Report on Electromechanical

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(mtt -u -q -q Electromechanical rep pdf)

Tue Aug 19 14:49:56 BST 2003

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Electromechanical

Chapter 1

Electrostatic

1.1 Electrostatic_abg.tex

MTT command:

```
mtt Electrostatic abg tex
```

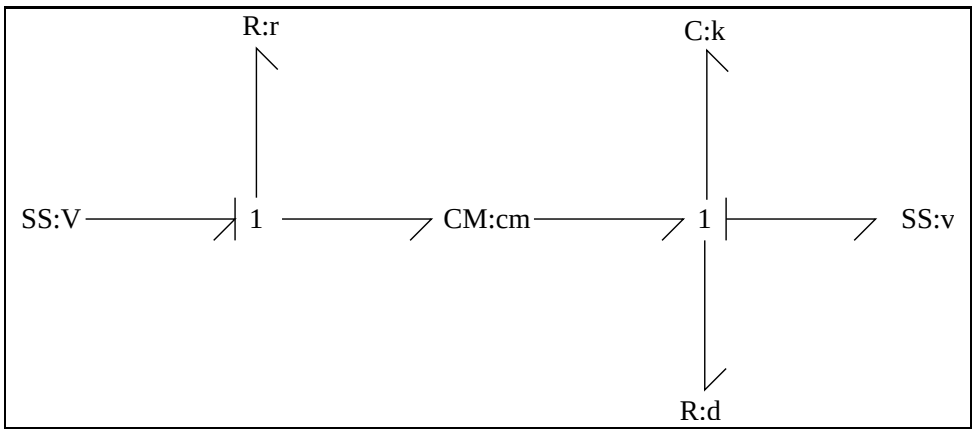

Figure 1.1: System **Electrostatic**: acausal bond graph

The acausal bond graph of system **Electrostatic** is displayed in Figure 1.1 (on page 9) and its label file is listed in Section 1.1.1 (on page 10). The subsystems are listed in Section 1.1.2 (on page 11).

This is a simple electrostatic speaker using the **CM** transducer component together with an electrical **R** and a mechanical **R** and **C** components to model a compliant support for the moving plate. See Karnopp, Margolis and Rosenberg Section 8.2 for a similar example.

1.1.1 Summary information

System Electrostatic::Simple electrostatic speaker model (uses CM) See Karnopp, Margolis Rosenberg Section 8.2

Interface information:

This component has no ALIAS declarations

Variable declarations:

This component has no PAR declarations

Units declarations:

This component has no UNITs declarations

The label file: Electrostatic_lbl.txt

```
%SUMMARY Electrostatic: Simple electrostatic speaker model (uses C
%DESCRIPTION See Karnopp, Margolis & Rosenberg Section 8.2
%% Label file for system Electrostatic (Electrostatic_lbl.txt)

% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% Version control history
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% $Id: Electrostatic_lbl.txt,v 1.1 2000/12/28 17:42:25 peterg E
% %% $Log: Electrostatic_lbl.txt,v $
% %% Revision 1.1  2000/12/28 17:42:25  peterg
% %% To RCS
% %%
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%% Each line should be of one of the following forms:
% a comment (ie starting with %)
% Component-name CR_name arg1,arg2,..argn
% blank



% Component type C
k lin state,k
```

```
% Component type CM
cm none c_0;x_0;m

% Component type R
d lin flow,d
r lin flow,r

% Component type SS
V SS external,internal
v SS 0,external
```

1.1.2 Subsystems

- CM: Mechanical (moving-plate) capacitor (1) No subsystems.

1.1.3 CM

The acausal bond graph of system **CM** is displayed in Figure 1.2 (on page 12) and its label file is listed in Section 1.1.3 (on page 11). The subsystems are listed in Section 1.1.3 (on page 14).

CM is an electromechanical moving-plate capacitor with linear electrical capacitance c of the form

$$c = c_0 \frac{x_0}{x} \tag{1.1}$$

where x_0 is the plate separation corresponding to a capacitance of c_0. The corresponding electrical constitutive relationship (which gives an energy-conserving two-port **C**) is

$$F = Qc_0 \frac{x_0}{x^2} \tag{1.2}$$

where F is the force between the plates and Q the charge on the capacitor. This is implemented in the *cm.cr* Constitutive Relationship.

Summary information

System CM::Mechanical (moving-plate) capacitor Parameter 1: Capacitance at plate separation of x_0 Parameter 2: x_0 Parameter 3: mass of moving-plate

Interface information:

