

**SIMULATION OF MOTIONS OF  
LOW COST INERTIAL SYSTEM**

**LOCISIM.MCD**  
MS9502091800/  
MS9607291600

Generation of test data for verification  
of identification algorithm  
using LOCIMOT with test = 1

Simulation für die Arcona See  
Plattform des IOW

**BEGIN LOCISIM**

**Notation**

dis	Position
disa	in raumfesten Koordinaten
disa0	Cardan Winkel
disa1	Ortskoordinaten des Bezugspunktes
der	Ableitung
dera	in raumfesten Koordinaten
dera0	Winkelgeschwindigkeit
dera1	Längsgeschwindigkeit des Bezugspunktes
vel	Geschwindigkeit
velb	in körperfesten Koordinaten
velb0	Drehgeschwindigkeit
velb1	Längsgeschwindigkeit des Bezugspunktes
acc	Beschleunigung
accb	in körperfesten Koordinaten
accb0	Drehbeschleunigung
accb1	Längsbeschleunigung des Bezugspunktes
fld	Quellstärke
fldb	in körperfesten Koordinaten
fldb0	neg. Winkelbeschleunigung
fldb1	Feldstärke am Bezugspunkt
fldbl	lokale relative Feldstärke, das sind die Meßwerte sechs Feldstärke-Sensoren

