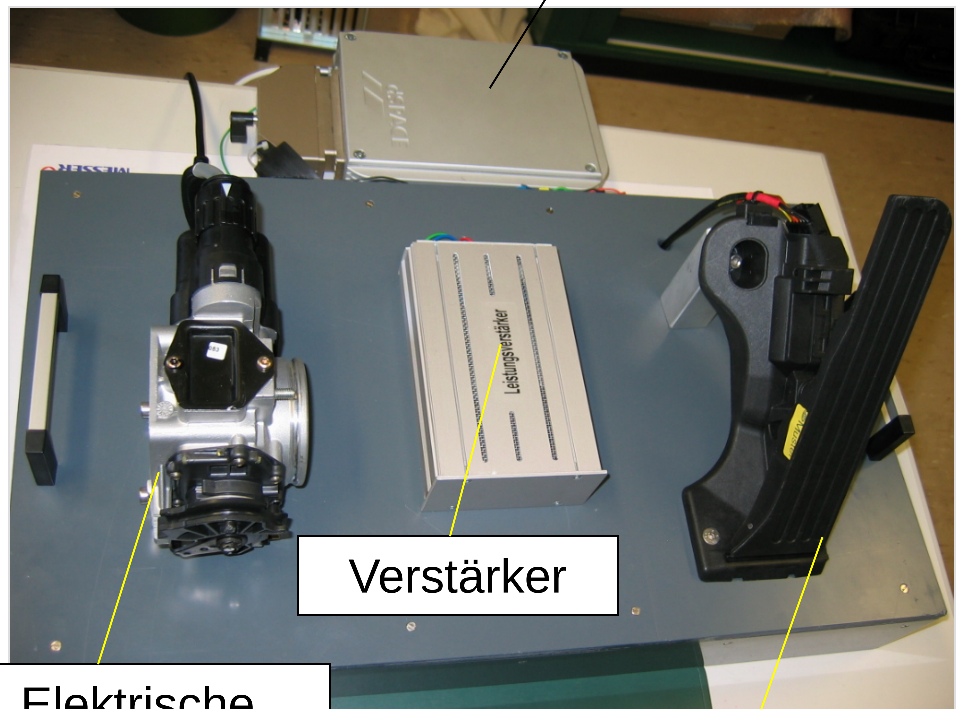
Elektrische Drosselklappe (2)

Versuchsaufbau

Elektronisches Steuergerät
(Rapid Control Prototyping)

