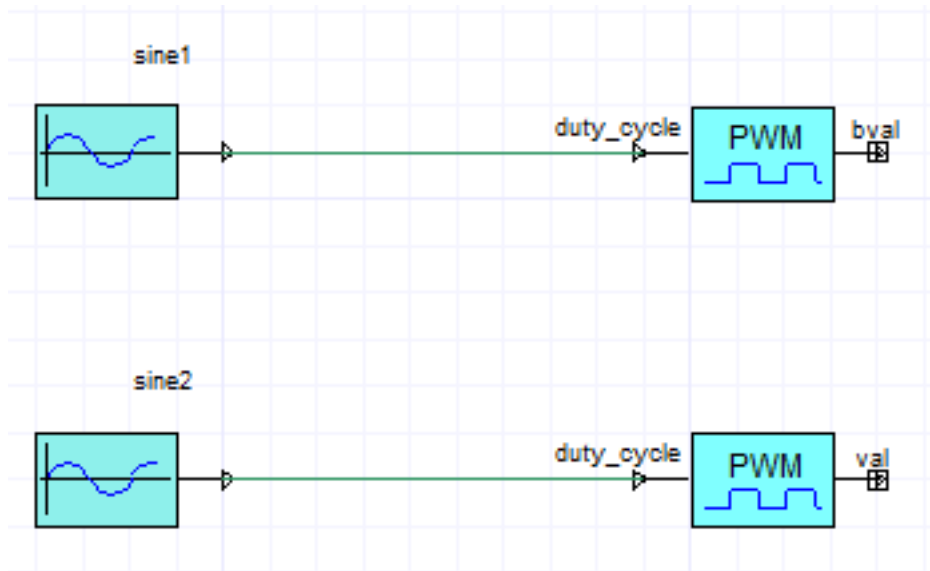


Figure 1. PWM Example Schematic

The system contains the `pwm_b` and `pwm_q` models from the Aircraft Electrical VHDL-AMS library.

Two demonstrative examples are shown in this example project:

- PWM signal with quantity output
- PWM signal with boolean output

Sine wave signals are used to describe changing duty ratio inputs for the PWM signal generators, the comparison of the duty ratio values and the PWM output signals are shown.

[Top](#)

Simulation Results

The duty cycle input and PWM generator output of `pwm_q` are shown in Figure 2.

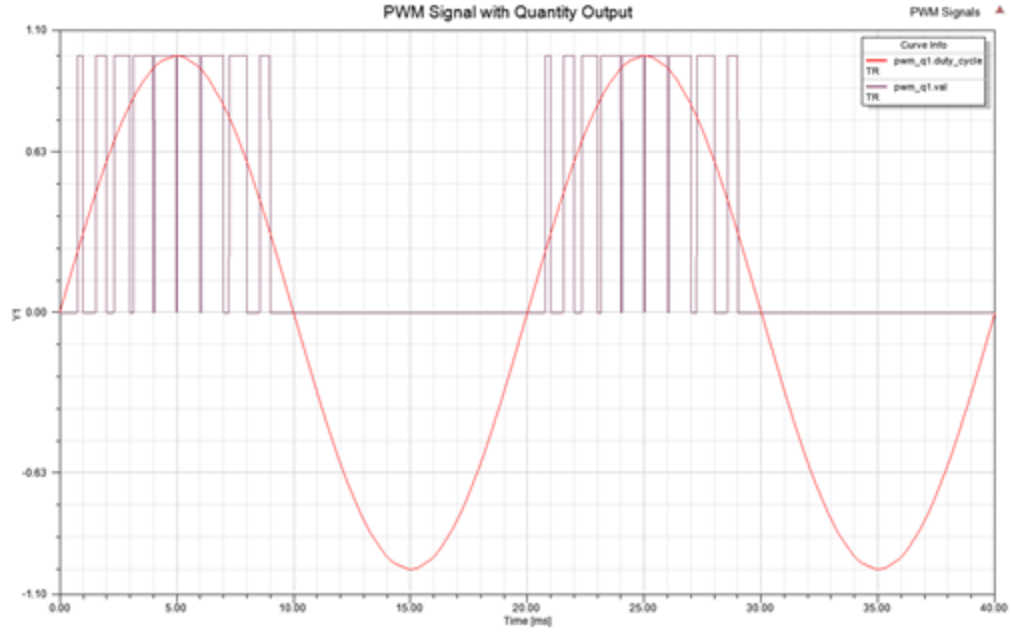


Figure 2. PWM Signal with Quantity Output

The duty cycle input and PWM generator output of pwm_b are shown in Figure 3.

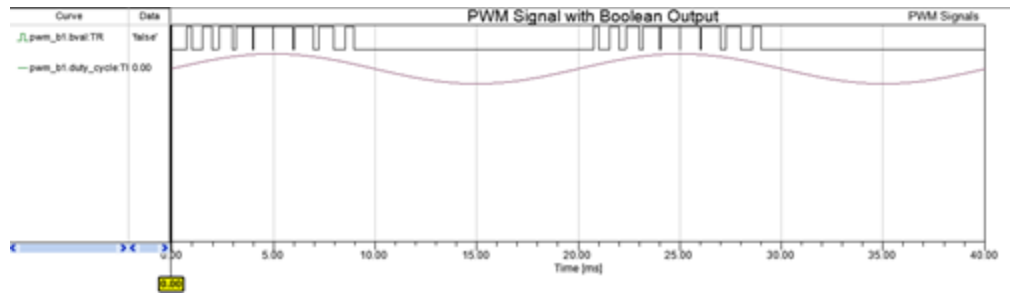


Figure 3: PWM Signal with Boolean Output

[Top](#)

Rectifier 4 Pulse Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Rectifier 4 Pulse Example** schematic is shown in Figure 1.

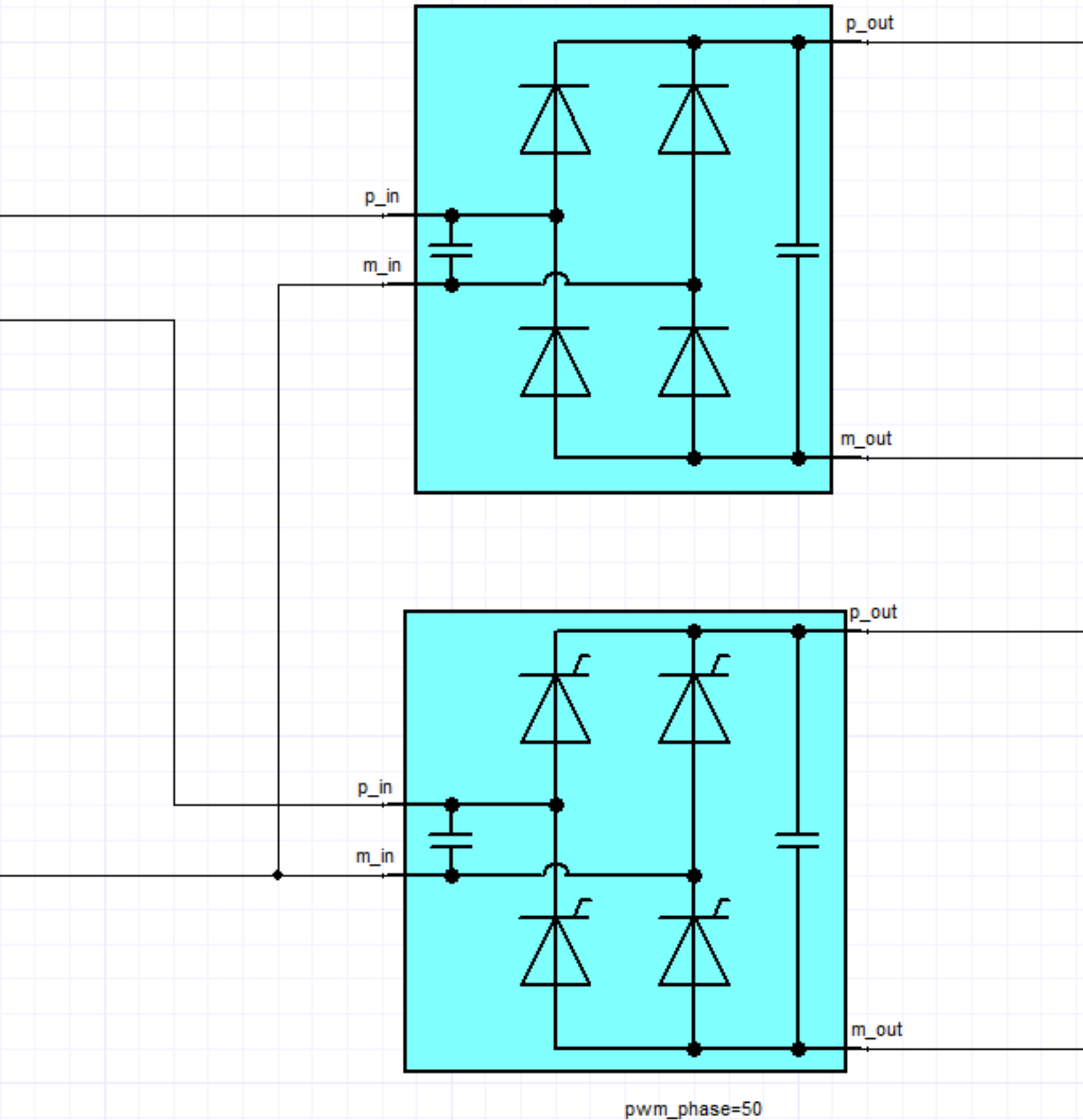


Figure 1. Rectifier 4 Pulse Example Schematic

The system contains the e_ac, rectifier_4pulse and rectifier_4pulse_thyristor models from the Aircraft Electrical VHDL-AMS library.

The rectifiers convert the AC source to DC source; the output voltages of the rectifier with 4 pulse diode and the rectifier with 4 pulse thyristor are compared. The PWM signal phase delay of the thyristors is 50 degree.

