Transformasi Laplace dan Diagram Blok

- Transformasi Laplace:Mentransformasi fungsi dari sistem fisis ke fungsi variabel kompleks S.

$D = s$ (if the initial conditions/derivatives are all zero at t=0s)

$s = \sigma + j\omega$

- Bentuk Integral :

$$F(s) = \int_0^\infty f(t)e^{-st}dt$$

where,

$f(t)$ = the function in terms of time t

$F(s)$ = the function in terms of the Laplace s

Transformasi Laplace (Cont.)

- Contoh:

For f(t) = 5,

$$F(s) = \int_0^\infty f(t)e^{-st}dt = \int_0^\infty 5e^{-st}dt = -\frac{5}{s}e^{-st}\Big|_0^\infty = \left[-\frac{5}{s}e^{-s\infty}\right] - \left[-\frac{5e^{-s0}}{s}\right] = \frac{5}{s}$$

- Bentuk Derivative

$$\boxed{\therefore L\left[\frac{d}{dt}f(t)\right] = -f(0) + sL[f(t)]}$$

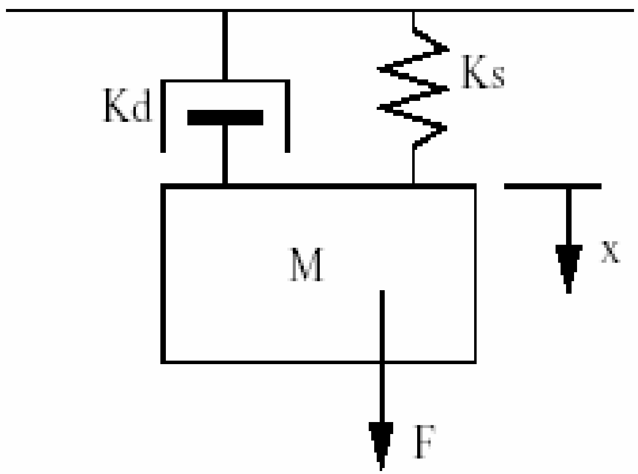
- Tabel :

TIME DOMAIN	FREQUENCY DOMAIN
$f(t)$	$f(s)$
$Kf(t)$	$KL[f(t)]$
$f_1(t)+f_2(t)-f_3(t)+\ldots$	$f_1(s)+f_2(s)-f_3(s)+\ldots$
$\frac{df(t)}{dt}$	$sL[f(t)]-f(0^-)$
$\frac{d^2f(t)}{dt^2}$	$s^2L[f(t)]-sf(0^-)-\frac{df(0^-)}{dt}$
$\frac{d^nf(t)}{dt^n}$	$s^nL[f(t)]-s^{n-1}f(0^-)-s^{n-2}\frac{df(0^-)}{dt}-\ldots-\frac{d^nf(0}{dt}$
$\int_0^t f(t)dt$	$\frac{L[f(t)]}{s}$
$f(t-a)u(t-a),\ a>0$	$e^{-as}L[f(t)]$
$e^{-at}f(t)$	$f(s-a)$
$f(at),\ a>0$	$\frac{1}{a}f\left(\frac{s}{a}\right)$
$tf(t)$	$\frac{-df(s)}{ds}$
$t^nf(t)$	$(-1)^n\frac{d^nf(s)}{ds^n}$
$\frac{f(t)}{t}$	$\int_s^\infty f(u)du$

TIME DOMAIN		FREQUENCY DOMAIN
$\delta(t)$	unit impulse	1
A	step	$\frac{A}{s}$
t	ramp	$\frac{1}{s^2}$
t^2		$\frac{2}{s^3}$
$t^n, n > 0$		$\frac{n!}{s^{n+1}}$
e^{-at}	exponential decay	$\frac{1}{s+a}$
$\sin(\omega t)$		$\frac{\omega}{s^2+\omega^2}$
$\cos(\omega t)$		$\frac{s}{s^2+\omega^2}$
te^{-at}		$\frac{1}{(s+a)^2}$
t^2e^{-at}		$\frac{2!}{(s+a)^3}$

TIME DOMAIN	FREQUENCY DOMAIN
$e^{-at}\sin(\omega t)$	$\dfrac{\omega}{(s+a)^2+\omega^2}$
$e^{-at}\cos(\omega t)$	$\dfrac{s+a}{(s+a)^2+\omega^2}$
$e^{-at}\sin(\omega t)$	$\dfrac{\omega}{(s+a)^2+\omega^2}$
$e^{-at}\left[B\cos\omega t+\left(\dfrac{C-aB}{\omega}\right)\sin\omega t\right]$	$\dfrac{Bs+C}{(s+a)^2+\omega^2}$
$2\lvert A\rvert e^{-\alpha t}\cos(\beta t+\theta)$	$\dfrac{A}{s+\alpha-\beta j}+\dfrac{A^{\text{complex conjugate}}}{s+\alpha+\beta j}$
$2t\lvert A\rvert e^{-\alpha t}\cos(\beta t+\theta)$	$\dfrac{A}{(s+\alpha-\beta j)^2}+\dfrac{A^{\text{complex conjugate}}}{(s+\alpha+\beta j)^2}$
$\dfrac{(c-a)e^{-at}-(c-b)e^{-bt}}{b-a}$	$\dfrac{s+c}{(s+a)(s+b)}$
$\dfrac{e^{-at}-e^{-bt}}{b-a}$	$\dfrac{1}{(s+a)(s+b)}$

Contoh



$$F = MD^2x + K_dDx + K_sx$$

$$\frac{F(t)}{x(t)} = MD^2 + K_dD + K_s$$

$$L\left[\frac{F(t)}{x(t)}\right] = \frac{F(s)}{x(s)} = Ms^2 + K_ds + K_s$$

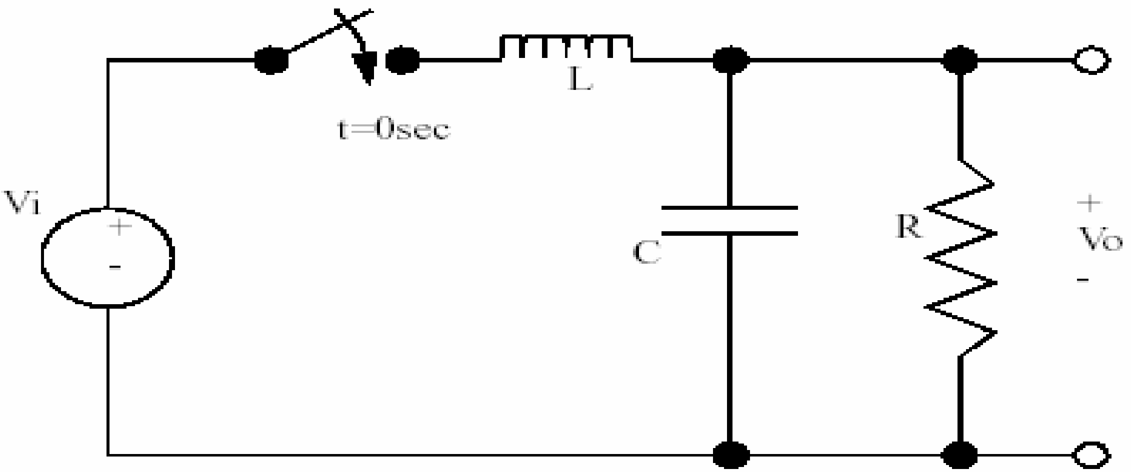
ASIDE: Here 'D' is simply replaced with 's'. Although this is very convenient, it is only valid if the initial conditions are zero, otherwise the more complex form, shown below, must be used.