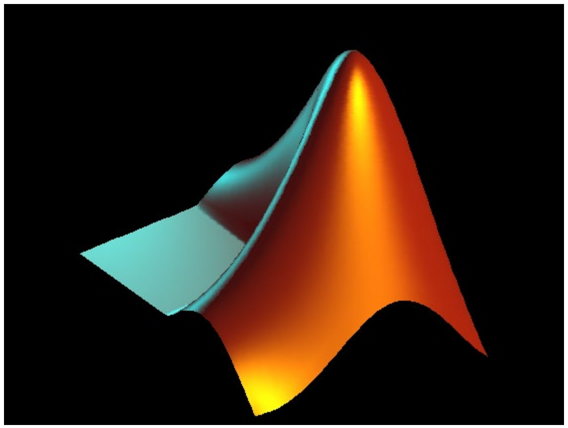


Verstärker

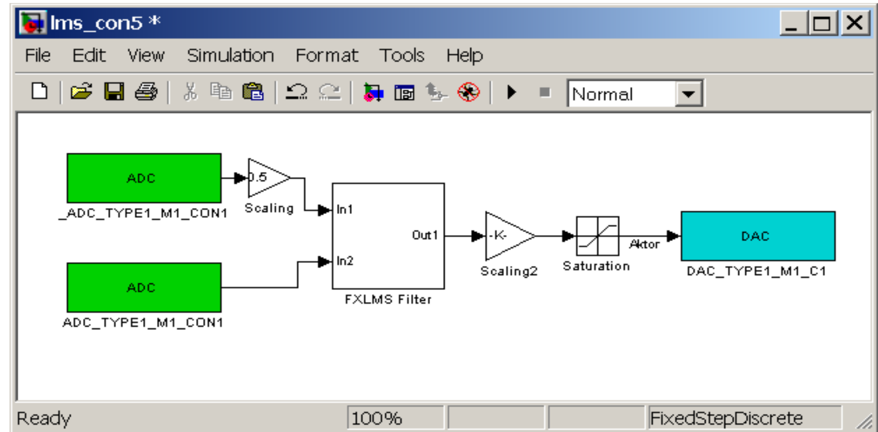
Elektrische
Drosselklappe

Fahrpedalsensor

Rapid Control Prototyping with dSPACE



Design and Analysis with Matlab



Implementation of Control Algorithms as Simulink Block Diagrams

dSPACE MicroAutoBox

Real-Time Interface

Generating and Modifying C Code → Invoking Compiler → Loading and Starting Application

Technische Daten der MicroAutoBox

dSPACE MicroAutoBox (1401/1501)

- **Motorola PowerPC 603e running at 200 MHz (from 2002: 300 MHz)**
- **8 MB main memory**
- **16 MB non-volatile flash memory**
- **16 A/D channels, 12 bits , <u>0 – 5 V input voltage range</u>**
- **8 D/A channels, 12-bits, <u>0 – 4.5 V output voltage range</u>**
- **Dual CAN interface**
- **Digital I/O**
- **Power Supply: 6 – 40 V DC**
- **Size: 200x225x50 mm**

Quelle: dSPACE 2004

dSPACE MicroAutoBox

Technische Daten:

- 200 MHz Motorola PowerPC
- 8 MB Hauptspeicher
- 16 MB Flashspeicher
- 4 MB Speicher für Kommunikation zwischen MicroAutoBox und Host-PC
- 16 A/D-Umsetzer (0 – 5 Volt)
- 8 D/A-Umsetzer (0 – 4.5 Volt)

- **Technische Daten MicroAutoBox II**
- 900 MHz IBM PowerPC
- 16 MB Hauptspeicher
- 16 MB Flashspeicher
- 6 MB Speicher für Kommunikation zwischen MicroAutoBox und Host-PC

