

# NIDays09

CONFERÊNCIA TECNOLÓGICA SOBRE  
PROJETO GRÁFICO DE SISTEMAS





# Implementando sistemas de teste Hardware-In-the-Loop (HIL) com LabVIEW e VeriStand

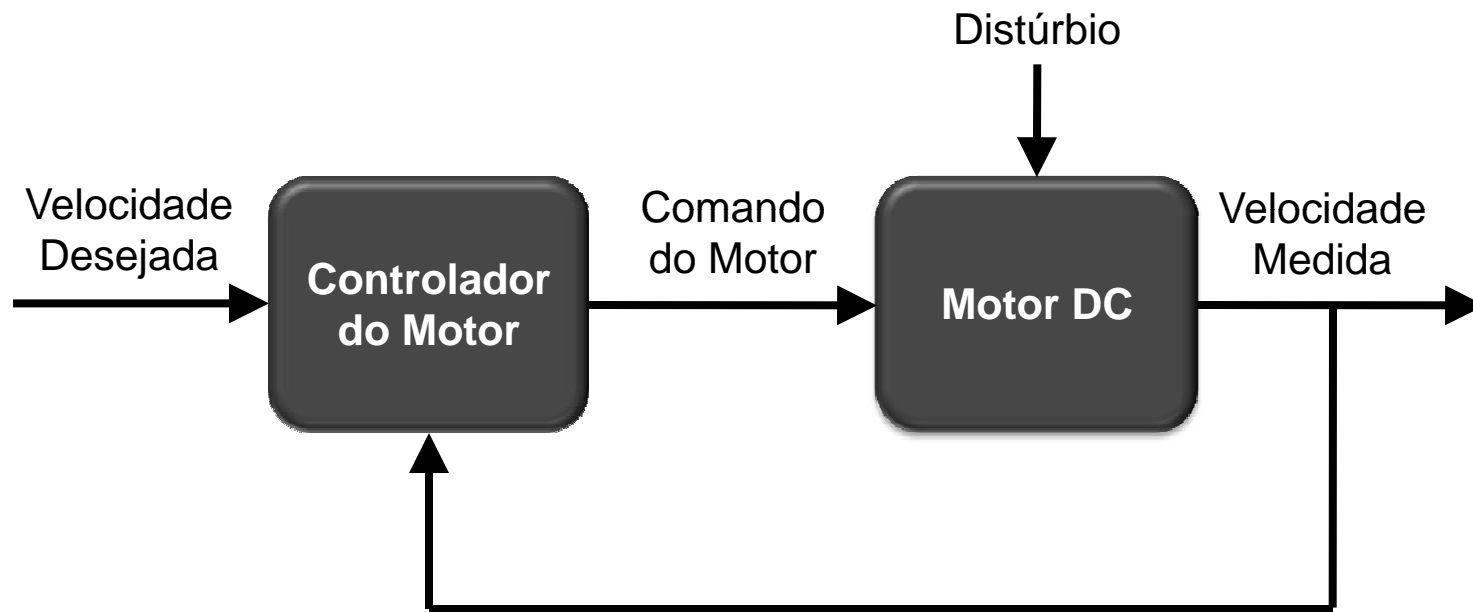
Leandro Fonseca – Gerente Distrital de Vendas  
Alisson Kokot – Engenheiro de Vendas



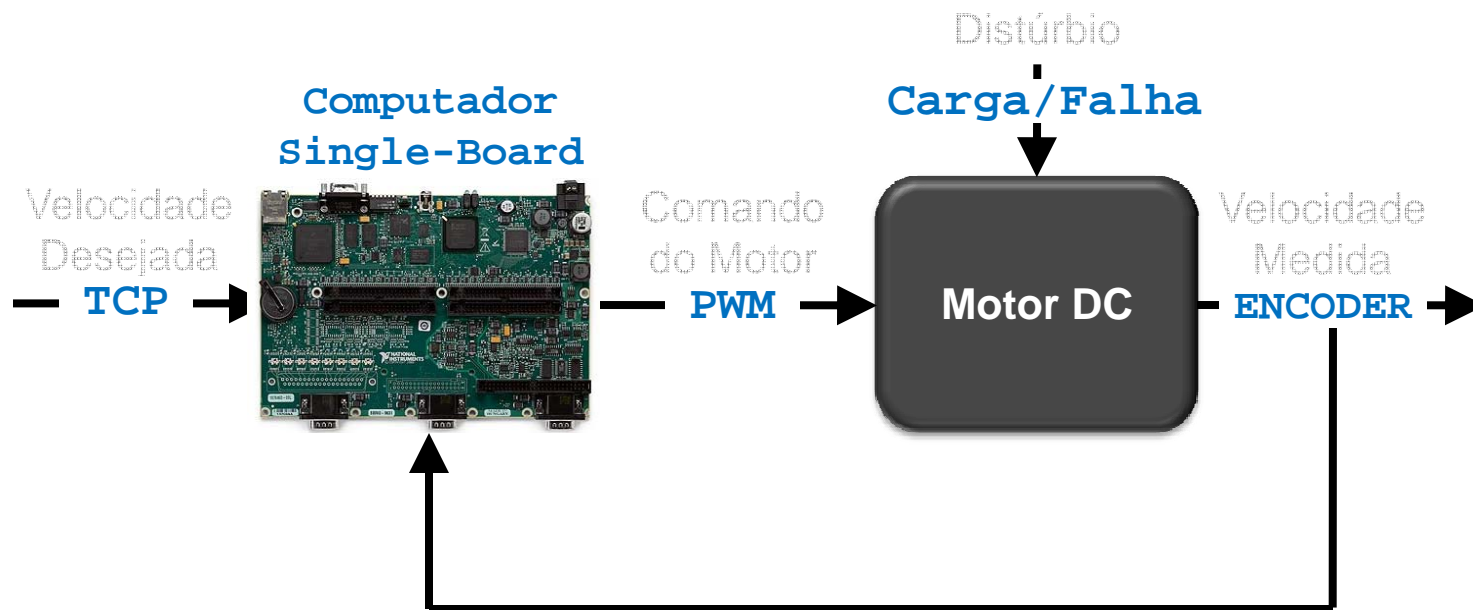
# Agenda

- Sistemas de controle embarcado
- Testes de sistemas e componentes
- Implementação de sistemas de teste com LabVIEW
- Utilização de ferramenta configurável VeriStand

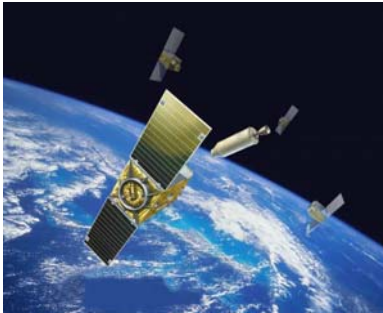
# Controle Malha Fechada



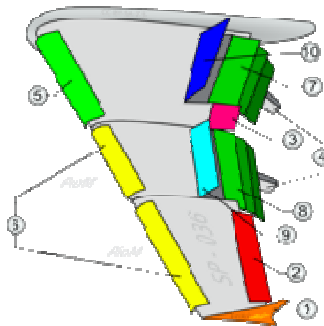
# DEMO – Sistema de Controle Malha Fechada



# Controle Malha Fechada



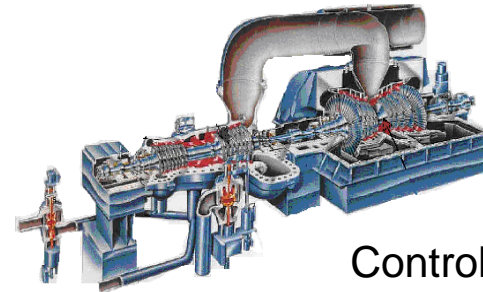
Controle de Navegação



Controle de vôo



Controle de Motor



Controle de Turbina à Vapor



Controle de Ciclo da Secadora



Controle de Cabeçote da Impressora



Controle de Equipamento Médico

# Desafio de Sistemas de Controle Embarcados

- Aumentando complexidade da aplicação
- Aumentando exigências de confiabilidade
- Diminuindo tempo de disponibilidade para o mercado
- Reduzindo custo de desenvolvimento