This component has no ALIAS declarations

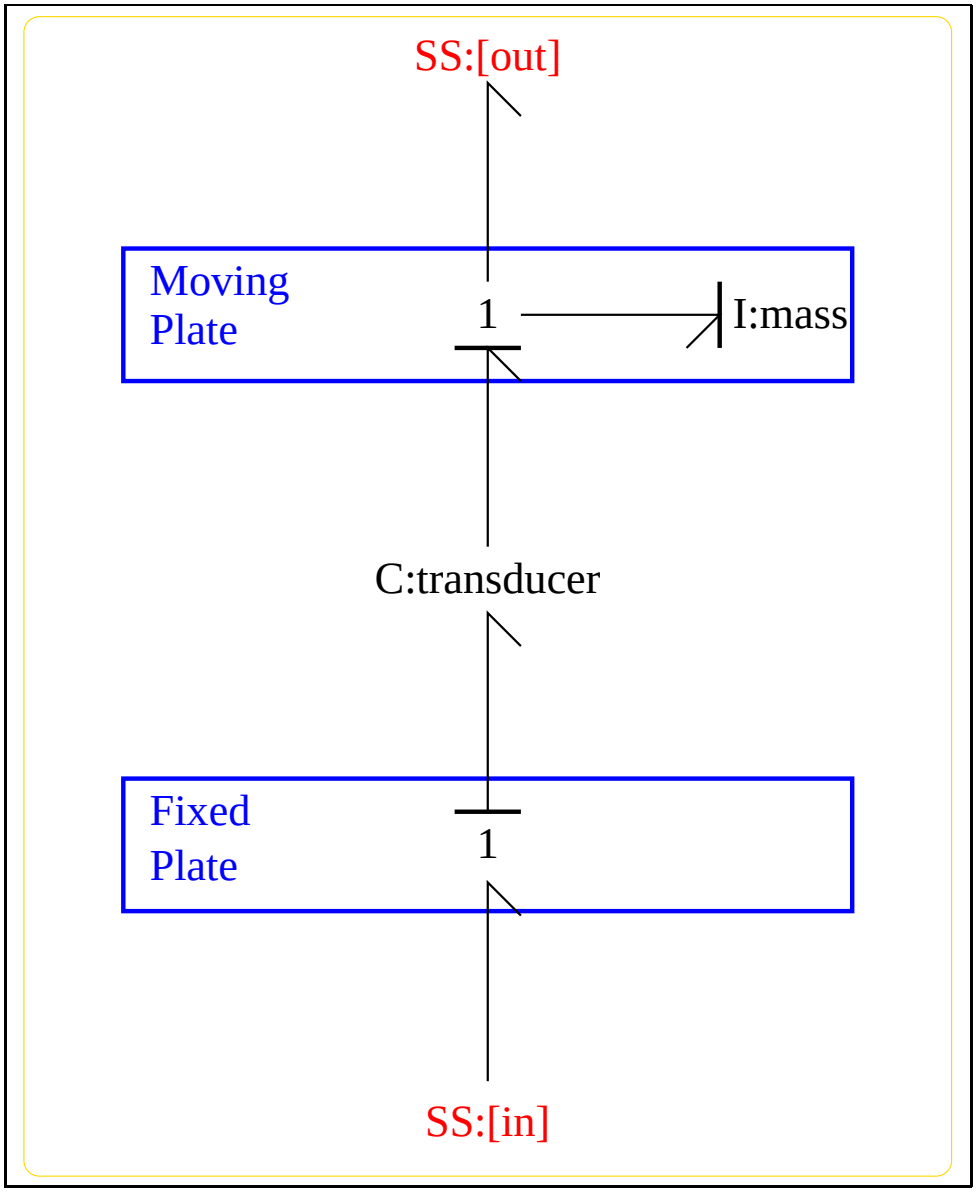

Figure 1.2: System **CM**: acausal bond graph

Variable declarations:

This component has no PAR declarations

Units declarations:

This component has no UNITs declarations

The label file: CM_lbl.txt

```
%SUMMARY CM: Mechanical (moving-plate) capacitor
%DESCRIPTION Parameter 1: Capacitance at plate separation of x_0
%DESCRIPTION Parameter 2: x_0
%DESCRIPTION Parameter 3: mass of moving-plate

%% Label file for system CM (CM_lbl.txt)

% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% Version control history
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% $Id: CM_lbl.txt,v 1.1 2000/12/28 10:21:22 peterg Exp $
% %% $Log: CM_lbl.txt,v $
% %% Revision 1.1  2000/12/28 10:21:22  peterg
% %% put under RCS
% %%
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%% Each line should be of one of the following forms:
% a comment (ie starting with %)
% Component-name CR_name arg1,arg2,..argn
% blank



% Component type C
transducer cm $1,$2

% Component type I
mass lin flow,$3

% Component type SS
[in] SS external,external
```

```
[out] SS external,external
```

Subsystems

No subsystems.

1.2 Electrostatic_struc.tex

MTT command:

```
mtt Electrostatic struc tex
```

List of inputs for system Electrostatic			
	Component	System	Repetition
1	V	Electrostatic__V	1

List of outputs for system Electrostatic			
	Component	System	Repetition
1	v	Electrostatic_v	1

List of states for system Electrostatic			
	Component	System	Repetition
1	k	Electrostatic_k	1
2	transducer	Electrostatic_cm_transducer	1
3	transducer	Electrostatic_cm_transducer_2	1
4	mass	Electrostatic_cm_mass	1

1.3 Electrostatic_ode.tex

MTT command:

```
mtt Electrostatic ode tex
```

$$
\begin{aligned}
\dot{x}_1 &= \frac{x_4}{m} \\
\dot{x}_2 &= \frac{(c_0 u_1 x_0 - x_2 x_3)}{(c_0 r x_0)} \\
\dot{x}_3 &= \frac{x_4}{m} \\
\dot{x}_4 &= \frac{\left(-c_0 m x_2^2 x_0 - 2 d x_3^2 x_4 - 2 k m x_1 x_3^2\right)}{\left(2 m x_3^2\right)}
\end{aligned}
\tag{1.3}
$$

$$
y_1 = \frac{x_4}{m} \tag{1.4}
$$

1.4 Electrostatic_numpar.txt

MTT command:

```
mtt Electrostatic numpar txt

# Numerical parameter file (Electrostatic_numpar.txt)
# Generated by MTT at Fri Sep 19 17:43:25 BST 1997

# %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# %% Version control history
# %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# %% $Id: Electrostatic_numpar.txt,v 1.2 2003/06/06 06:40:06 gawthrop Ex
# %% $Log: Electrostatic_numpar.txt,v $
# %% Revision 1.2  2003/06/06 06:40:06  gawthrop
# %% Made compatible with current MTT.
# %%
# %% Revision 1.1  2000/12/28 17:42:25  peterg
# %% To RCS
# %%
# %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

# Parameters
c_0 =  1.0; # Parameter c_0 for Electrostatic
d =  1.0; # Parameter d for Electrostatic
k =  100.0; # Parameter k for Electrostatic
m =  1.0; # Parameter m for Electrostatic
```

```
r =  1.0; # Parameter r for Electrostatic
x_0 =  1.0; # Parameter x_0 for Electrostatic

# Initial states
## Removed by MTT on Thu Jun  5 15:45:05 BST 2003: x(1) =  0.0; #
## Removed by MTT on Thu Jun  5 15:45:05 BST 2003: x(2) =  0.0; #
## Removed by MTT on Thu Jun  5 15:45:05 BST 2003: x(3) =  1.0; #
## Removed by MTT on Thu Jun  5 15:45:05 BST 2003: x(4) =  0.0; #
```

