ANALYSIS OF FIELD STRENGTHS OF LOW COST INERTIAL SYSTEM **LOCIANA.MCD**
MS9502092000

if test=0: Analysis of measured data
if test=1: Analysis of simulated data
and verification of identification algorithm

Prinzipiell fertig, aber noch immer kleine Unsauberkeiten!
MS9502102130/9502261600

BEGIN LOCIANA

Notation

dis	Position
disa	in raumfesten Koordinaten
disa0	Cardan Winkel
disa1	Ortskoordinaten des Bezugspunktes
vel	Geschwindigkeit
vela	in raumfesten Koordinaten
vela0	Winkelgeschwindigkeit
vela1	Längsgeschwindigkeit des Bezugspunktes
velb	in körperfesten Koordinaten
velb0	Winkelgeschwindigkeit
acc	Beschleunigung
acca	in raumfesten Koordinaten
acca1	Längsbeschleunigung des Bezugspunktes
accb	in körperfesten Koordinaten
accb0	Winkelbeschleunigung
fld	Impulsquellstärke
flda	in raumfesten Koordinaten
flda1	Feldstärke am Bezugspunkt
fldb	in körperfesten Koordinaten
fldb0	neg. Winkelbeschleunigung
fldb1	Feldstärke am Bezugspunkt

Input files

LOCIPAR
LOCIDA
LOCIVB
LOCIFB
LOCIBCD
LOCICFG
LOCIFBL

Output files

none

Bei den Tests zumindest nicht!

Input

par := READPRN("LOCIPAR.prn")

disa := READPRN("LOCIDA.prn")

velb := READPRN("LOCIVB.prn")

fldb := READPRN("LOCIFB.prn")

bcd := READPRN("LOCIBCD.prn")

cfg := READPRN("LOCICFG.prn")

fldbl := READPRN("LOCIFBL.prn")

Parameters

$n_S := cols(fldb) - 1$ $n_S = 512$ test := 1

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

$t_1 := par_{7,1}$ $t_1 = 10.24$

$i := 0 .. n_S$ $j := 0 .. 2$

$t_i := t_0 + i \cdot \frac{t_1 - t_0}{n_S}$ $om_1 := \frac{2 \cdot \pi}{t_1 - t_0}$ $n_F := \frac{n_S}{2}$

Boundary values

$disa1\ 0_j := bcd_{j,0}$ $\quad$ $disa1\ 1_j := bcd_{j,1}$

$disa0\ 0_j := bcd_{3+j,0}$ $\quad$ $disa0\ 1_j := bcd_{3+j,1}$

$vela1\ 0_j := bcd_{6+j,0}$ $\quad$ $vela1\ 1_j := bcd_{6+j,1}$

$velb0\ 0_j := bcd_{9+j,0}$ $\quad$ $velb0\ 1_j := bcd_{9+j,1}$

Angular 'source strengths'

Geometry

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

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

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

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

$$r1 := \begin{bmatrix} 0 & r_{0,0} & r_{0,0} \\ r_{1,1} & 0 & r_{1,1} \\ r_{2,2} & r_{2,2} & 0 \end{bmatrix} \qquad l = \begin{bmatrix} 0 & 0 & 0.686 \\ -0.35 & 0 & 0.67 \\ 0.303 & 0.67 & 0 \end{bmatrix}$$

$$r2 := \begin{bmatrix} 0 & r_{2,0} & r_{1,0} \\ r_{2,1} & 0 & r_{0,1} \\ r_{1,2} & r_{0,2} & 0 \end{bmatrix}$$

$V1 := l^{-1} \cdot r1$

$V2 := l^{-1} \cdot r2$

Source strengths

$dfbl_{0,i} := fldbl_{0,i} - fldbl_{5,i}$

$dfbl_{1,i} := fldbl_{2,i} - fldbl_{1,i}$

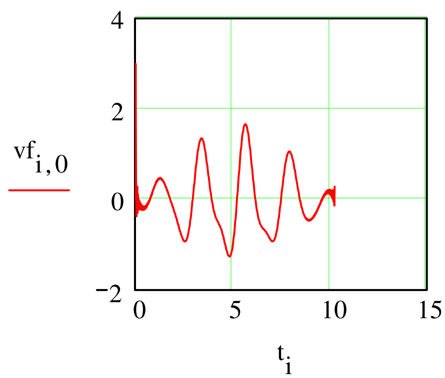
$dfbl_{2,i} := fldbl_{4,i} - fldbl_{3,i}$