Desafios de  
Teste

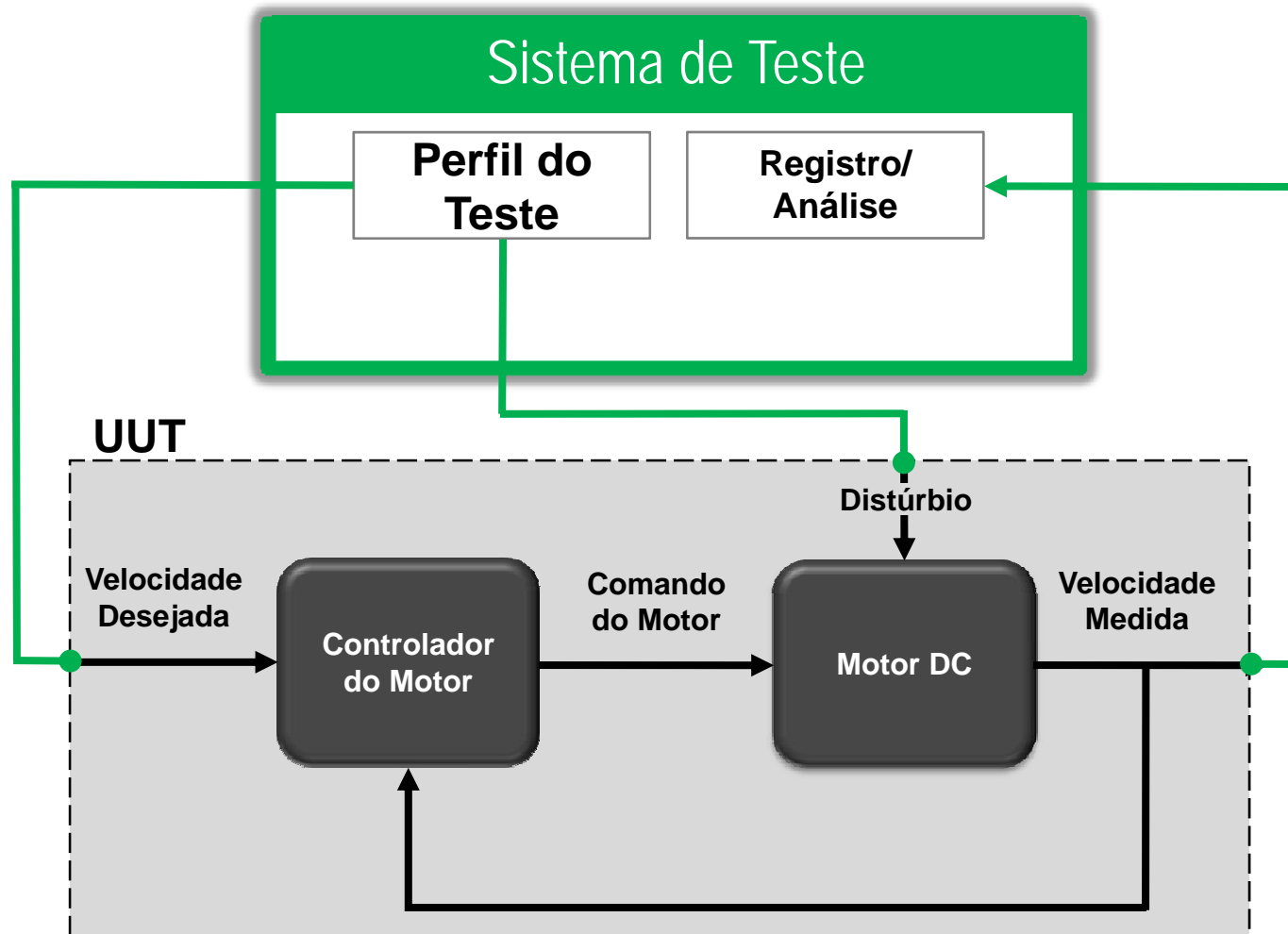


Recursos de  
Teste

**São estes mutuamente exclusivos?**

# Testando Sistemas de Controle Embarcado

## Teste de Sistema

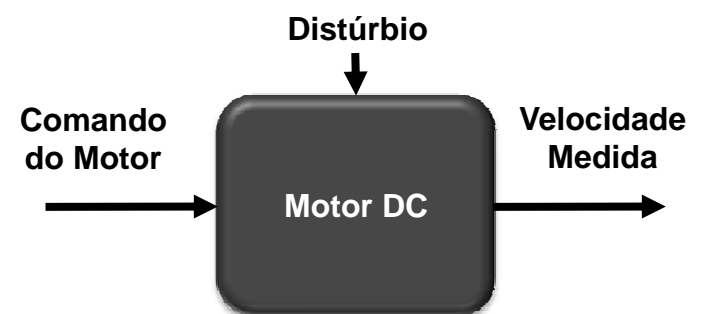




# Testando Sistemas de Controle Embarcado

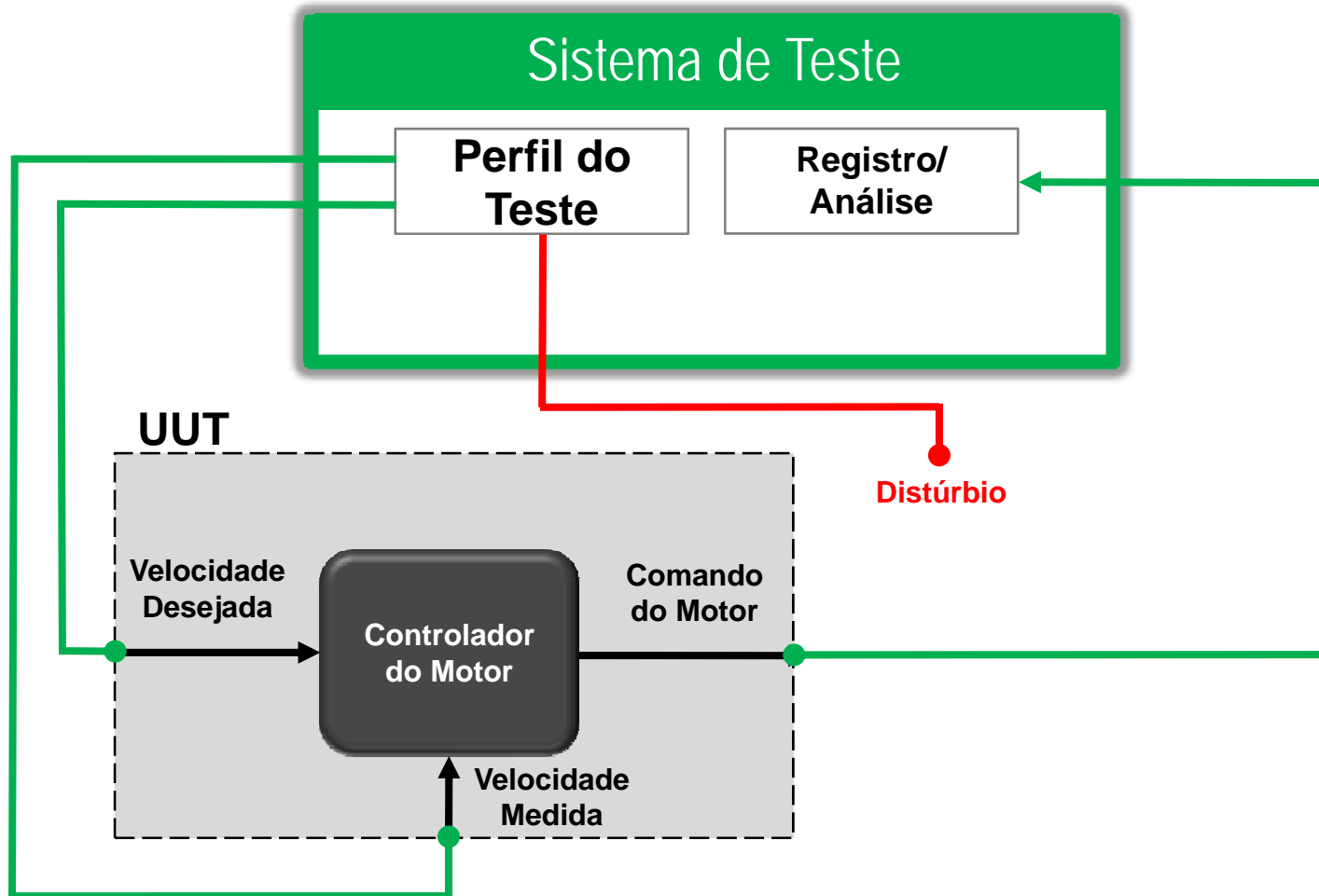
## Teste de Sistema

- O que fazer se o “*Motor DC*” não está disponível ainda ?
- O que fazer se falhas de teste puderem danificar o “*Motor DC*”?
- O que fazer se o “*Motor DC*” é muito caro (investimento, manutenção, operação, instalações)?
- O que fazer com relação a **repetibilidade** das condições de testes do “*Motor DC*”?
- O que fazer se existem inúmeras variações do “*Motor DC*” ?



# Testando Sistemas de Controle Embarcado

## Teste um Componente do Sistema



# O que é Simulação HIL

- Tipos de Teste

- Funcional
- Paramétrico
- Validação (V e V)
- Durabilidade (HALT/HAST)
- Fim-de-linha

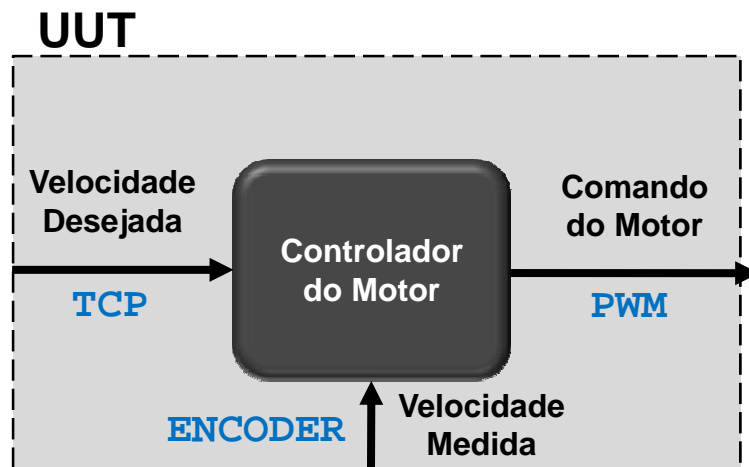
- Métodos de Teste

- Temperatura/variação de potência
- Pulverização de sal/areia
- Radiação Eletromagnética
- Carregamento/resistência Mecânica
- Simulação HIL

# *Realidade Virtual para sua UUT*

*(Unidade sob Teste)*

O que sua UUT sabe sobre o mundo em torno dela?