### Input files

none:      Laws of motion given

### Output files

LOCIPAR  
LOCIDA  
LOCIVB  
LOCIFB  
LOCIBCD  
LOCICFG  
LOCIFBL

### Generation of test signals

Individual amplitudes

$j := 0..5$

$am_j := 0.002 \cdot (j + 1)$        $bm_j := 0.4 \cdot (j + 1)$

Frequency, signal width

$t_P := 3$        $t_Q := 6$

### Sampling data

$n_S := 512$        $i := 0..n_S$

$t_0 := 0$        $t_1 := 10.24$

$t_S := \frac{t_1 - t_0}{n_S}$        $t_m := \frac{t_1 + t_0}{2}$

$\omega_{m1} := \frac{2 \cdot \pi}{t_1 - t_0}$        $n_F := \frac{n_S}{2}$

$t_i := t_0 + i \cdot t_S$

### Parameters

$par^{<0>} := am$        $par^{<1>} := bm$

$par_{6,0} := t_P$        $par_{6,1} := t_Q$

$par_{7,0} := t_0$        $par_{7,1} := t_1$

**Generating linear (0..2)  
and angular (3..5) displacements in space fixed coordinates**

$$l := 0..n_F$$

$$\text{disas}_{1,j} := 0$$

$$\text{disas}_{4,j} := \text{am}_j \cdot \exp(i \cdot \text{bm}_j)$$

$$\text{disas}_{5,j} := \frac{-\text{am}_j}{2} \cdot \exp(i \cdot \text{bm}_j)$$

$$\text{disa}_{0,j} := 0.0006 \cdot j$$

$$\text{disa}_{1,j} := -0.0001 \cdot j$$

$$\text{disat}^{<j>} := \text{IFFT}(\text{disas}^{<j>})$$

$$\text{disau} := \text{disat}^T$$

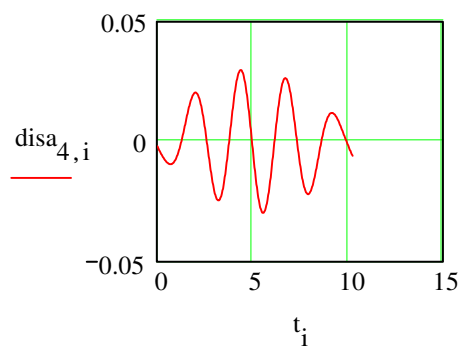
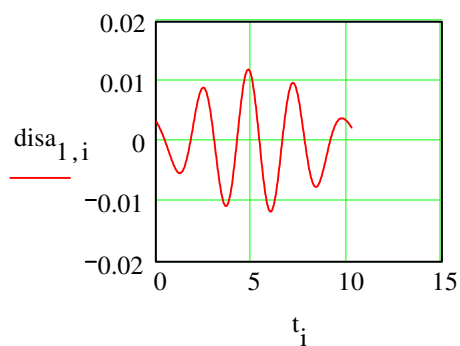
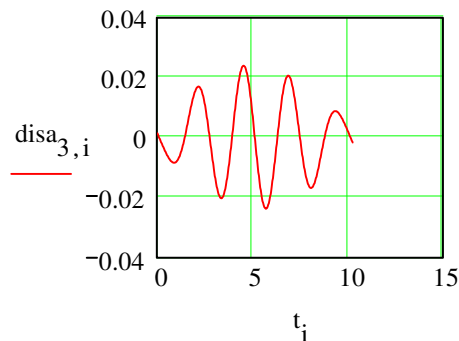
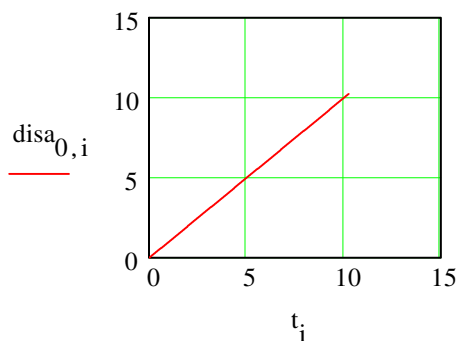
$$\text{disau}^{<n_s>} := \text{disau}^{<0>}$$

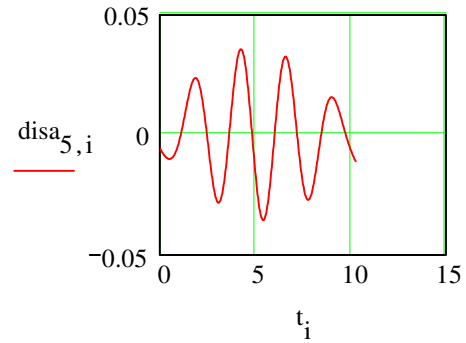
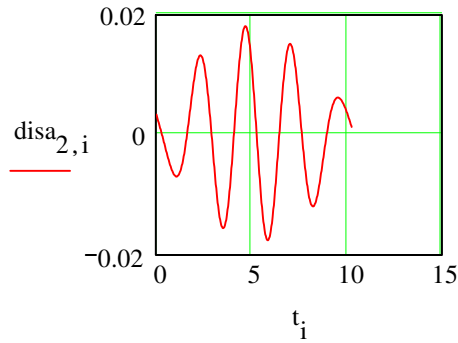
$$\text{disa}^{<i>} := \text{disau}^{<i>} + \text{disa}_0 + \text{disa}_1 \cdot (t_i - t_0)$$

Diese Darstellung des Testsignals im Frequenzbereich wurde gewählt, nachdem die Darstellung im Zeitbereich wegen des Rundungsrauschens zu unnötigen Problemen führte.

$$\text{disa}_{1_0} := \text{disa}_{1_0} + 1$$

**Displaying linear and angular displacements in space fixed coordinates**





### Generating derivatives of displacements in space fixed coordinates

$$\text{disa}_1 := \frac{\text{disa}^{<n S>} - \text{disa}^{<0>}}{t_1 - t_0}$$

$$k := 0..n_S - 1$$

$$\text{disar}_{k,j} := \text{disa}_{j,k} - \text{disa}_{1,j} \cdot (t_k - t_0)$$