$$L\left[\frac{d^nf(t)}{dt^n}\right] = s^nL[f(t)] - s^{n-1}f(0^-) - s^{n-2}\frac{df(0^-)}{dt} - \ldots - \frac{d^nf(0^-)}{dt^n}$$

Contoh (Cont.)

Device	Time domain	s-domain	Impedance
Resistor	$V(t) = RI(t)$	$V(s) = RI(s)$	$Z = R$
Capacitor	$V(t) = \frac{1}{C}\int I(t)dt$	$V(s) = \left(\frac{1}{C}\right)\frac{I(s)}{s}$	$Z = \frac{1}{sC}$
Inductor	$V(t) = L\frac{d}{dt}I(t)$	$V(s) = LsI(s)$	$Z = Ls$

Contoh (Cont.)



Treat the circuit as a voltage divider,

$$V_o = \frac{Vi\left(\frac{1}{DC+\frac{1}{R}}\right)}{DL+\left(\frac{1}{DC+\frac{1}{R}}\right)} = \frac{V_i\left(\frac{R}{1+DCR}\right)}{DLR+\left(\frac{R}{1+DCR}\right)} = V_i\left(\frac{R}{D^2R^2LC+DLR+R}\right)$$

$$\frac{V_o}{V_i} = \left(\frac{R}{s^2R^2LC+sLR+R}\right)$$

Contoh (Cont.)

Given,

$$\frac{x(s)}{F(s)} = \frac{1}{Ms^2 + K_d s + K_s}$$

$$F(s) = \frac{A}{s}$$

Therefore,

$$x(s) = \left(\frac{x(s)}{F(s)}\right)F(s) = \left(\frac{1}{Ms^2 + K_d s + K_s}\right)\frac{A}{s}$$

Assume,

$$K_d = 3000\frac{Ns}{m}$$

$$K_s = 2000\frac{N}{m}$$

$$M = 1000kg$$

$$A = 1000N$$

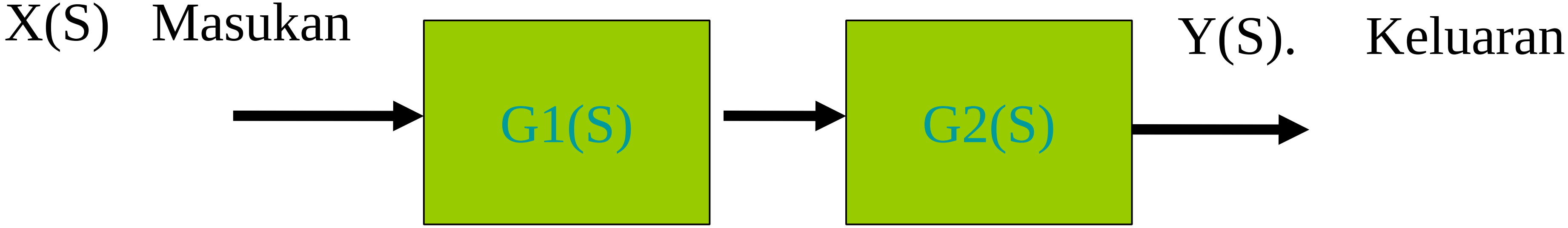
$$\therefore x(s) = \frac{1}{(s^2 + 3s + 2)s}$$

Fungsi Alih dan Blok Diagram:

- Fungsi Alih :Digunakan untuk mencirikan hubungan masukan keluaran dari komponen/elemen sistem kontrol dengan menggunakan dengan menggunakan model matematik sistem dan Transformasi Laplace
- Diagram Blok : Diagram yang menggambarkan/menunjukkan fungsi yang dilakukan oleh tiap komponen/elemen sistem kontrol

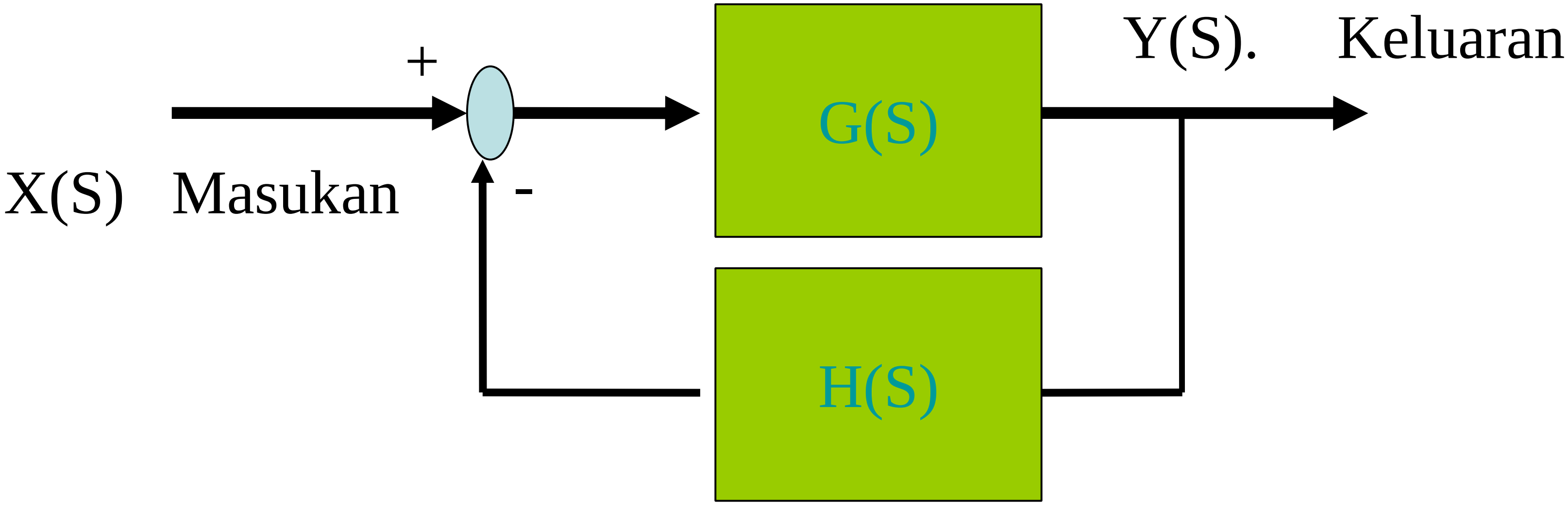
- Fungsi alih untuk diagram blok sederhana:

$$\frac{Y(S)}{X(S)} = G(S)$$



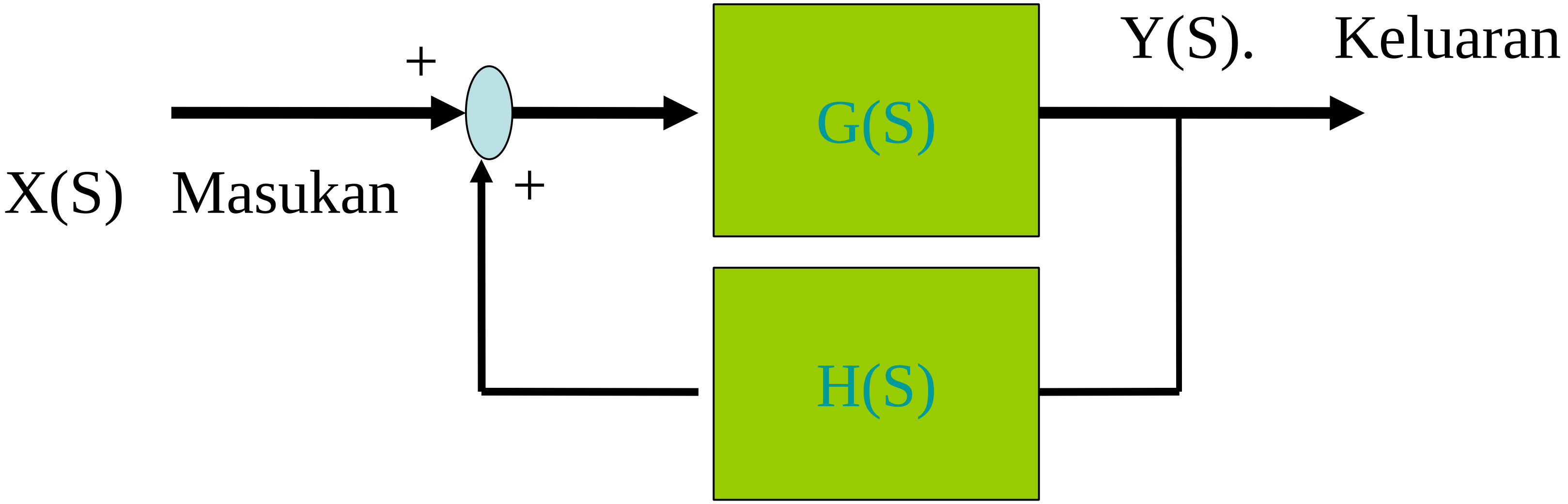
$$\frac{Y(S)}{X(S)} = G1(S)G2(S)$$

Diagram Blok dengan FeedBack



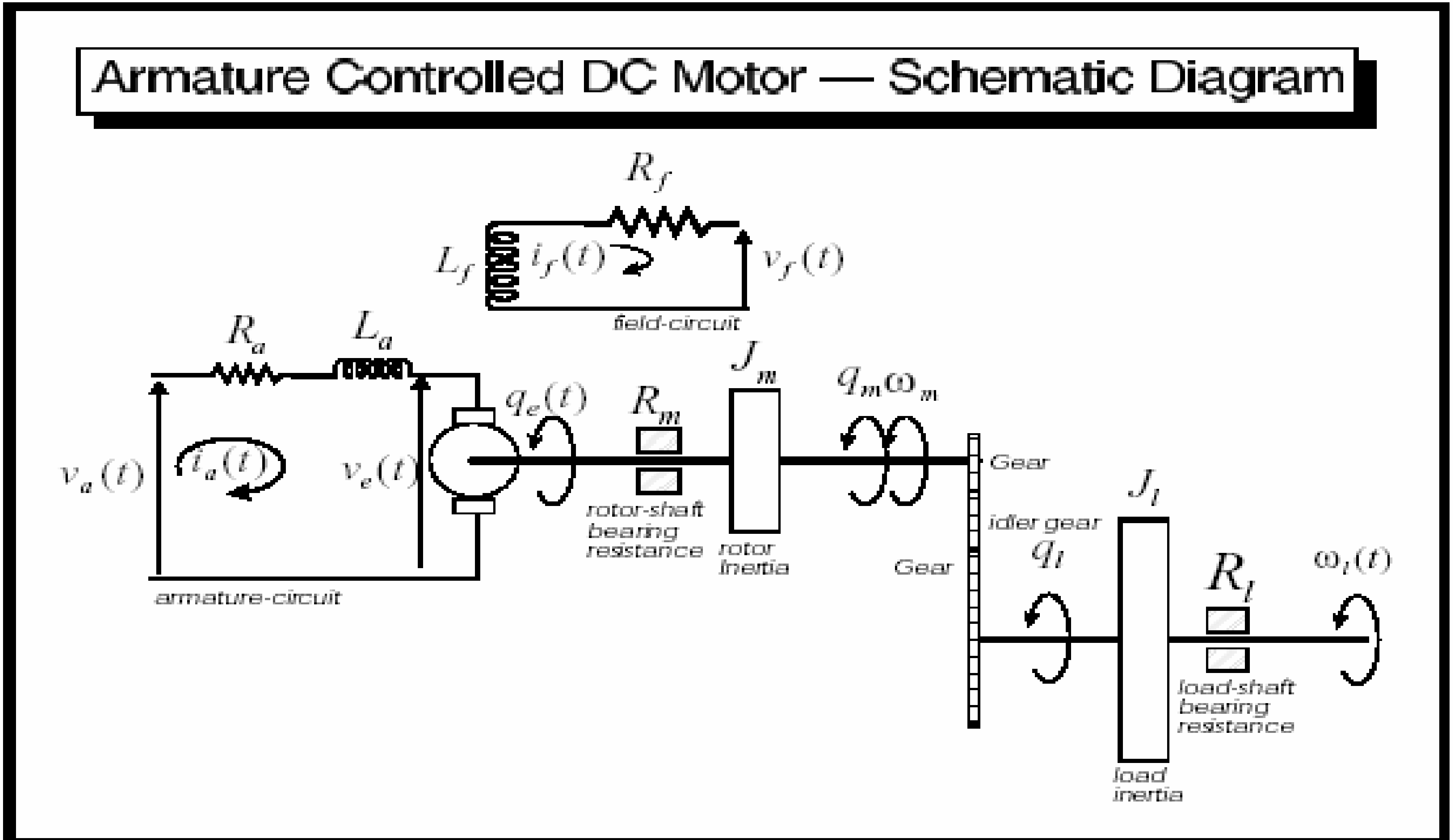
$$\frac{Y(S)}{X(S)} = \frac{G(S)}{1+G(S)H(s)}$$