Tabelle 2.3: Verhalten der wichtigsten Regelkreisglieder

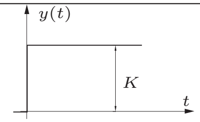
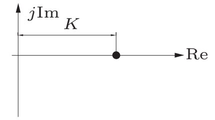
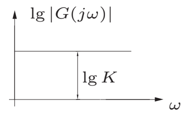
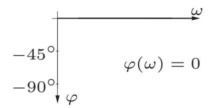
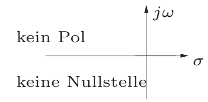
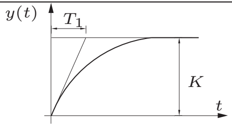
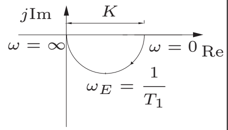
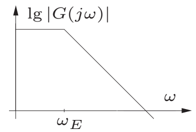
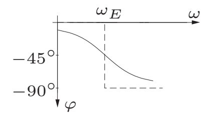
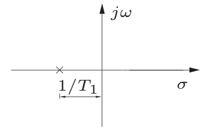
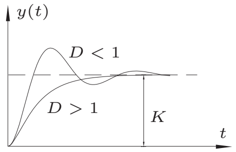
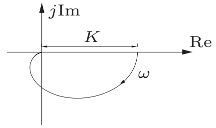
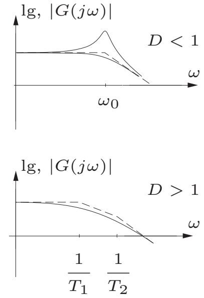
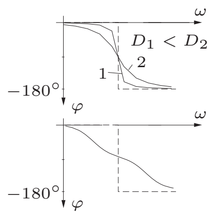
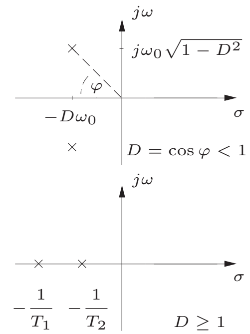
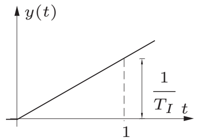
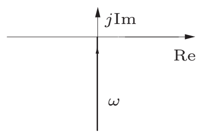
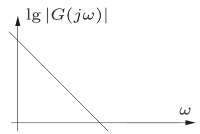
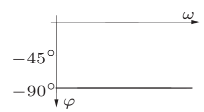
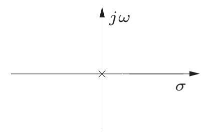
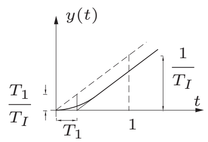
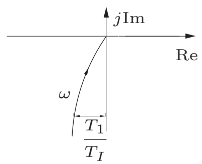
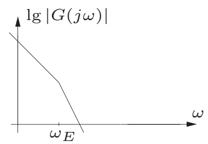
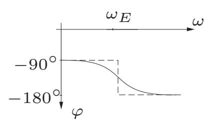
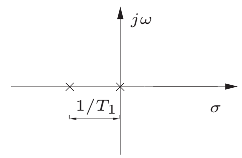
System	Zeitbereich Bildbereich	Übergangsfunktion	Ortskurve	Bode–Diagramm (Amplitudengang)	Bode–Diagramm (Phasengang)	s–Ebene × Pol ○ Nullstelle
P	$y(t) = K\,u(t)$ $G(s) = K$					
PT_1	$T_1\,\dot{y}(t) + y(t) = K\,u(t)$ $G(s) = K\dfrac{1}{1 + T_1\,s}$					
PT_2	$\dfrac{1}{\omega_0^2}\ddot{y}(t) + \dfrac{2\,D}{\omega_0}\dot{y}(t) + y(t)$ $= K\,u(t)$ $G(s) = K\dfrac{1}{\dfrac{1}{\omega_0^2}s^2 + \dfrac{2\,D}{\omega_0}s + 1}$ $D < 1$: konjugiert komplexe Wurzeln der char. Gleichung $\lambda_{1,2} = -\omega_0(D \pm j\sqrt{1 - D^2})$ $D \geq 1$: reelle Wurzeln der char. Gleichung $\lambda_{1,2} = -\omega_0(D \pm \sqrt{D^2 - 1}) = -1/T_{1,2}$					
I	$y(t) = \dfrac{1}{T_I}\displaystyle\int u\mathrm{d}t$ $G(s) = \dfrac{1}{T_I\,s}$					
IT_1	$T_1\,\dot{y}(t) + y(t) =$ $\dfrac{1}{T_I}\displaystyle\int u(t)\mathrm{d}t$ $G(s) = \dfrac{1}{T_I\,s(1 + T_1\,s)}$					