Tensão

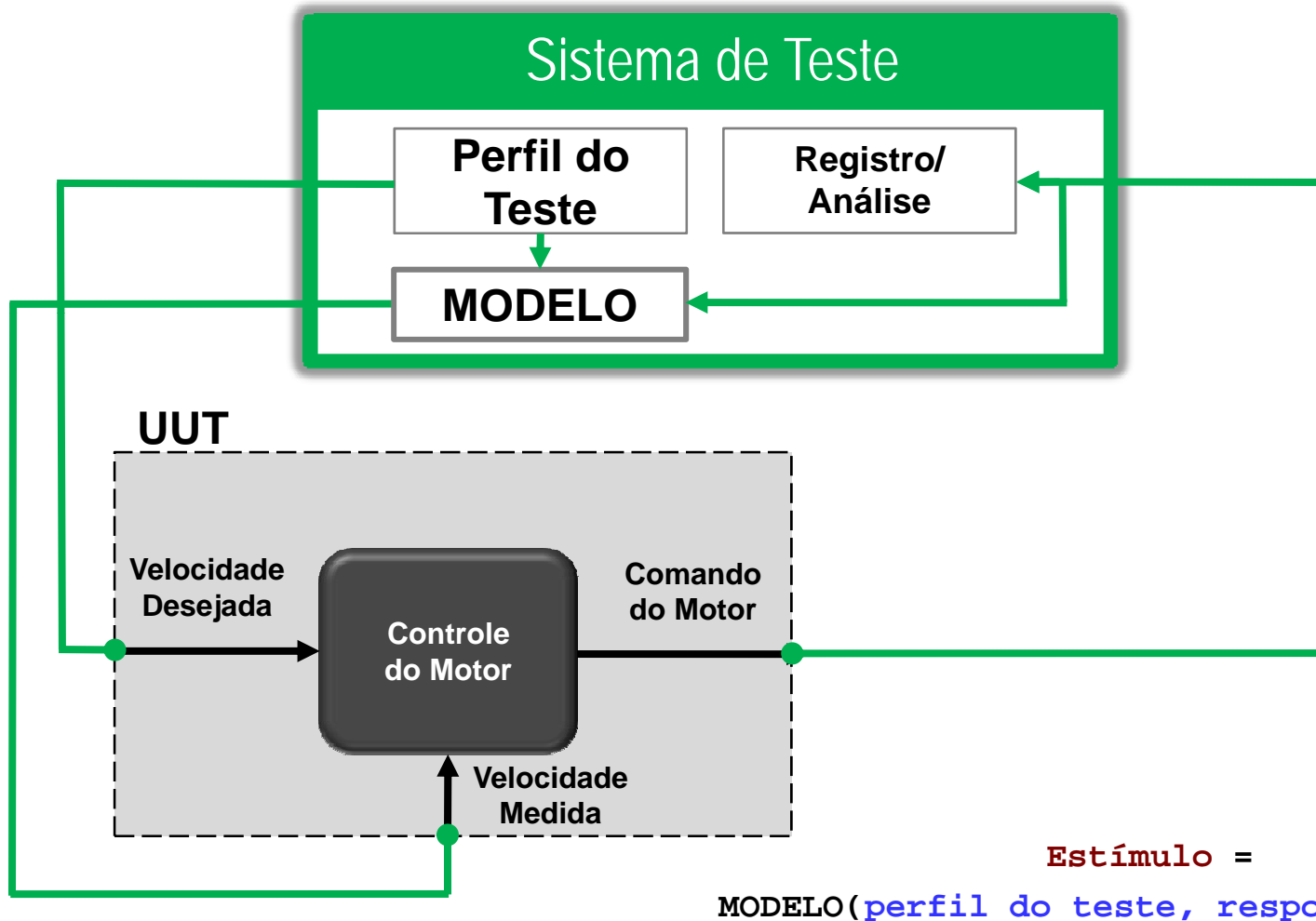
Corrente

Impedância

Temporização

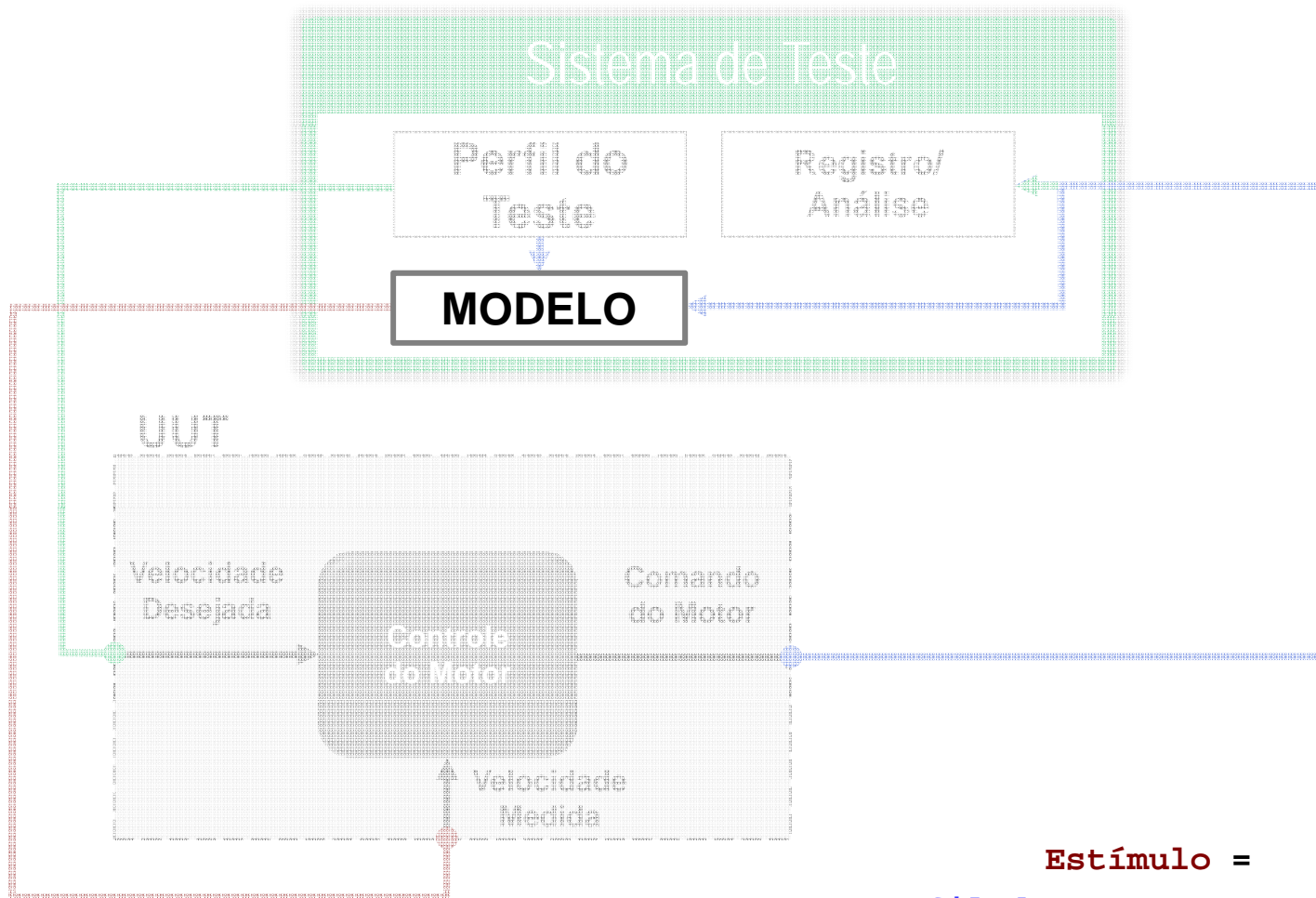
# Testando Sistemas de Controle Embarcado

## Teste Virtual do Sistema



# Testando Sistemas de Controle Embarcado

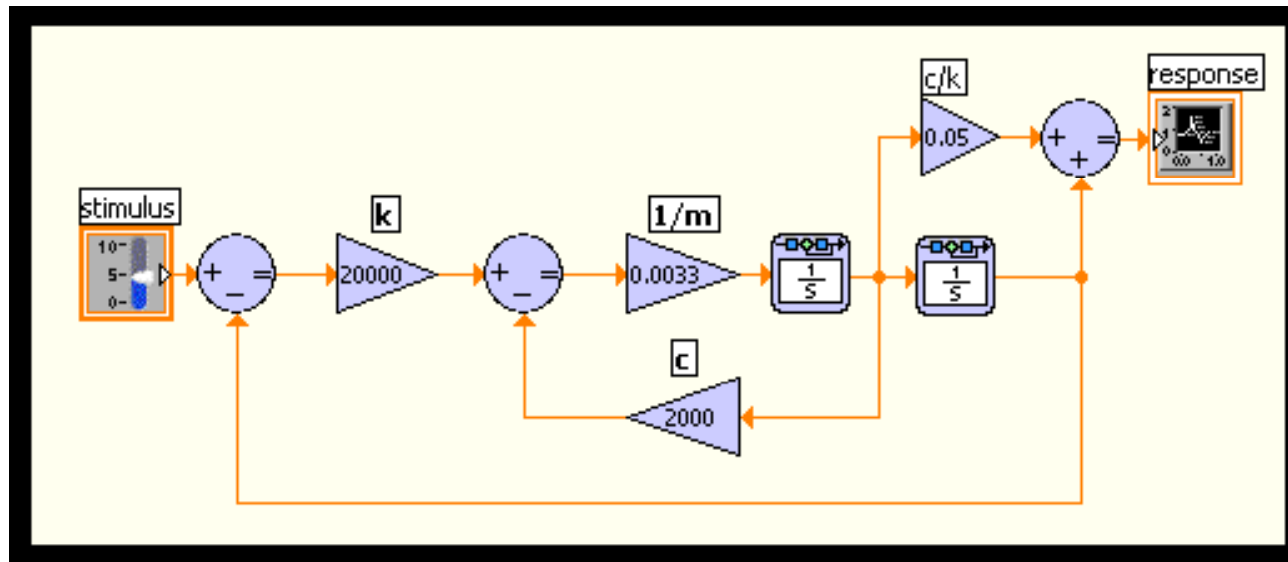
## Teste Virtual do Sistema



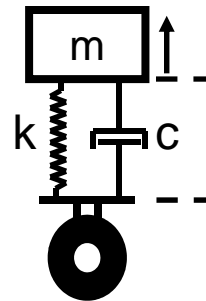
**Estímulo =**

**MODELO(perfil do teste, resposta da UUT)**

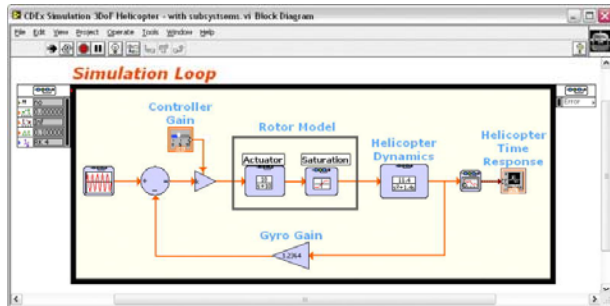
# O que é um Modelo?



