DC Motor drives

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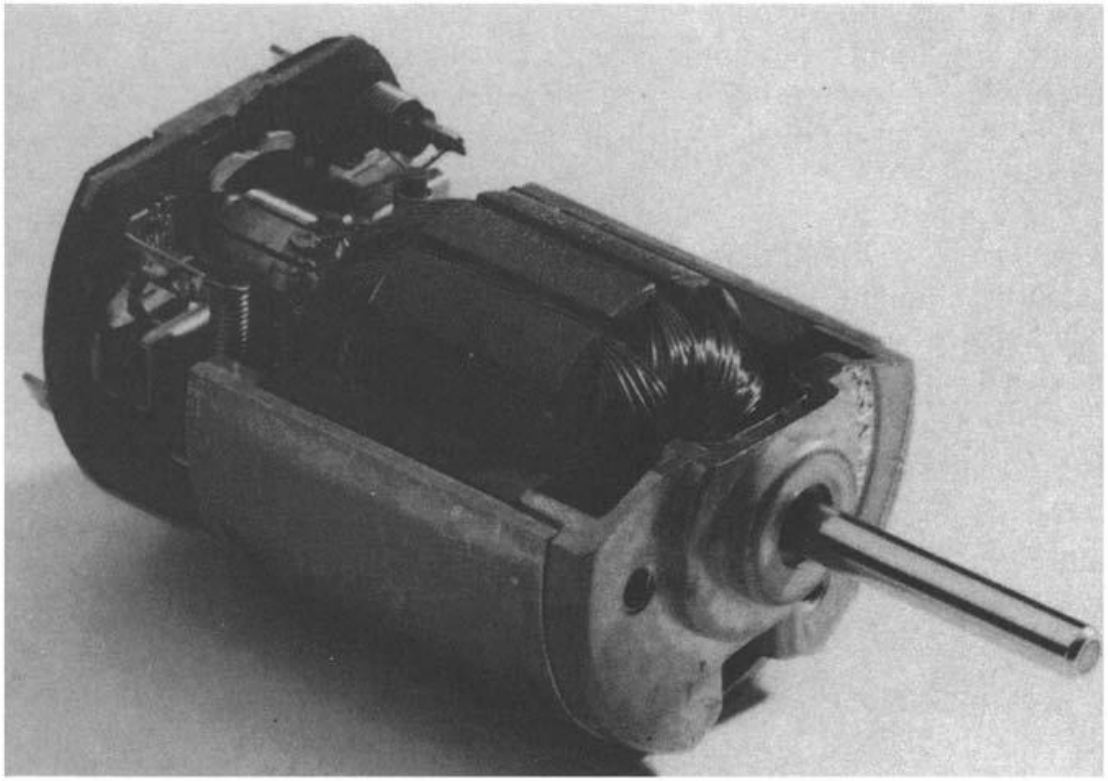
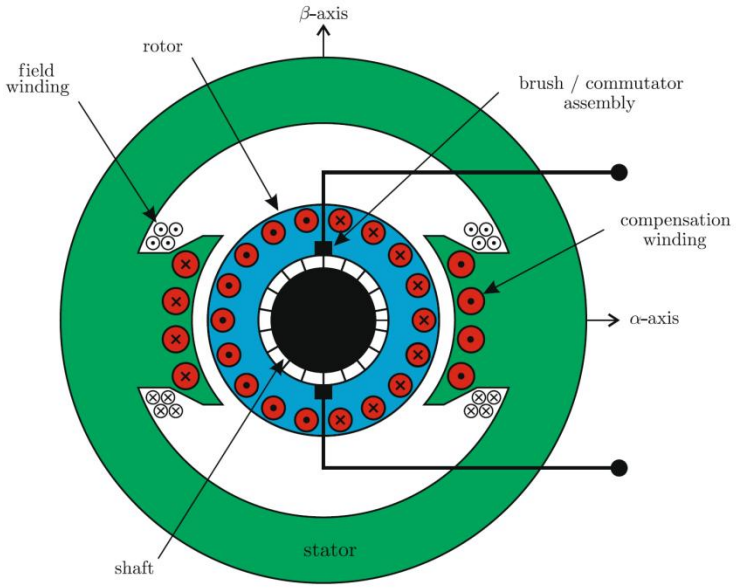
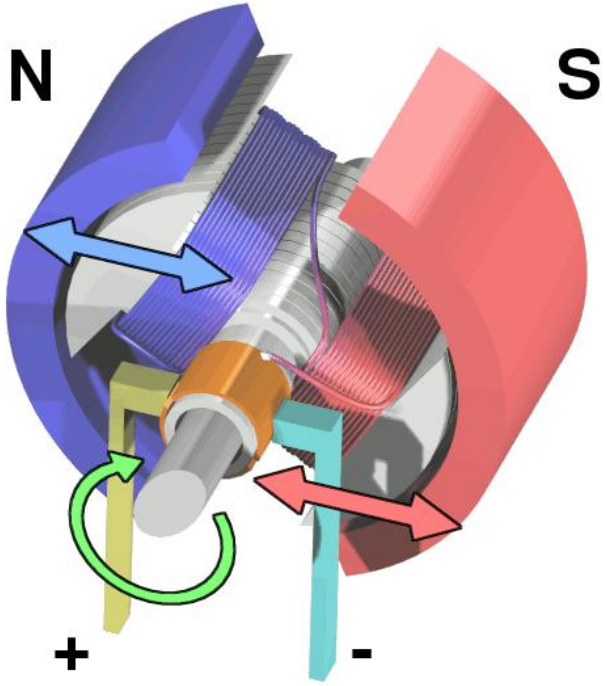
Plan

