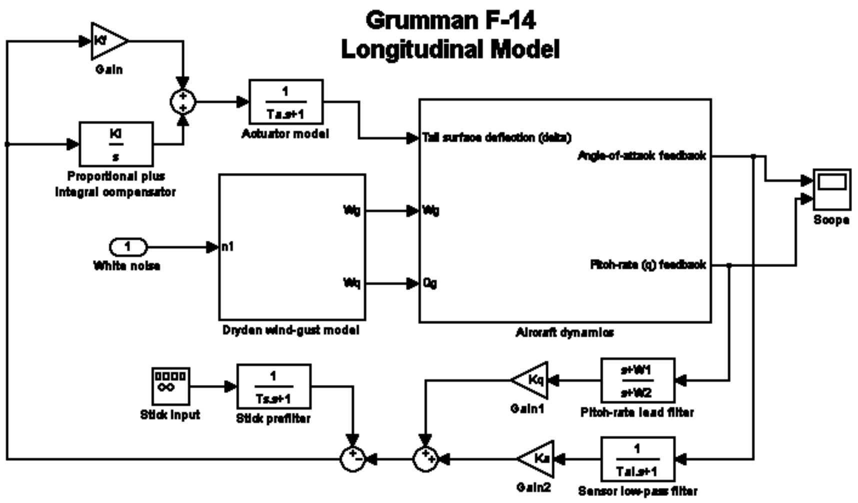
F-14 Longitudinal Model

NOTE: You will need to have an installed and functioning version of MATLAB™ and Simulink™ to run this example.



Section Layout

Import the System

Simulate the System

Import the Subsystem

▼ Initialization

with(*BlockImporter*)

$$[BuildDE, Import, PrintSummary, Simp, SimplifyModel] \quad (1.1)$$

▼ Import the System

We import the model with the following command. We need to specify the name of the model to import, as well as a MATLAB script that initializes the variable names.

datadir := *BlockImporter*:-*DataDirectory*( )

"C:\Program Files\Maple 11\toolbox\BlockImporter\data" (2.1)

model1 := *Import*("m_f14", *path* = *datadir*, *init* = "f14_init", *inplace* = *true*) :

Using the *Summary* command, we can view the model that we have imported.

PrintSummary(*model1*)

Equations [92]:

$$\Big[u_{35,1,1}=y_{4,1,1}, u_{34,1,1}=y_{4,1,1}, u_{34,2,1}=y_{4,2,1}, u_{32,1,1}=y_{4,2,1}, u_{11,1,1}=y_{5,1,1},$$

$$u_{12,1,1}=y_{5,1,1}, y_{5,1,1}=u_{4,1,1}, u_{13,2,1}=y_{6,1,1}, y_{6,1,1}=u_{4,2,1}, u_{14,2,1}=y_{7,1,1}, y_{7,1,1}$$

$$=u_{4,3,1}, u_{13,3,1}=y_{8,1,1}, u_{14,1,1}=y_{9,1,1}, u_{17,1,1}=y_{10,1,1}, u_{13,1,1}=y_{11,1,1}, u_{14,3,1}$$

$$=y_{12,1,1}, u_{15,1,1}=y_{13,1,1}, u_{16,1,1}=y_{14,1,1}, u_{10,1,1}=y_{15,1,1}, u_{9,1,1}=y_{15,1,1}, u_{8,1,1}$$

$$=y_{16,1,1}, u_{18,1,1}=y_{16,1,1}, y_{4,1,1}=u_{17,1,1}, y_{4,2,1}=u_{18,1,1}, u_{4,2,1}=y_{19,1,1}, u_{4,3,1}$$

$$=y_{19,2,1}, u_{26,1,1}=y_{20,1,1}, y_{20,1,1}=u_{19,1,1}, u_{24,2,1}=y_{21,1,1}, u_{27,1,1}=y_{22,1,1},$$

$$u_{24,1,1}=y_{23,1,1}, u_{28,1,1}=y_{24,1,1}, u_{21,1,1}=y_{25,1,1}, u_{23,1,1}=y_{26,1,1}, u_{25,1,1}$$

$$=y_{26,1,1}, u_{22,1,1}=y_{26,1,1}, y_{19,1,1}=u_{27,1,1}, y_{19,2,1}=u_{28,1,1}, u_{19,1,1}=y_{2,1,1}, y_{2,1,1}$$

$$=u_{1,1,1}, u_{4,1,1}=y_{3,1,1}, u_{38,1,1}=y_{29,1,1}, u_{40,1,1}=y_{30,1,1}, u_{40,2,1}=y_{31,1,1}, u_{30,1,1}$$

$$=y_{32,1,1}, u_{38,2,1}=y_{33,1,1}, u_{31,1,1}=y_{35,1,1}, u_{37,1,1}=y_{36,1,1}, u_{39,1,1}=y_{37,1,1},$$

$$u_{3,\,1,\,1} = y_{38,\,1,\,1},\ u_{33,\,1,\,1} = y_{39,\,1,\,1},\ u_{29,\,1,\,1} = y_{39,\,1,\,1},\ u_{39,\,2,\,1} = y_{40,\,1,\,1},\ \mathrm{D}\left(x_{3,\,1}\right) = u_{3,\,1,\,1}$$

