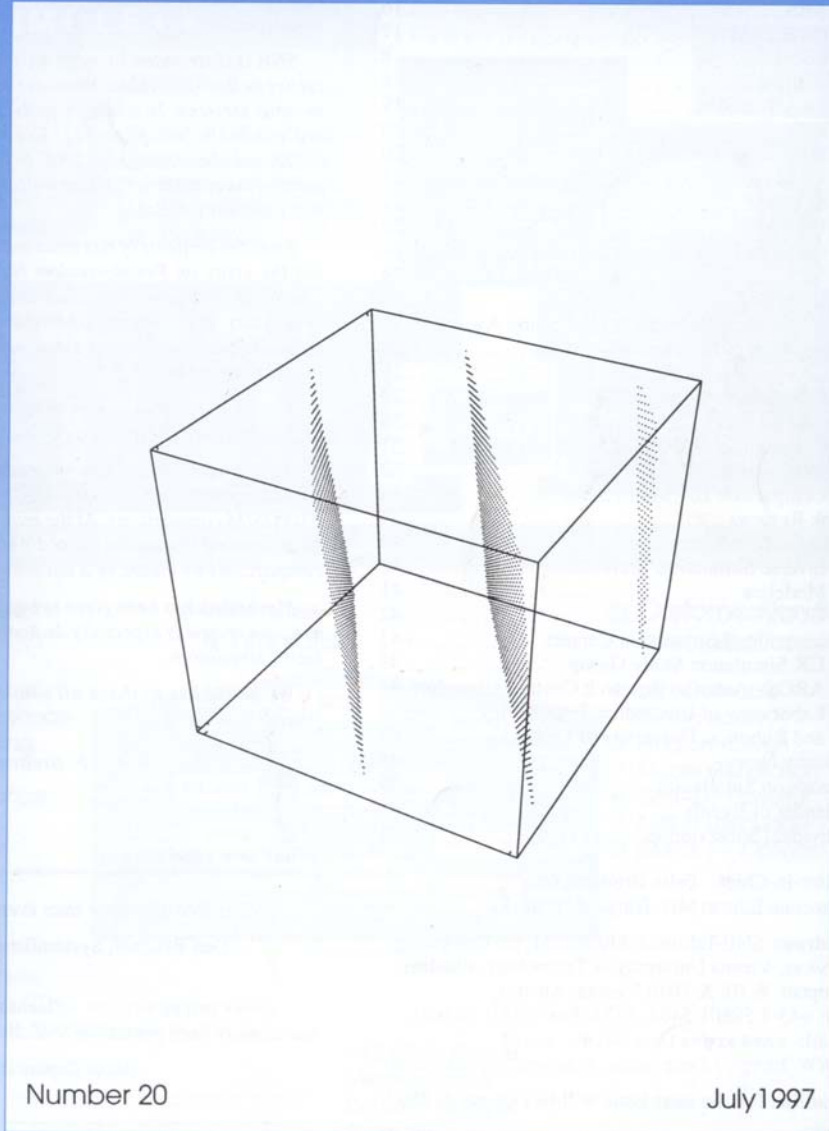


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GODYS-PC: An Interactive Continuous System Simulation Language

GODYS (graph oriented dynamic system simulator) continuous system simulation language was originally developed at the Jagiellonian University in Kraków, Poland, in the mid-1970s and has been installed on Honeywell, ICL 1900 and IBM 360 computers. It has been further developed in recent years and has been installed on PCs (GODYS-PC). Using the same basic approach as GODYS, GODYS-PC provides an interactive simulation facility and a number of advanced features. It has been developed for the purpose of modelling dynamic systems described by a set of algebraic and differential equations. GODYS-PC is written in FORTRAN and consists of two modules. One of them is the syntax-directed translator, which generates the object program in the language of some abstract machine. This machine is implemented by the effective interpreter, which is the main part of the second module. Typical areas in which GODYS-PC is currently applied come from a wide diversity of realistic situations in engineering, control system design, economics and biology.

Simulation using GODYS-PC: A GODYS-PC program consists of two parts: the model description and the runtime commands. Runtime commands can be entered interactively or in a batch process.

The model description consists of two parts: initial section (for calculations performed once before each dynamic run) and dynamic section (comprises a set of algebraic and differential equations defining the model). The equations defining the model can be written in any order. The translator sorts the equations. The sort algorithm is based on the theory of functional graphs. The language consists of a set of arithmetic, relational and logical operators, and standard functions. The functions consist of special GODYS-PC operators such as INTEG (integration function), DERIVT (derivative function), STEP (step function) and so on. The language provides over fifty standard functions. The user can define his own functions in FORTRAN.

As an example of GODYS-PC let us consider the spring damping model. The model can be written mathematically as follows:

$$\frac{dx}{dt} = v, \quad \frac{dv}{dt} = -\frac{k}{m}x - \frac{d}{m}v + \frac{f}{m}$$

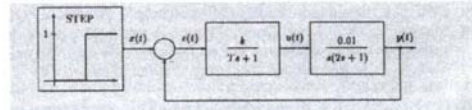
The description of the model in GODYS-PC is:

```
MODEL spring
  PREPARE x, v
  PARAMT k, d, m, a, t0
DYNAMIC
  x = INTEG(v; 0)
  v = INTEG((a/m)*STEP(t-t0) - (d/m)*v - (k/m)*x; 0)
END
```

```
LOAD spring
  DATA k=1, d=0.3, m=1, a=-1, t0=10
  EXECUTE (dt=0.1, tmax=50, comdel=0.1)
  PLOTXY(t = (0, 50), x)
FINISH
```

Parameter optimization in GODYS-PC: In the case of parameter optimization a finite number of parameters has to be determined such that a cost function of these parameters is minimal. Max. 8 parameters can be optimized in a cost function in GODYS-PC. The language provides four function minimization algorithms. The following control loop example illustrates the use of parameter optimization in GODYS-PC.

Control loop block diagram (T = 8).



The parameter k has to be determined such that the following cost function

$$f = \int_0^{\infty} e^2(t) dt$$

is minimal. The description of the model in GODYS-PC is the following:

```
MODEL contr
  PREPARE x, y, e, f
  PARAMT k, t0
DYNAMIC
  x = STEP(t - t0)
  e = x - y
  u = k*REALPL(e; 8, 0)
  y = REALPL(0.01*INTEG(u; 0); 2, 0)
  f = INTEG(e*e; 0)
END
```

Runtime commands with parameter optimization:

```
LOAD contr
  DATA k = 5, t0 = 20
  EXECUTE(tmax = 175, dt = 0.1, comdel = 1, @
  OPT = (f(k = (5,25)), alg = mgs, lim = 10))
  PLOTXY(t, e)
FINISH
```

The parameter opt initiates parameter optimization in the run. The parameter alg specifies the method for the function minimization algorithm. Each function evaluation involves a simulation run. The parameter lim specifies the number of runs during parameter optimization. The minimal value of the cost function ($F = 9.958$) has been found for $k = 17.36$.

GODYS-PC continuous simulation language for PC provides an integrated development environment and an interactive simulation facility running on MS-DOS with 640 K of RAM and 2 MB on the hard disk. GODYS-PC is easy to learn even for somebody who is not an experienced programmer.

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