Diagram Blok dengan FeedBack



$$\frac{Y(S)}{X(S)} = \frac{G(S)}{1-G(S)H(s)}$$

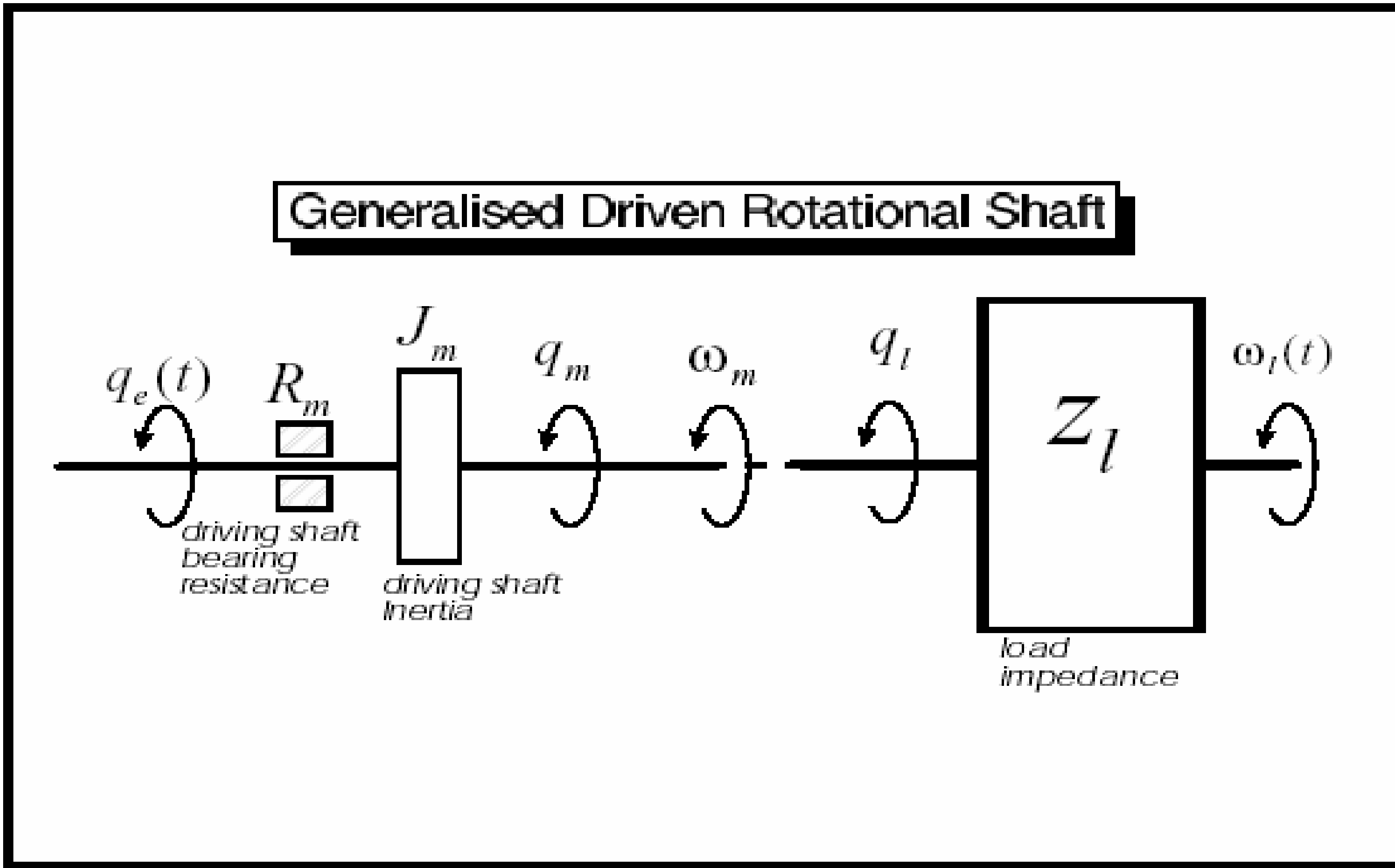
Pemodelan Sistem Kontrol Posisi Sudut Azimuth (Contoh)



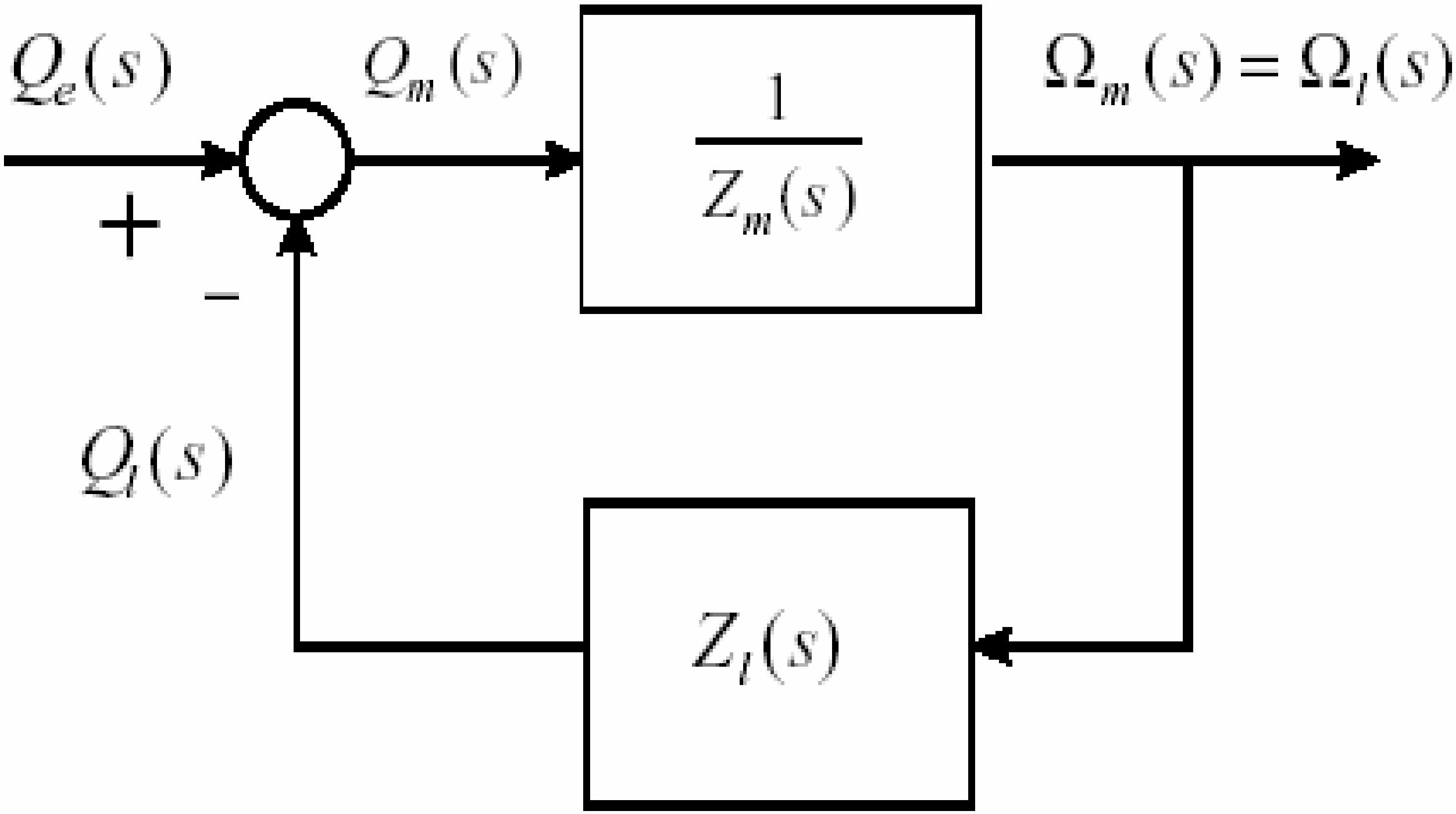
$$\Omega_l(s) = \frac{1}{Z_m(s) + Z_l(s)} Q_e(s)$$