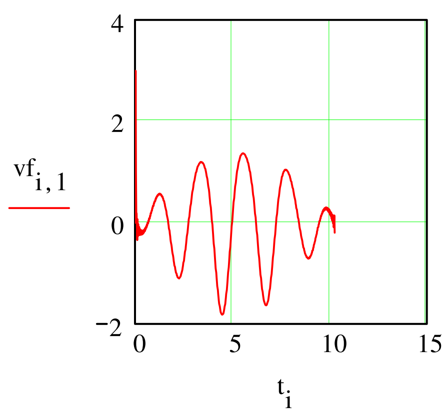
$f^{\langle i \rangle} := \Gamma^{-1} \cdot dfbl^{\langle i \rangle}$

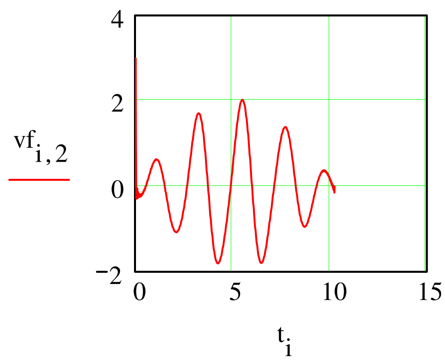
$ft := f^{T}$

$vf^{\langle j \rangle} := pspline\left(t, ft^{\langle j \rangle}\right)$

$$FS(T) := \begin{bmatrix} interp\left(vf^{\langle 0 \rangle}, t, ft^{\langle 0 \rangle}, T\right) \\ interp\left(vf^{\langle 1 \rangle}, t, ft^{\langle 1 \rangle}, T\right) \\ interp\left(vf^{\langle 2 \rangle}, t, ft^{\langle 2 \rangle}, T\right) \end{bmatrix}$$







Differential equation

$$O1(O) := \begin{bmatrix} O_0 \cdot O_0 \\ O_1 \cdot O_1 \\ O_2 \cdot O_2 \end{bmatrix} \qquad O2(O) := \begin{bmatrix} O_1 \cdot O_2 \\ O_2 \cdot O_0 \\ O_0 \cdot O_1 \end{bmatrix}$$

$$OR(T,O) := V1 \cdot O1(O) - V2 \cdot O2(O) - FS(T)$$

$$velb0t := rkfixed\left(velb0_0, t_0, t_1, n_S, OR\right)$$

$$velb0_{j,i} := velb0t_{i,1+j}$$

$$dvelb0_S := velb0^{\langle n_S \rangle} - velb0_1 \qquad dvelb0_S = \begin{bmatrix} 3.077 \cdot 10^{-9} \\ -8.912 \cdot 10^{-10} \\ 1.172 \cdot 10^{-9} \end{bmatrix}$$

Ab hier Korrektur!