Tabelle 2.3: Fortsetzung

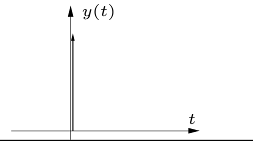
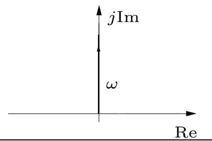
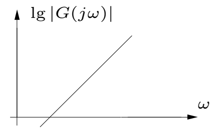
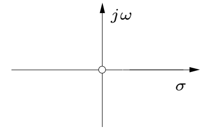
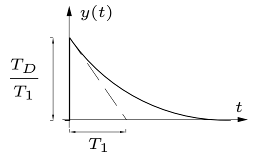
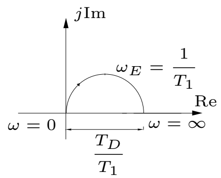
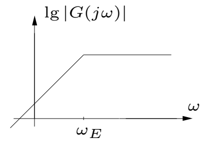
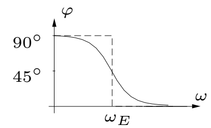
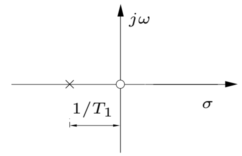
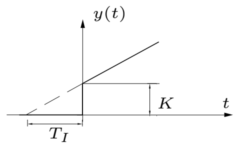
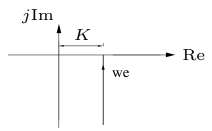
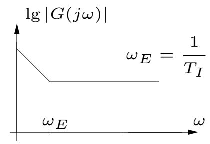
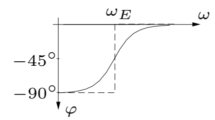
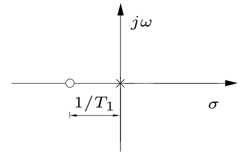
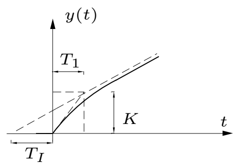
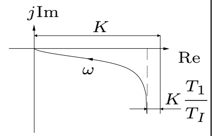
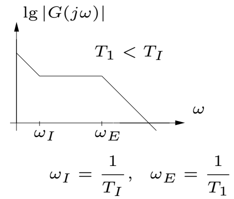
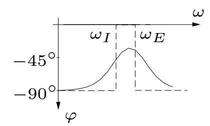
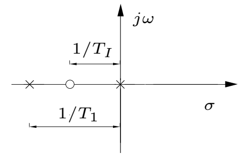
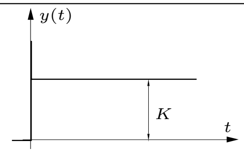
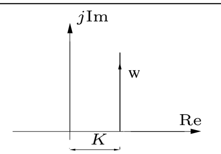
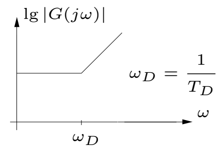
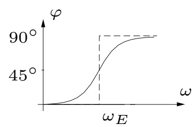
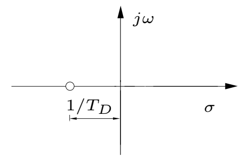
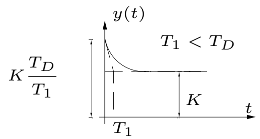
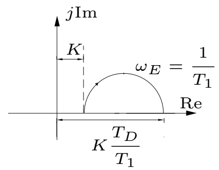
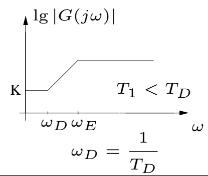
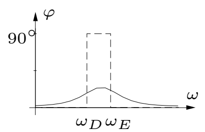
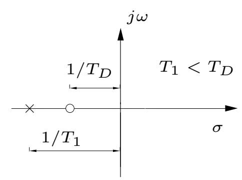
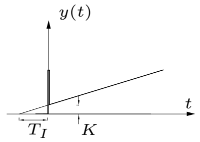
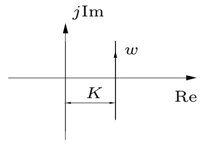
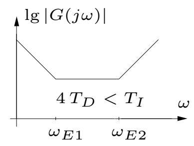
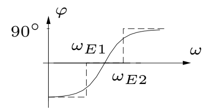
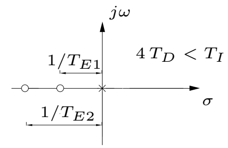
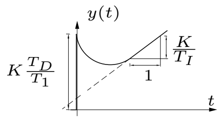
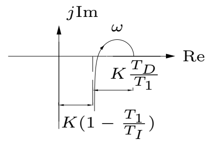
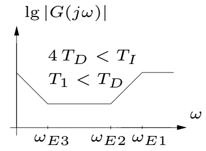
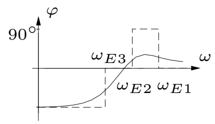
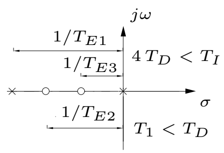
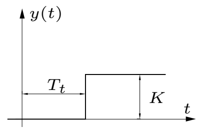
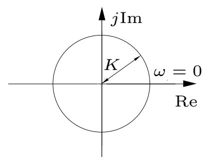
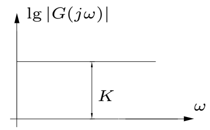
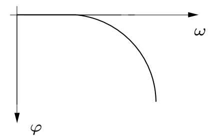
System	Zeitbereich Bildbereich	Übergangsfunktion	Ortskurve	Bode–Diagramm (Amplitudengang)	 (Phasengang)	s–Ebene × Pol ∘ Nullstelle
D	$y(t) = T_D \frac{\mathrm{d}u}{\mathrm{d}t}$ $G(s) = T_D\, s$					
DT_1	$T_1\dot{y}(t) + y(t) = T_D \frac{\mathrm{d}u}{\mathrm{d}t}$ $G(s) = T_D \frac{s}{1 + T_1\, s}$					
PI	$y(t) = K \left[u(t) + \frac{1}{T_I}\int u(t)\mathrm{d}t\right]$ $G(s) = K\left[1 + \frac{1}{T_I\, s}\right]$					
PIT_1	$T_1\, \dot{y}(t) + y(t) =$ $K\left[u(t) + \frac{1}{T_I}\int u\mathrm{d}t\right]$ $G(s) = K\frac{1 + \frac{1}{T_I\, s}}{1 + T_1\, s}$					
PD	$y(t) = K\left[u(t) + T_D\dot{u}(t)\right]$ $G(s) = K\left[1 + T_D\, s\right]$					
PDT_1	$T_1\dot{y}(t) + y(t) =$ $K\left[u(t) + T_D\dot{u}(t)\right]$ $G(s) = K\frac{1 + T_D\, s}{1 + T_1\, s}$					