r: reduced

$$\text{disa}_{0,j} := \text{mean}(\text{disar}^{<j>})$$

up to this point trend removal

$$\text{disar}_{k,j} := \text{disar}_{k,j} - \text{disa}_{0,j}$$

$$\text{disas}^{<j>} := \text{FFT}(\text{disar}^{<j>})$$

s: spectral

$$l := 0..n_F$$

$$\text{deras}_{1,j} := \text{disas}_{1,j} \cdot (i \cdot l \cdot \text{om}_1)$$

$$\text{derat}^{<j>} := \text{IFFT}(\text{deras}^{<j>})$$

t: transposed

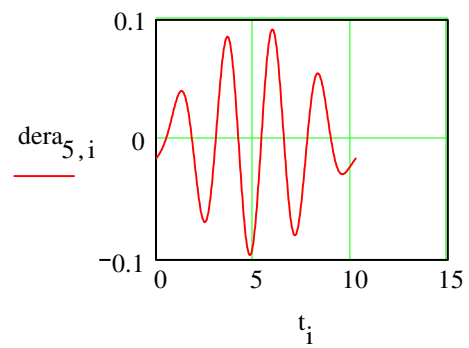
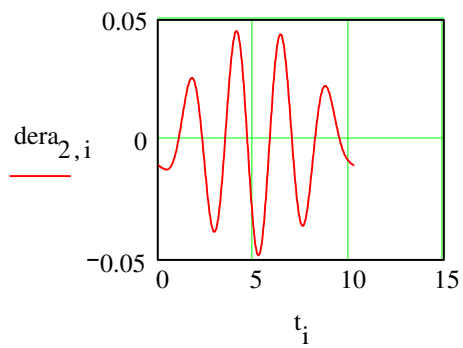
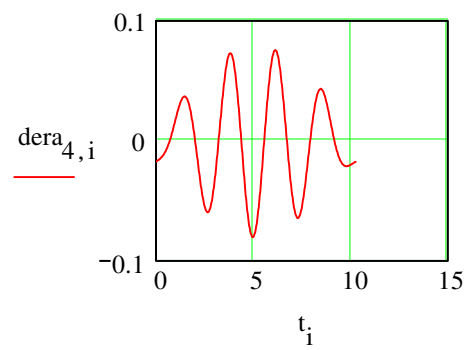
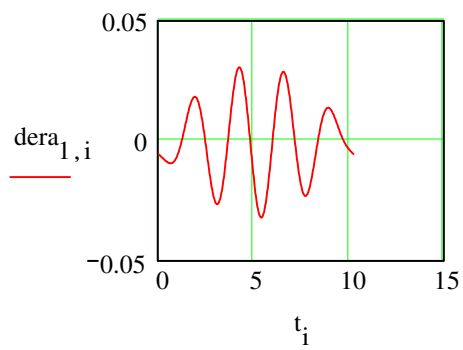
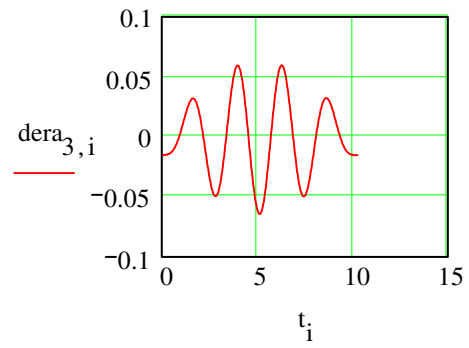
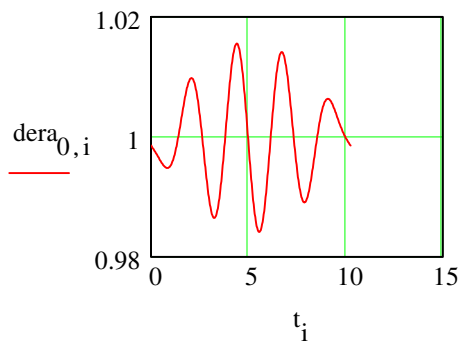
$$\text{derau} := \text{derat}^T$$

u: undetermined

$$\text{derau}^{<n S>} := \text{derau}^{<0>}$$

$$\text{dera}^{<i>} := \text{derau}^{<i>} + \text{disa}_1$$

replace trend



**Transformation matrices**

$$T_2(A) := \begin{bmatrix} \cos(A_2) & \sin(A_2) & 0 \\ -\sin(A_2) & \cos(A_2) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$T_1(A) := \begin{bmatrix} \cos(A_1) & 0 & -\sin(A_1) \\ 0 & 1 & 0 \\ \sin(A_1) & 0 & \cos(A_1) \end{bmatrix}$$