$$ae^{\langle 0 \rangle} := dvelb0_S$$

Variations

$$const := 10^{-3}$$

$$velb0d := \begin{bmatrix} const \\ 0 \\ 0 \end{bmatrix}$$

$FS1(T) := FS(T) - velb0d$

$OR(T,O) := V1 \cdot O1(O) - V2 \cdot O2(O) - FS1(T)$

$velb0t := rkfixed\left(velb0_0, t_0, t_1, n_S, OR\right)$

$velb0_{j,i} := velb0t_{i,1+j}$

$dvelb0 := velb0^{\langle n_S \rangle} - velb0_1$

$ae^{\langle 1 \rangle} := dvelb0$

$$velb0d := \begin{bmatrix} 0 \\ const \\ 0 \end{bmatrix}$$

$FS1(T) := FS(T) - velb0d$

$OR(T,O) := V1 \cdot O1(O) - V2 \cdot O2(O) - FS1(T)$

$velb0t := rkfixed\left(velb0_0, t_0, t_1, n_S, OR\right)$

$velb0_{j,i} := velb0t_{i,1+j}$

$dvelb0 := velb0^{\langle n_S \rangle} - velb0_1$

$ae^{\langle 2 \rangle} := dvelb0$

$$velb0d := \begin{bmatrix} 0 \\ 0 \\ const \end{bmatrix}$$

$FS1(T) := FS(T) - velb0d$

$OR(T,O) := V1 \cdot O1(O) - V2 \cdot O2(O) - FS1(T)$

$velb0t := rkfixed\left(velb0_0, t_0, t_1, n_S, OR\right)$

$velb0_{j,i} := velb0t_{i,1+j}$

$dvelb0 := velb0^{\langle n_S \rangle} - velb0_1$

$ae^{\langle 3 \rangle} := dvelb0$

Correction

$k := 0..2$

$LE_{j,k} := \dfrac{ae_{j,k+1} - ae_{j,0}}{const}$

$RE_j := -ae_{j,0}$

$velb0d := LE^{-1} \cdot RE \qquad velb0d = \begin{bmatrix} -3.178 \cdot 10^{-10} \\ 9.209 \cdot 10^{-11} \\ -1.16 \cdot 10^{-10} \end{bmatrix}$

Solution

$FS1(T) := FS(T) - velb0d$

$OR(T,O) := V1 \cdot O1(O) - V2 \cdot O2(O) - FS1(T)$

$velb0t := rkfixed\left(velb0_0, t_0, t_1, n_S, OR\right)$

$velb0_{j,i} := velb0t_{i,1+j}$

$dvelb0 := velb0^{\langle n_S \rangle} - velb0_1$

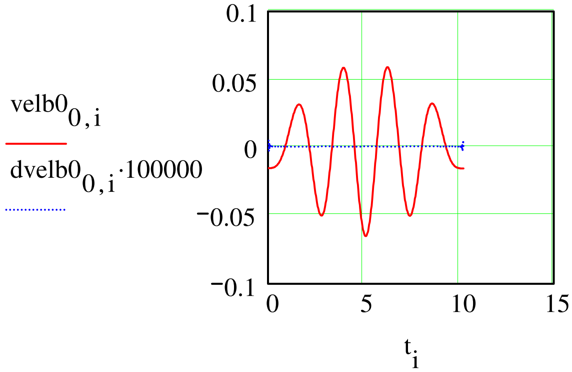
$velb0_{j,i} := velb0_{j,i} - velb0d_j$

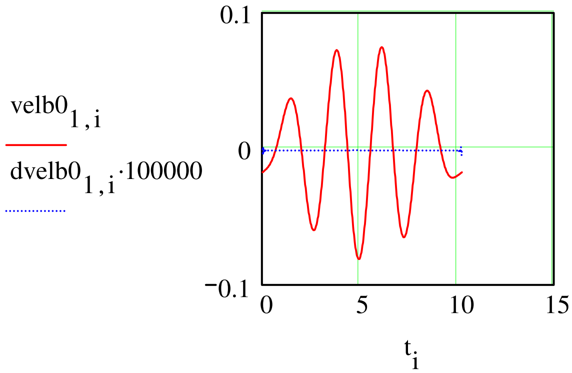
Bis hier Korrektur!

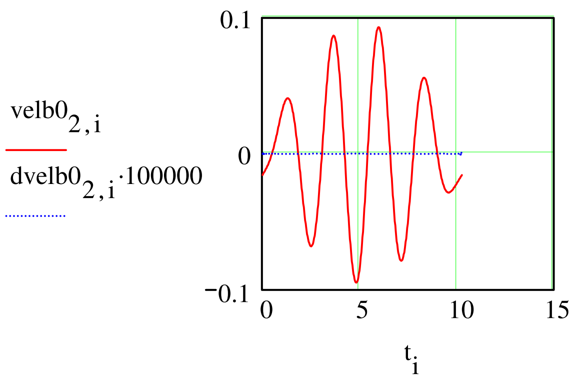
Comparison with test signals

$zero_{j,i} := 0$

$dvelb0_{j,i} := if\left(test = 1, velb0_{j,i} - velb_{3+j,i}, zero_{j,i}\right)$