$$-\frac{x_{3,\,1}}{K_{0,\,\text{"Ta"}}},\ y_{3,\,1,\,1} = \frac{x_{3,\,1}}{K_{0,\,\text{"Ta"}}},\ y_{8,\,1,\,1} = K_{0,\,\text{"Uo"}}\, u_{8,\,1,\,1},\ y_{9,\,1,\,1} = K_{0,\,\text{"Mw"}}\, u_{9,\,1,\,1},\ y_{10,\,1,\,1}$$

$$= \frac{u_{10,\,1,\,1}}{K_{0,\,\text{"Uo"}}},\ y_{11,\,1,\,1} = K_{0,\,\text{"Zd"}}\, u_{11,\,1,\,1},\ y_{12,\,1,\,1} = K_{0,\,\text{"Md"}}\, u_{12,\,1,\,1},\ y_{13,\,1,\,1} = u_{13,\,1,\,1}$$

$$-u_{13,\,2,\,1} + u_{13,\,3,\,1},\ y_{14,\,1,\,1} = u_{14,\,1,\,1} - u_{14,\,2,\,1} + u_{14,\,3,\,1},\ \mathrm{D}\left(x_{15,\,1}\right) = u_{15,\,1,\,1}$$

$$+K_{0,\,\text{"Zw"}}\, x_{15,\,1},\ y_{15,\,1,\,1} = x_{15,\,1},\ \mathrm{D}\left(x_{16,\,1}\right) = u_{16,\,1,\,1} + K_{0,\,\text{"Mq"}}\, x_{16,\,1},\ y_{16,\,1,\,1} = x_{16,\,1},$$

$$y_{21,\,1,\,1} = K_{0,\,\text{"Mq"}}\, u_{21,\,1,\,1},\ y_{22,\,1,\,1} = K_{0,\,\text{"Zw"}}\, u_{22,\,1,\,1},\ y_{23,\,1,\,1} = K_{0,\,\text{"Mw"}}\, u_{23,\,1,\,1},\ y_{24,\,1,\,1}$$

$$= u_{24,\,1,\,1} + u_{24,\,2,\,1},\ \mathrm{D}\left(x_{25,\,1}\right) = u_{25,\,1,\,1} - \frac{1}{4}\,\frac{\pi\, K_{0,\,\text{"Vto"}}\, x_{25,\,1}}{K_{0,\,\text{"b"}}},\ y_{25,\,1,\,1}$$

$$= \frac{1}{4}\,\frac{\pi\left(u_{25,\,1,\,1} - \frac{1}{4}\,\frac{\pi\, K_{0,\,\text{"Vto"}}\, x_{25,\,1}}{K_{0,\,\text{"b"}}}\right)}{K_{0,\,\text{"b"}}},\ \mathrm{D}\left(x_{26,\,1}\right) = x_{26,\,2},\ \mathrm{D}\left(x_{26,\,2}\right) = u_{26,\,1,\,1}$$

$$-\frac{x_{26,\,1}}{K_{0,\,\text{"a"}}^{2}} - \frac{2\, x_{26,\,2}}{K_{0,\,\text{"a"}}},\ y_{26,\,1,\,1} = \frac{x_{26,\,1}\, K_{0,\,\text{"Swg"}}}{\sqrt{K_{0,\,\text{"a"}}^{3}}} + \frac{x_{26,\,2}\, K_{0,\,\text{"Swg"}}\, \sqrt{3}\, K_{0,\,\text{"a"}}}{\sqrt{K_{0,\,\text{"a"}}^{3}}},$$

$$y_{29,\,1,\,1} = K_{0,\,\text{"Kf"}}\, u_{29,\,1,\,1},\ y_{30,\,1,\,1} = K_{0,\,\text{"Kq"}}\, u_{30,\,1,\,1},\ y_{31,\,1,\,1} = K_{0,\,\text{"Ka"}}\, u_{31,\,1,\,1},\ \mathrm{D}\left(x_{32,\,1}\right)$$

$$= u_{32,\,1,\,1} - K_{0,\,\text{"W2"}}\, x_{32,\,1},\ y_{32,\,1,\,1} = x_{32,\,1}\, K_{0,\,\text{"W1"}} + u_{32,\,1,\,1} - K_{0,\,\text{"W2"}}\, x_{32,\,1},$$

$$\mathrm{D}\left(x_{33,\,1}\right) = u_{33,\,1,\,1},\ y_{33,\,1,\,1} = x_{33,\,1}\, K_{0,\,\text{"Ki"}},\ Sink_{Scope,\,34,\,1,\,1} = u_{34,\,1,\,1},\ Sink_{Scope,\,34,\,2,\,1}$$

$$= u_{34,\,2,\,1},\ \mathrm{D}(x_{35,\,1}) = u_{35,\,1,\,1} - \frac{x_{35,\,1}}{K_{0,\,\text{"Tal"}}},\ y_{35,\,1,\,1} = \frac{x_{35,\,1}}{K_{0,\,\text{"Tal"}}},\ y_{36,\,1,\,1}$$

$$= Source_{SigGen,\,36,\,1},\ \mathrm{D}(x_{37,\,1}) = u_{37,\,1,\,1} - \frac{x_{37,\,1}}{K_{0,\,\text{"Ts"}}},\ y_{37,\,1,\,1} = \frac{x_{37,\,1}}{K_{0,\,\text{"Ts"}}},\ y_{38,\,1,\,1}$$

$$= u_{38,\,1,\,1} + u_{38,\,2,\,1},\ y_{39,\,1,\,1} = u_{39,\,1,\,1} - u_{39,\,2,\,1},\ y_{40,\,1,\,1} = u_{40,\,1,\,1} + u_{40,\,2,\,1}\Big]$$