1.5 Electrostatic_input.txt

MTT command:

```
mtt Electrostatic input txt
```

```
# Numerical parameter file (Electrostatic_input.txt)
# Generated by MTT at Fri Sep 19 17:34:53 BST 1997

# %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# %% Version control history
# %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
# %% $Id: Electrostatic_input.txt,v 1.2 2003/06/06 06:39:59 gawthr
# %% $Log: Electrostatic_input.txt,v $
# %% Revision 1.2  2003/06/06 06:39:59  gawthrop
# %% Made compatible with current MTT.
# %%
# %% Revision 1.1  2000/12/28 17:42:25  peterg
# %% To RCS
# %%
# %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

# Set the inputs
## Removed by MTT on Thu Jun  5 15:47:51 BST 2003: u(1) =
1.0; # V (Default value)
electrostatic__v = 1.0; # Added by MTT on Thu Jun 05 15:47:54 BST
```

1.6 Electrostatic_simpar.txt

MTT command:

```
mtt Electrostatic simpar txt

# -*-octave-*- Put Emacs into octave-mode
# Simulation parameters for system Electrostatic (Electrostatic_simpar.t
# Generated by MTT on Tue Aug 19 14:48:57 BST 2003.
##################################################################
## Version control history
##################################################################
## $Id: rcs_header.sh,v 1.1 2000/12/28 11:58:07 peterg Exp $
## $Log: rcs_header.sh,v $
## Revision 1.1  2000/12/28 11:58:07  peterg
## Put under RCS
##
##################################################################


FIRST        = 0.0;       # First time in simulation output
DT          = 0.1;        # Print interval
LAST        = 10.0;       # Last time in simulation
STEPFACTOR  = 1;          # Integration steps per print interval
WMIN        = -1;         # Minimum frequency = 10^WMIN
WMAX        = 2;          # Maximum frequency = 10^WMAX
WSTEPS      = 100;        # Number of frequency steps
INPUT       = 1;          # Index of the input
```

1.7 Electrostatic_odeso.ps

MTT command:

```
mtt Electrostatic odeso ps
```

This representation is given as Figure 1.3 (on page 18).

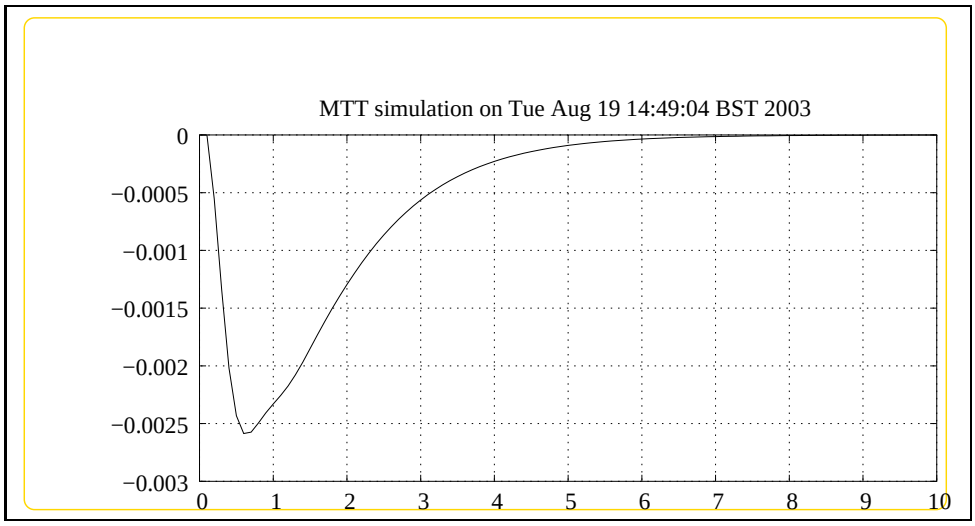

Figure 1.3: System **Electrostatic**, representation odeso (-noargs)

Chapter 2

MotorGenerator

2.1 MotorGenerator_abg.tex

MTT command:

```
mtt MotorGenerator abg tex
```

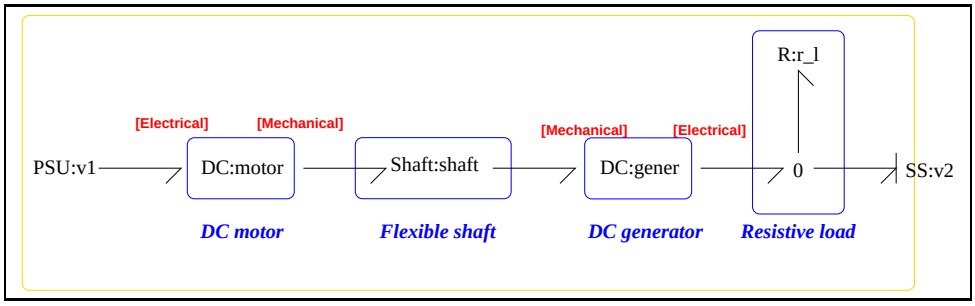

Figure 2.1: System **MotorGenerator**: acausal bond graph

The acausal bond graph of system **MotorGenerator** is displayed in Figure 2.1 (on page 19) and its label file is listed in Section 2.1 (on page 22). The subsystems are listed in Section 2.1.1 (on page 23).
This example illustates:

- The reuse of the DC model as both a motor and a generator
- The assignment of a *domain* and *units* to component ports.