$$T_0(A) := \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(A_0) & \sin(A_0) \\ 0 & -\sin(A_0) & \cos(A_0) \end{bmatrix}$$

$$T_{11}(A) := T_0(A) \cdot T_1(A) \cdot T_2(A)$$

$$T_{10}(A) := \begin{bmatrix} 1 & 0 & -\sin(A_1) \\ 0 & \cos(A_0) & \sin(A_0) \cdot \cos(A_1) \\ 0 & -\sin(A_0) & \cos(A_0) \cdot \cos(A_1) \end{bmatrix}$$

**Generating linear velocities  
and angular velocities in body fixed coordinate**

$$j := 0..2$$

$$\text{disa0}_{j,i} := \text{disa}_{j+3,i}$$

$$\text{vela1}_{j,i} := \text{dera}_{j,i}$$

$$\text{velb1}^{<i>} := T_{11}(\text{disa0}^{<i>}) \cdot \text{vela1}^{<i>}$$

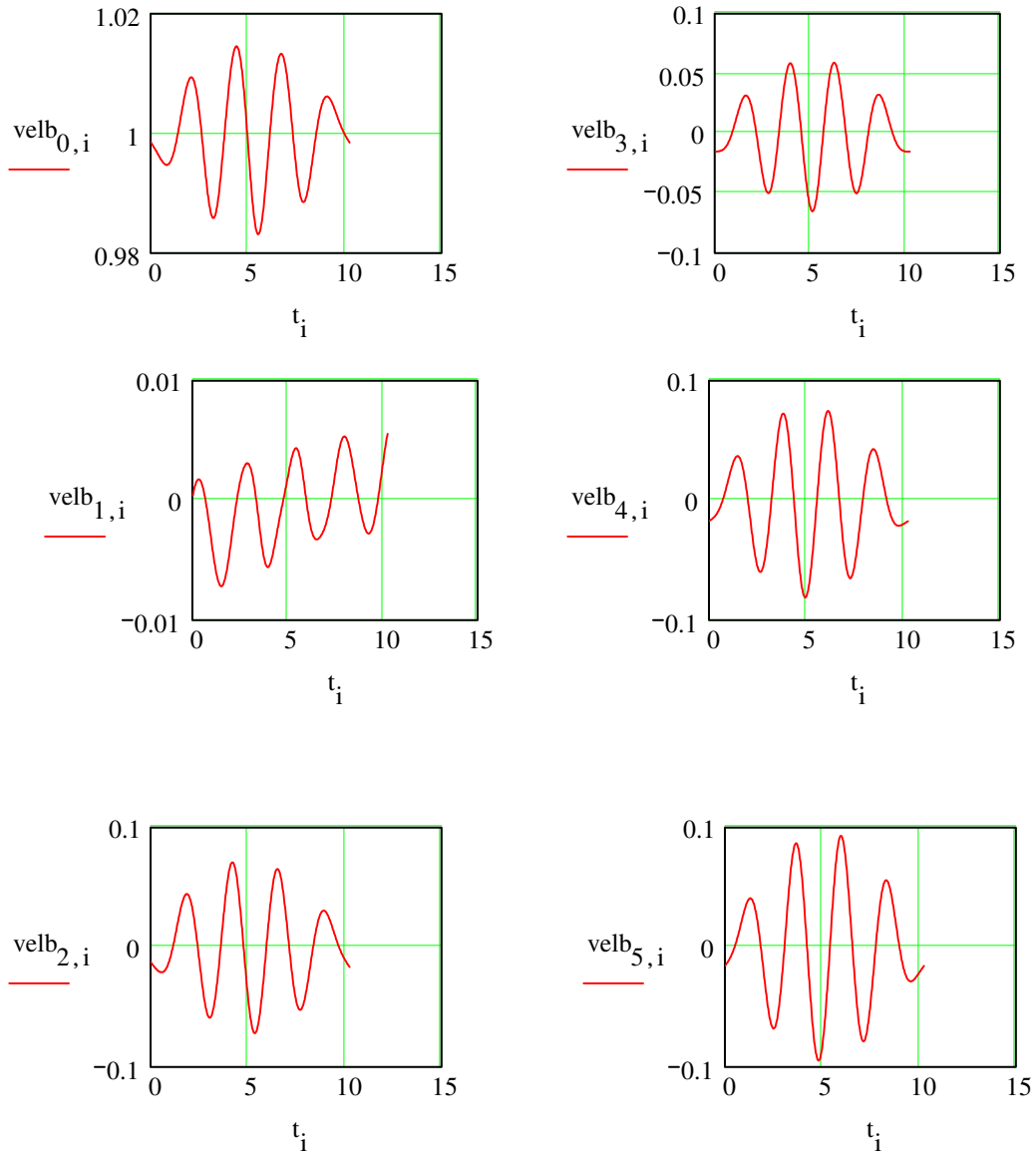
$$\text{velb}^{<i>} := \text{velb1}^{<i>}$$