[Top](#)

Simulation Results

The comparison of the output voltages of the rectifier 4pulse example is shown in Figure 2.

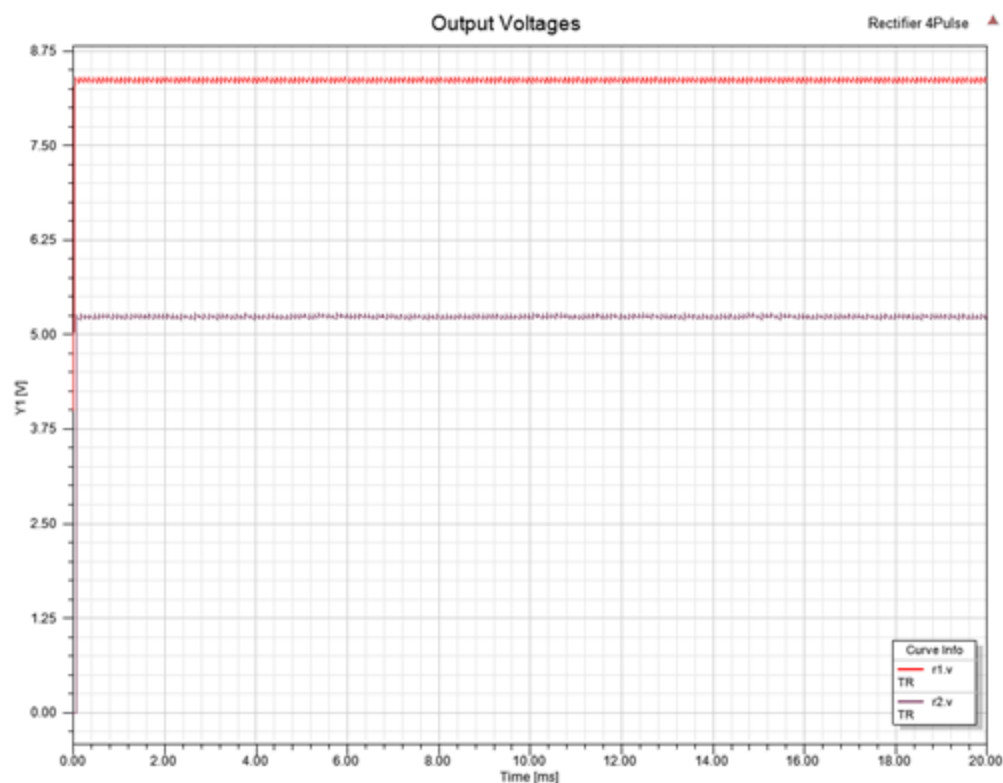


Figure 2. Output Voltages

[Top](#)

Rectifier 6 Pulse Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Rectifier 6 Pulse Example** schematic is shown in Figure 1.

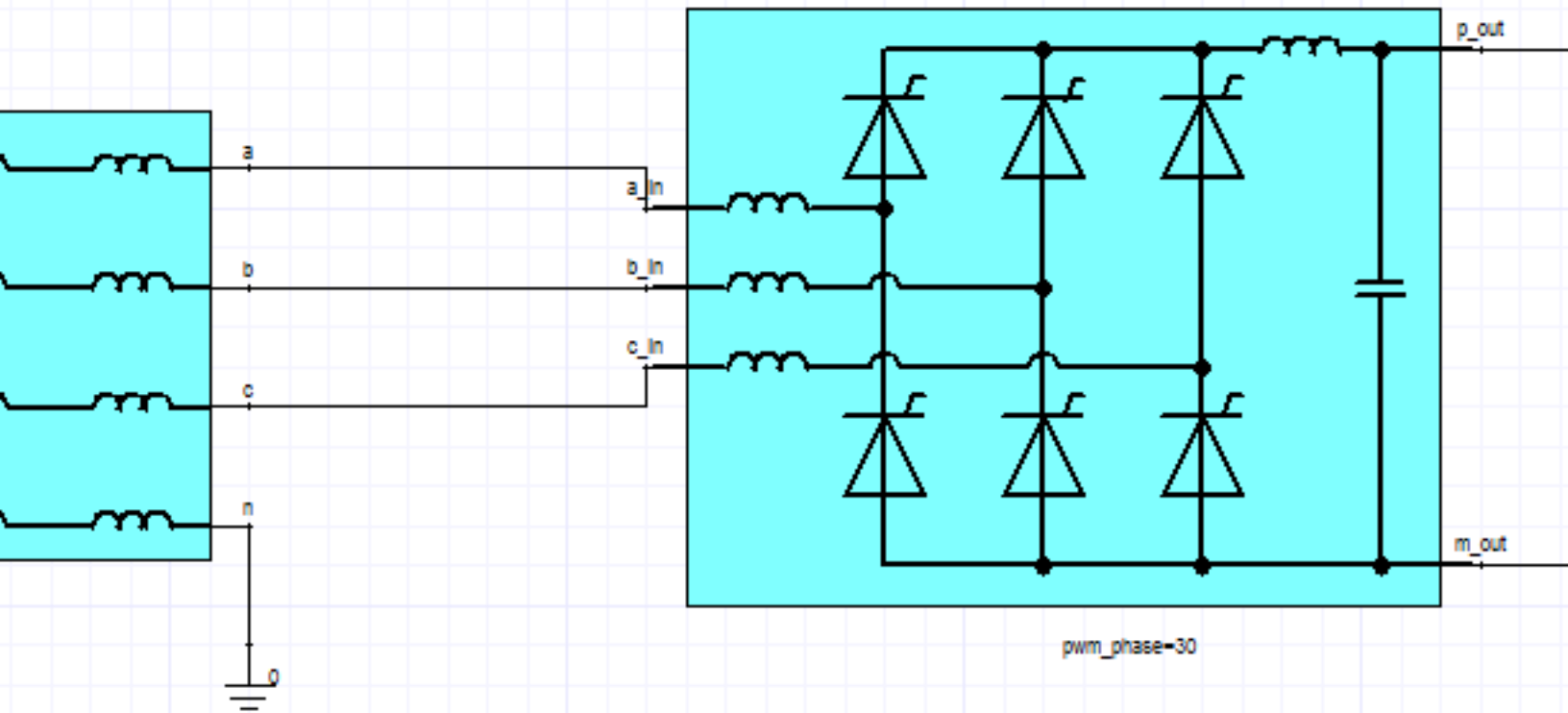
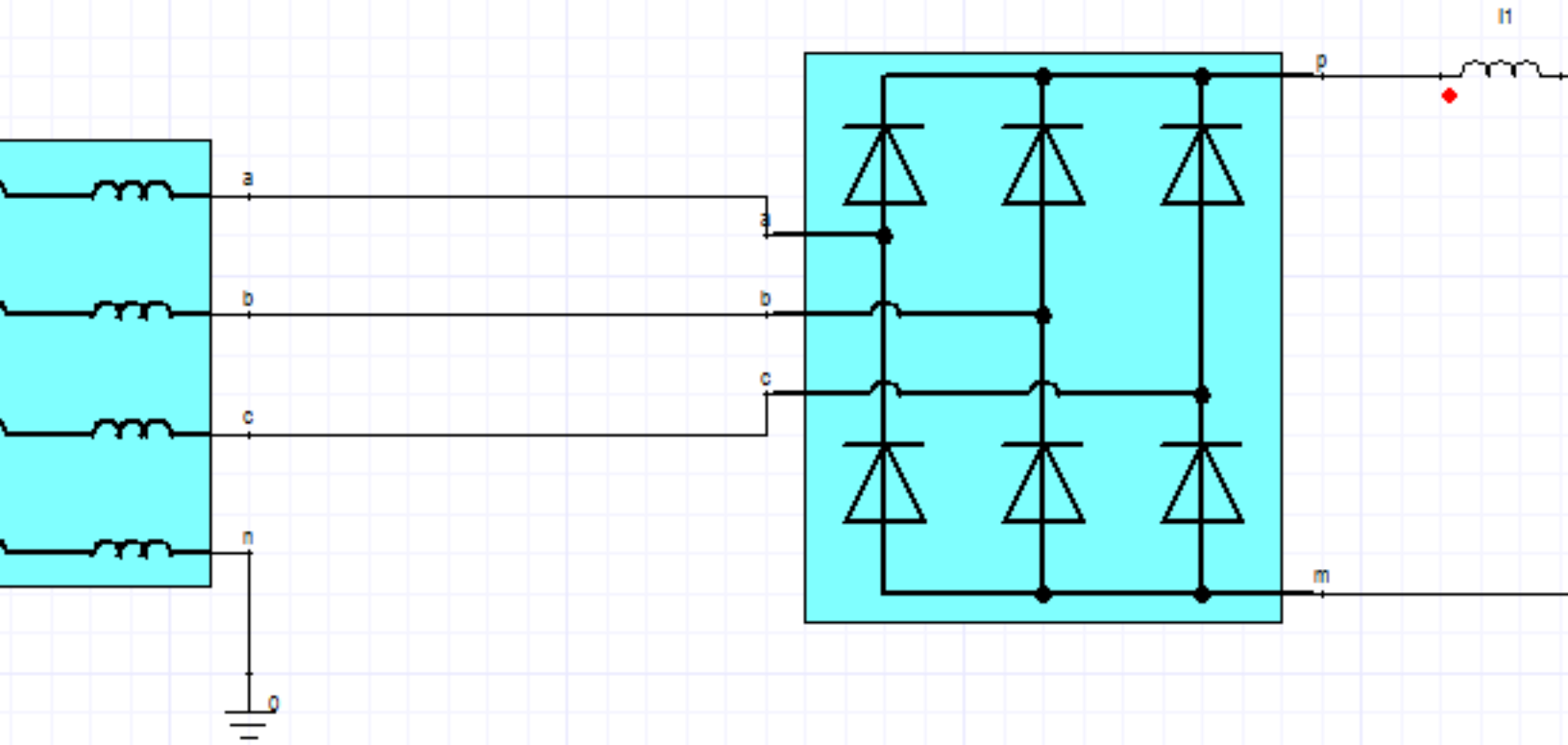


Figure 1. Rectifier 6 Pulse Example Schematic

The system contains the e_ac_3phase, rectifier_6pulse and rectifier_6pulse_thyristor models from the Aircraft Electrical VHDL-AMS library.