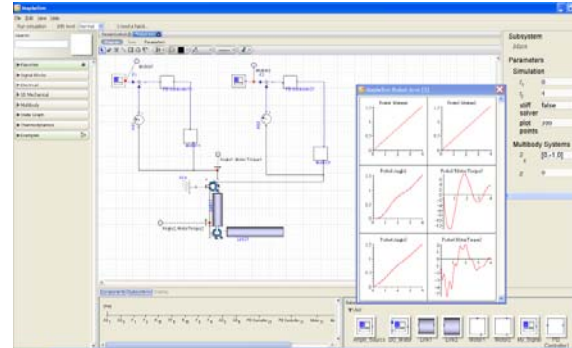
$$\frac{cs + k}{ms^2 + cs + k}$$



# Modelos de Sistemas Dinâmicos



NI LabVIEW



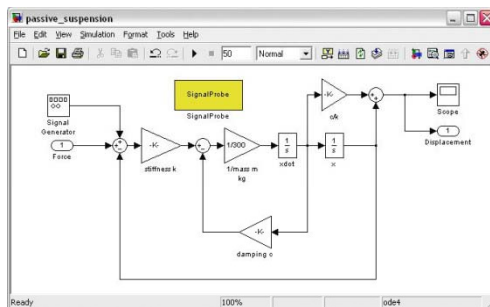
Maplesoft MapleSim

```

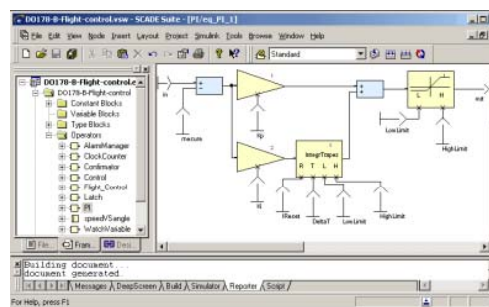
#include "stdio.h"

void main(void)
{
    int i;
    int j;
    int k;
    int l;
    int m;
    int n;
    int o;
    int p;
    int q;
    int r;
    int s;
    int t;
    int u;
    int v;
    int w;
    int x;
    int y;
    int z;
    int aa;
    int ab;
    int ac;
    int ad;
    int ae;
    int af;
    int ag;
    int ah;
    int ai;
    int aj;
    int ak;
    int al;
    int am;
    int an;
    int ao;
    int ap;
    int aq;
    int ar;
    int as;
    int at;
    int au;
    int av;
    int aw;
    int ax;
    int ay;
    int az;
    int ba;
    int bb;
    int bc;
    int bd;
    int be;
    int bf;
    int bg;
    int bh;
    int bi;
    int bj;
    int bk;
    int bl;
    int bm;
    int bn;
    int bo;
    int bp;
    int bq;
    int br;
    int bs;
    int bt;
    int bu;
    int bv;
    int bw;
    int bx;
    int by;
    int bz;
    int ca;
    int cb;
    int cc;
    int cd;
    int ce;
    int cf;
    int cg;
    int ch;
    int ci;
    int cj;
    int ck;
    int cl;
    int cm;
    int cn;
    int co;
    int cp;
    int cq;
    int cr;
    int cs;
    int ct;
    int cu;
    int cv;
    int cw;
    int cx;
    int cy;
    int cz;
    int da;
    int db;
    int dc;
    int dd;
    int de;
    int df;
    int dg;
    int dh;
    int di;
    int dj;
    int dk;
    int dl;
    int dm;
    int dn;
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    int dp;
    int dq;
    int dr;
    int ds;
    int dt;
    int du;
    int dv;
    int dw;
    int dx;
    int dy;
    int dz;
    int ea;
    int eb;
    int ec;
    int ed;
    int ee;
    int ef;
    int eg;
    int eh;
    int ei;
    int ej;
    int ek;
    int el;
    int em;
    int en;
    int eo;
    int ep;
    int eq;
    int er;
    int es;
    int et;
    int eu;
    int ev;
    int ew;
    int ex;
    int ey;
    int ez;
    int fa;
    int fb;
    int fc;
    int fd;
    int fe;
    int ff;
    int fg;
    int fh;
    int fi;
    int fj;
    int fk;
    int fl;
    int fm;
    int fn;
    int fo;
    int fp;
    int fq;
    int fr;
    int fs;
    int ft;
    int fu;
    int fv;
    int fw;
    int fx;
    int fy;
    int fz;
    int ga;
    int gb;
    int gc;
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    int ge;
    int gf;
    int gg;
    int gh;
    int gi;
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    int gk;
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    int gm;
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    int go;
    int gp;
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    int gr;
    int gs;
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    int gv;
    int gw;
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    int gz;
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    int hc;
    int hd;
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    int hf;
    int hg;
    int hh;
    int hi;
    int hj;
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    int hl;
    int hm;
    int hn;
    int ho;
    int hp;
    int hq;
    int hr;
    int hs;
    int ht;
    int hu;
    int hv;
    int hw;
    int hx;
    int hy;
    int hz;
    int ia;
    int ib;
    int ic;
    int id;
    int ie;
    int if;
    int ig;
    int ih;
    int ii;
    int ij;
    int ik;
    int il;
    int im;
    int in;
    int io;
    int ip;
    int iq;
    int ir;
    int is;
    int it;
    int iu;
    int iv;
    int iw;
    int ix;
    int iy;
    int iz;
    int ja;
    int jb;
    int jc;
    int jd;
    int je;
    int jf;
    int jg;
    int jh;
    int ji;
    int jj;
    int jk;
    int jl;
    int jm;
    int jn;
    int jo;
    int jp;
    int jq;
    int jr;
    int js;
    int jt;
    int ju;
    int jv;
    int jw;
    int jx;
    int jy;
    int jz;
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    int kb;
    int kc;
    int kd;
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    int kf;
    int kg;
    int kh;
    int ki;
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    int kk;
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    int km;
    int kn;
    int ko;
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    int kq;
    int kr;
    int ks;
    int kt;
    int ku;
    int kv;
    int kw;
    int kx;
    int ky;
    int kz;
    int la;
    int lb;
    int lc;
    int ld;
    int le;
    int lf;
    int lg;
    int lh;
    int li;
    int lj;
    int lk;
    int ll;
    int lm;
    int ln;
    int lo;
    int lp;
    int lq;
    int lr;
    int ls;
    int lt;
    int lu;
    int lv;
    int lw;
    int lx;
    int ly;
    int lz;
    int ma;
    int mb;
    int mc;
    int md;
    int me;
    int mf;
    int mg;
    int mh;
    int mi;
    int mj;
    int mk;
    int ml;
    int mm;
    int mn;
    int mo;
    int mp;
    int mq;
    int mr;
    int ms;
    int mt;
    int mu;
    int mv;
    int mw;
    int mx;
    int my;
    int mz;
    int na;
    int nb;
    int nc;
    int nd;
    int ne;
    int nf;
    int ng;
    int nh;
    int ni;
    int nj;
    int nk;
    int nl;
    int nm;
    int nn;
    int no;
    int np;
    int nq;
    int nr;
    int ns;
    int nt;
    int nu;
    int nv;
    int nw;
    int nx;
    int ny;
    int nz;
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    int ob;
    int oc;
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    int oe;
    int of;
    int og;
    int oh;
    int oi;
    int oj;
    int ok;
    int ol;
    int om;
    int on;
    int oo;
    int op;
    int oq;
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    int qj;
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    int qz;
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    int rb;
    int rc;
    int rd;
    int re;
    int rf;
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    int rh;
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    int rj;
    int rk;
    int rl;
    int rm;
    int rn;
    int ro;
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    int rv;
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    int se;
    int sf;
    int sg;
    int sh;
    int si;
    int sj;
    int sk;
    int sl;
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    int sn;
    int so;
    int sp;
    int sq;
    int sr;
    int ss;
    int st;
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    int sv;
    int sw;
    int sx;
    int sy;
    int sz;
    int ta;
    int tb;
    int tc;
    int td;
    int te;
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    int tq;
    int tr;
    int ts;
    int tt;
    int tu;
    int tv;
    int tw;
    int tx;
    int ty;
    int tz;
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    int uc;
    int ud;
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    int uf;
    int ug;
    int uh;
    int ui;
    int uj;
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    int un;
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    int wu;
    int wv;
    int ww;
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    int xc;
    int xd;
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    int xf;
    int xg;
    int xh;
    int xi;
    int xj;
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    int xm;
    int xn;
    int xo;
    int xp;
    int xq;
    int xr;
    int xs;
    int xt;
    int xu;
    int xv;
    int xw;
    int xx;
    int xy;
    int xz;
    int ya;
    int yb;
    int yc;
    int yd;
    int ye;
    int yf;
    int yg;
    int yh;
    int yi;
    int yj;
    int yk;
    int yl;
    int ym;
    int yn;
    int yo;
    int yp;
    int yq;
    int yr;
    int ys;
    int yt;
    int yu;
    int yv;
    int yw;
    int yx;
    int yy;
    int yz;
    int za;
    int zb;
    int zc;
    int zd;
    int ze;
    int zf;
    int zg;
    int zh;
    int zi;
    int zj;
    int zk;
    int zl;
    int zm;
    int zn;
    int zo;
    int zp;
    int zq;
    int zr;
    int zs;
    int zt;
    int zu;
    int zv;
    int zw;
    int zx;
    int zy;
    int zz;
}
    
```