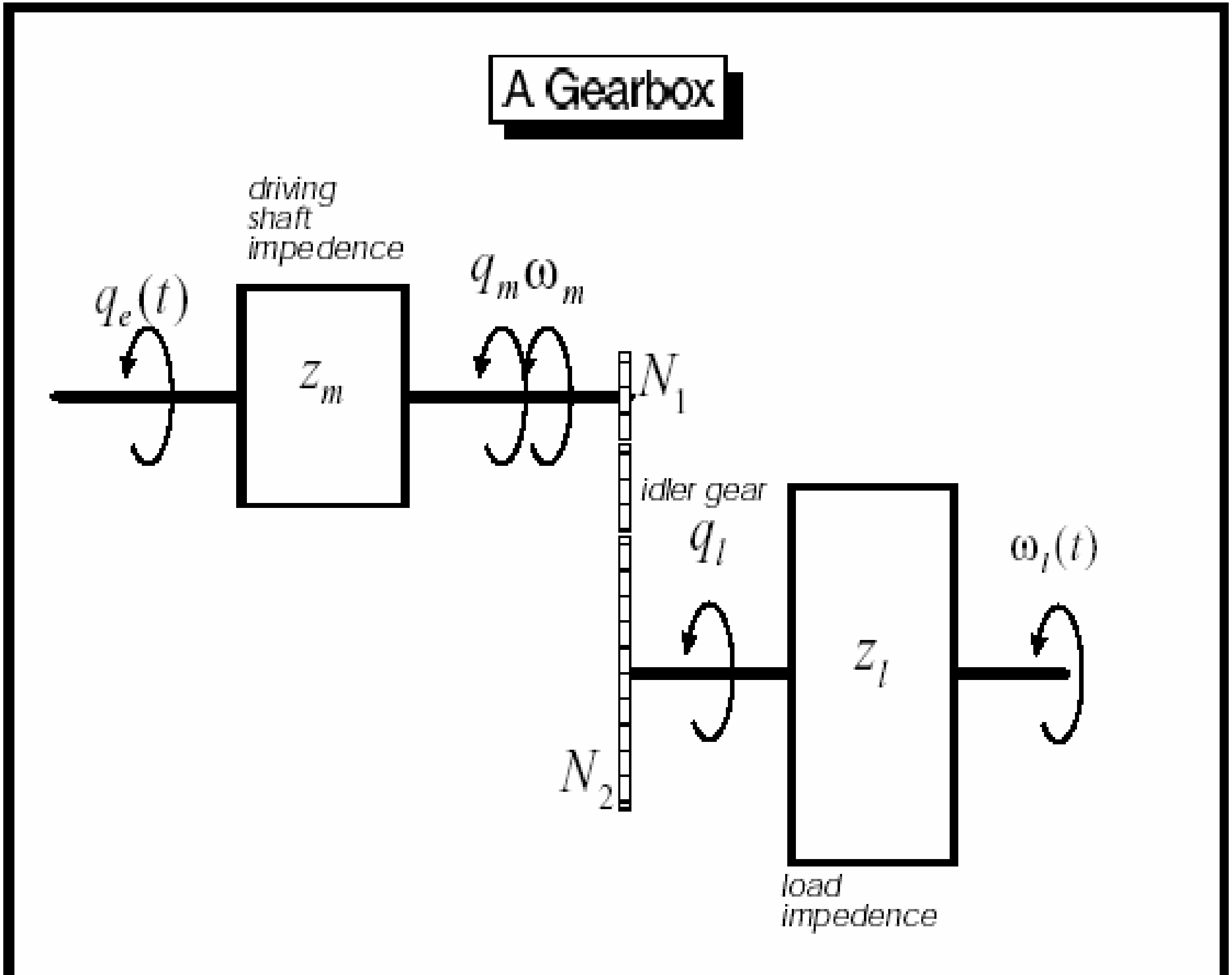
$$\frac{Q_l(s)}{\Omega_l(s)} = Z_l(s)$$

$$Q_l(s) = \frac{Z_l(s)}{Z_m(s) + Z_l(s)} Q_e(s)$$

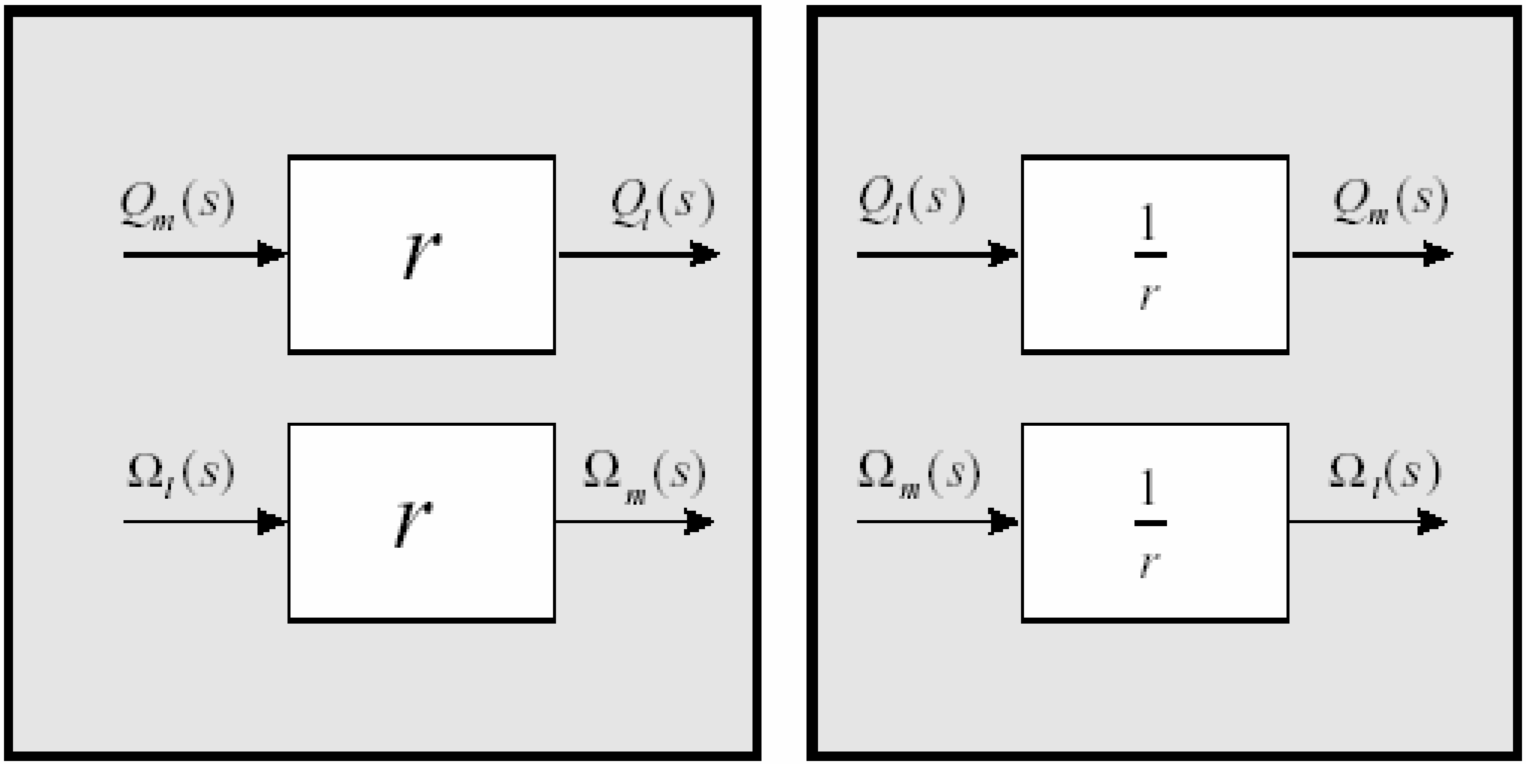


Block Diagram




A Gearbox
driving shaft impedence
$q_e(t)$
z_m
$q_m \omega_m$
N_1
idler gear
N_2
q_l
z_l
$\omega_l(t)$
load impedence