The rectifiers convert the three phase AC source to DC source; the output voltages of the rectifier with 6 pulse diode and the rectifier with 6 pulse thyristor are compared. The PWM signal phase delay of the thyristors is 30 degree.

[Top](#)

Simulation Results

The comparison of the output voltages of the rectifier 6pulse example is shown in Figure 2.

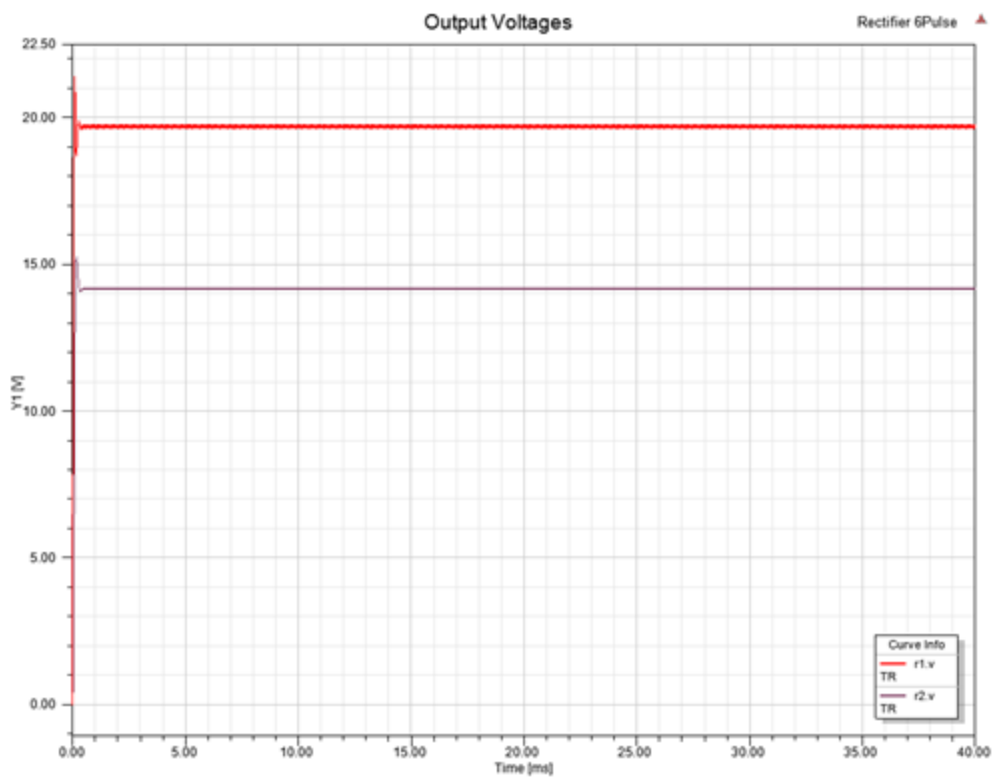


Figure 2. Output Voltages

[Top](#)

Simple Heater Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Simple Heater Example** schematic is shown in Figure 1.

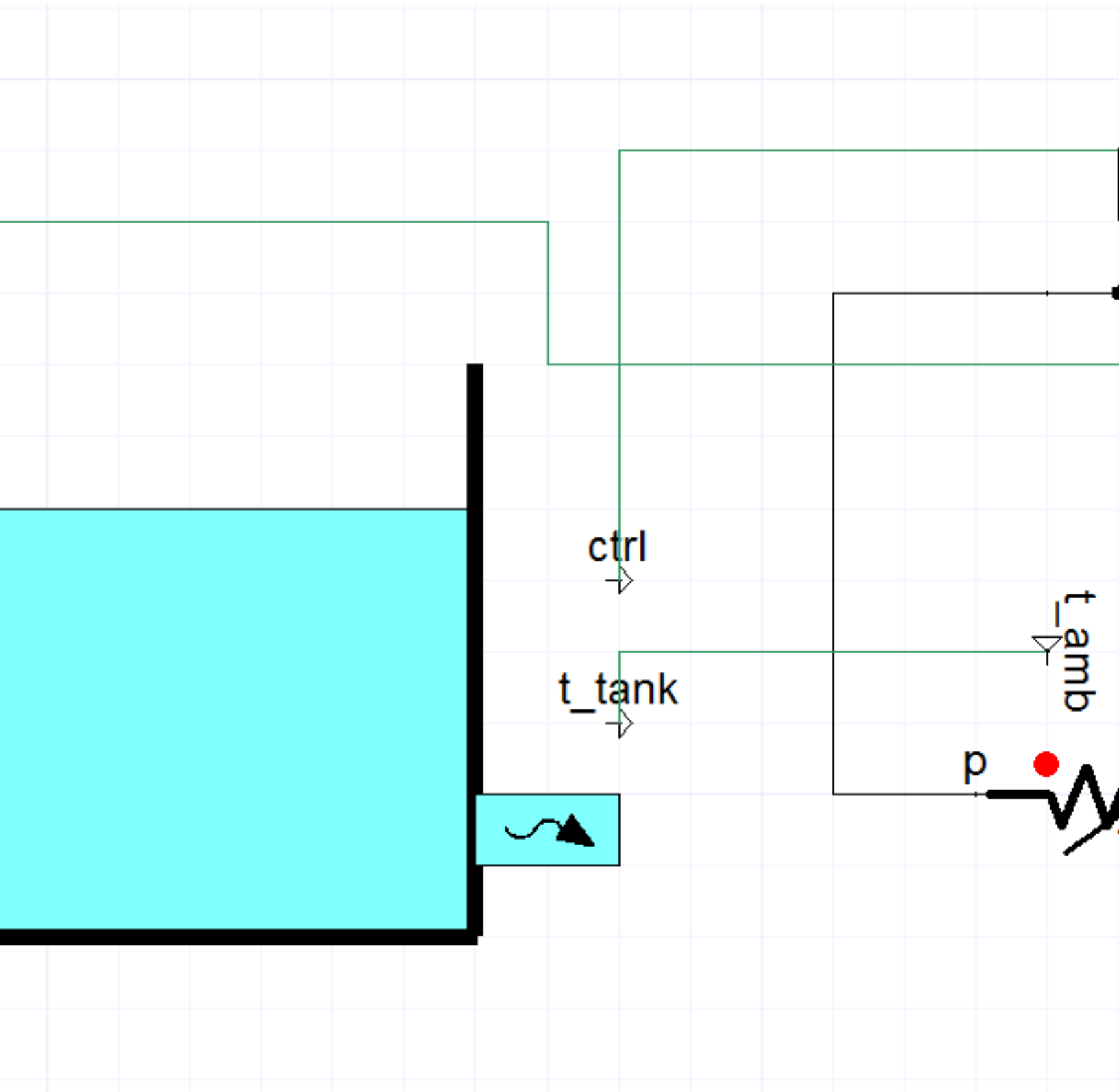


Figure 1. Simple Heater Example Schematic

The example contains the tank_w and r_thermal models from the Aircraft Electrical VHDL-AMS library.

In the example, the r_thermal is used to heat the tank_w, the tank_w will give a ctrl signal to the switch s1 when the temperature requirements are satisfied.

[Top](#)

Simulation Results

The hflow of the r_thermal is shown in Figure 2.

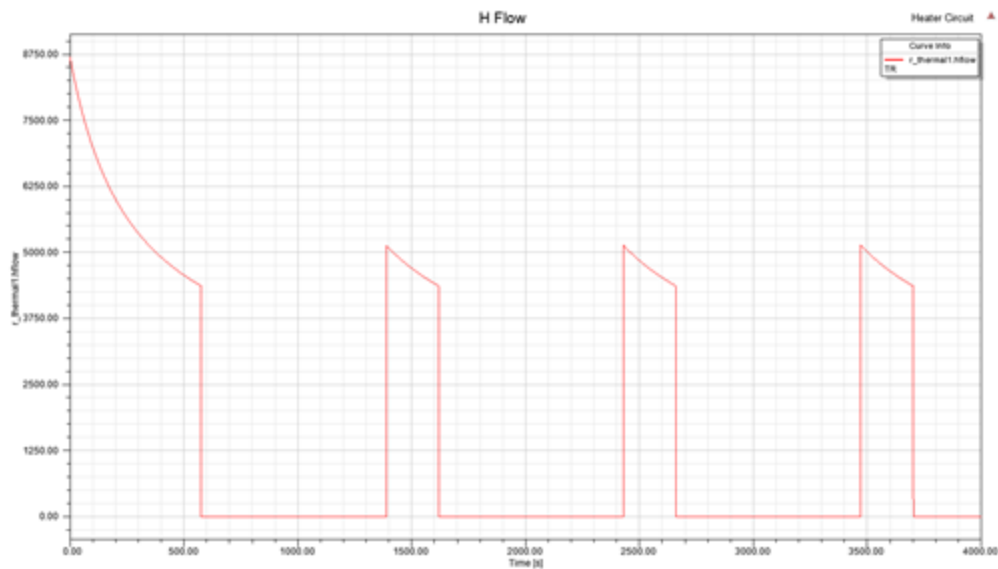


Figure 2. H Flow of R_Thermal

The tank control vs. tank temperature is shown in Figure 3.