State Variables [10]:

$$[[x_{3,\,1}, x_{15,\,1}, x_{16,\,1}, x_{25,\,1}, x_{26,\,1}, x_{26,\,2}, x_{32,\,1}, x_{33,\,1}, x_{35,\,1}, x_{37,\,1}]]$$

Initial Equations [10]:

$$[[x_{3,\,1}([0]) = 0, x_{15,\,1}([0]) = 0, x_{16,\,1}([0]) = 0, x_{25,\,1}([0]) = 0, x_{26,\,1}([0]) = 0,$$
$$x_{26,\,2}([0]) = 0, x_{32,\,1}([0]) = 0, x_{33,\,1}([0]) = 0, x_{35,\,1}([0]) = 0, x_{37,\,1}([0]) = 0]]$$

Source Equations [1]:

$$\Big[Source_{SigGen,\,36,\,1} =$$

$$\begin{cases} -1 & t - 4.000000000\,\pi\,\mathrm{trunc}\left(\frac{0.2500000000\,t}{\pi}\right) < 2.000000000\,\pi \\ 1 & \text{otherwise} \end{cases}\Big]$$

Input Variables [2]:

$$[u_{1,\,1,\,1}, Source_{SigGen,\,36,\,1}]$$

Output Variables [2]:

$$[Sink_{Scope,\,34,\,1,\,1}, Sink_{Scope,\,34,\,2,\,1}]$$

Parameters [19]:

$$[K_{0,\,\text{"W2"}} = 4.14400000000000013, K_{0,\,\text{"Kq"}} = 0.815599999999999992, K_{0,\,\text{"Swg"}} = 3.,$$ (2.2)
$$K_{0,\,\text{"Ts"}} = 0.100000000000000004, K_{0,\,\text{"Ta"}} = 0.0500000000000000028, K_{0,\,\text{"Uo"}}$$
$$= 689.399999999999976, K_{0,\,\text{"Mw"}} = -0.00591999999999999992, K_{0,\,\text{"Zd"}}$$
$$= -63.9979000000000014, K_{0,\,\text{"Md"}} = -6.88469999999999960, K_{0,\,\text{"Zw"}}$$
$$= -.638499999999999958, K_{0,\,\text{"Mq"}} = -.657100000000000018, K_{0,\,\text{"b"}}$$
$$= 64.1299999999999955, K_{0,\,\text{"Vto"}} = 690.399999999999977, K_{0,\,\text{"a"}}$$
$$= 2.53480000000000016, K_{0,\,\text{"Kf"}} = -1.74600000000000000, K_{0,\,\text{"Ka"}}$$
$$= 0.677000000000000046, K_{0,\,\text{"W1"}} = 2.97100000000000010, K_{0,\,\text{"Ki"}}$$
$$= -3.86399999999999988, K_{0,\,\text{"Tal"}} = 0.395899999999999974]$$

We can now simplify the model to reduce the number of equations.
smodel1 := *SimplifyModel*(*model1*) :

PrintSummary(*smodel1*)

Equations [12]:

$$\left[D(x_{3,1}) = \frac{K_{0,\text{"Kf"}}\, D(x_{33,1})\, K_{0,\text{"Ta"}} + x_{33,1}\, K_{0,\text{"Ki"}}\, K_{0,\text{"Ta"}} - x_{3,1}}{K_{0,\text{"Ta"}}},\ D(x_{15,1}) = \right.$$

$$-\frac{1}{K_{0,\text{"Ta"}} \sqrt{K_{0,\text{"a"}}^{3}}} \Big(-K_{0,\text{"Zd"}}\, x_{3,1} \sqrt{K_{0,\text{"a"}}^{3}} + K_{0,\text{"Zw"}}\, K_{0,\text{"Swg"}}\, K_{0,\text{"Ta"}}\, x_{26,1}$$

$$+ K_{0,\text{"Zw"}}\, K_{0,\text{"Swg"}}\, K_{0,\text{"Ta"}}\, x_{26,2} \sqrt{3}\, K_{0,\text{"a"}} - K_{0,\text{"Uo"}}\, x_{16,1}\, K_{0,\text{"Ta"}} \sqrt{K_{0,\text{"a"}}^{3}}$$

$$- K_{0,\text{"Zw"}}\, x_{15,1}\, K_{0,\text{"Ta"}} \sqrt{K_{0,\text{"a"}}^{3}} \Big),\ D(x_{16,1})$$

$$= \frac{1}{16} \frac{1}{\sqrt{K_{0,\text{"a"}}^{3}}\, K_{0,\text{"b"}}^{2}\, K_{0,\text{"Ta"}}} \Big(16\, K_{0,\text{"Mw"}}\, x_{15,1} \sqrt{K_{0,\text{"a"}}^{3}}\, K_{0,\text{"b"}}^{2}\, K_{0,\text{"Ta"}}$$

$$- 16\, K_{0,\text{"Mw"}}\, K_{0,\text{"Swg"}}\, K_{0,\text{"b"}}^{2}\, K_{0,\text{"Ta"}}\, x_{26,1} - 16\, K_{0,\text{"Mw"}}\, K_{0,\text{"Swg"}}$$