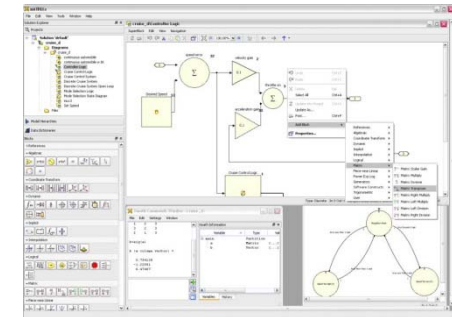
ANSI C



MathWorks, Inc. Simulink® Software



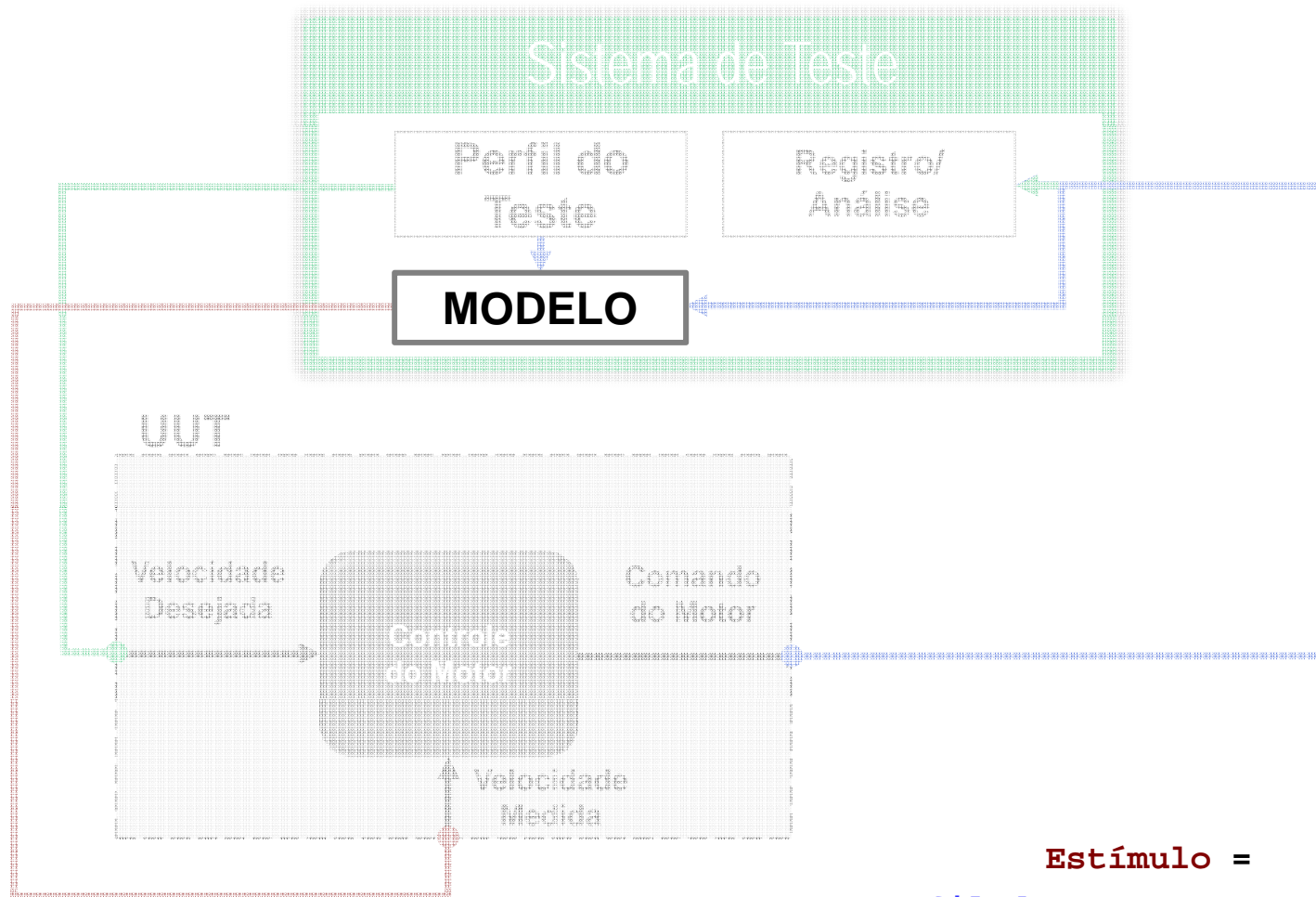
Esterel SCADA



NI MATRIXx SystemBuild

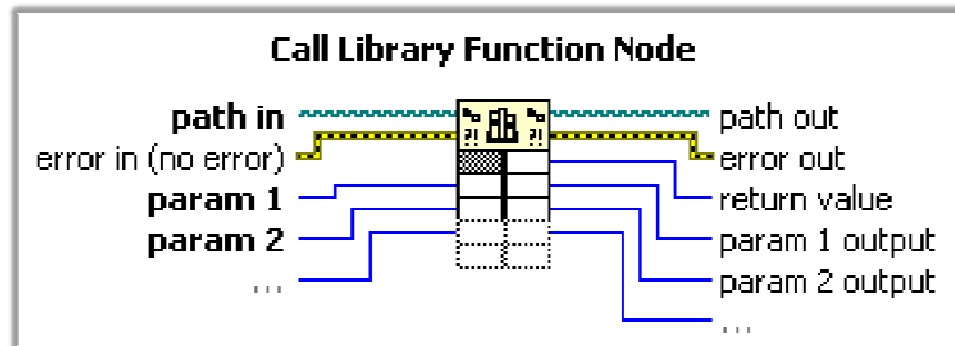


# Você precisa de um um Modelo



**Estímulo =**  
**MODELO(perfil do teste, resposta da UUT)**

# Modelo de Terceiros – Chamada de \*.dll



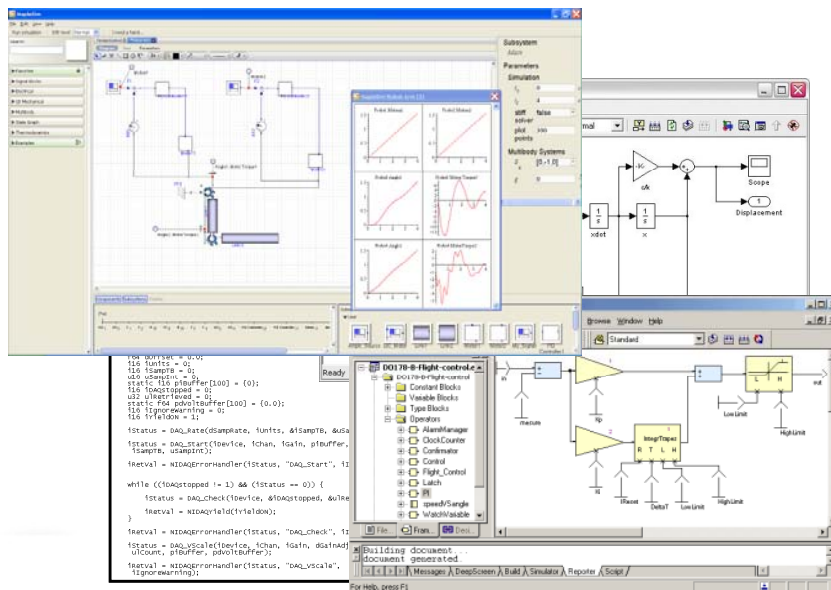
```
InitModel()
```

StepModel()

CloseModel()

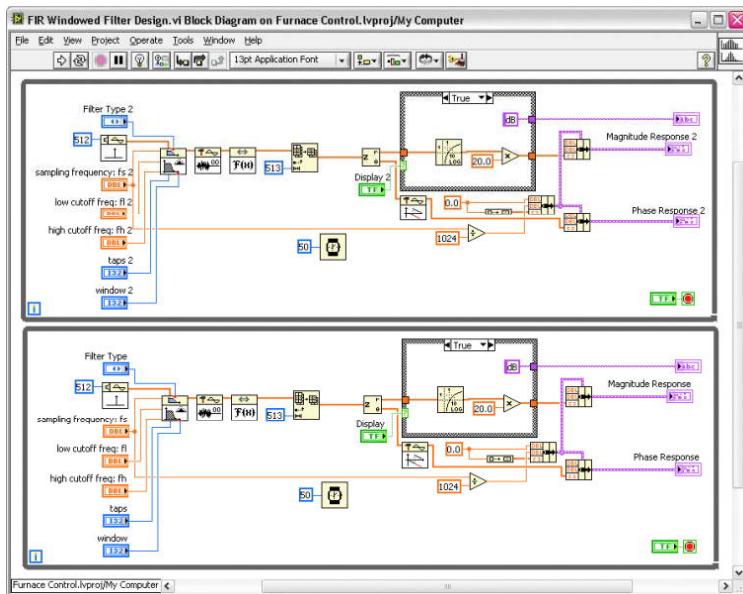
## ProbeSig()

SetParam()

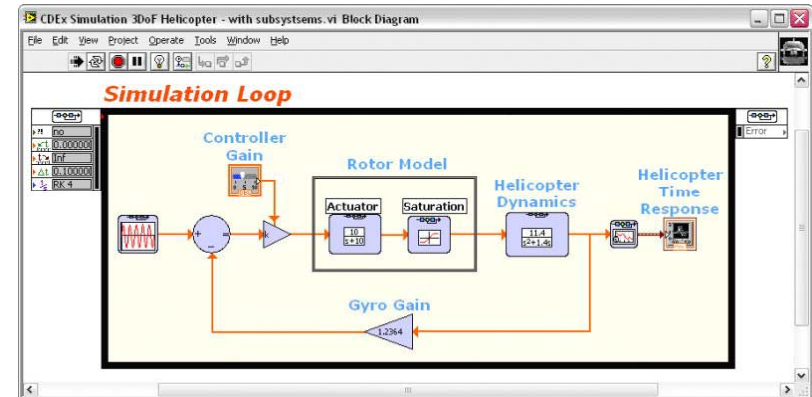


\*.dll

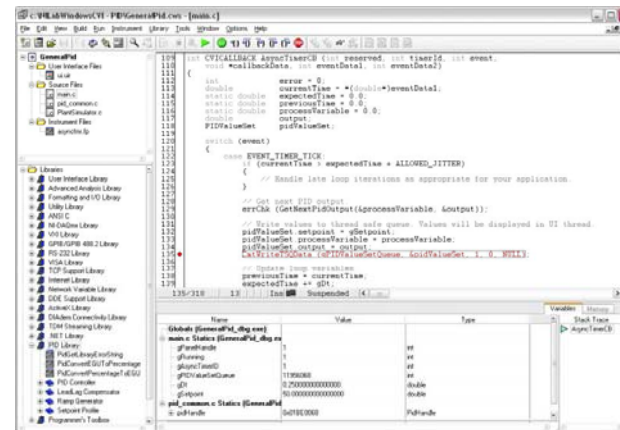
# Criação de Modelo Baseado no Conhecimento do Sistema



LabVIEW

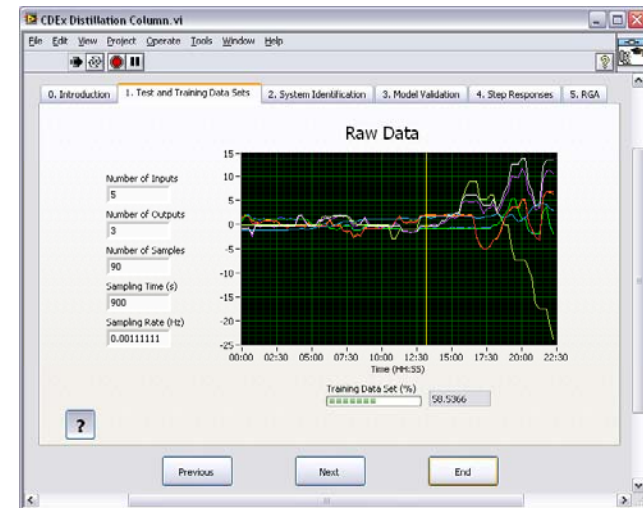
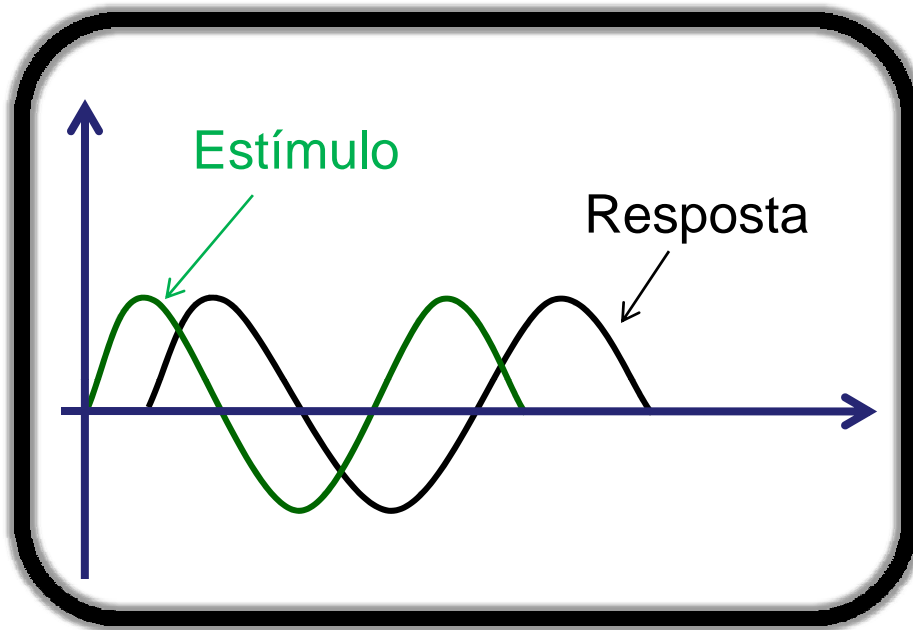