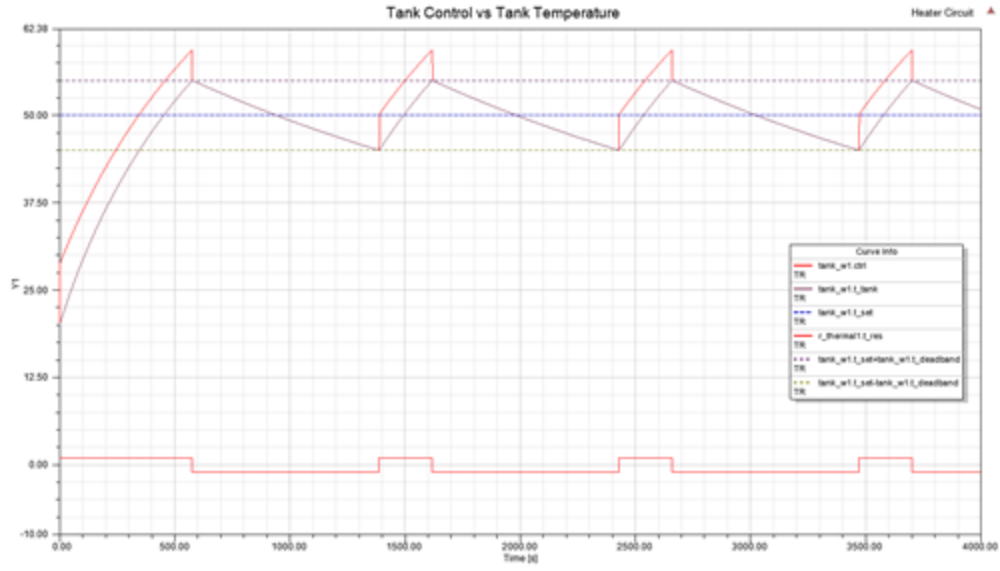


Figure 3: Tank Control vs. Tank Temperature

[Top](#)

Simple Lamp Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Simple Lamp Example** schematic is shown in Figure 1.

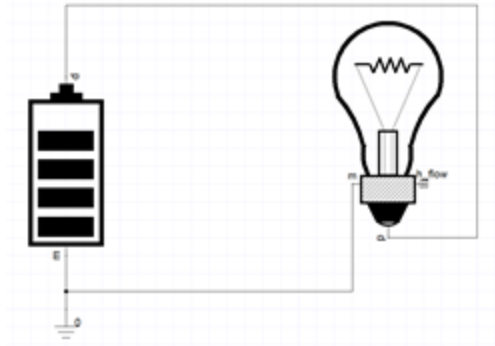


Figure 1. Simple Lamp Example Schematic

The example contains the battery and lamp_simple models from the Aircraft Electrical VHDL-AMS library.

In the example, the battery is used to light the lamp. The battery SOC and the lamp performance are shown.

[Top](#)

Simulation Results

The battery SOC is shown in Figure 2.

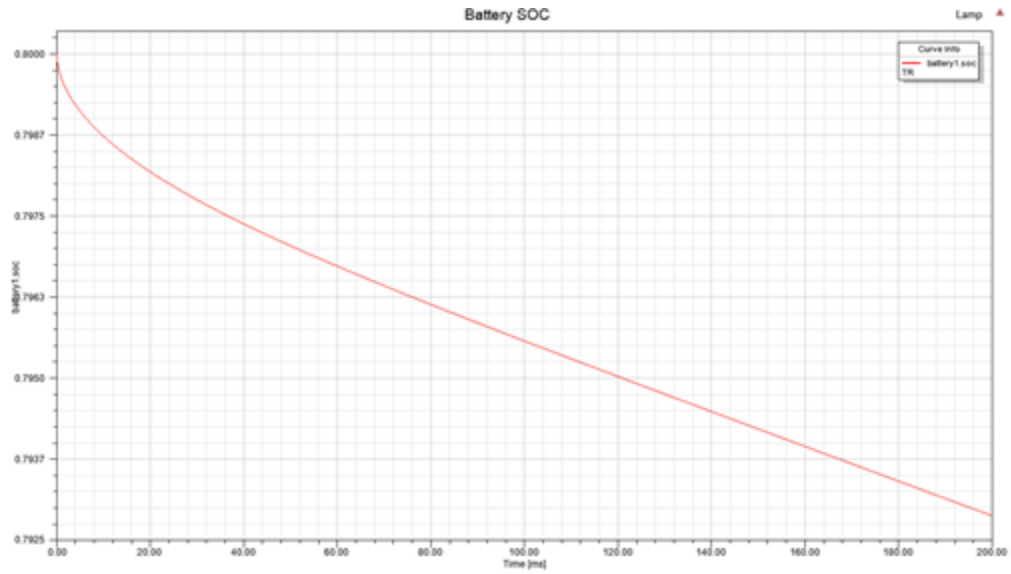


Figure 2. Battery SOC

The lamp_simple performance is shown in Figure 3.

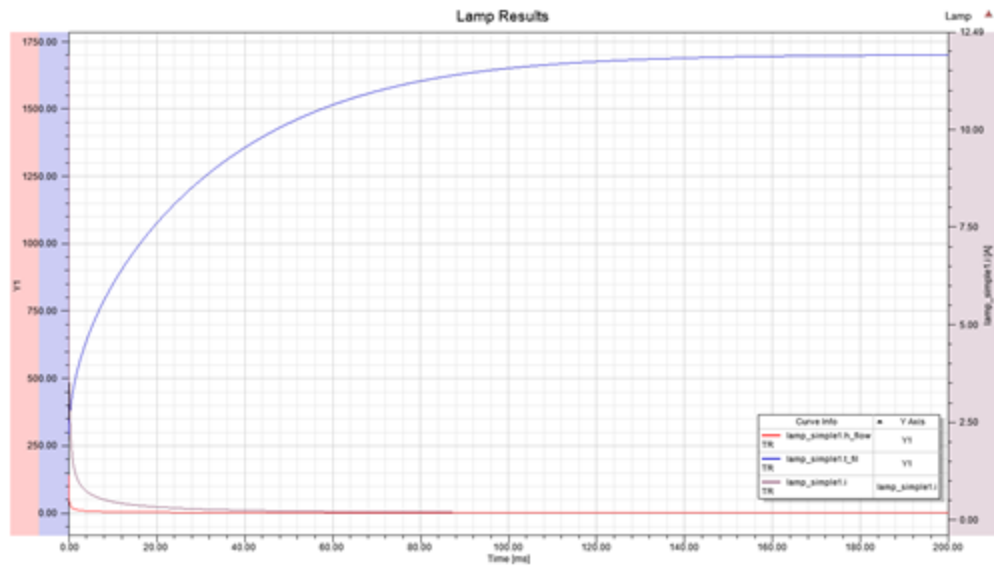


Figure 3: Lamp Results

[Top](#)

Simplified Power System Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The simplified power system example schematics are shown in Figure 1 and Figure 2.

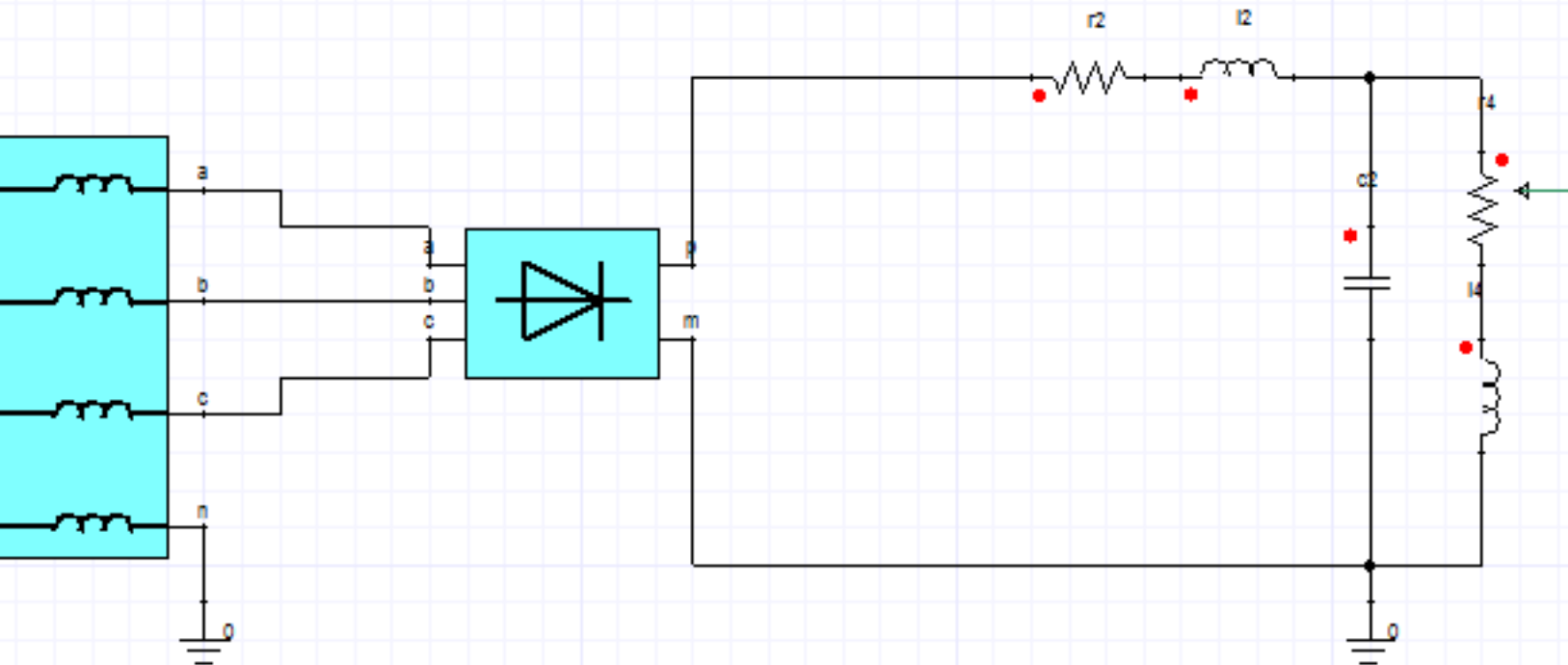
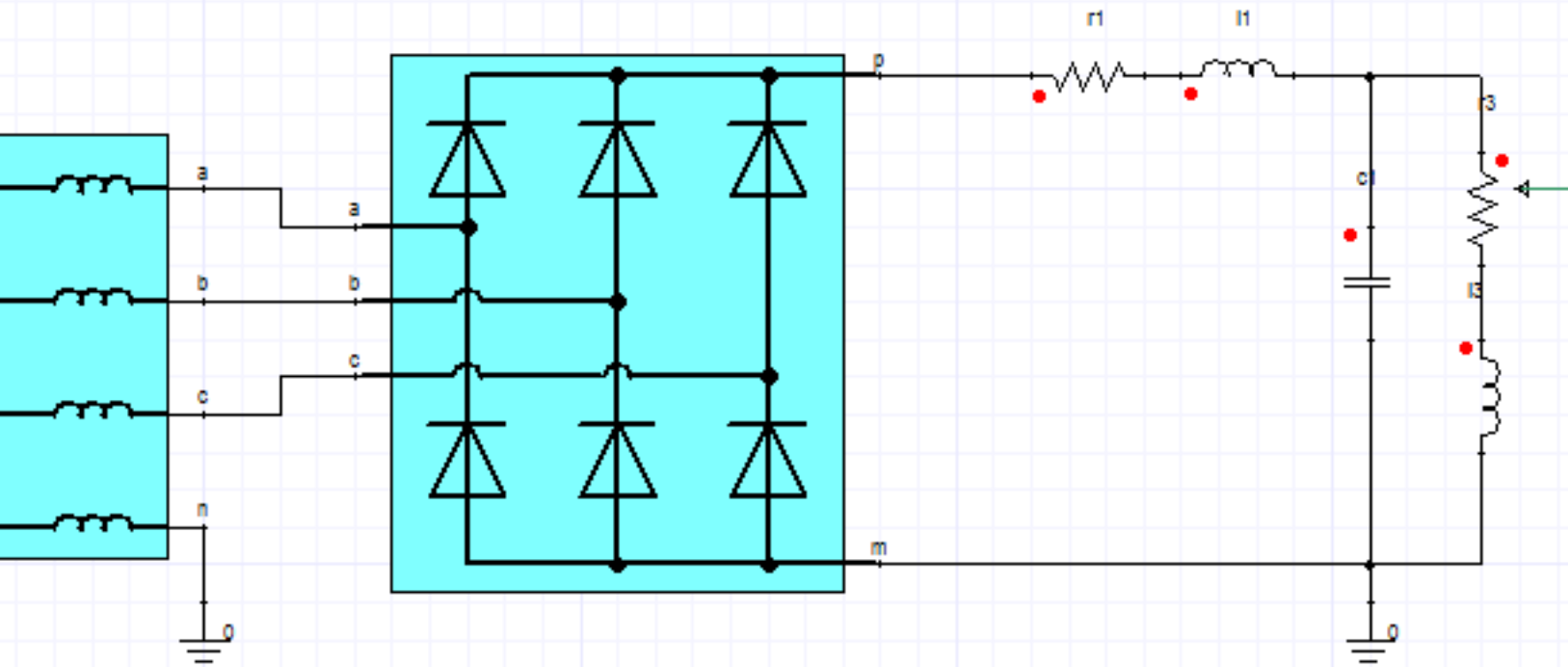