Differentiation

Trend removed

$j := 0 .. 2$

$$velb0_{\ 1} := \frac{velb0^{\langle n_S \rangle} - velb0^{\langle 0 \rangle}}{t_{\ 1} - t_{\ 0}}$$

$k := 0 .. n_{\ S} - 1$

$velb0r_{k,j} := velb0_{j,k} - velb0_{1_j} \cdot (t_k - t_0)$

$velb0_{0_j} := mean(velb0r^{\langle j \rangle})$

$velb0r_{k,j} := velb0r_{k,j} - velb0_{0_j}$

Differentiation

$velb0s^{\langle j \rangle} := FFT(velb0r^{\langle j \rangle})$

$om_1 := \frac{2 \cdot \pi}{t_1 - t_0}$ $\qquad n_F := \frac{n_S}{2}$

$l := 0 .. n_F$

$accb0s_{l,j} := velb0s_{l,j} \cdot (i \cdot l \cdot om_1)$

$accb0t^{\langle j \rangle} := IFFT(accb0s^{\langle j \rangle})$

$accb0u := accb0t^T$

$accb0u^{\langle n_S \rangle} := accb0u^{\langle 0 \rangle}$

Trend replaced

$accb0^{\langle i \rangle} := accb0u^{\langle i \rangle} + velb0_1$

Cardan angles

Die Cardan Winkel führen beim Durchkentern eventuell zu Singularitäten. Für diesen Fall habe ich die Lösung mit Euler Parametern entwickelt.

$ot := velb0^T$

$vo^{\langle j \rangle} := pspline(t, ot^{\langle j \rangle})$

$$OS(T) := \begin{bmatrix} interp(vo^{\langle 0 \rangle}, t, ot^{\langle 0 \rangle}, T) \\ interp(vo^{\langle 1 \rangle}, t, ot^{\langle 1 \rangle}, T) \\ interp(vo^{\langle 2 \rangle}, t, ot^{\langle 2 \rangle}, T) \end{bmatrix}$$

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

$$AR(T,A) := AM(A)\cdot OS(T)$$

$$disa0t := rkfixed(disa0_0, t_0, t_1, n_S, AR)$$

$$disa0_{j,i} := disa0t_{i,1+j}$$

$$ddisa0 := disa0^{\langle n_S \rangle} - disa0_1$$

$$ae^{\langle 0 \rangle} := ddisa0$$

Variations

$$const := 10^{-6}$$

$$velb0d := \begin{bmatrix} const \\ 0 \\ 0 \end{bmatrix}$$

$$OS1(T) := OS(T) - velb0d$$

$$AR(T,A) := AM(A)\cdot OS1(T)$$

$$disa0t := rkfixed(disa0_0, t_0, t_1, n_S, AR)$$

$$disa0_{j,i} := disa0t_{i,1+j}$$

$$ddisa0 := disa0^{\langle n_S \rangle} - disa0_1$$

$$ae^{\langle 1 \rangle} := ddisa0$$

$$velb0d := \begin{bmatrix} 0 \\ const \\ 0 \end{bmatrix}$$

$$OS1(T) := OS(T) - velb0d$$

$$AR(T, A) := AM(A) \cdot OS1(T)$$

$$disa0t := rkfixed\left(disa0_{0}, t_{0}, t_{1}, n_{S}, AR\right)$$

$$disa0_{j,i} := disa0t_{i,1+j}$$

$$ddisa0 := disa0^{\langle n_S \rangle} - disa0_{1}$$

$$ae^{\langle 2 \rangle} := ddisa0$$

$$velb0d := \begin{bmatrix} 0 \\ 0 \\ const \end{bmatrix}$$

$$OS1(T) := OS(T) - velb0d$$

$$AR(T, A) := AM(A) \cdot OS1(T)$$

$$disa0t := rkfixed\left(disa0_{0}, t_{0}, t_{1}, n_{S}, AR\right)$$

$$disa0_{j,i} := disa0t_{i,1+j}$$

$$ddisa0 := disa0^{\langle n_S \rangle} - disa0_{1}$$

$$ae^{\langle 3 \rangle} := ddisa0$$

Correction

$$k := 0 .. 2$$

$$LE_{j,k} := \frac{ae_{j,k+1} - ae_{j,0}}{const}$$

$$RE_{j} := -ae_{j,0}$$

$velb0d := LE^{-1} \cdot RE$

$$velb0d = \begin{bmatrix} 9.271 \cdot 10^{-9} \\ -1.063 \cdot 10^{-8} \\ 2.111 \cdot 10^{-9} \end{bmatrix}$$