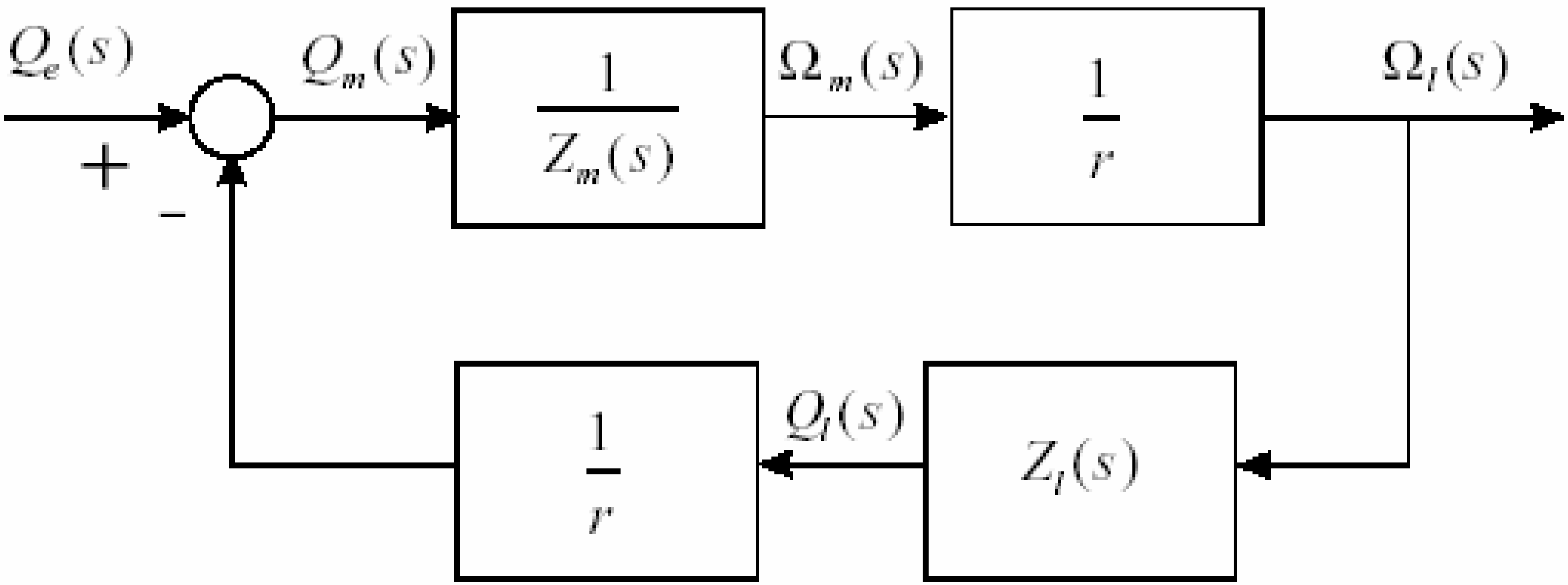
Alternative Block Diagrams of a Gearbox



Motor speed - load torque

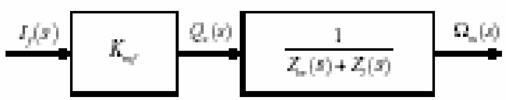
Load speed - motor torque

Block Diagram of a Gearbox Coupled Drive and Load

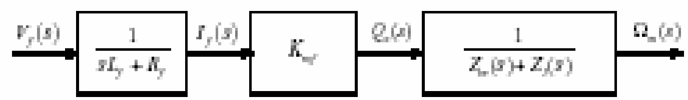


Possible DC Motor Configurations

Field-current controlled

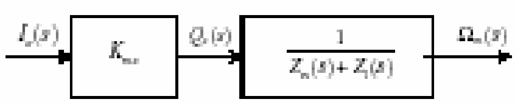


Field-voltage controlled

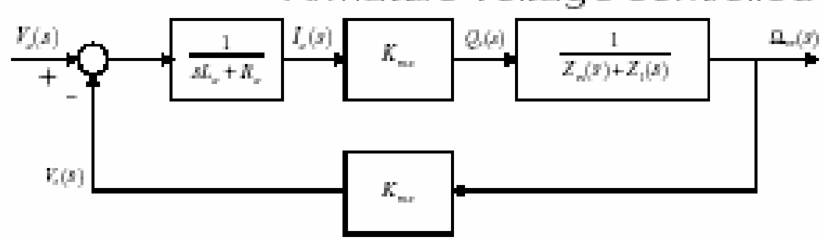