Figure 1: Ideal Rectifier Example Schematic

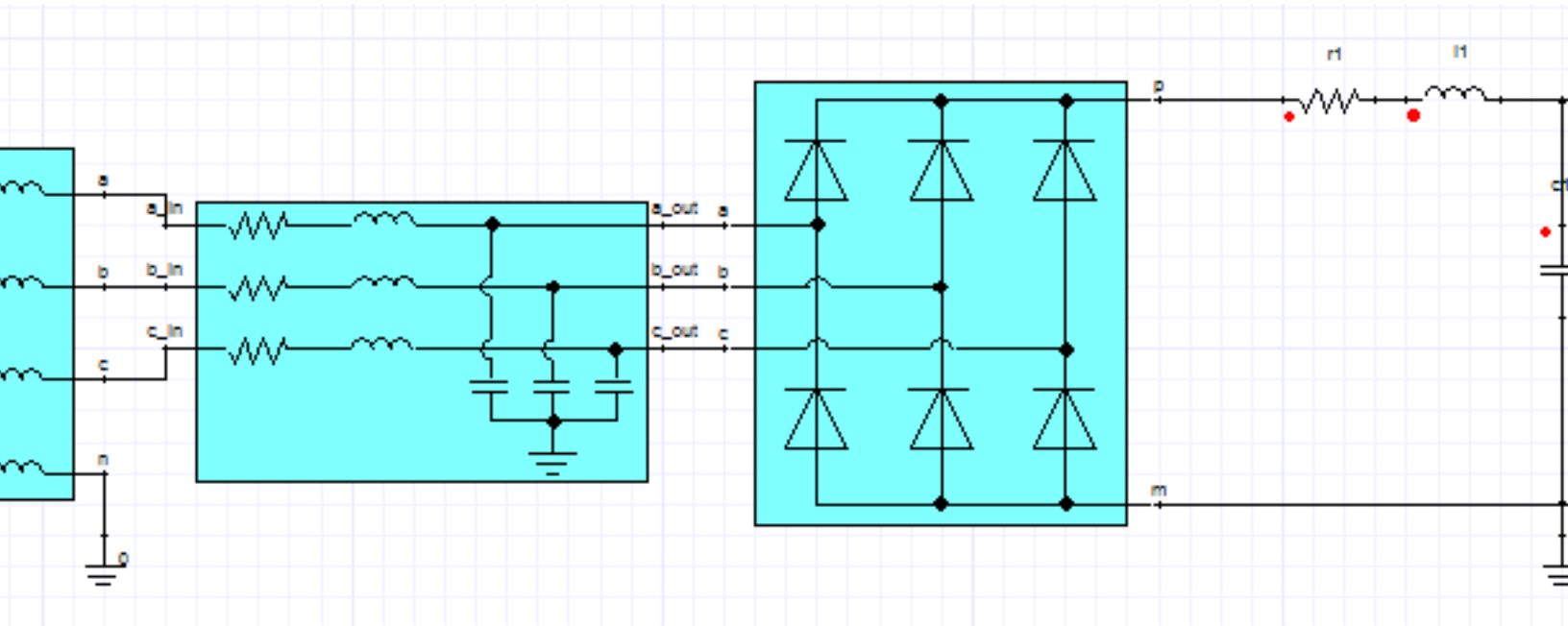


Figure 2: Simplified Power System with CPL Example Schematic

The ideal rectifier example contains the `e_ac_3phase`, `rectifier_6pulse` and `rectifier_a2d_ideal` models from the Aircraft Electrical VHDL-AMS library. The performances of the device based `rectifier_6pulse` model and the behavior based `rectifier_a2d_ideal` model are compared. A step change on the load resistance value at 1.0 sec, from 10 to 100 is introduced to show the system dynamics.

The simplified power system with CPL example contains the `e_ac_3phase`, `rlc_3phase`, `rectifier_6pulse` and `cpl_ideal` models from the Aircraft Electrical VHDL-AMS library. A step change of the power demand of the constant power load (CPL) is introduced at 1.0 sec, from 2000 W to 3000 W to show the dynamic change of the system.

[Top](#)

Simulation Results

The load voltages and the load currents comparisons of the ideal rectifier example are shown in Figure 3 and Figure 4.