The command:

```
mtt -I MotorGenerator ese r
```

gives the following output (irrelevant parts ommitted)

```
MTT (Model Transformation Tools) version 4.8
($Date: 2001/02/05 03:07:10 $)
This is free software with ABSOLUTELY NO WARRANTY.
Type ‘mtt warranty’ for details.

Creating MotorGenerator_rbg.m
Creating MotorGenerator_cmp.m
Creating MotorGenerator_fig.fig
Creating MotorGenerator_sabg.fig
Creating MotorGenerator_alias.txt
Creating MotorGenerator_alias.m
Creating MotorGenerator_sub.sh
Copying DC from /home/peterg/mtt_new/mtt-lib/comp/compound/Electro
Creating DC_rbg.m
Creating DC_cmp.m
Creating DC_fig.fig
Creating DC_sabg.fig
Creating DC_alias.txt
Creating DC_alias.m
Creating DC_sub.sh
Creating DC_abg.m
Checking port domains and units
     domains and units are OK

...

Creating PSU_rbg.m
Creating PSU_cmp.m
Creating PSU_fig.fig
Creating PSU_sabg.fig
Creating PSU_alias.txt
Creating PSU_alias.m
Creating PSU_sub.sh
Copying Se from /home/peterg/mtt_new/mtt-lib/comp/compound/General
Creating Se_rbg.m
Creating Se_cmp.m
Creating Se_fig.fig
Creating Se_sabg.fig
Creating Se_alias.txt
```

```
Creating Se_alias.m
Creating Se_sub.sh
Creating Se_abg.m
Checking port domains and units
  no domains or units declared
....

Creating PSU_abg.m
Checking port domains and units
     domains and units are OK
...

Creating Shaft_rbg.m
Creating Shaft_cmp.m
Creating Shaft_fig.fig
Creating Shaft_sabg.fig
Creating Shaft_alias.txt
Creating Shaft_alias.m
Creating Shaft_sub.sh
Creating Shaft_abg.m
Checking port domains and units
     domains and units are OK
....

Creating MotorGenerator_abg.m
Checking port domains and units
  no domains or units declared

Creating MotorGenerator_cbg.m (maximise integral causality)
Creating MotorGenerator_type.sh
 .....
Creating MotorGenerator_ese.r
Creating MotorGenerator_def.r
Creating MotorGenerator_struc.txt
...
INFORMATION: Component MotorGenerator connects ports with units volt and
INFORMATION: Component MotorGenerator connects ports with units amp and
...
INFORMATION: Component MotorGenerator connects ports with units N*m and
INFORMATION: Component MotorGenerator connects ports with units radians/
...
```

```
INFORMATION: Component MotorGenerator connects ports with units N*
INFORMATION: Component MotorGenerator connects ports with units ra
Creating MotorGenerator_aliased.txt
Copying MotorGenerator_ese.r
```

System MotorGenerator::Motor-generator example A simple example of DC motor driving a generator via a flexible shaft

Interface information:

This component has no ALIAS declarations

Variable declarations:

This component has no PAR declarations

Units declarations:

This component has no UNITs declarations

The label file: MotorGenerator_lbl.txt

```
%SUMMARY MotorGenerator: Motor-generator example
%DESCRIPTION A simple example of DC motor driving a generator via
%DESCRIPTION a flexible shaft

%% Label file for system MotorGenerator (MotorGenerator_lbl.txt)

% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% Version control history
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% $Id: MotorGenerator_lbl.txt,v 1.2 2000/12/28 17:43:16 peterg
% %% $Log: MotorGenerator_lbl.txt,v $
% %% Revision 1.2  2000/12/28 17:43:16  peterg
% %% To RCS
% %%
% %% Revision 1.1  2000/11/16 09:58:49  peterg
% %% Initial revision
% %%
% %% Revision 1.3  2000/05/20 16:38:40  peterg
```

```
% %% New SS foramt
% %%
% %% Revision 1.2  1998/04/04 10:51:59  peterg
% %% New version using port coercion
% %%
% %% Revision 1.1  1996/12/04  16:24:01  peterg
% %% Initial revision
% %%
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%% Each line should be of one of the following forms:
% a comment (ie starting with %)
% Component-name CR_name arg1,arg2,..argn
% blank

%Voltage in
v1 SS external,internal

% Voltage out
v2 SS external,0

%Motor
motor lin k_m;l_m;r_m;j_m;b_m

%Shaft
shaft         lin     c_s

%Generator
gener lin k_g;l_g;r_g;j_g;b_g

% Resistive load
r_l lin flow,r_l
```

2.1.1 Subsystems

- DC: DC motor (or generator) (4) No subsystems.
- PSU (1)
  - Se Simple effort source (1)

- Shaft (1) No subsystems.