$$K_{0,\text{"b"}}^{2}\, K_{0,\text{"Ta"}}\, x_{26,2} \sqrt{3}\, K_{0,\text{"a"}} - 4\, K_{0,\text{"Mq"}}\, \pi\, K_{0,\text{"Ta"}}\, x_{26,1}\, K_{0,\text{"Swg"}}\, K_{0,\text{"b"}}$$

$$- 4\, K_{0,\text{"Mq"}}\, \pi\, K_{0,\text{"Ta"}}\, x_{26,2}\, K_{0,\text{"Swg"}} \sqrt{3}\, K_{0,\text{"a"}}\, K_{0,\text{"b"}}$$

$$+ K_{0,\text{"Mq"}}\, \pi^{2}\, K_{0,\text{"Ta"}}\, K_{0,\text{"Vto"}}\, x_{25,1} \sqrt{K_{0,\text{"a"}}^{3}} + 16\, K_{0,\text{"Md"}}\, x_{3,1} \sqrt{K_{0,\text{"a"}}^{3}}\, K_{0,\text{"b"}}^{2}$$

$$+ 16\, K_{0,\text{"Mq"}}\, x_{16,1} \sqrt{K_{0,\text{"a"}}^{3}}\, K_{0,\text{"b"}}^{2}\, K_{0,\text{"Ta"}} \Big),\ D(x_{25,1}) =$$

$$-\frac{1}{4} \frac{1}{\sqrt{K_{0,\text{"a"}}^{3}}\, K_{0,\text{"b"}}} \Big(-4\, x_{26,1}\, K_{0,\text{"Swg"}}\, K_{0,\text{"b"}} - 4\, x_{26,2}\, K_{0,\text{"Swg"}} \sqrt{3}\, K_{0,\text{"a"}}\, K_{0,\text{"b"}}$$

$$+ \pi\, K_{0,\text{"Vto"}}\, x_{25,1} \sqrt{K_{0,\text{"a"}}^{3}} \Big),\ D(x_{26,1}) = x_{26,2},\ D(x_{26,2})$$

$$= \frac{u_{1,1,1}\, K_{0,\text{"a"}}^{2} - x_{26,1} - 2\, x_{26,2}\, K_{0,\text{"a"}}}{K_{0,\text{"a"}}^{2}},\ D(x_{32,1}) = x_{16,1} - K_{0,\text{"W2"}}\, x_{32,1},$$

$$Sink_{Scope,\,34,\,1,\,1} = \frac{x_{15,\,1}}{K_{0,\,\text{"Uo"}}},\ Sink_{Scope,\,34,\,2,\,1} = x_{16,\,1},\ \mathrm{D}(x_{35,\,1}) = -\frac{-x_{15,\,1} K_{0,\,\text{"Tal"}} + x_{35,\,1} K_{0,\,\text{"Uo"}}}{K_{0,\,\text{"Uo"}} K_{0,\,\text{"Tal"}}},\ \mathrm{D}(x_{37,\,1}) = \frac{Source_{SigGen,\,36,\,1} K_{0,\,\text{"Ts"}} - x_{37,\,1}}{K_{0,\,\text{"Ts"}}},$$

$$\mathrm{D}(x_{33,\,1}) = \frac{1}{K_{0,\,\text{"Ts"}} K_{0,\,\text{"Tal"}}} \big(x_{37,\,1} K_{0,\,\text{"Tal"}} - K_{0,\,\text{"Kq"}} K_{0,\,\text{"Ts"}} K_{0,\,\text{"Tal"}} x_{32,\,1} K_{0,\,\text{"W1"}} - K_{0,\,\text{"Kq"}} K_{0,\,\text{"Ts"}} K_{0,\,\text{"Tal"}} x_{16,\,1} + K_{0,\,\text{"Kq"}} K_{0,\,\text{"Ts"}} K_{0,\,\text{"Tal"}} K_{0,\,\text{"W2"}} x_{32,\,1} - K_{0,\,\text{"Ka"}} x_{35,\,1} K_{0,\,\text{"Ts"}}\big) \big]$$

State Variables [10]:

$$[[x_{3,\,1}, x_{15,\,1}, x_{16,\,1}, x_{25,\,1}, x_{26,\,1}, x_{26,\,2}, x_{32,\,1}, x_{33,\,1}, x_{35,\,1}, x_{37,\,1}]]$$

Initial Equations [10]:

$$[[x_{3,\,1}([0]) = 0, x_{15,\,1}([0]) = 0, x_{16,\,1}([0]) = 0, x_{25,\,1}([0]) = 0, x_{26,\,1}([0]) = 0, x_{26,\,2}([0]) = 0, x_{32,\,1}([0]) = 0, x_{33,\,1}([0]) = 0, x_{35,\,1}([0]) = 0, x_{37,\,1}([0]) = 0]]$$

Source Equations [1]:

$$\Bigg[Source_{SigGen,\,36,\,1} = \begin{cases} -1 & t - 4.000000000\,\pi\,\mathrm{trunc}\left(\dfrac{0.2500000000\,t}{\pi}\right) < 2.000000000\,\pi \\ 1 & \mathit{otherwise} \end{cases} \Bigg]$$