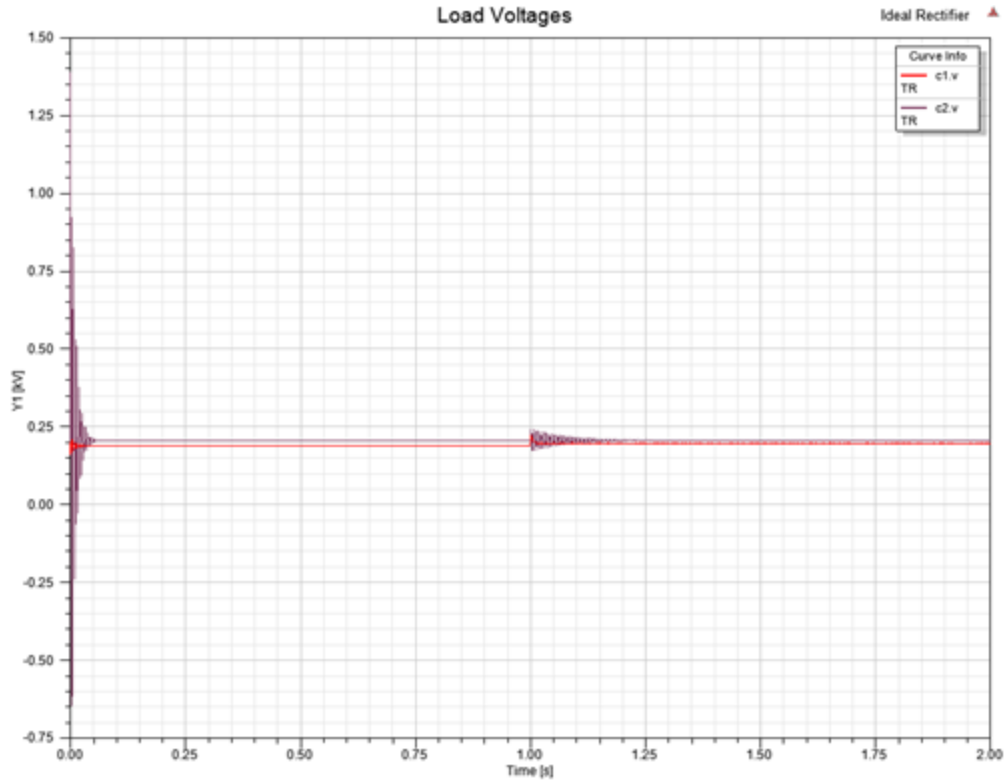


Figure 3: Ideal Rectifier, Load Voltages

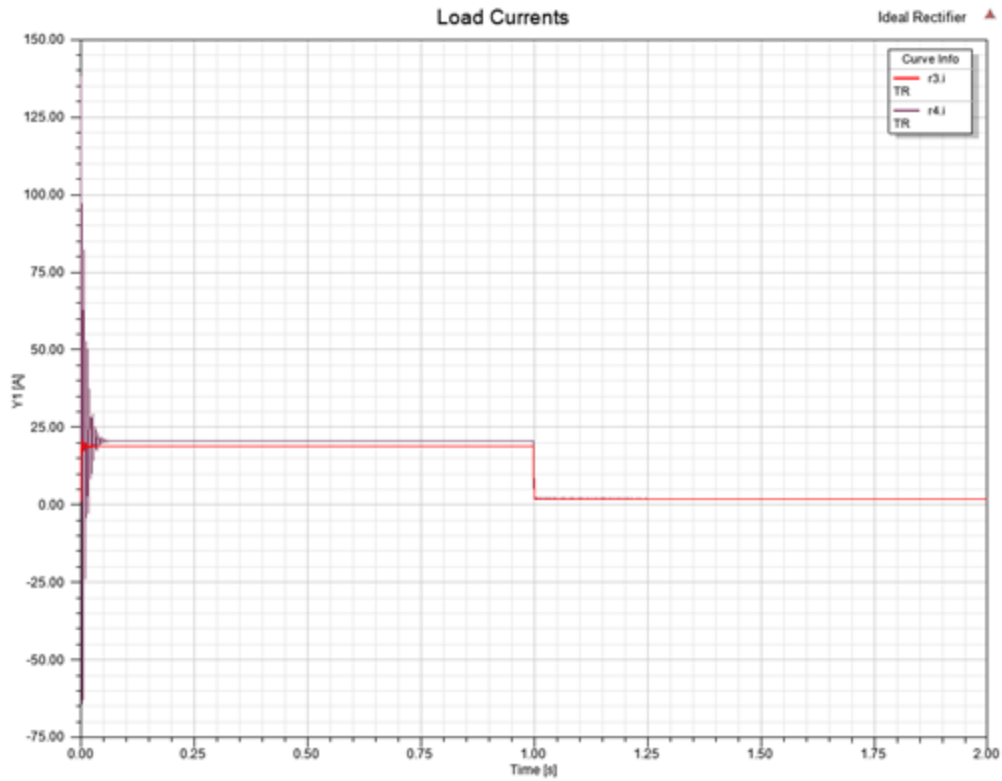


Figure 4: Ideal Rectifier, Load Currents

The constant power load performance of the simplified power system with CPL example is shown in Figure 5.

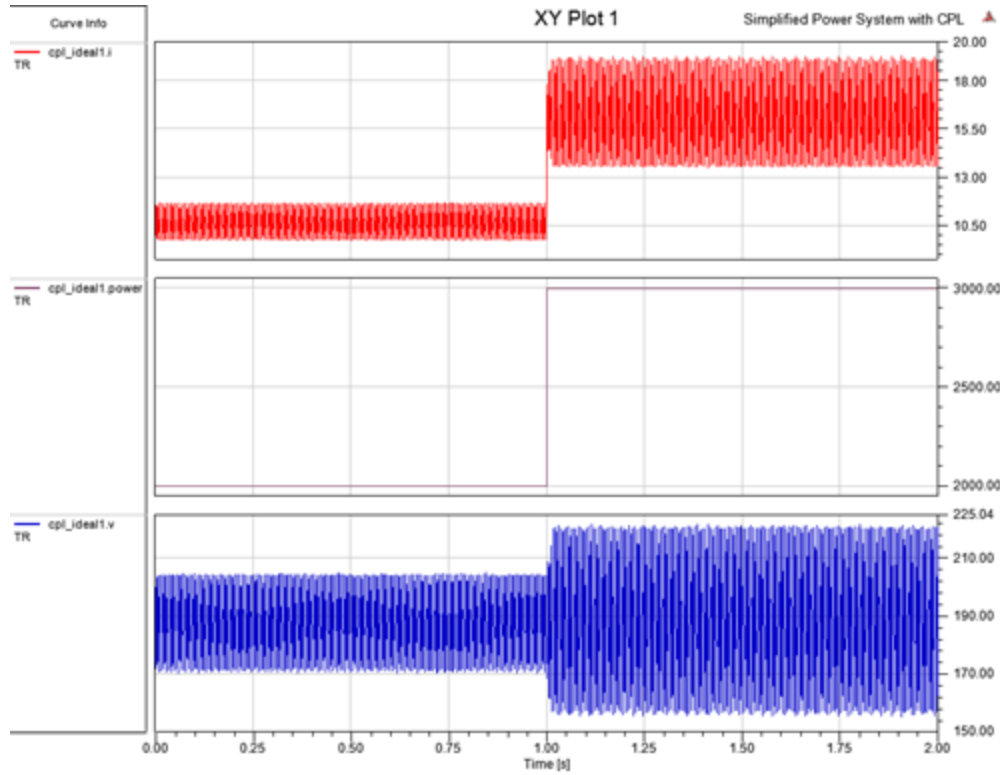


Figure 5: Simplified Power System with CPL, CPL Performance

[Top](#)

Sources Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Sources Example** schematic is shown in Figure 1.

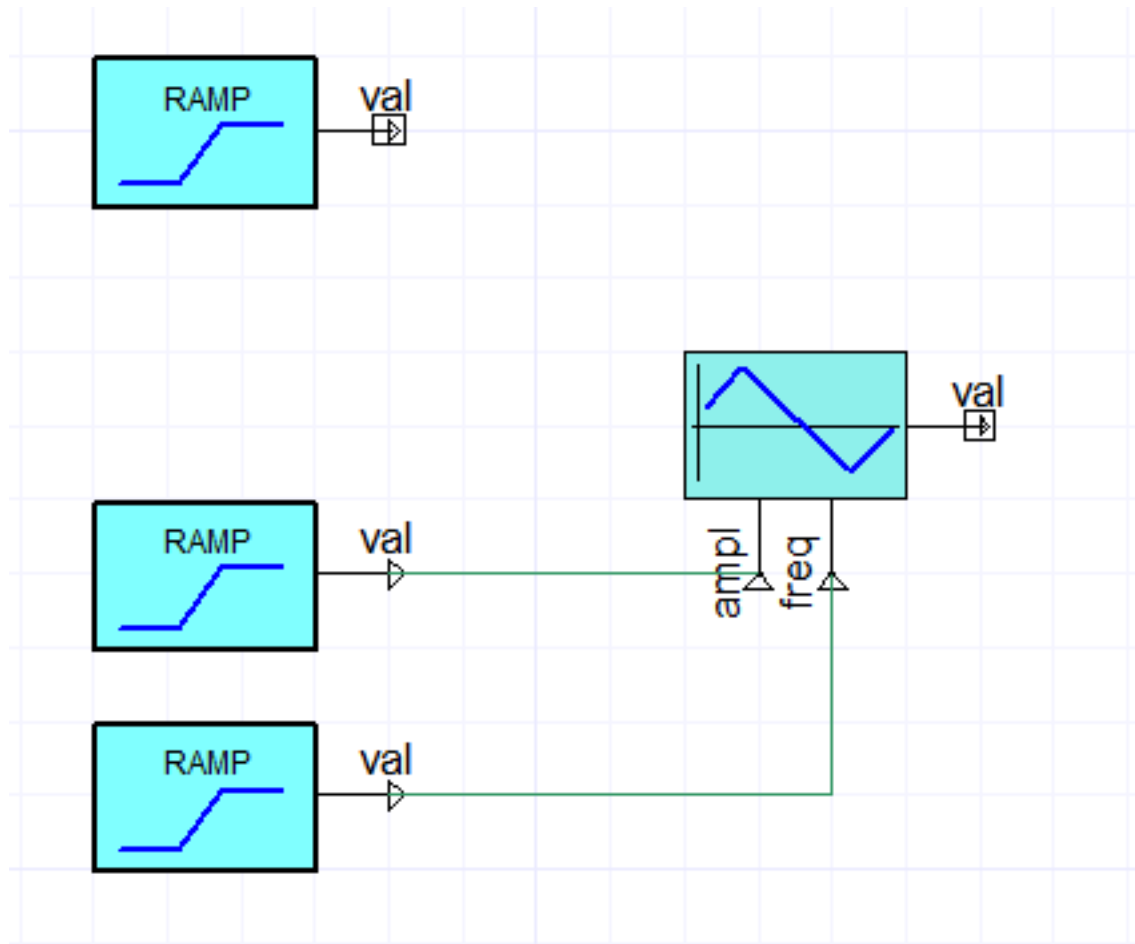


Figure 1. Sources Example Schematic

The system contains the ramp and triangle models from the Aircraft Electrical VHDL-AMS library.

Two demonstrative examples are shown in this example project:

- Ramp, signal changes at 1.0 sec, from 0.5 to -1.5 within 2.0 sec.

- Triangle, the amplitude of the triangle signal changes at 1.0 sec, from 1 to 6 within 1.0 sec. The frequency of the triangle signal changes at 3.0 sec, from 100 Hz to 20 Hz within 1.0 sec.

[Top](#)

Simulation Results

The output of ramp is shown in Figure 2.