LabVIEW Control Design e Simulation Module

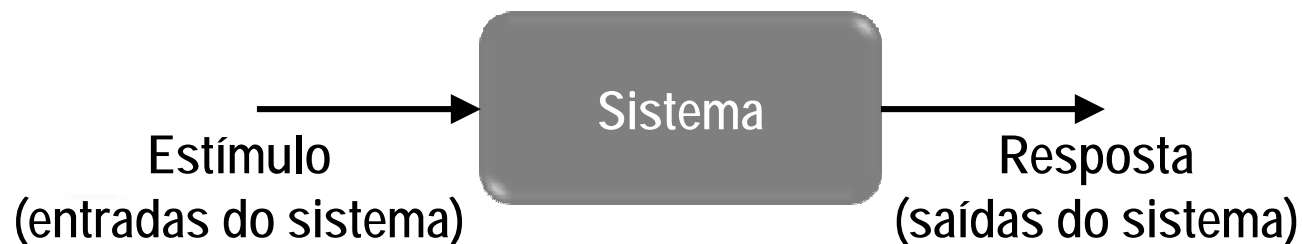


NI LabWindows™/CVI Software

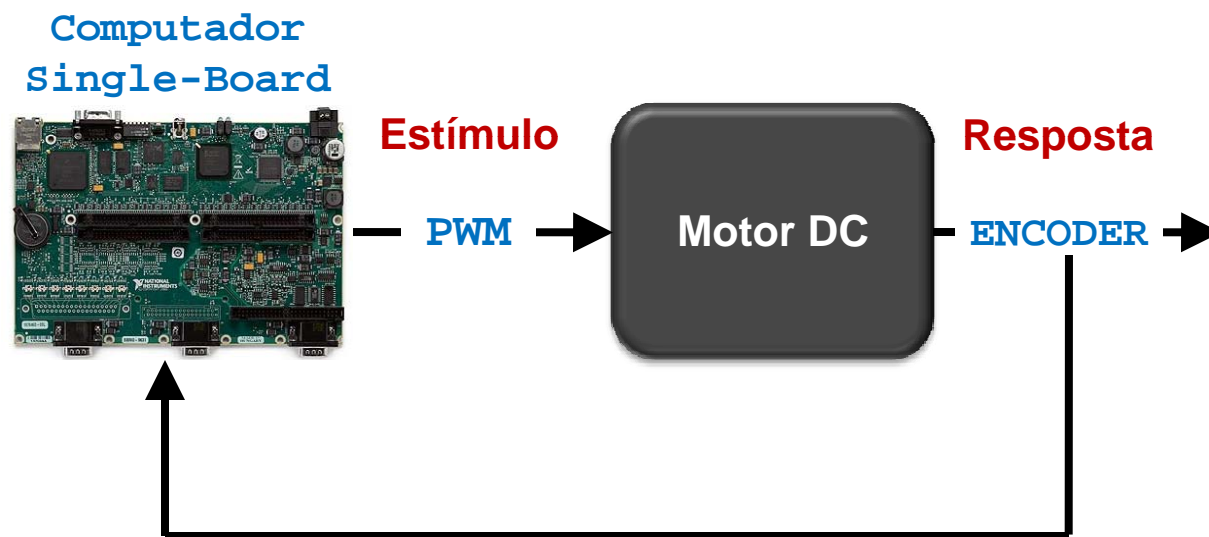
# Geração Automática de Modelo



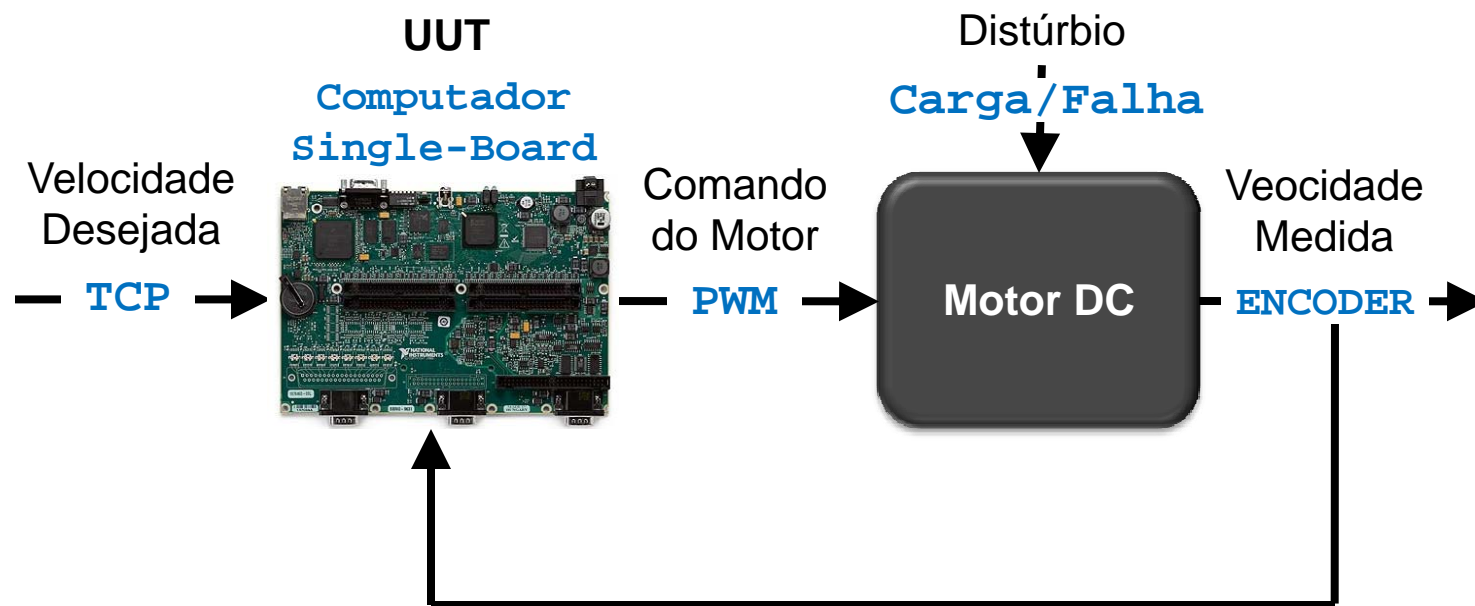
**LabVIEW System  
Identification Toolkit**



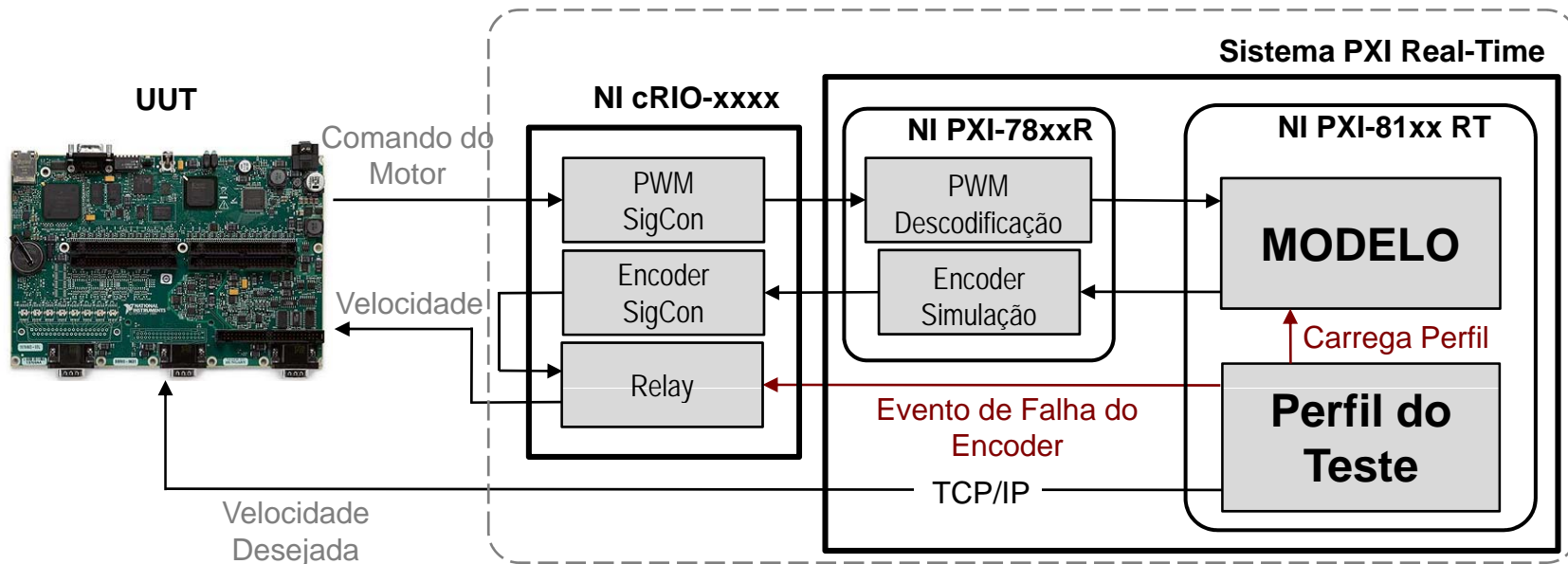
# DEMO – Identificação de Sistema



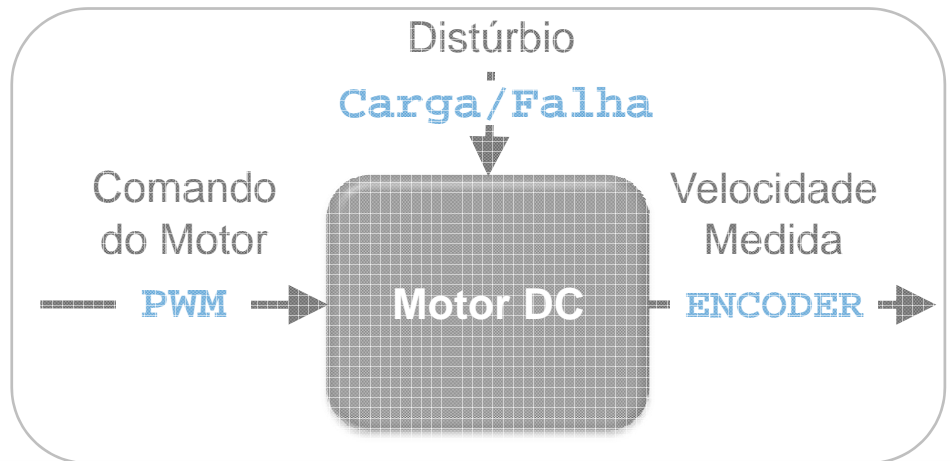
# Teste com Simulação HIL



# Demo - Teste com Simulação HIL



- Teste de resposta para falha do encoder
- Teste de resposta para carga no motor



# VeriStand

## Software para Testes Dinâmicos com *Hardware-in-the-Loop*

Lançamento Pioneiro



# Aplicações em Teste Dinâmico

## Teste do Módulo de Controle do Motor (HIL)

Emulação do Motor



Temp, fluxo, pressão, 1553...