Constant Armature Current

Armature-current controlled

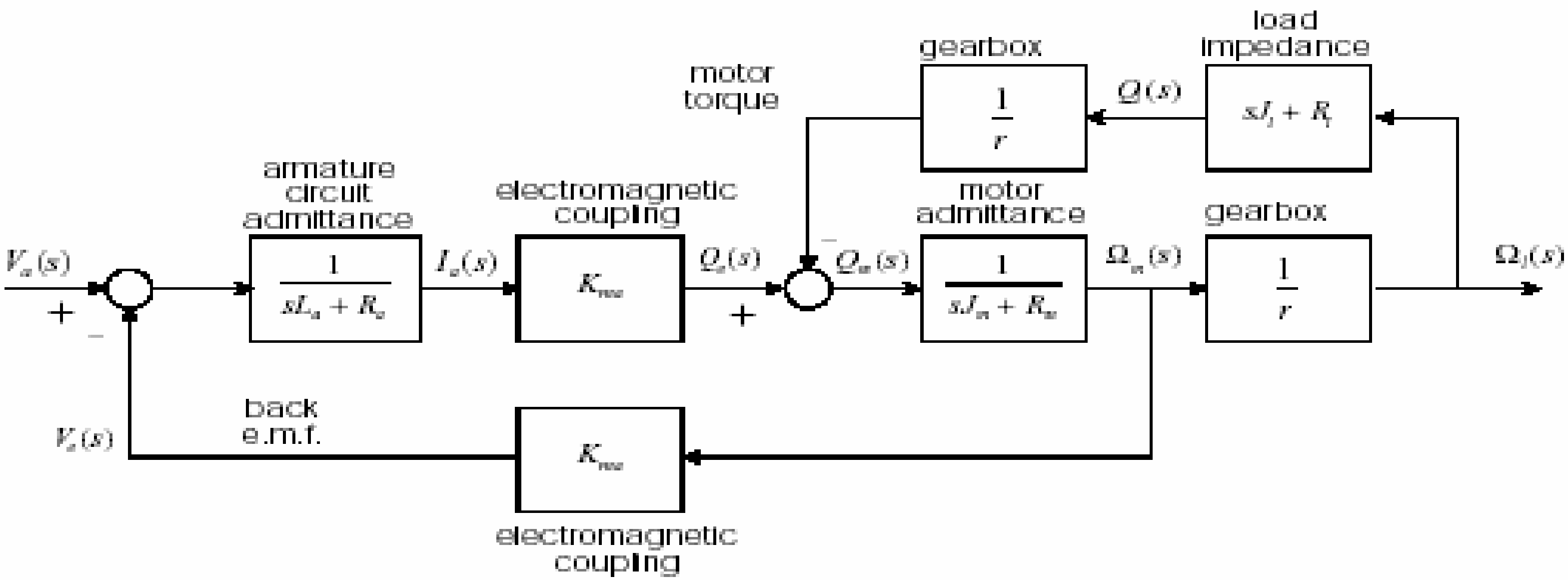


Armature voltage controlled

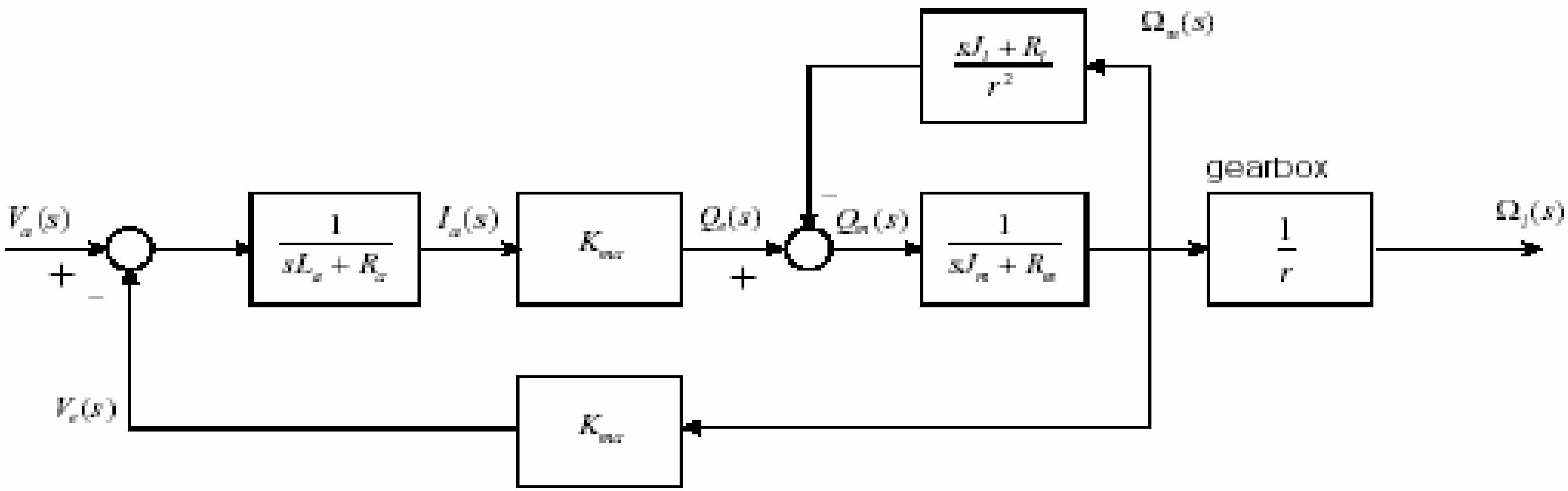


Constant Field Current

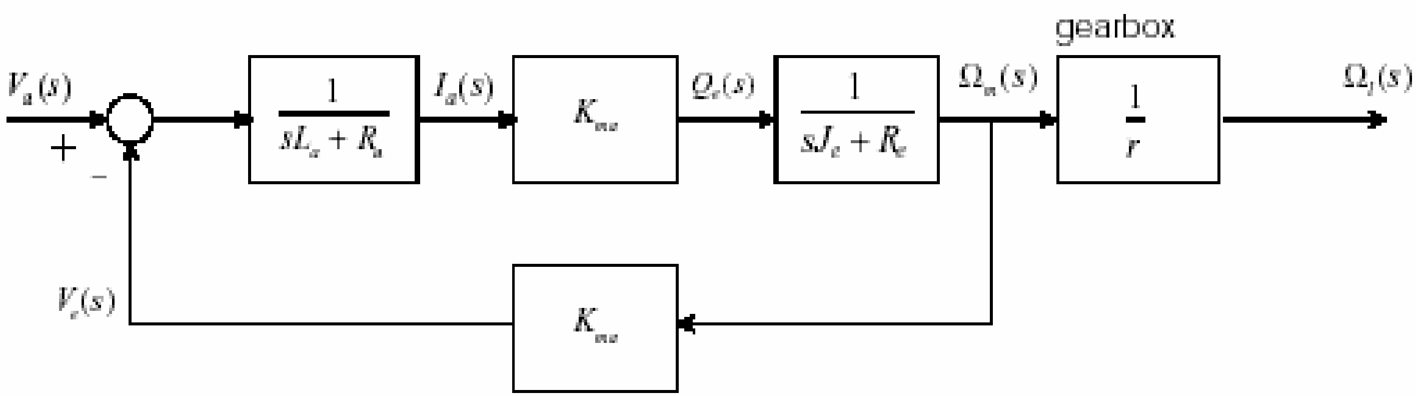
Block Diagram Model



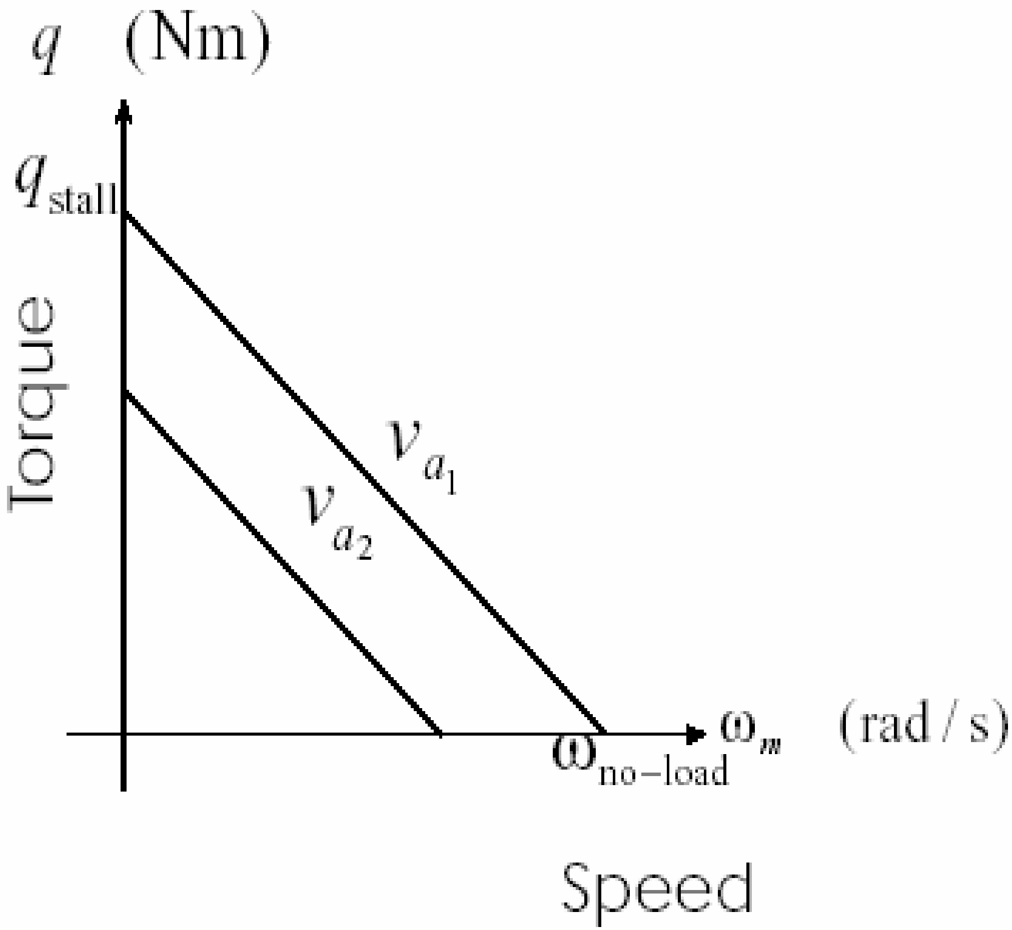
Gear-box Loop



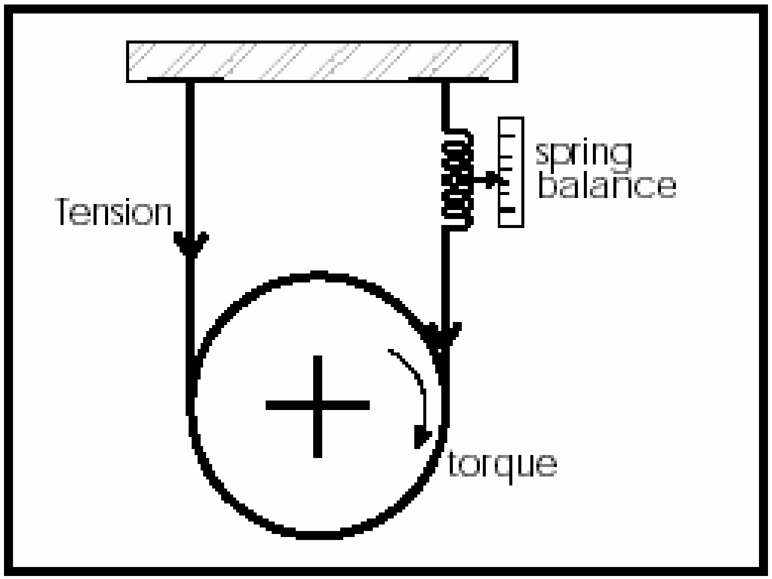
Reduced Block Diagram



Torque-Speed Relationship for a DC Motor



Dynameter



A Dynameter

The disk is attached to the motor under test. The belt is held against the edge of the disk under tension. As the motor rotates, the friction between the disk and the belt due to the torque generated by the motor causes the tension in the belt to increase. This increase is measured by the spring balance. At the same time the speed of the disk can be measured by using a tachometer or a stroboscope.