Input Variables [2]:

$$[u_{1,\,1,\,1}, Source_{SigGen,\,36,\,1}]$$

Output Variables [2]:

$$[Sink_{Scope,\,34,\,1,\,1}, Sink_{Scope,\,34,\,2,\,1}]$$

Parameters [19]:

$$[K_{0,\,\text{"W2"}} = 4.14400000000000013, K_{0,\,\text{"Kq"}} = 0.815599999999999992, K_{0,\,\text{"Swg"}} = 3., K_{0,\,\text{"Ts"}} = 0.100000000000000004, K_{0,\,\text{"Ta"}} = 0.0500000000000000028, K_{0,\,\text{"Uo"}} = 689.399999999999976, K_{0,\,\text{"Mw"}} = -0.00591999999999999992, K_{0,\,\text{"Zd"}} = -63.9979000000000014, K_{0,\,\text{"Md"}} = -6.88469999999999960, K_{0,\,\text{"Zw"}} = -.638499999999999958, K_{0,\,\text{"Mq"}} = -.657100000000000018, K_{0,\,\text{"b"}} = 64.1299999999999955, K_{0,\,\text{"Vto"}} = 690.399999999999977, K_{0,\,\text{"a"}} = 2.53480000000000016, K_{0,\,\text{"Kf"}} = -1.74600000000000000, K_{0,\,\text{"Ka"}} = 0.677000000000000046, K_{0,\,\text{"W1"}} = 2.97100000000000010, K_{0,\,\text{"Ki"}} = -3.86399999999999988, K_{0,\,\text{"Tal"}} = 0.395899999999999974] \quad (2.3)$$

Simulate the System

First we take the system and build a set of differential equations from the system and assign the result to a variable *sys.*

sys1 := *BuildDE*(*smodel1*) :

The following table illustrates the different components of the variable *sys1*.

Differential Equations

sys1[1]

$$\left[\frac{d}{dt}\, x_{3,\,1}(t) = \frac{K_{0,\,\text{"Kf"}} \left(\frac{d}{dt}\, x_{33,\,1}(t)\right) K_{0,\,\text{"Ta"}} + x_{33,\,1}(t)\, K_{0,\,\text{"Ki"}}\, K_{0,\,\text{"Ta"}} - x_{3,\,1}(t)}{K_{0,\,\text{"Ta"}}}, \right. \tag{3.1}$$

$$\frac{d}{dt}\, x_{15,\,1}(t) = -\frac{1}{K_{0,\,\text{"Ta"}} \sqrt{K_{0,\,\text{"a"}}^{3}}} \Big(-K_{0,\,\text{"Zd"}}\, x_{3,\,1}(t) \sqrt{K_{0,\,\text{"a"}}^{3}}$$

$$+ K_{0,\,\text{"Zw"}}\, K_{0,\,\text{"Swg"}}\, K_{0,\,\text{"Ta"}}\, x_{26,\,1}(t) + K_{0,\,\text{"Zw"}}\, K_{0,\,\text{"Swg"}}\, K_{0,\,\text{"Ta"}}\, x_{26,\,2}(t) \sqrt{3}\, K_{0,\,\text{"a"}}$$

$$- K_{0,\,\text{"Uo"}}\, x_{16,\,1}(t)\, K_{0,\,\text{"Ta"}} \sqrt{K_{0,\,\text{"a"}}^{3}} - K_{0,\,\text{"Zw"}}\, x_{15,\,1}(t)\, K_{0,\,\text{"Ta"}} \sqrt{K_{0,\,\text{"a"}}^{3}} \Big),$$

$$\frac{d}{dt}\, x_{16,\,1}(t) = \frac{1}{16}\, \frac{1}{\sqrt{K_{0,\,\text{"a"}}^{3}}\, K_{0,\,\text{"b"}}^{2}\, K_{0,\,\text{"Ta"}}} \Big(16\, K_{0,\,\text{"Mw"}}\, x_{15,\,1}(t) \sqrt{K_{0,\,\text{"a"}}^{3}}$$

$$K_{0,\,\text{"b"}}^{2}\, K_{0,\,\text{"Ta"}} - 16\, K_{0,\,\text{"Mw"}}\, K_{0,\,\text{"Swg"}}\, K_{0,\,\text{"b"}}^{2}\, K_{0,\,\text{"Ta"}}\, x_{26,\,1}(t) - 16\, K_{0,\,\text{"Mw"}}\, K_{0,\,\text{"Swg"}}$$

$$K_{0,\,\text{"b"}}^{2}\, K_{0,\,\text{"Ta"}}\, x_{26,\,2}(t) \sqrt{3}\, K_{0,\,\text{"a"}} - 4\, K_{0,\,\text{"Mq"}}\, \pi\, K_{0,\,\text{"Ta"}}\, x_{26,\,1}(t)\, K_{0,\,\text{"Swg"}}\, K_{0,\,\text{"b"}}$$

$$- 4\, K_{0,\,\text{"Mq"}}\, \pi\, K_{0,\,\text{"Ta"}}\, x_{26,\,2}(t)\, K_{0,\,\text{"Swg"}} \sqrt{3}\, K_{0,\,\text{"a"}}\, K_{0,\,\text{"b"}}$$

$$+ K_{0,\,\text{"Mq"}}\, \pi^{2}\, K_{0,\,\text{"Ta"}}\, K_{0,\,\text{"Vto"}}\, x_{25,\,1}(t) \sqrt{K_{0,\,\text{"a"}}^{3}} + 16\, K_{0,\,\text{"Md"}}\, x_{3,\,1}(t) \sqrt{K_{0,\,\text{"a"}}^{3}}$$