PWM, analógico, digital

FADEC



## Teste de Mísseis

Sistema de Emulação Onboard



Estímulo



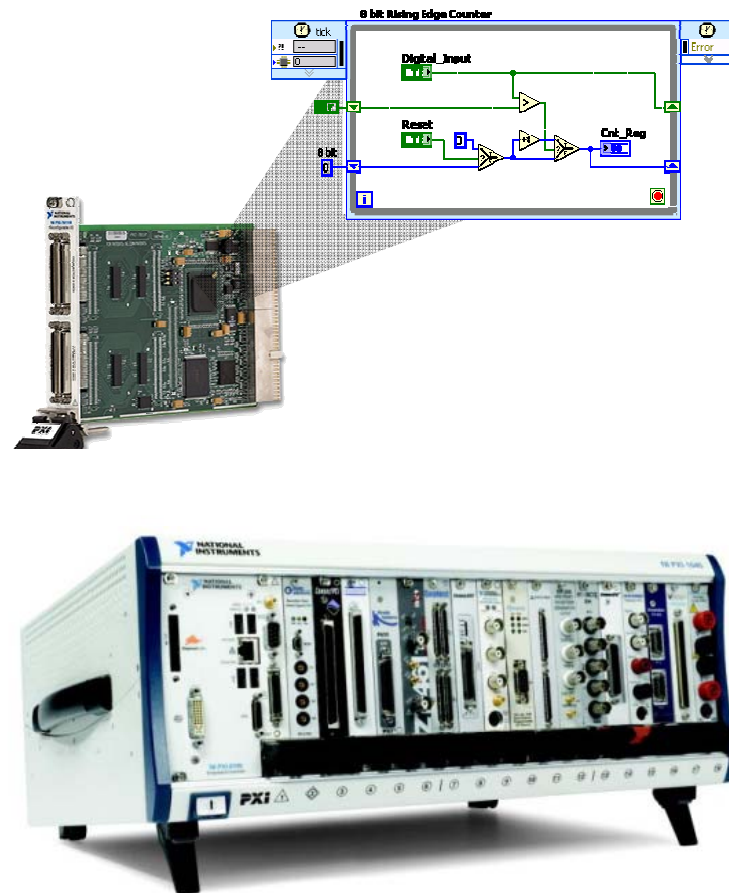
Resposta

Míssil

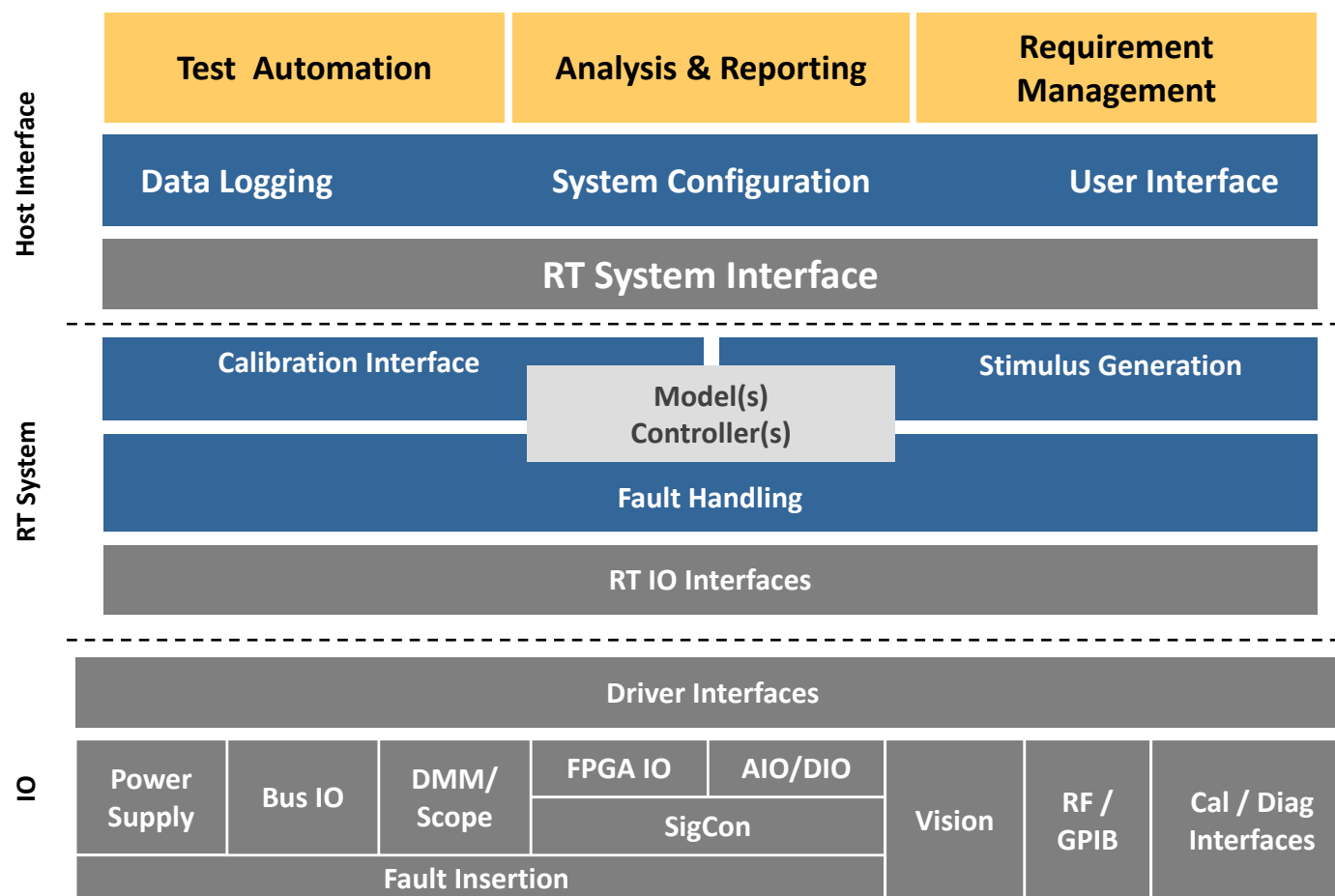


# VeriStand

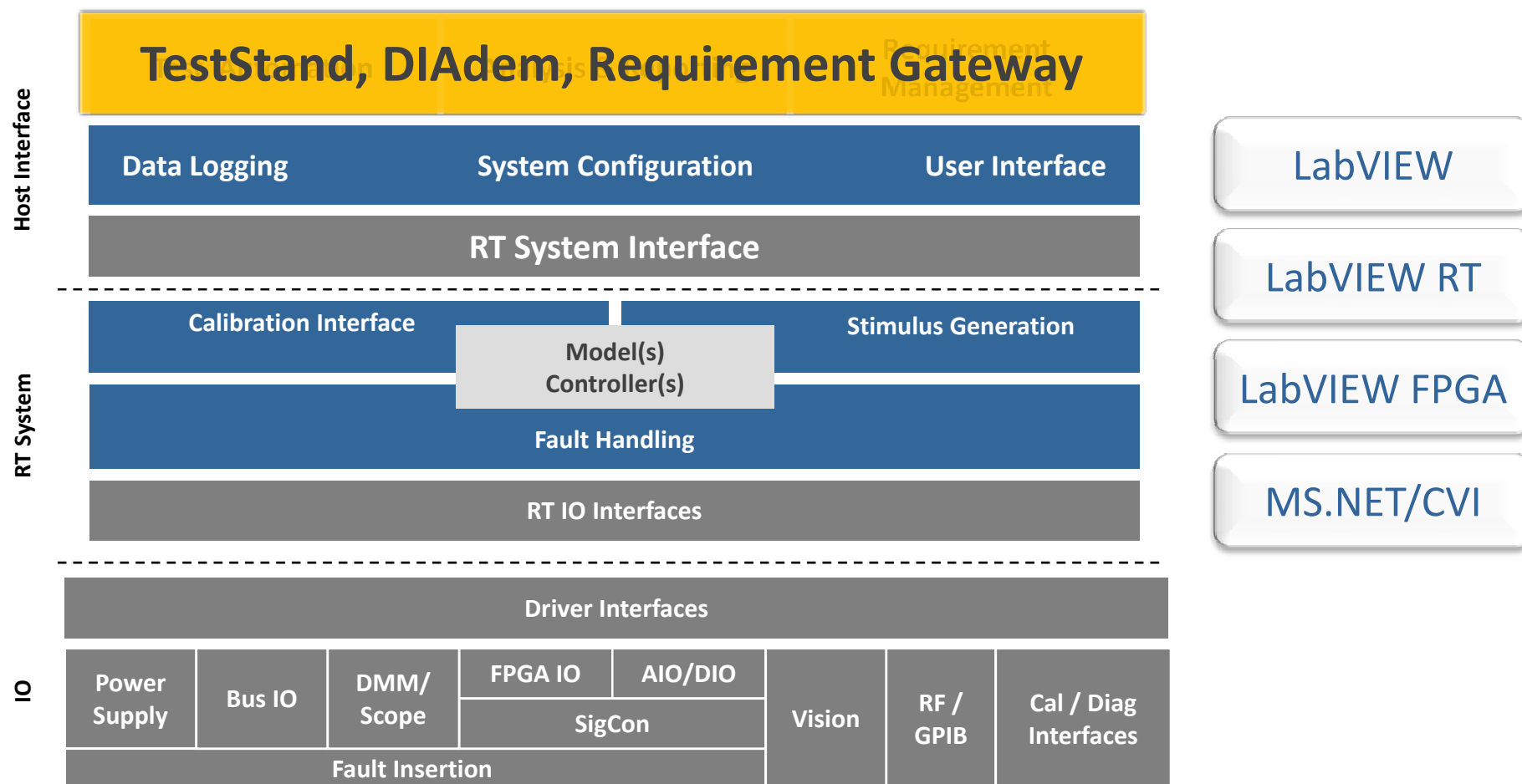
## Software de Teste Dinâmico e Simulação