$$\text{vela0}_{j,i} := \text{dera}_{3+j,i}$$

$$\text{velb0}^{<i>} := T_{10}(\text{disa0}^{<i>}) \cdot \text{vela0}^{<i>}$$

$$\text{velb}_{3+j,i} := \text{velb0}_{j,i}$$

**Displaying linear velocities and angular velocities in body fixed coordinates**



**Generating linear  
and angular accelerations in body fixed coordinates**

$j := 0..5$

$$velb_{1,j} := \frac{velb^{<n_s>} - velb^{<0>}}{t_1 - t_0}$$

$k := 0..n_s - 1$

$$\text{velbr}_{k,j} := \text{velb}_{j,k} - \text{velb}_{1,j} \cdot (t_k - t_0)$$

$$\text{velb}_{0,j} := \text{mean}(\text{velbr}^{<j>})$$

$$\text{velbr}_{k,j} := \text{velbr}_{k,j} - \text{velb}_{0,j}$$

$$\text{velbs}^{<j>} := \text{FFT}(\text{velbr}^{<j>})$$

$$l := 0..n_F$$

$$\text{accs}_{l,j} := \text{velbs}_{l,j} \cdot (i \cdot l \cdot \text{om}_1)$$

$$\text{acct}^{<j>} := \text{IFFT}(\text{accs}^{<j>})$$

$$\text{accu} := \text{acct}^T$$

$$\text{accu}^{<n_S>} := \text{accu}^{<0>}$$

$$\text{accb}^{<i>} := \text{accu}^{<i>} + \text{velb}_1$$

#### Determining field strength in body fixed coordinates

$$g := 9.81$$

$$i := 0..n_S$$

$$\text{grava1} := \begin{bmatrix} 0 \\ 0 \\ -g \end{bmatrix}$$

$$\text{gravb1}^{<i>} := T_{11}(\text{disa0}^{<i>}) \cdot \text{grava1}$$

$$j := 0..2$$

$$\text{accb1}_{j,i} := \text{accb}_{j,i}$$

$$\text{velb0}_{j,i} := \text{velb}_{3+j,i}$$

$$\text{velb1}_{j,i} := \text{velb}_{j,i}$$



$$\text{fldb1}^{<i>} := \text{gravb1}^{<i>} - \text{accb1}^{<i>} - \text{velb0}^{<i>} \times \text{velb1}^{<i>}$$

$$\text{fldb}_{j,i} := \text{fldb1}_{j,i}$$

$$\text{fldb}_{3+j,i} := -\text{accb}_{3+j,i}$$

Achtung! Diese  
Speicherung ist eine  
mißverständliche  
Bequemlichkeit.

### Boundary conditions

$$j := 0..5$$

$$\text{bcd}_{j,0} := \text{disa}_{j,0} \quad \text{bcd}_{j,1} := \text{disa}_{j,n_S}$$

$$\text{bcd}_{6+j,0} := \text{velb}_{j,0} \quad \text{bcd}_{6+j,1} := \text{velb}_{j,n_S}$$

$$j := 0..2$$

$$\text{bcd}_{6+j,0} := \text{dera}_{j,0} \quad \text{bcd}_{6+j,1} := \text{dera}_{j,n_S}$$

Achtung! Dies ist notwendig,  
weil bei der Rekonstruktion  
der linearen  
Geschwindigkeiten die  
absoluten einfacher zu haben  
sind!