Tabelle 2.3: Fortsetzung

System	Zeitbereich Bildbereich	Übergangsfunktion	Ortskurve	Bode–Diagramm (Amplitudengang)	 (Phasengang)	s–Ebene $\times$ Pol $\circ$ Nullstelle
PID	$y(t) =$ $K\left[u(t) + \frac{1}{T_I}\int u\mathrm{d}t + T_D\frac{\mathrm{d}u}{\mathrm{d}t}\right]$ $G(s) = K\left[1 + T_D\,s + \frac{1}{T_I\,s}\right]$					
$PIDT_1$	$T_1\dot{y}(t) + y(t) =$ $K\left[u(t) + \frac{1}{T_I}\int u\mathrm{d}t + T_D\frac{\mathrm{d}u}{\mathrm{d}t}\right]$ $G(s) = K\frac{1 + T_D\,s + \frac{1}{T_I\,s}}{1 + T_1\,s}$					
T_t	$y(t) = K\,u(t - T_t)$ $G(s) = K\,e^{-s\,T_t}$					Pole bei $-\infty$ Nullstellen bei $+\infty$

Technische Daten der MicroAutoBox

dSPACE MicroAutoBox (1401/1501)

- Motorola PowerPC 603e running at 200 MHz (from 2002: 300 MHz)
- 8 MB main memory
- 16 MB non-volatile flash memory
- 16 A/D channels, 12 bits , 0 – 5 V input voltage range
- 8 D/A channels, 12-bits, 0 – 4.5 V output voltage range
- Dual CAN interface
- Digital I/O
- Power Supply: 6 – 40 V DC
- Size: 200x225x50 mm

Auflösung:

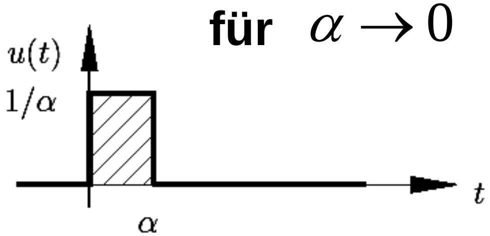
$$\frac{5\,\text{Volt}}{2^{12}} = \frac{5\,\text{Volt}}{4096} = 0{,}0012\,\text{Volt}$$