$$K_{0,\,\text{"b"}}^{2} + 16\, K_{0,\,\text{"Mq"}}\, x_{16,\,1}(t) \sqrt{K_{0,\,\text{"a"}}^{3}}\, K_{0,\,\text{"b"}}^{2}\, K_{0,\,\text{"Ta"}} \Big), \quad \frac{d}{dt}\, x_{25,\,1}(t) =$$

$$-\frac{1}{4}\frac{1}{\sqrt{K_{0,\text{"a"}}^{3}\,K_{0,\text{"b"}}}}\Big(-4\,x_{26,1}(t)\,K_{0,\text{"Swg"}}\,K_{0,\text{"b"}}$$

$$-4\,x_{26,2}(t)\,K_{0,\text{"Swg"}}\sqrt{3}\,K_{0,\text{"a"}}\,K_{0,\text{"b"}}+\pi\,K_{0,\text{"Vto"}}\,x_{25,1}(t)\,\sqrt{K_{0,\text{"a"}}^{3}}\Big),$$

$$\frac{d}{dt}\,x_{26,1}(t)=x_{26,2}(t),\ \frac{d}{dt}\,x_{26,2}(t)$$

$$=\frac{u_{1,1,1}(t)\,K_{0,\text{"a"}}^{2}-x_{26,1}(t)-2\,x_{26,2}(t)\,K_{0,\text{"a"}}}{K_{0,\text{"a"}}^{2}},\ \frac{d}{dt}\,x_{32,1}(t)=x_{16,1}(t)$$

$$-K_{0,\text{"W2"}}\,x_{32,1}(t),\ Sink_{Scope,34,1,1}(t)=\frac{x_{15,1}(t)}{K_{0,\text{"Uo"}}},\ Sink_{Scope,34,2,1}(t)=x_{16,1}(t),$$

$$\frac{d}{dt}\,x_{35,1}(t)=-\frac{-x_{15,1}(t)\,K_{0,\text{"Tal"}}+x_{35,1}(t)\,K_{0,\text{"Uo"}}}{K_{0,\text{"Uo"}}\,K_{0,\text{"Tal"}}},\ \frac{d}{dt}\,x_{37,1}(t)$$

$$=\frac{Source_{SigGen,36,1}(t)\,K_{0,\text{"Ts"}}-x_{37,1}(t)}{K_{0,\text{"Ts"}}},\ \frac{d}{dt}\,x_{33,1}(t)$$

$$=\frac{1}{K_{0,\text{"Ts"}}\,K_{0,\text{"Tal"}}}\Big(x_{37,1}(t)\,K_{0,\text{"Tal"}}-K_{0,\text{"Kq"}}\,K_{0,\text{"Ts"}}\,K_{0,\text{"Tal"}}\,x_{32,1}(t)\,K_{0,\text{"W1"}}$$

$$-K_{0,\text{"Kq"}}\,K_{0,\text{"Ts"}}\,K_{0,\text{"Tal"}}\,x_{16,1}(t)+K_{0,\text{"Kq"}}\,K_{0,\text{"Ts"}}\,K_{0,\text{"Tal"}}\,K_{0,\text{"W2"}}\,x_{32,1}(t)$$

$$-K_{0,\text{"Ka"}}\,x_{35,1}(t)\,K_{0,\text{"Ts"}}\Big)\Big]$$

Differential Equations with the parameter values substituted in

sys1[2]

$$\Big[\frac{d}{dt}\,x_{3,1}(t)=-1.746000000\,\frac{d}{dt}\,x_{33,1}(t)-3.864000000\,x_{33,1}(t) \tag{3.2}$$

$$-20.00000000\,x_{3,1}(t),\ \frac{d}{dt}\,x_{15,1}(t)=-1279.958000\,x_{3,1}(t)$$

$$+0.4746424846\,x_{26,1}(t)+1.203123770\,x_{26,2}(t)\sqrt{3}+689.4000002\,x_{16,1}(t)$$

$$-0.6384999998\,x_{15,1}(t),\ \frac{d}{dt}\,x_{16,1}(t)=-0.005920000001\,x_{15,1}(t)$$

$$+0.004400757258\,x_{26,1}(t)+0.01115503950\,x_{26,2}(t)\sqrt{3}$$

$$+0.001904214830\,\pi\,x_{26,1}(t)+0.004826803751\,\pi\,x_{26,2}(t)\sqrt{3}$$

$$-0.006894293806\,\pi^{2}\,x_{25,1}(t)-137.6940000\,x_{3,1}(t)-0.6571000000\,x_{16,1}(t),$$

$$\frac{d}{dt}\,x_{25,1}(t)=0.7433711582\,x_{26,1}(t)+1.884297212\,x_{26,2}(t)\sqrt{3}$$

$$-2.691408078\,\pi\,x_{25,1}(t),\ \frac{d}{dt}\,x_{26,1}(t)=x_{26,2}(t),\ \frac{d}{dt}\,x_{26,2}(t)$$

$= 1.000000000\, u_{1,1,1}(t) - 0.1556369112\, x_{26,1}(t) - 0.7890168850\, x_{26,2}(t),$

$\frac{d}{dt} x_{32,1}(t) = x_{16,1}(t) - 4.14400000000000013\, x_{32,1}(t), Sink_{Scope, 34, 1, 1}(t)$

$= 0.001450536699\, x_{15,1}(t), Sink_{Scope, 34, 2, 1}(t) = x_{16,1}(t), \frac{d}{dt} x_{35,1}(t)$