2.1.2 DC

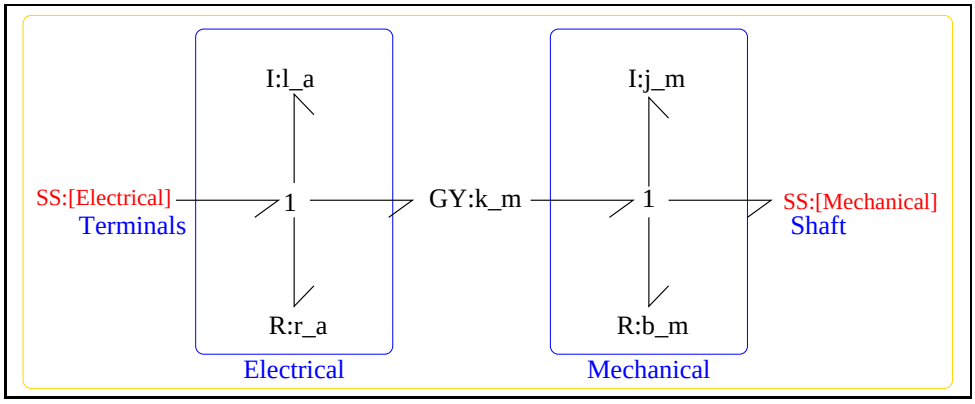

Figure 2.2: System **DC**: acausal bond graph

The acausal bond graph of system **DC** is displayed in Figure 2.2 (on page 24) and its label file is listed in Section 2.1.2 (on page 24). The subsystems are listed in Section 2.1.2 (on page 27).

Index	Parameter
1	Motor gain (k_m)
2	Armature inductance (l_a)
3	Armature resistance (r_a)
4	Inertia (j_m)
5	Friction coefficient (b_m)

Table 2.1: DC motor parameters

DC is a two-port component representing a DC motor. It has the 5 parameters listed in Table 2.1 (on page 24).

Summary information

System DC::DC motor (or generator)

Interface information:

Parameter $1 represents actual parameter **k_m**

Parameter $2 represents actual parameter **l_a**

Parameter $3 represents actual parameter **r_a**

Parameter $4 represents actual parameter **j_m**

Parameter $5 represents actual parameter **b_m**

Port in represents actual port **Electrical**

Port out represents actual port **Mechanical**

Variable declarations:

This component has no PAR declarations

Units declarations:

Port Electrical has domain electrical

Effort units volt

Flow units amp

Port Mechanical has domain rotational

Effort units N*m

Flow units radians/s

The label file: DC_lbl.txt

```
%SUMMARY DC: DC motor (or generator)

%% Port Alias
%ALIAS in Electrical
%ALIAS out Mechanical

%% Unit definition
%UNITS Electrical electrical volt amp
%UNITS Mechanical rotational N*m radians/s

%ALIAS $1 k_m
```

```
%ALIAS $2 l_a
%ALIAS $3 r_a
%ALIAS $4 j_m
%ALIAS $5 b_m


%% Label file for system DC (DC_lbl.txt)

% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% Version control history
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% $Id: DC_lbl.txt,v 1.7 2001/02/05 03:07:10 geraint Exp $
% %% $Log: DC_lbl.txt,v $
% %% Revision 1.7  2001/02/05 03:07:10  geraint
% %% angular displacement units: changed rads to radians
% %%
% %% Revision 1.6  2000/11/16 09:45:51  peterg
% %% Added unit definitions
% %%
% %% Revision 1.5  1998/07/26 12:49:24  peterg
% %% Corrected some errors
% %%
% %% Revision 1.4  1998/07/26 12:45:33  peterg
% %% Added ports
% %%
% %% Revision 1.3  1998/07/22 12:01:17  peterg
% %% Aliased ports and parameters.
% %%
% %% Revision 1.2  1996/12/04  16:01:42  peterg
% %% Documantation added.
% %%
% %% Revision 1.1  1996/12/04  16:00:56  peterg
% %% Initial revision
% %%
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%% Each line should be of one of the following forms:
% a comment (ie starting with %)
% Component-name CR_name arg1,arg2,..argn
% blank
```

```
%Motor gain
k_m lin flow,k_m

% Electrical components
%Inductance
l_a lin effort,l_a

%Resistance
r_a lin flow,r_a

% Mechanical components
%Inertia
j_m lin flow,j_m

%Friction
b_m lin flow,b_m

% Ports
[Electrical] SS external,external
[Mechanical] SS external,external
```

Subsystems

No subsystems.

2.1.3 PSU

The acausal bond graph of system **PSU** is displayed in Figure 2.3 (on page 28) and its label file is listed in Section 2.1.3 (on page 27). The subsystems are listed in Section 2.1.3 (on page 29).

Summary information

System PSU:

Interface information:

This component has no ALIAS declarations

Variable declarations:

This component has no PAR declarations

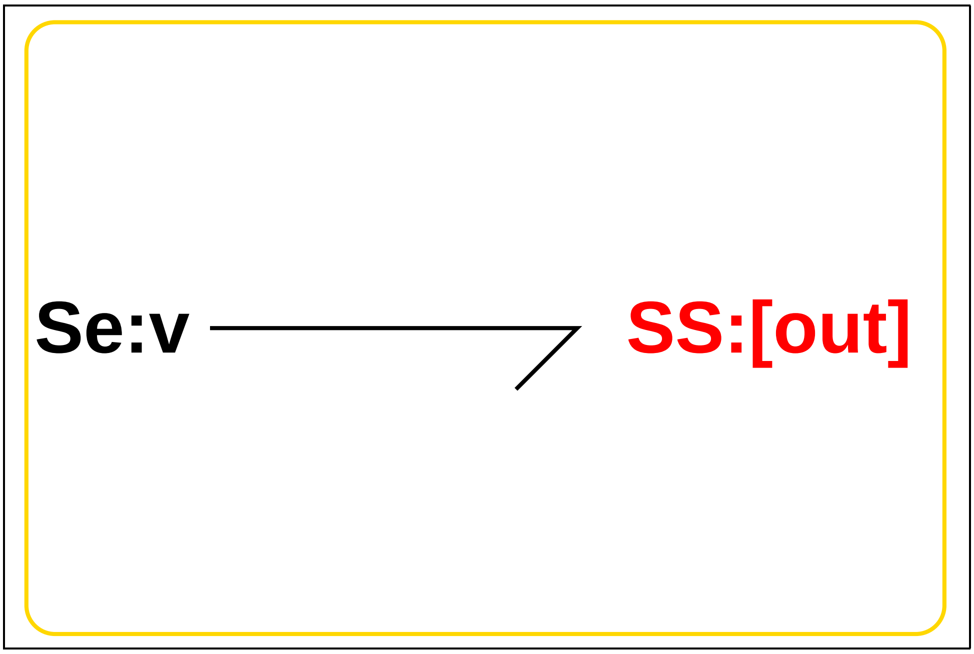

Figure 2.3: System **PSU**: acausal bond graph

Units declarations:

Port out has domain electrical

Effort units volt

Flow units amp

The label file: PSU_lbl.txt

```
%% Label file for system PSU (PSU_lbl.txt)
%SUMMARY PSU
%DESCRIPTION

% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% Version control history
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% $Id: PSU_lbl.txt,v 1.1 2000/12/28 17:43:16 peterg Exp $
% %% $Log: PSU_lbl.txt,v $
% %% Revision 1.1  2000/12/28 17:43:16  peterg
% %% To RCS
% %%
```

```
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


%UNITS out electrical volt amp
% Port aliases

% Argument aliases

%% Each line should be of one of the following forms:
%      a comment (ie starting with %)
%      component-name cr_name arg1,arg2,..argn
%      blank

% ---- Component labels ----

% Component type SS
[out] SS external,external

% Component type Se
v SS external
```

Subsystems

- Se Simple effort source (1) No subsystems.

2.1.4 Se

The acausal bond graph of system **Se** is displayed in Figure 2.4 (on page 30) and its label file is listed in Section 2.1.4 (on page 29). The subsystems are listed in Section 2.1.4 (on page 31).

Summary information

System Se:Simple effort source Simple effort source constructed from SS with fixed causality

Interface information:

Parameter $1 represents actual parameter **e_s**

Port in represents actual port **out**

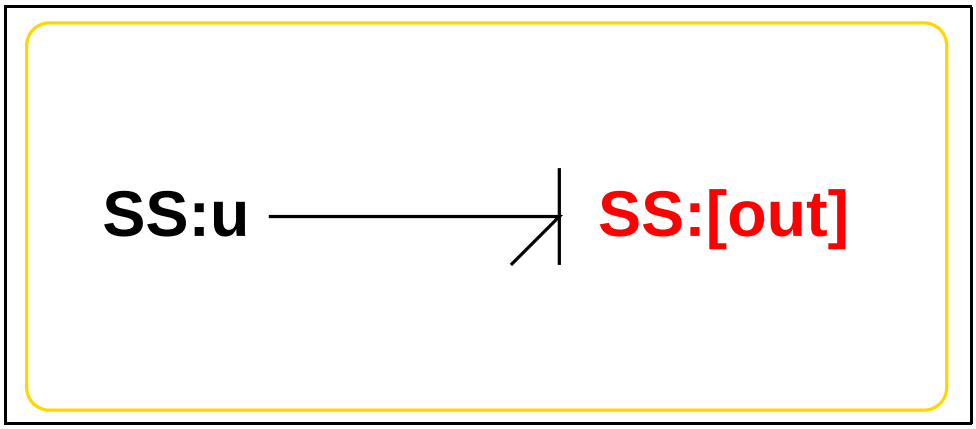

Figure 2.4: System **Se**: acausal bond graph

Port out represents actual port **out**

Variable declarations:

This component has no PAR declarations

Units declarations:

This component has no UNITs declarations

The label file: Se_lbl.txt

```
%% Label file for system Se (Se_lbl.txt)
%SUMMARY Se Simple effort source
%DESCRIPTION Simple effort source constructed from SS with fixed c


% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% Version control history
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% $Id: Se_lbl.txt,v 1.3 1999/08/05 07:31:39 peterg Exp $
% %% $Log: Se_lbl.txt,v $
% %% Revision 1.3  1999/08/05 07:31:39  peterg
% %% Added in alias
% %%
% %% Revision 1.2  1999/03/12 04:04:27  peterg
% %% Single argument - the effort value e_s
```

```
% %%
% %% Revision 1.1  1999/03/03 21:55:46  peterg
% %% Initial revision
% %%
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


% Port aliases
%ALIAS out|in out

% Argument aliases
%ALIAS $1 e_s

%% Each line should be of one of the following forms:
%      a comment (ie starting with %)
%      component-name cr_name arg1,arg2,..argn
%      blank

% ---- Component labels ----

% Component type SS
[out] SS external,external
u SS e_s,internal
```

Subsystems

No subsystems.

2.1.5 Shaft

The acausal bond graph of system **Shaft** is displayed in Figure 2.5 (on page 32) and its label file is listed in Section 2.1.5 (on page 31). The subsystems are listed in Section 2.1.5 (on page 34).