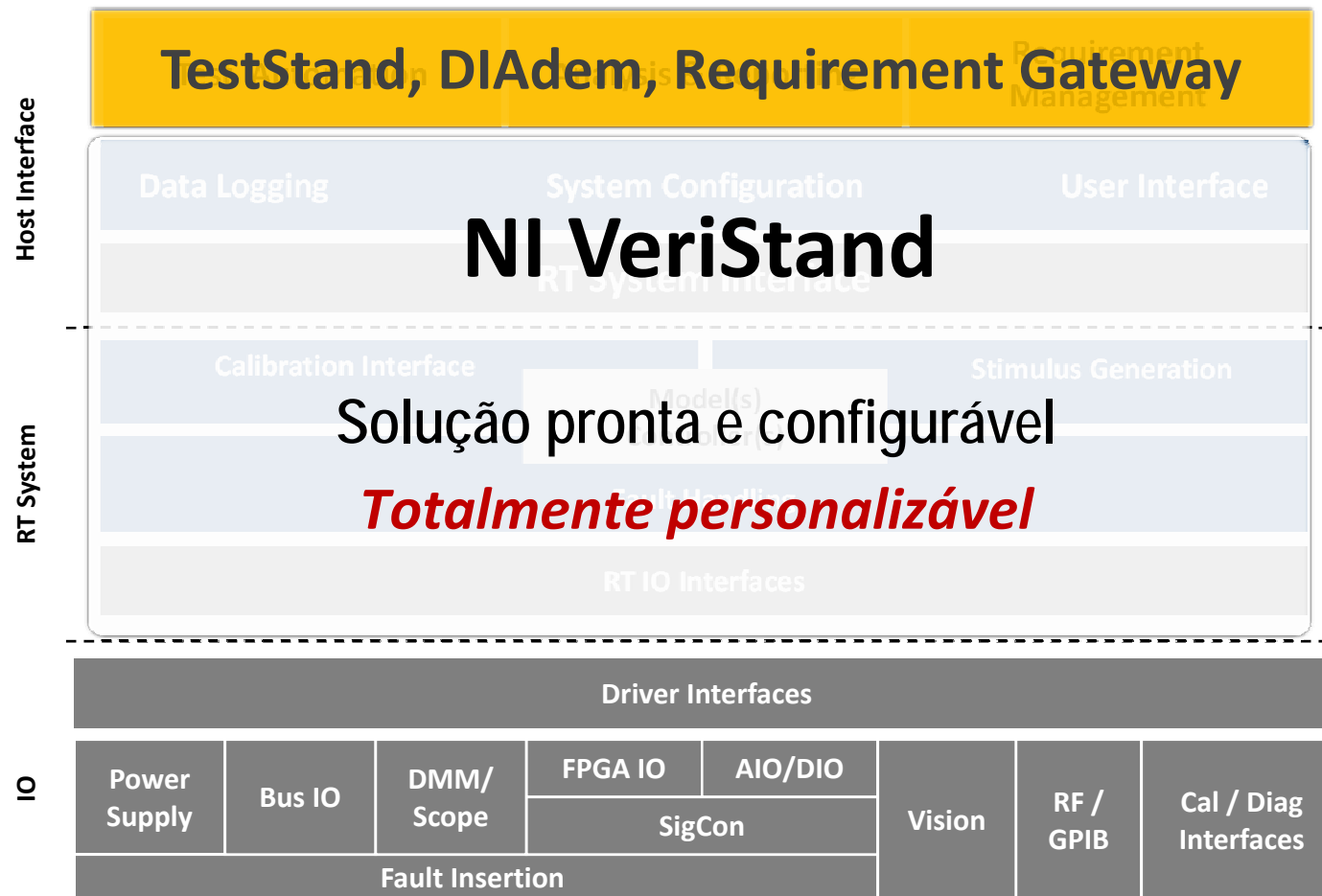
# Plataforma de Testes HIL em Tempo Real



# Plataforma de Testes HIL em Tempo Real



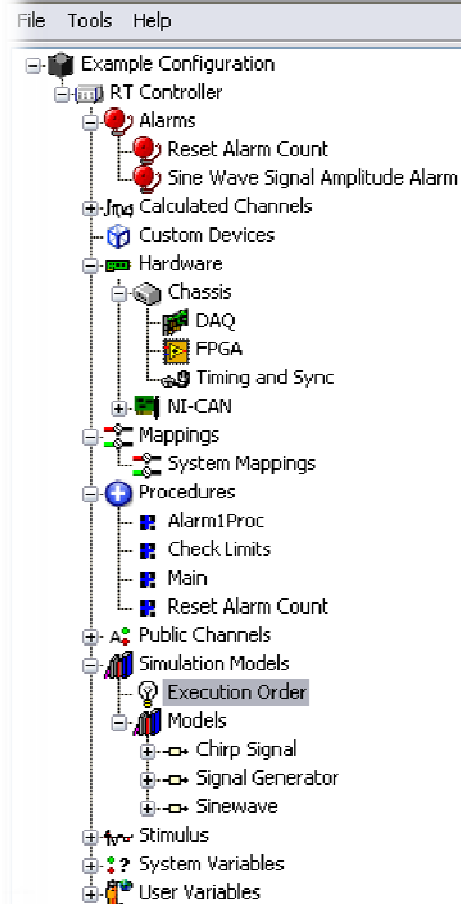
# Plataforma de Testes HIL em Tempo Real



- Geração de perfil de estímulo em Tempo-Real
- Registro em múltiplos arquivos com disparo dinâmico
- Interface de usuário reconfigurável
- Inserção de falhas
- Monitoração de alarmes em Tempo-real
- Pronto para Multicore
- Plataformas de hardware e software abertas
- E/S baseadas em FPGA

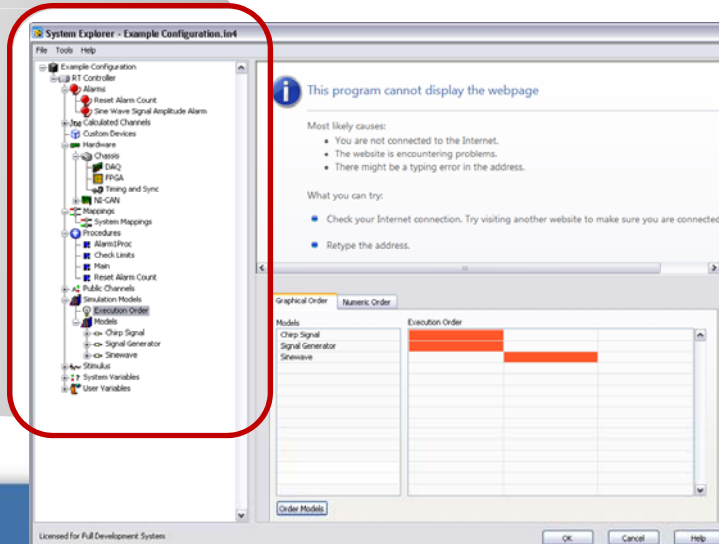
# NI VeriStand - Arquitetura

System Explorer - Example Configuration.in4



## SYSTEM EXPLORER

Engine Resources  
I/O  
Model(s)  
Calc Ch / User Ch  
Resource Mapping  
Alarms/Procedures  
Aliases



# NI VeriStand - Arquitetura

## SYSTEM EXPLORER

Engine Resources  
I/O  
Model(s)  
Calc Ch / User Ch  
Resource Mapping  
Alarms/Procedures  
Aliases

NI VeriStand Host Server

## NI VERISTAND ENGINE

### Server Communication

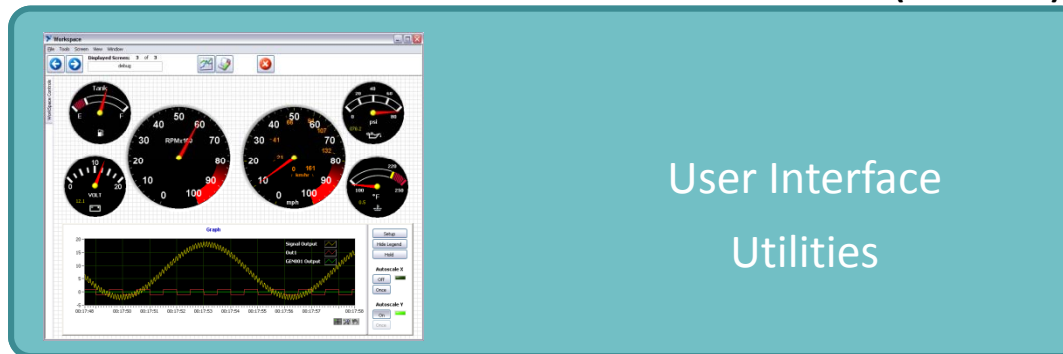
I/O	Calc Ch Processing
Channel Forcing	Stimulus Generation
Model DLL Execution	Alarm / Procedure Exec
Parameter Updates	Custom Devices

### I/O Drivers

FPGA I/O

# NI VeriStand - Arquitetura

WORKSPACE (Windows)



NI VeriStand Host Server



NI VERISTAND ENGINE  
(Tempo-Real)

Server Communication

I/O	Calc Ch Processing
Channel Forcing	Stimulus Generation
Model DLL Execution	Alarm / Procedure Exec
Parameter Updates	Custom Devices

I/O Drivers



ni.com

FPGA I/O



# Demo - VeriStand

# Ferramentas de modelagem suportadas

- C/C++
- The MathWorks Simulink(r)
- NI MatrixX SystemBuild
- Tesis DYNAware  
(enDYNA/veDYNA)
- MapleSoft MapleSim
- MSC CarSim/TruckSim/BikeSim
- VI-Grade
- Esterel Scade
- LMS AmeSim

# Resumo

- HIL é um método valioso para Testes de Sistemas de Controle Embarcado
- Use o LabVIEW para criar modelos ou reuse modelos de terceiros para implementar sistemas de teste HIL
- Implemente seu sistema de teste com uma ferramenta pronta e totalmente personalizável: VerisStand

[ni.com/hil](http://ni.com/hil)

[ni.com/embeddedcontrol](http://ni.com/embeddedcontrol)



# Obrigado!

Não esqueça de preencher a avaliação.

Para mais informações acesse [ni.com](http://ni.com) ou  
ligue para (11) 3149-3149