Solution

$OS1(T) := OS(T) - velb0d$

$AR(T, A) := AM(A) \cdot OS1(T)$

$disa0t := rkfixed\left(disa0_{0}, t_{0}, t_{1}, n_{S}, AR\right)$

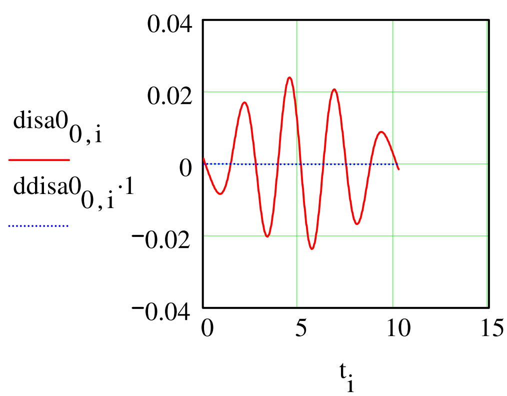
$disa0_{j,i} := disa0t_{i,1+j}$

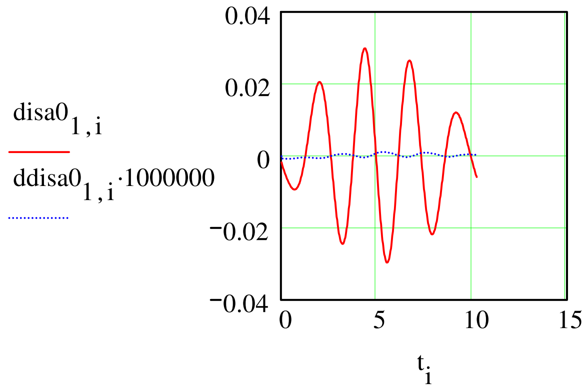
$ddisa0 := disa0^{\langle n_S \rangle} - disa0_{1}$

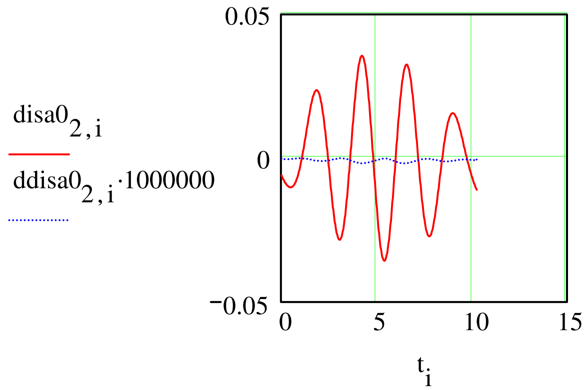
$velb0_{j,i} := velb0_{j,i} - velb0d_{j}$

Comparison with test signals

$ddisa0_{j,i} := if\left(test = 1, disa0_{j,i} - disa_{3+j,i}, zero_{j,i}\right)$







Linear accelerations in body fixed coordinates

$fldb0_{j,i} := -accb0_{j,i}$

$r := cfg^{\langle 5 \rangle} + cfg^{\langle 0 \rangle}$

$fldbr^{\langle i \rangle} := fldb0^{\langle i \rangle} \times r - velb0^{\langle i \rangle} \times \left(velb0^{\langle i \rangle} \times r\right)$

$fldb1_{0,i} := \frac{1}{2} \cdot \left(fldbl_{5,i} + fldbl_{0,i} - fldbr_{0,i}\right)$

$r := cfg^{\langle 1 \rangle} + cfg^{\langle 2 \rangle}$

$fldbr^{\langle i \rangle} := fldb0^{\langle i \rangle} \times r - velb0^{\langle i \rangle} \times \left(velb0^{\langle i \rangle} \times r\right)$

$fldb1_{1,i} := \frac{1}{2} \cdot \left(fldbl_{1,i} + fldbl_{2,i} - fldbr_{1,i}\right)$