$= 0.001450536699\, x_{15,1}(t) - 2.525890377\, x_{35,1}(t), \frac{d}{dt} x_{37,1}(t)$

$= 1.000000000\, Source_{SigGen, 36, 1}(t) - 10.00000000\, x_{37,1}(t), \frac{d}{dt} x_{33,1}(t)$

$= 9.999999999\, x_{37,1}(t) + 0.9566988006\, x_{32,1}(t) - 0.8155999999\, x_{16,1}(t)$

$- 1.710027785\, x_{35,1}(t)]$

Initial conditions

sys1[3]

$$[x_{3,1}(0) = 0, x_{15,1}(0) = 0, x_{16,1}(0) = 0, x_{25,1}(0) = 0, x_{26,1}(0) = 0, x_{26,2}(0) = 0, x_{32,1}(0) = 0, x_{33,1}(0) = 0, x_{35,1}(0) = 0, x_{37,1}(0) = 0] \quad (3.3)$$

Equations for the sources (inputs)

sys1[4]

$$\left[u_{1,1,1}(t) = 0, Source_{SigGen, 36, 1}(t) = \begin{cases} -1 & t - 4.000000000\,\pi\,\mathrm{trunc}\left(\frac{0.2500000000\, t}{\pi}\right) < 2.000000000\,\pi \\ 1 & \mathit{otherwise} \end{cases}\right] \quad (3.4)$$

List of sinks (outputs)

sys1[5]

$$[Sink_{Scope, 34, 1, 1}(t), Sink_{Scope, 34, 2, 1}(t)] \quad (3.5)$$

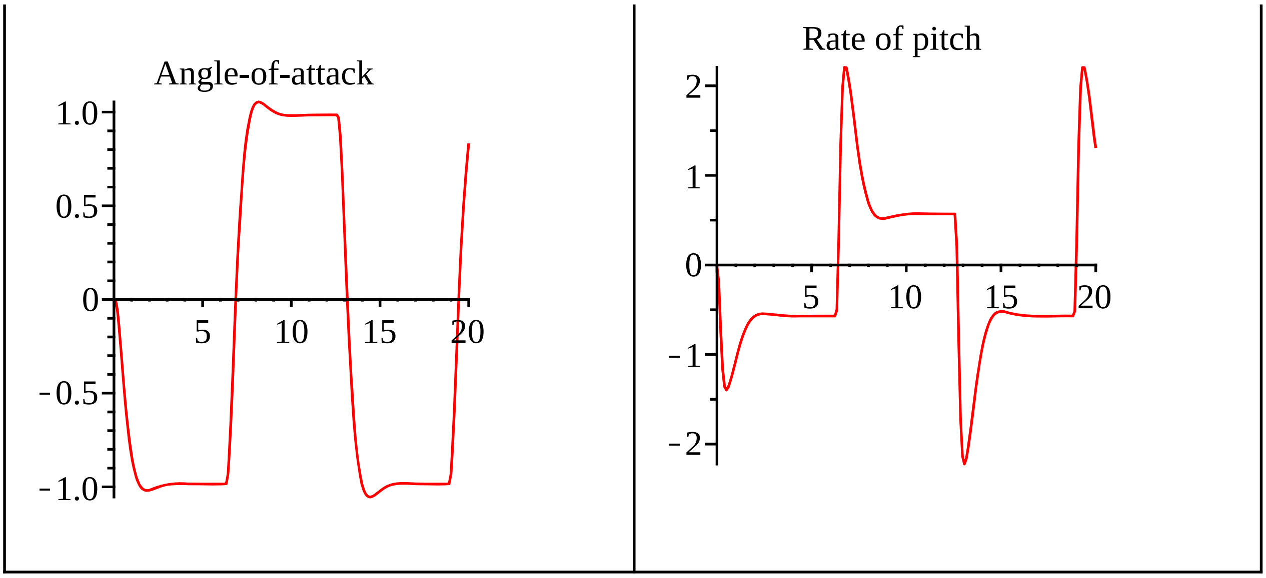
Using the information in the variable *sys*, we construct a simulation procedure.

sol1 := *dsolve*([*eval*(*sys1*[2], *sys1*[4])[ ], *sys1*[3][ ]], *numeric*)

proc(*x_rkf45_dae*) ... **end proc** (3.6)

Then we plot the simulation results.

plots[*odeplot*](*sol1*, [*t*, *sys1*[5][1]], 0 ..20, *numpoints* = 200, *title* = "Angle-of-attack")	*plots*[*odeplot*](*sol1*, [*t*, *sys1*[5][2]], 0 ..20, *numpoints* = 200, *title* = "Rate of pitch")



Import the Subsystem

First we want to close the Simulink model without saving it, so we can reload it with the subsystem. We send the command `close_system('m_f14', 0)` through the link to MATLAB.