Computation of field strengths at transducers  
from field strength at and motion of the reference point

### Configuration of LOCI

$$\text{cfg} := \begin{bmatrix} -0.264 & -0.264 & 0.406 & 0.406 & -0.264 & -0.264 \\ -0.343 & -0.303 & 0 & 0 & 0.303 & 0.343 \\ 0 & 0 & 0.35 & 0 & 0 & 0 \end{bmatrix}$$

$$\text{r}^{<0>} := \text{cfg}^{<0>} - \text{cfg}^{<5>}$$

$$\text{r}^{<1>} := \text{cfg}^{<2>} - \text{cfg}^{<1>}$$

$$\text{r}^{<2>} := \text{cfg}^{<4>} - \text{cfg}^{<3>}$$

$$l := \begin{bmatrix} 0 & r_{2,0} & -r_{1,0} \\ -r_{2,1} & 0 & r_{0,1} \\ r_{1,2} & -r_{0,2} & 0 \end{bmatrix}$$

$$l = \begin{bmatrix} 0 & 0 & 0.686 \\ -0.35 & 0 & 0.67 \\ 0.303 & 0.67 & 0 \end{bmatrix}$$

$$\Gamma^1 = \begin{bmatrix} 2.791 & -2.857 & 0 \\ -1.262 & 1.292 & 1.493 \\ 1.458 & 0 & 0 \end{bmatrix}$$

Reference field strengths

$$j := 0..2$$

$$\text{fldb0}_{j,i} := \text{fldb}_{3+j,i}$$

Local field strengths

$$\text{fldbj}^{<i>} := \left( \text{fldb1}^{<i>} + \text{fldb0}^{<i>} \times \text{cfg}^{<0>} \right) - \text{velb0}^{<i>} \times \left( \text{velb0}^{<i>} \times \text{cfg}^{<0>} \right)$$

$$\text{fldbl}_{0,i} := \text{fldbj}_{0,i}$$

$$\text{fldbj}^{<i>} := \left( \text{fldb1}^{<i>} + \text{fldb0}^{<i>} \times \text{cfg}^{<1>} \right) - \text{velb0}^{<i>} \times \left( \text{velb0}^{<i>} \times \text{cfg}^{<1>} \right)$$

$$\text{fldbl}_{1,i} := \text{fldbj}_{1,i}$$

$$\text{fldbj}^{<i>} := \left( \text{fldb1}^{<i>} + \text{fldb0}^{<i>} \times \text{cfg}^{<2>} \right) - \text{velb0}^{<i>} \times \left( \text{velb0}^{<i>} \times \text{cfg}^{<2>} \right)$$

$$\text{fldbl}_{2,i} := \text{fldbj}_{1,i}$$

$$\text{fldbj}^{<i>} := \left( \text{fldb1}^{<i>} + \text{fldb0}^{<i>} \times \text{cfg}^{<3>} \right) - \text{velb0}^{<i>} \times \left( \text{velb0}^{<i>} \times \text{cfg}^{<3>} \right)$$

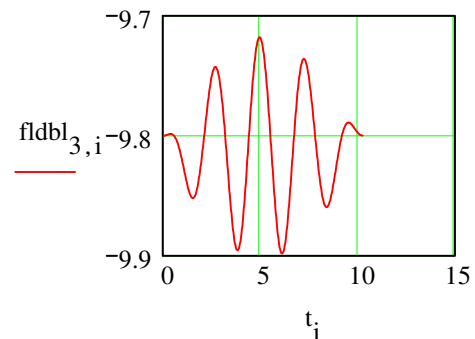
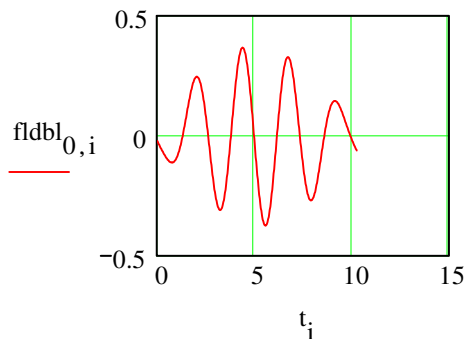
$$\text{fldbl}_{3,i} := \text{fldbj}_{2,i}$$