Summary information

System Shaft:

Interface information:

Parameter $1 represents actual parameter **c_s**

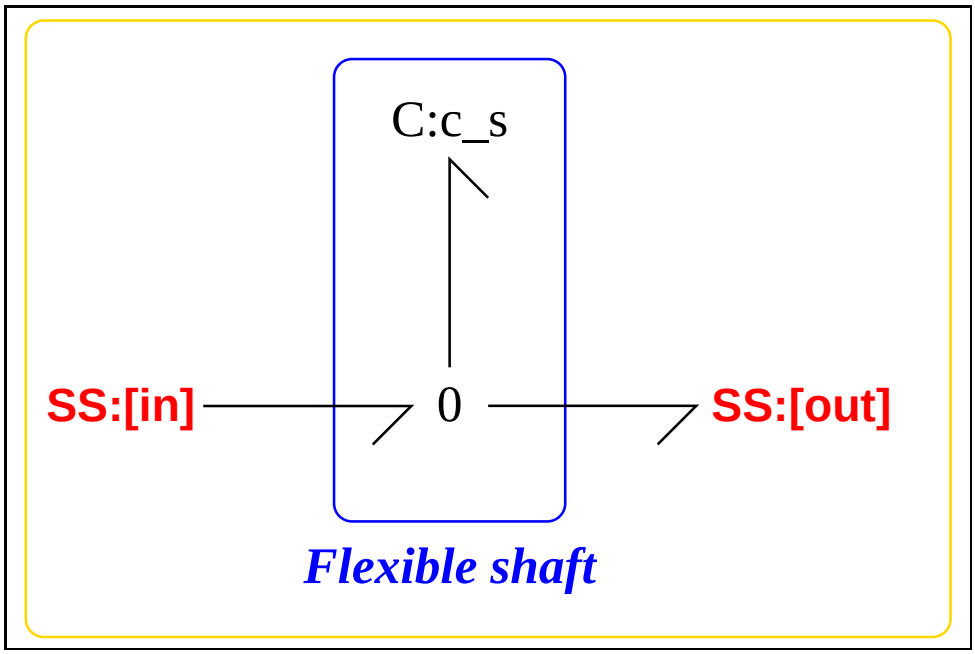

Figure 2.5: System **Shaft**: acausal bond graph

Variable declarations:

This component has no PAR declarations

Units declarations:

Port in has domain rotational

Effort units N*m

Flow units radians/s

Port out has domain rotational

Effort units N*m

Flow units radians/s

The label file: Shaft_lbl.txt

```
%% Label file for system Shaft (Shaft_lbl.txt)
%SUMMARY Shaft
%DESCRIPTION
```

```
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% Version control history
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% %% $Id: Shaft_lbl.txt,v 1.2 2001/02/05 03:07:10 geraint Exp $
% %% $Log: Shaft_lbl.txt,v $
% %% Revision 1.2  2001/02/05 03:07:10  geraint
% %% angular displacement units: changed rads to radians
% %%
% %% Revision 1.1  2000/12/28 17:43:16  peterg
% %% To RCS
% %%
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


% Port aliases


% Unit definitions
%UNITS in  rotational N*m radians/s
%UNITS out rotational N*m radians/s

% Argument aliases
%ALIAS $1 c_s

%% Each line should be of one of the following forms:
%      a comment (ie starting with %)
%      component-name cr_name arg1,arg2,..argn
%      blank

% ---- Component labels ----

% Component type C
c_s lin effort,c_s

% Component type SS
[in] SS external,external
[out] SS external,external
```

Subsystems

No subsystems.

2.2 MotorGenerator_cbg.ps

MTT command:

```
mtt MotorGenerator cbg ps
```

This representation is given as Figure 2.6 (on page 34).

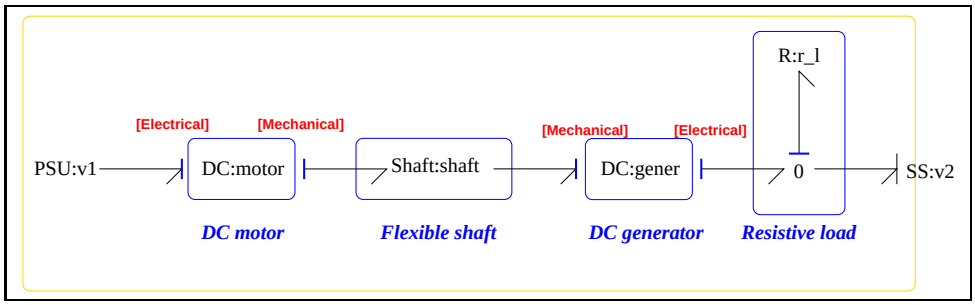

Figure 2.6: System **MotorGenerator**, representation cbg (-noargs)

2.3 MotorGenerator_struc.tex

MTT command:

```
mtt MotorGenerator struc tex
```

List of inputs for system MotorGenerator			
	Component	System	Repetition
1	u	MotorGenerator_v1_v_u	1

List of outputs for system MotorGenerator			
	Component	System	Repetition
1	v2	MotorGenerator_v2	1

List of states for system MotorGenerator			
	Component	System	Repetition
1	l_a	MotorGenerator__motor__l_a	1
2	j_m	MotorGenerator__motor__j_m	1
3	c_s	MotorGenerator__shaft__c_s	1
4	l_a	MotorGenerator__gener__l_a	1
5	j_m	MotorGenerator__gener__j_m	1

2.4 MotorGenerator_sympar.tex

MTT command:

```
mtt MotorGenerator sympar tex
```

Parameter	System
b_g	MotorGenerator
b_m	MotorGenerator
c_s	MotorGenerator
j_g	MotorGenerator
j_m	MotorGenerator
k_g	MotorGenerator
k_m	MotorGenerator
l_g	MotorGenerator
l_m	MotorGenerator
r_g	MotorGenerator
r_l	MotorGenerator
r_m	MotorGenerator