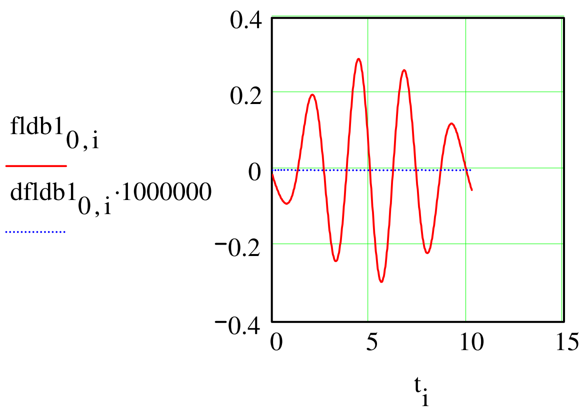
$$r := cfg^{\langle 3\rangle} + cfg^{\langle 4\rangle}$$

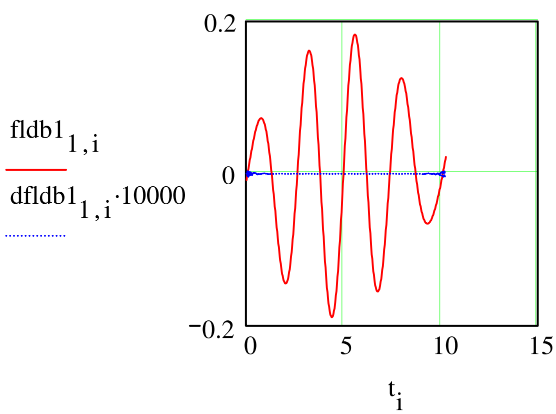
$$fldbr^{\langle i\rangle} := fldb0^{\langle i\rangle} \times r - velb0^{\langle i\rangle} \times \left(velb0^{\langle i\rangle} \times r\right)$$

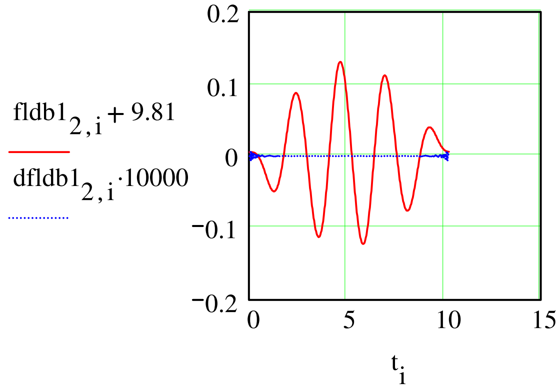
$$fldb1_{2,i} := \frac{1}{2}\cdot\left(fldbl_{3,i} + fldbl_{4,i} - fldbr_{2,i}\right)$$

Comparison with test signals

$$dfldb1_{j,i} := if\left(test = 1, fldb1_{j,i} - fldb_{j,i}, zero_{j,i}\right)$$







Field strength in space fixed fixed coordinates

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

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

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

$$T_v(A) := T_0(A) \cdot T_1(A) \cdot T_2(A)$$

$$flda1^{\langle i \rangle} := T_v\left(disa0^{\langle i \rangle}\right)^T \cdot fldb1^{\langle i \rangle}$$

'Gravity field'

$$g := 9.81$$

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

Acceleration in space fixed coordinates

$$acca1^{\langle i\rangle} := grava - flda1^{\langle i\rangle}$$

$$acca1_1 := \frac{acca1^{\langle n_S\rangle} - acca1^{\langle 0\rangle}}{t_1 - t_0}$$