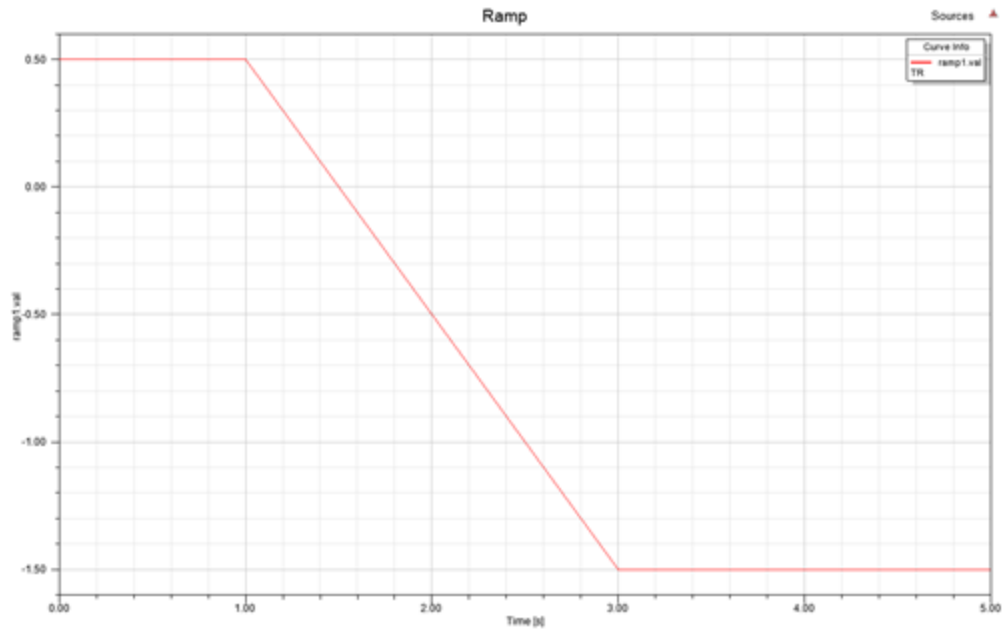


Figure 2. Ramp

The ampl input, freq input and output of triangle are shown in Figure 3.

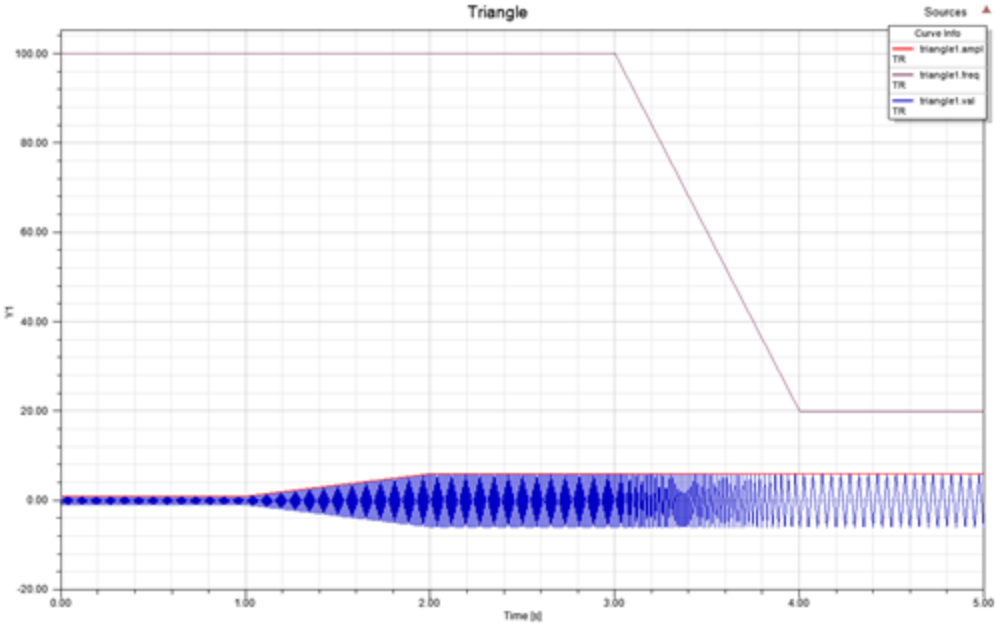


Figure 3. Triangle

Top

Sum Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Sum Example** schematic is shown in Figure 1.

sine1



sine3



triangle1

Figure 1. Sum Example Schematic

The system contains the sum2, sum3, ramp and triangle models from the Aircraft Electrical VHDL-AMS library.

Two demonstrative examples are shown in this example project:

- Sum2, this example use sum2 block to show the result of (sine1 - sine2).
- Sum3, this example use sum3 block to show the result of (sine3 + ramp1 + triangle1).

[Top](#)

Simulation Results

The inputs and output of sum2 are shown in Figure 2.

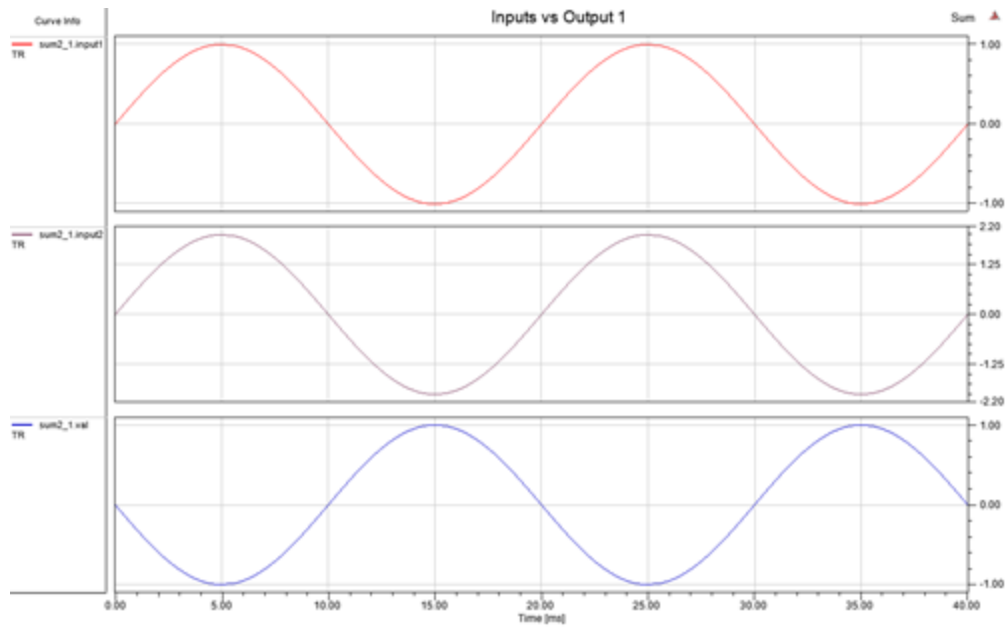


Figure 2. Sum2, Inputs vs. Output

The inputs and output of sum3 are shown in Figure 3.

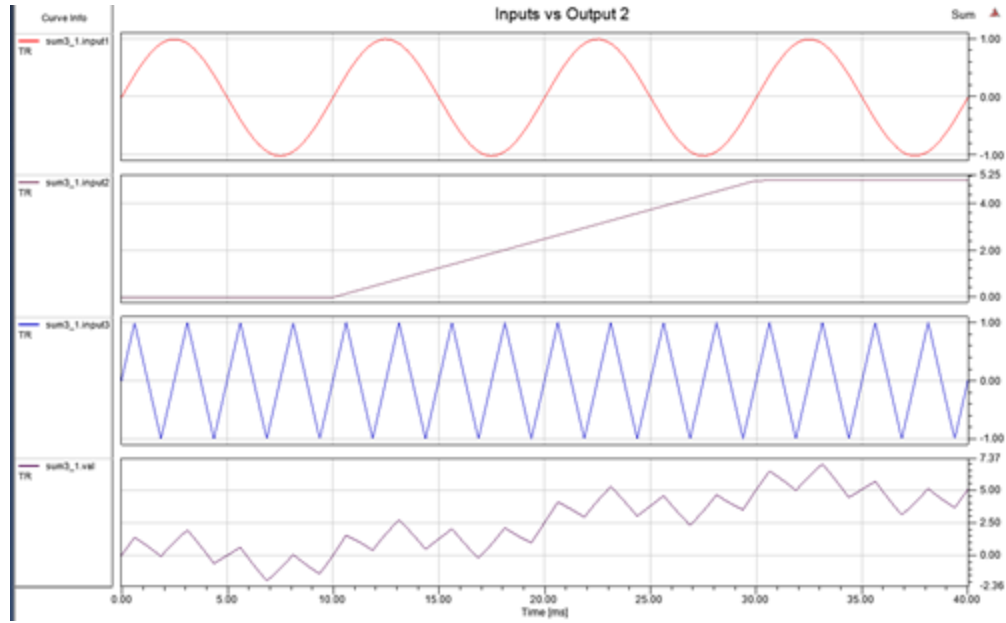


Figure 3. Sum3, Input vs. Output

Top

Thyristor Example

Library: Aircraft Electrical VHDL-AMS	Modeling Language: VHDL-AMS	Version Number: Twin Builder 2024.2
--	--------------------------------	--

Description

The **Thyristor Example** schematic is shown in Figure 1.