Matlab:-*evalM*("close_system ('m_f14',0)")

We can import a subsystem from the model.

model2 := *Import*("m_f14", "m_f14/Aircraft dynamics", *path* = *datadir*, *init* = "f14_init") :

The set of equations are simplified and the simplified set of equations is printed using the *PrintSummary* command.

smodel2 := *SimplifyModel*(*model2*) :
PrintSummary(*smodel2*) :

Equations [4]:

$$\left[y_{1,1,1} = \frac{x_{12,1}}{K_{0,\text{"Uo"}}},\ \mathrm{D}(x_{12,1}) = K_{0,\text{"Zd"}}\, u_{1,1,1} - u_{1,2,1} + K_{0,\text{"Uo"}}\, y_{1,2,1} + K_{0,\text{"Zw"}}\, x_{12,1},\right.$$
$$\left.\mathrm{D}(x_{13,1}) = K_{0,\text{"Mw"}}\, x_{12,1} - u_{1,3,1} + K_{0,\text{"Md"}}\, u_{1,1,1} + K_{0,\text{"Mq"}}\, x_{13,1},\ y_{1,2,1} = x_{13,1}\right]$$

State Variables [2]:

$$[x_{12,1}, x_{13,1}]$$

Initial Equations [2]:

$$[x_{12,1}(0) = 0, x_{13,1}(0) = 0]$$

Input Variables [3]:

$$[u_{1,1,1}, u_{1,2,1}, u_{1,3,1}]$$

Output Variables [2]:

$$[y_{1,1,1}, y_{1,2,1}]$$

Parameters [6]:

$$[K_{0,\text{"Uo"}} = 689.399999999999976, K_{0,\text{"Mw"}} = -0.00591999999999999992, K_{0,\text{"Zd"}} = -63.9979000000000014, K_{0,\text{"Md"}} = -6.88469999999999960, K_{0,\text{"Zw"}} = -.638499999999999958, K_{0,\text{"Mq"}} = -.657100000000000018] \quad (4.1)$$

The differential equations are created.
sys2 := *BuildDE*(*smodel2*)

$$\left[y_{1,1,1}(t) = \frac{x_{12,1}(t)}{K_{0,\text{"Uo"}}}, \frac{d}{dt} x_{12,1}(t) = K_{0,\text{"Zd"}} u_{1,1,1}(t) - u_{1,2,1}(t) + K_{0,\text{"Uo"}} y_{1,2,1}(t) + K_{0,\text{"Zw"}} x_{12,1}(t), \frac{d}{dt} x_{13,1}(t) = K_{0,\text{"Mw"}} x_{12,1}(t) - u_{1,3,1}(t) + K_{0,\text{"Md"}} u_{1,1,1}(t) + K_{0,\text{"Mq"}} x_{13,1}(t), y_{1,2,1}(t) = x_{13,1}(t) \right], \left[y_{1,1,1}(t) = 0.001450536699\, x_{12,1}(t), \frac{d}{dt} x_{12,1}(t) = -63.9979000000000014\, u_{1,1,1}(t) - u_{1,2,1}(t) + 689.399999999999976\, y_{1,2,1}(t) - 0.638499999999999958\, x_{12,1}(t), \frac{d}{dt} x_{13,1}(t) = -0.00591999999999999992\, x_{12,1}(t) - u_{1,3,1}(t) - 6.88469999999999960\, u_{1,1,1}(t) - 0.657100000000000018\, x_{13,1}(t), y_{1,2,1}(t) = x_{13,1}(t) \right], [x_{12,1}(0) = 0, x_{13,1}(0) = 0], [u_{1,1,1}(t) = 0, u_{1,2,1}(t) = 0, u_{1,3,1}(t) = 0], [y_{1,1,1}(t), y_{1,2,1}(t)] \quad (4.2)$$

The following table illustrates the different components of the variable *sys2*.

Differential Equations *sys2*[1] $$\left[y_{1,1,1}(t) = \frac{x_{12,1}(t)}{K_{0,\text{"Uo"}}}, \frac{d}{dt} x_{12,1}(t) = K_{0,\text{"Zd"}} u_{1,1,1}(t) - u_{1,2,1}(t) + K_{0,\text{"Uo"}} y_{1,2,1}(t) + K_{0,\text{"Zw"}} x_{12,1}(t), \frac{d}{dt} x_{13,1}(t) = K_{0,\text{"Mw"}} x_{12,1}(t) - u_{1,3,1}(t) + K_{0,\text{"Md"}} u_{1,1,1}(t) + K_{0,\text{"Mq"}} x_{13,1}(t), y_{1,2,1}(t) = x_{13,1}(t) \right] \quad (4.3)$$
Differential Equations with the parameter values substituted in *sys2*[2] $$\left[y_{1,1,1}(t) = 0.001450536699\, x_{12,1}(t), \frac{d}{dt} x_{12,1}(t) = -63.9979000000000014\, u_{1,1,1}(t) - u_{1,2,1}(t) + 689.399999999999976\, y_{1,2,1}(t) - 0.638499999999999958\, x_{12,1}(t), \frac{d}{dt} x_{13,1}(t) = \right. \quad (4.4)$$

$$-0.00591999999999999992\, x_{12,1}(t) - u_{1,3,1}(t) - 6.88469999999999960\, u_{1,1,1}(t) - 0.657100000000000018\, x_{13,1}(t), y_{1,2,1}(t) = x_{13,1}(t) \Big]$$

Initial conditions

sys2[3]

$$\left[x_{12,1}(0) = 0, x_{13,1}(0) = 0\right] \quad (4.5)$$

Equations for the sources (inputs)

sys2[4]

$$\left[u_{1,1,1}(t) = 0, u_{1,2,1}(t) = 0, u_{1,3,1}(t) = 0\right] \quad (4.6)$$

List of sinks (outputs)

sys2[5]

$$\left[y_{1,1,1}(t), y_{1,2,1}(t)\right] \quad (4.7)$$