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

$$acca1r^{\langle k\rangle} := acca1^{\langle k\rangle} - acca1_1 \cdot (t_k - t_0)$$

$$acca1_{0_j} := mean\left[\left(acca1r^T\right)^{\langle j\rangle}\right]$$

$$acca1r^{\langle k\rangle} := acca1r^{\langle k\rangle} - acca1_0$$

$$acca1t := Re\left(acca1r^T\right)$$

$$acca1s^{\langle j\rangle} := FFT\left(acca1t^{\langle j\rangle}\right)$$

$$l := 1 .. n_F$$

$$vela1s_{l,j} := \frac{acca1s_{l,j}}{i \cdot l \cdot om_1}$$

$$vela1s_{n_F,j} := vela1s_{n_F - 1,j}$$

$$vela1t^{\langle j\rangle} := IFFT\left(vela1s^{\langle j\rangle}\right)$$

$$vela1u := vela1t^T$$

$$vela1u^{\langle n_S\rangle} := vela1u^{\langle 0\rangle}$$

$$vela1^{\langle i\rangle} := vela1u^{\langle i\rangle} + acca1_0 \cdot (t_i - t_0) + acca1_1 \cdot \frac{(t_i - t_0)^2}{2}$$

$$c_0 := vela1_0 - vela1^{\langle 0\rangle}$$

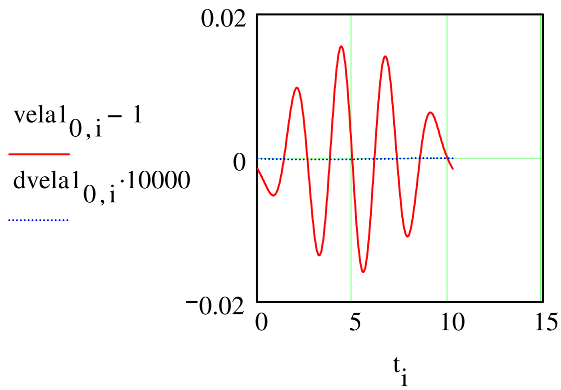
$$c_1 := vela1_1 - vela1^{\langle n_S\rangle}$$

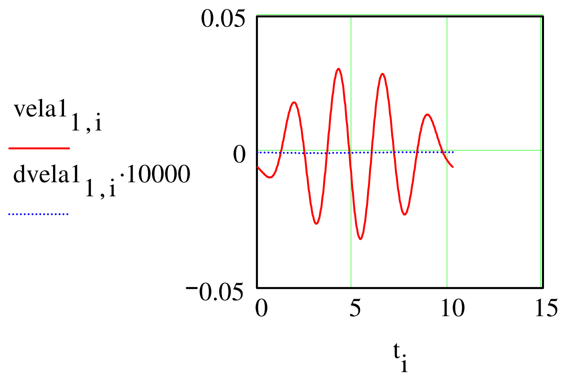
$$vela1^{\langle i \rangle} := vela1^{\langle i \rangle} + c_0 + \frac{c_1 - c_0}{t_1 - t_0} \cdot \left(t_i - t_0\right)$$

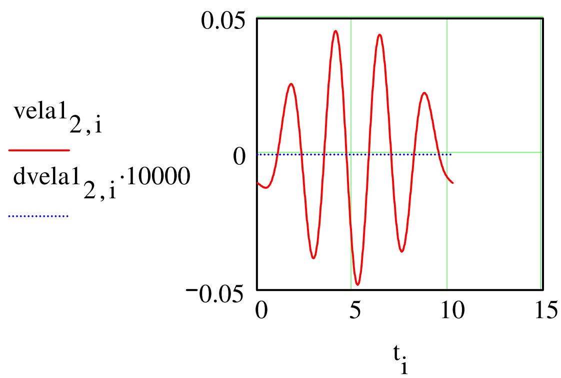
$$velb1^{\langle i \rangle} := T_v\left(disa0^{\langle i \rangle}\right) \cdot vela1^{\langle i \rangle}$$

Comparison with test signals

$$dvela1_{j,i} := if\left(test = 1, velb1_{j,i} - velb_{j,i}, zero_{j,i}\right)$$







Displacements

$$\mathrm{vela1}_1 := \frac{\mathrm{vela1}^{\langle n_S \rangle} - \mathrm{vela1}^{\langle 0 \rangle}}{t_1 - t_0}$$