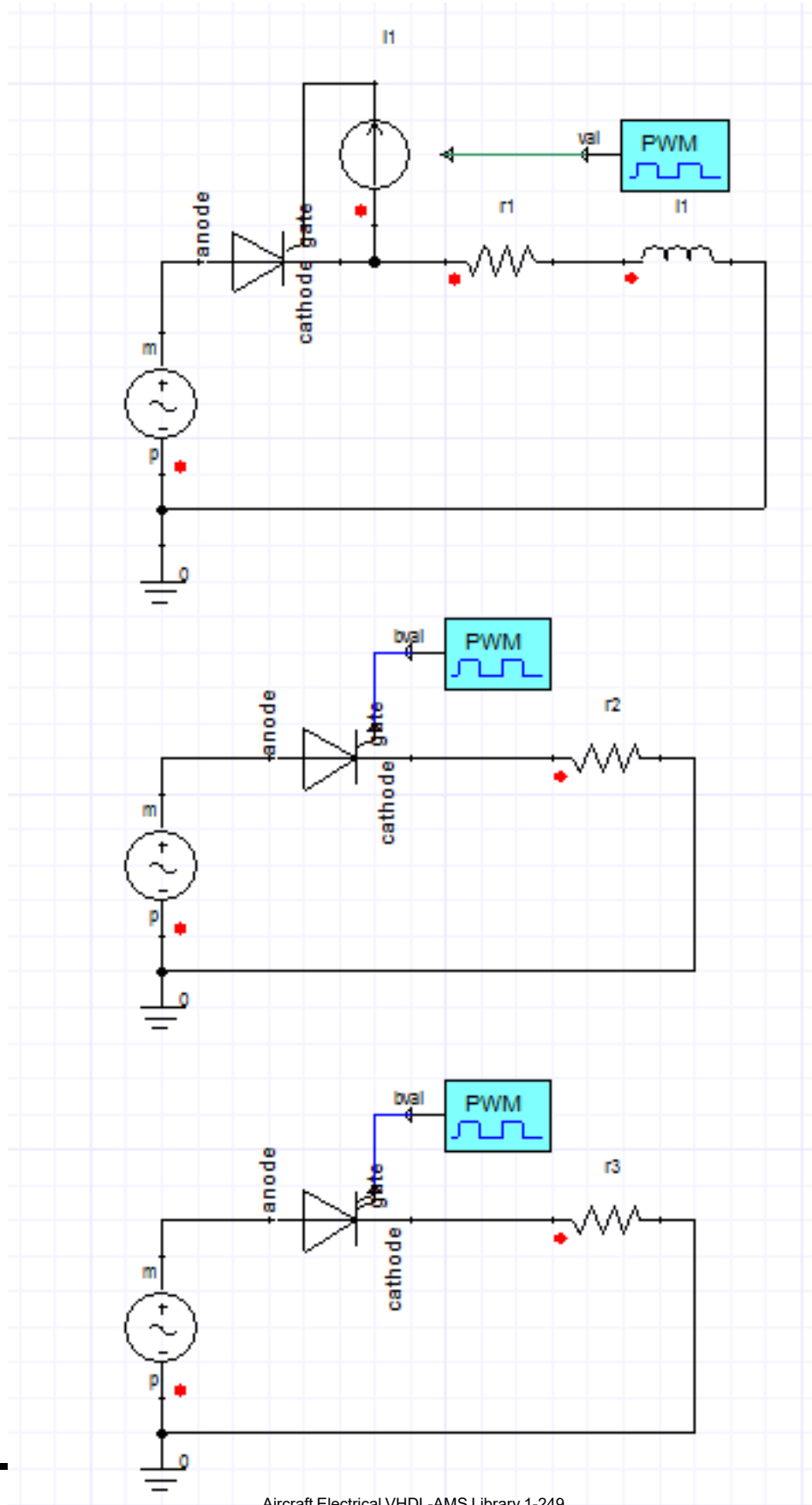


Figure 1. Thyristor Example Schematic

The system contains the `pwm_b`, `pwm_q`, `e_ac`, `thyristor_ideal`, `thyristor_gto_ideal` and `thyristor_dynamic` models from the Aircraft Electrical VHDL-AMS library.

Three demonstrative examples are shown in this example project:

- Dynamic thyristor example, it uses a PWM signal driven current source to control the gate of the dynamic thyristor model.
- Ideal thyristor example, it uses a Boolean output PWM signal to control the ideal thyristor model.
- Ideal thyristor GTO example, it uses a Boolean output PWM signal to control the ideal thyristor model.

[Top](#)

Simulation Results

The source voltage, PWM control signal and load voltage of the dynamic thyristor example are shown in Figure 2.

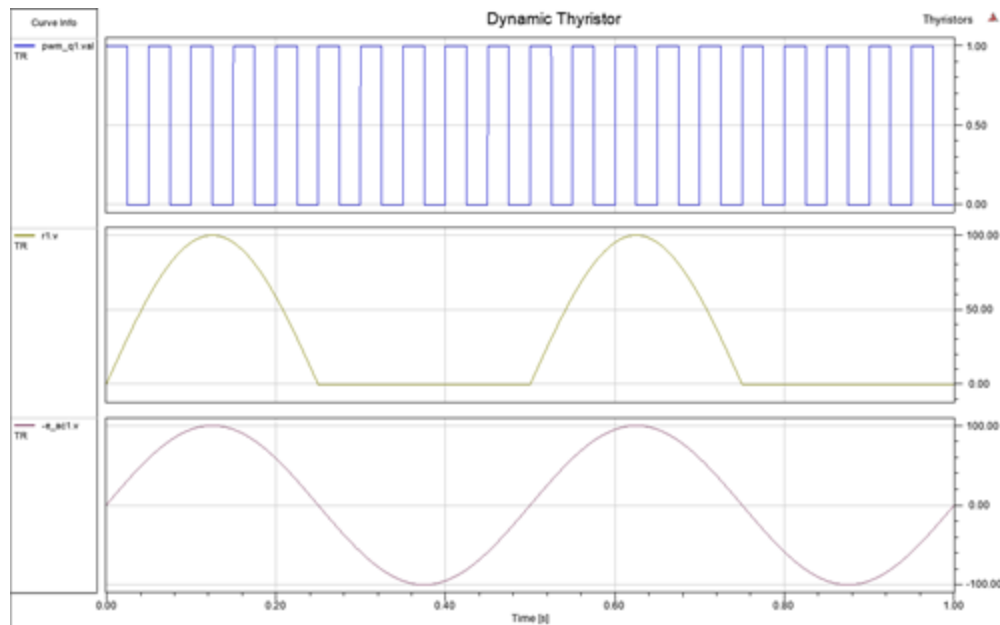


Figure 2. Dynamic Thyristor

The source voltage, PWM control signal and load voltage of the ideal thyristor example are shown in Figure 3.

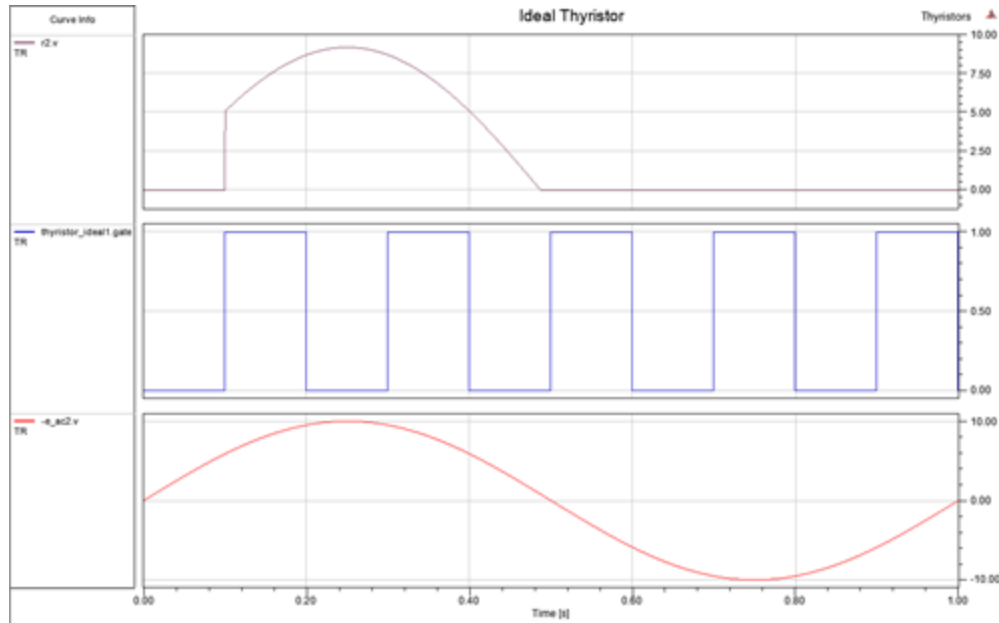


Figure 3. Ideal Thyristor

The source voltage, PWM control signal and load voltage of the ideal thyristor GTO example are shown in Figure 4.

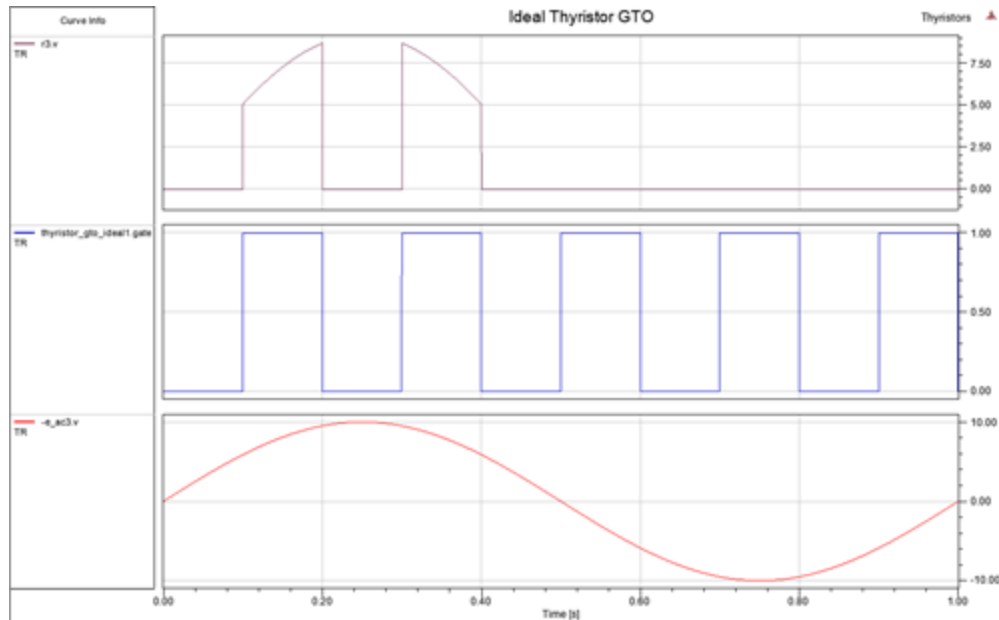


Figure 4. Ideal Thyristor GTO

[Top](#)