$$= 1{,}2\,\text{mV}$$

Quelle: dSPACE 2004

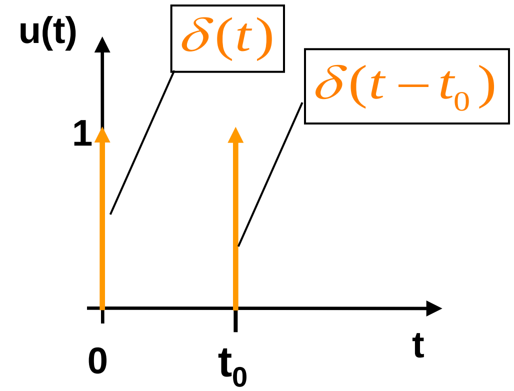
Impulsfunktion und Impulsantwort

$$u(t) = \frac{1}{\alpha}[1(t) - 1(t-\alpha)]$$



für $\alpha \to 0$ $\Rightarrow$

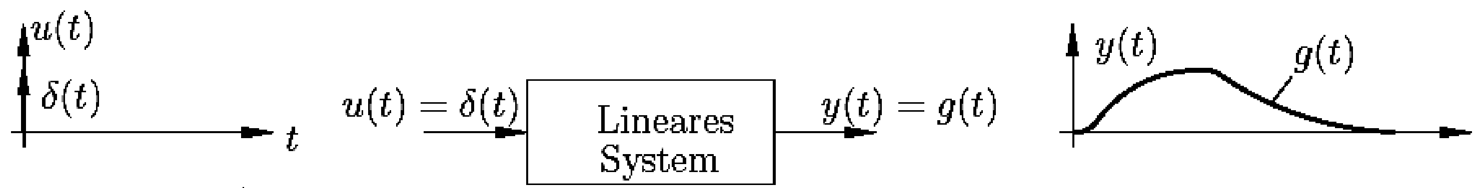
Dirac'scher Deltaimpuls $\delta(t)$



Recheckimpuls mit normierter Impulsfläche 1

Symbolische Darstellung

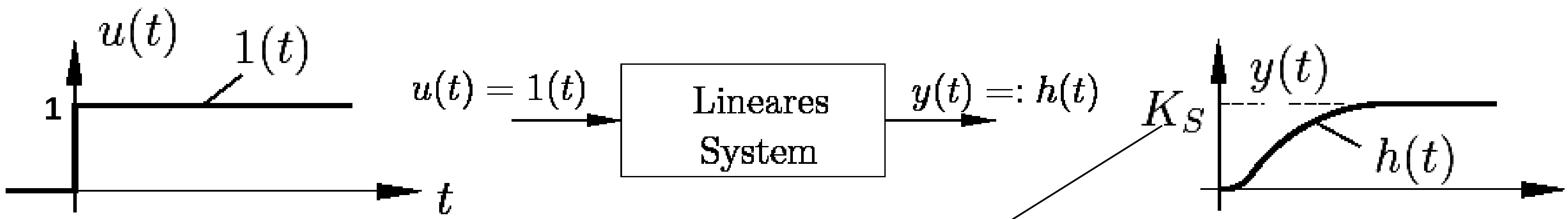
Definition 2.5
Die Systemantwort eines Systems bei Erregung durch $\delta(t)$ heißt: **Impulsantwort** oder Gewichtsfunktion $g(t)$. □



Dirac'scher Deltaimpuls $\delta(t)$

Gewichtsfunktion $g(t)$

Definition 2.4 Ein dynamisches System sei zu einem Zeitpunkt $t = t_0$ energiefrei, d.h. alle Anfangsbedingungen der beschreibenden Differentialgleichung sind Null. Die Systemantwort des durch die Einheitssprungfunktion $u(t) = 1(t)$ erregten Systems heißt die **Sprungantwort** oder Übergangsfunktion $h(t)$. □



Sprungfunktion 1(t)

Sprungantwort h(t)

$$K_S = h(\infty) = \lim_{t \to \infty} h(t)$$

Systemverstärkung

Faltungsintegral

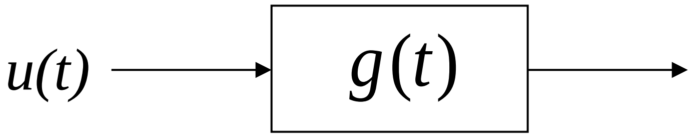
Definition:

$$y(t) = g(t) * u(t) = \int_0^t g(t-\tau)u(\tau)\mathrm{d}\tau$$

Eigenschaften:

- **Beschreibt die Beziehung zwischen Eingangs- und Ausgangssignal im Zeitbereich.**
- **Bestimmung des Ausgangssignals für beliebige Eingangssignale.**

Achtung: t ist eine Konstante



$$y(t) = \int_0^t g(v)u(t-v)\mathrm{d}v$$

Gewichtsfunktion enthält die gesamte Information über das dynamische Verhalten eines linearen Systems.