Table 2.2: Parameters

2.5 MotorGenerator_ode.tex

MTT command:

```
mtt MotorGenerator ode tex
```

$$
\begin{aligned}
\dot{x}_1 &= \frac{(j_m l_m u_1 - j_m x_1 r_m - k_m l_m x_2)}{(j_m l_m)} \\
\dot{x}_2 &= \frac{(-b_m c_s l_m x_2 + c_s j_m k_m x_1 - j_m l_m x_3)}{(c_s j_m l_m)} \\
\dot{x}_3 &= \frac{(j_g x_2 - j_m x_5)}{(j_g j_m)} \\
\dot{x}_4 &= \frac{(-(j_g x_4 r_g + j_g x_4 r_l + k_g l_g x_5))}{(j_g l_g)} \\
\dot{x}_5 &= \frac{(-b_g c_s l_g x_5 + c_s j_g k_g x_4 + j_g l_g x_3)}{(c_s j_g l_g)}
\end{aligned} \tag{2.1}
$$

$$
y_1 = \frac{(x_4 r_l)}{l_g} \tag{2.2}
$$

2.6 MotorGenerator_sm.tex

MTT command:

```
mtt MotorGenerator sm tex
```

$$
A = \begin{pmatrix}
\frac{(-r_m)}{l_m} & \frac{(-k_m)}{j_m} & 0 & 0 & 0 \\
\frac{k_m}{l_m} & \frac{(-b_m)}{j_m} & \frac{(-1)}{c_s} & 0 & 0 \\
0 & \frac{1}{j_m} & 0 & 0 & \frac{(-1)}{j_g} \\
0 & 0 & 0 & \frac{(-(r_g+r_l))}{l_g} & \frac{(-k_g)}{j_g} \\
0 & 0 & \frac{1}{c_s} & \frac{k_g}{l_g} & \frac{(-b_g)}{j_g}
\end{pmatrix} \tag{2.3}
$$

$$
B = \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \tag{2.4}
$$

$$
C = \begin{pmatrix} 0 & 0 & 0 & \frac{r_l}{l_g} & 0 \end{pmatrix} \tag{2.5}
$$

$$
D = \begin{pmatrix} 0 \end{pmatrix} \tag{2.6}
$$

2.7 MotorGenerator_odeso.ps

MTT command:

```
mtt MotorGenerator odeso ps
```

This representation is given as Figure 2.7 (on page 37).

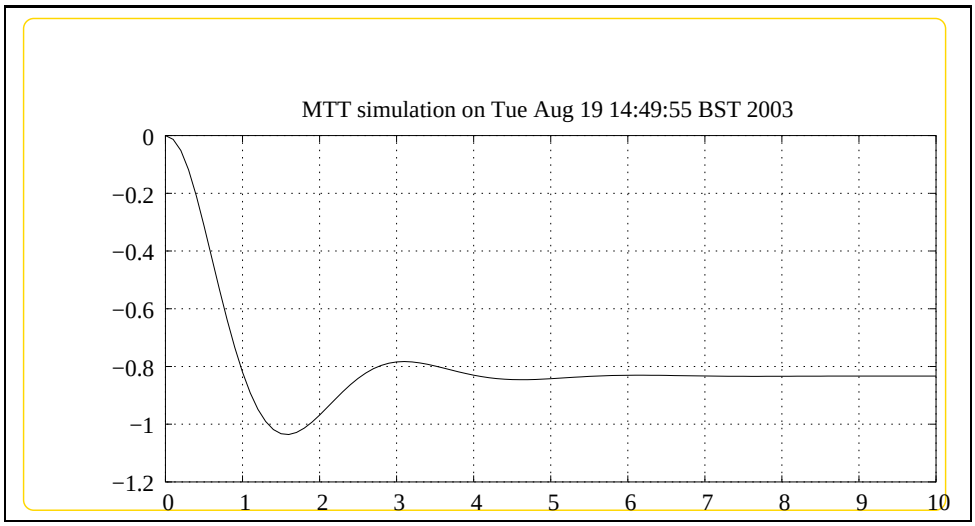

Figure 2.7: System **MotorGenerator**, representation odeso (-noargs)

2.8 MotorGenerator_rep.txt

MTT command:

```
mtt MotorGenerator rep txt
```

```
## -*-octave-*- Put Emacs into octave-mode
## Outline report file for system MotorGenerator (MotorGenerator_rep.txt
## Generated by MTT on" Thu Nov 16 13:37:07 GMT 2000.

##################################################################
## Version control history
##################################################################
## $Id: MotorGenerator_rep.txt,v 1.1 2000/12/28 17:43:16 peterg Exp $
## $Log: MotorGenerator_rep.txt,v $
## Revision 1.1  2000/12/28 17:43:16  peterg
```

```
## To RCS
##
#################################################################

mtt MotorGenerator abg tex # The system description
mtt MotorGenerator cbg ps          # The causal bond graph
mtt MotorGenerator struc tex         # The system structure
mtt MotorGenerator sympar tex         # The system parameters
## Uncomment the following lines or add others
## mtt MotorGenerator dae tex         # The system dae
mtt MotorGenerator ode tex         # The system ode
## mtt MotorGenerator sspar tex # Steady-state parameters
## mtt MotorGenerator ss tex  # Steady state
## mtt MotorGenerator dm tex # Descriptor matrices (of linearised
mtt MotorGenerator sm tex # State matrices (of linearised system)
##mtt MotorGenerator tf tex # Transfer function (of linearised sys
## mtt MotorGenerator lmfr ps # log modulus of frequency response
## mtt MotorGenerator simpar tex # Simulation parameters
## mtt MotorGenerator numpar tex # Numerical simulation parameters
## mtt MotorGenerator state tex # Simulation initial state
## mtt MotorGenerator input tex # Simulation input
## mtt MotorGenerator logic tex # Logic control
mtt MotorGenerator odeso ps # Simulation output

mtt MotorGenerator rep txt # This file
```

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