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

$$\mathrm{vela1r}^{\langle k \rangle} := \mathrm{vela1}^{\langle k \rangle} - \mathrm{vela1}_1 \cdot (t_k - t_0)$$

$$\mathrm{vela1}_{0_j} := \mathrm{mean}\left[\left(\mathrm{vela1r}^T\right)^{\langle j \rangle}\right]$$

$$\mathrm{vela1r}^{\langle k \rangle} := \mathrm{vela1r}^{\langle k \rangle} - \mathrm{vela1}_0$$

$$\mathrm{vela1t} := \mathrm{vela1r}^T$$

$$\mathrm{vela1s}^{\langle j \rangle} := \mathrm{FFT}\left(\mathrm{vela1t}^{\langle j \rangle}\right)$$

$$l := 1 .. n_F$$

$$\mathrm{disa1s}_{l,j} := \frac{\mathrm{vela1s}_{l,j}}{i \cdot l \cdot \mathrm{om}_1}$$

$$\mathrm{disa1s}_{n_F,j} := \mathrm{disa1s}_{n_F - 1,j}$$

$$\mathrm{disa1t}^{\langle j \rangle} := \mathrm{IFFT}\left(\mathrm{disa1s}^{\langle j \rangle}\right)$$

$$\mathrm{disa1u} := \mathrm{disa1t}^T$$

$$\mathrm{disa1u}^{\langle n_S \rangle} := \mathrm{disa1u}^{\langle 0 \rangle}$$

$$\mathrm{disa1}^{\langle i \rangle} := \mathrm{disa1u}^{\langle i \rangle} + \mathrm{vela1}_0 \cdot (t_i - t_0) + \mathrm{vela1}_1 \cdot \frac{(t_i - t_0)^2}{2}$$

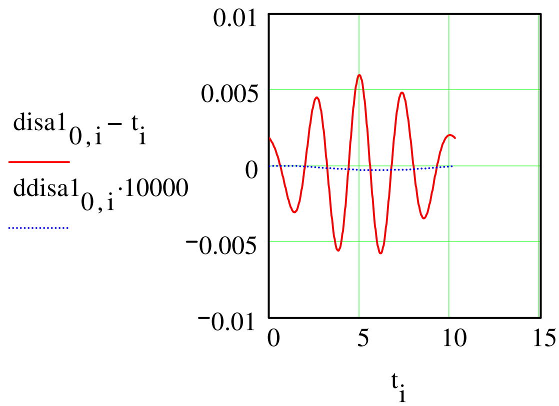
$$c_0 := \mathrm{disa1}_0 - \mathrm{disa1}^{\langle 0 \rangle}$$

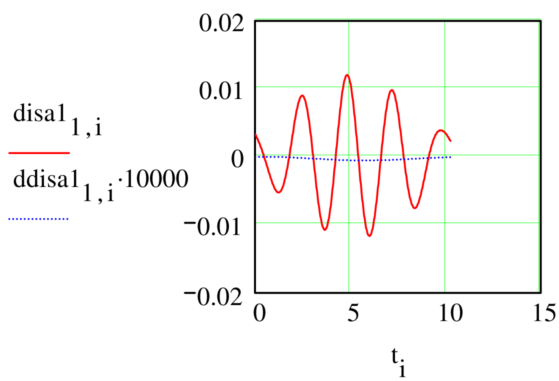
$$c_1 := \mathrm{disa1}_1 - \mathrm{disa1}^{\langle n_S \rangle}$$

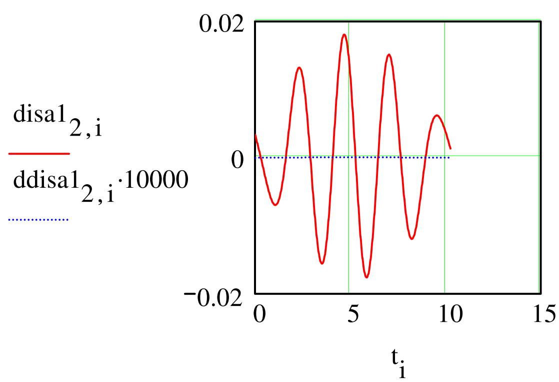
$$\mathrm{disa1}^{\langle i \rangle} := \mathrm{disa1}^{\langle i \rangle} + c_0 + \frac{c_1 - c_0}{t_1 - t_0} \cdot (t_i - t_0)$$

Comparison with test signals

$$ddisa1_{j,i} := \text{if}\left(test = 1, disa1_{j,i} - disa_{j,i}, zero_{j,i}\right)$$







END LOCIANA