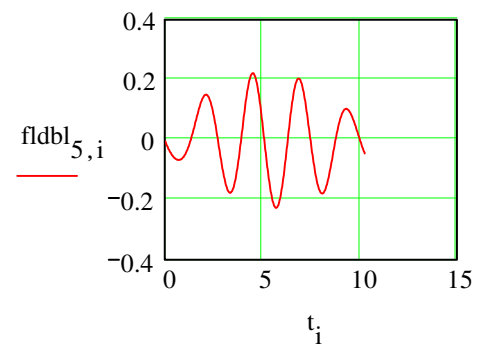
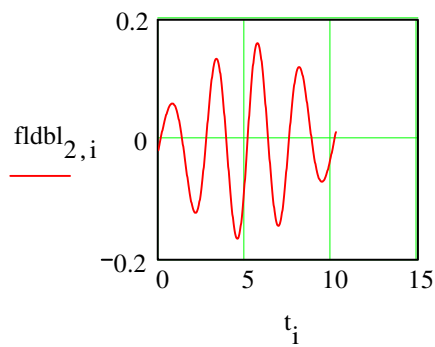
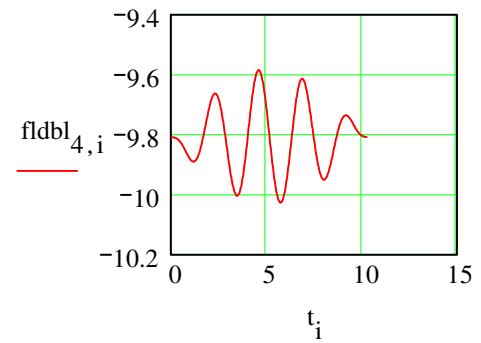
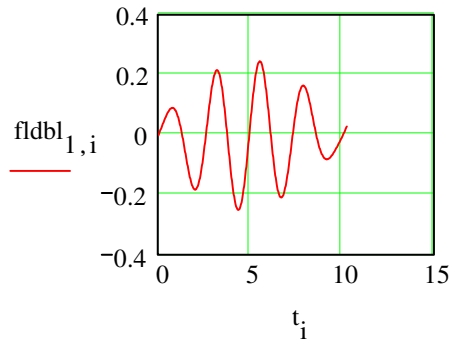
$$\text{fldbj}^{<i>} := \left( \text{fldb1}^{<i>} + \text{fldb0}^{<i>} \times \text{cfg}^{<4>} \right) - \text{velb0}^{<i>} \times \left( \text{velb0}^{<i>} \times \text{cfg}^{<4>} \right)$$

$$\text{fldbl}_{4,i} := \text{fldbj}_{2,i}$$

$$\text{fldbj}^{<i>} := \left( \text{fldb1}^{<i>} + \text{fldb0}^{<i>} \times \text{cfg}^{<5>} \right) - \text{velb0}^{<i>} \times \left( \text{velb0}^{<i>} \times \text{cfg}^{<5>} \right)$$

$$\text{fldbl}_{5,i} := \text{fldbj}_{0,i}$$





### Output

```
WRITEPRN("LOCIPAR.prn") := par
WRITEPRN("LOCIDA.prn") := disa
WRITEPRN("LOCIVB.prn") := velb
WRITEPRN("LOCIFB.prn") := fldb
WRITEPRN("LOCIBCD.prn") := bcd
WRITEPRN("LOCICFG.prn") := cfg
WRITEPRN("LOCIFBL.prn") := fdbl
```

**END LOCISIM**