- Introduction
- Equivalent Circuit of DC Motors
  - PM Motors
  - Separately excited Field Winding
- Armature Current Waveform
- DC Servo Drives

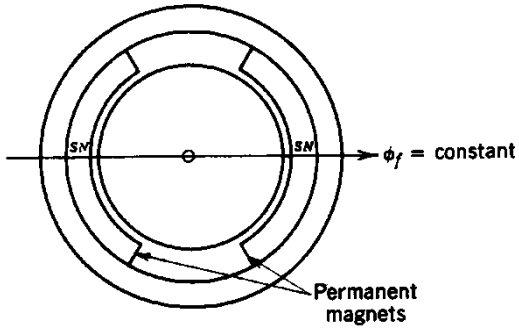


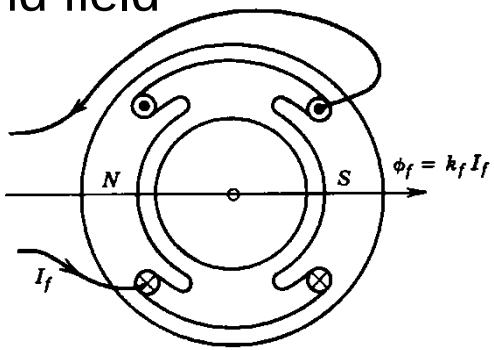
DC-Motor Structure



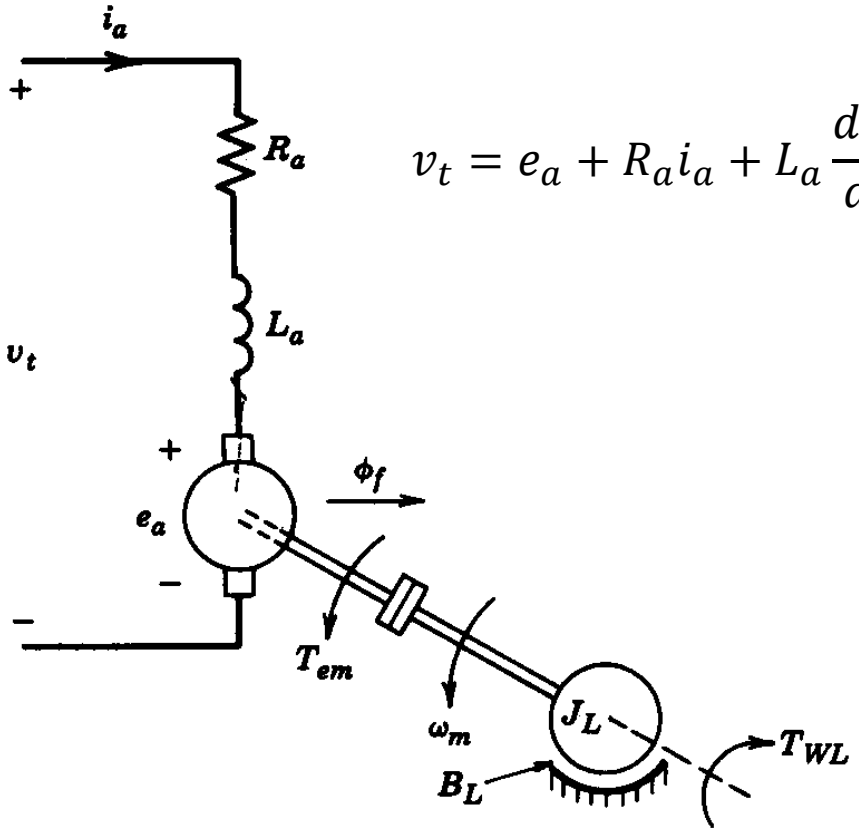


- With permanent magnets or a wound field

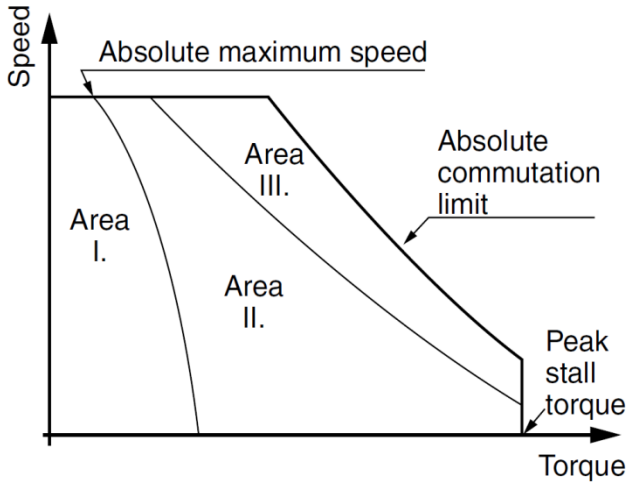




DC-Motor Equivalent Circuit



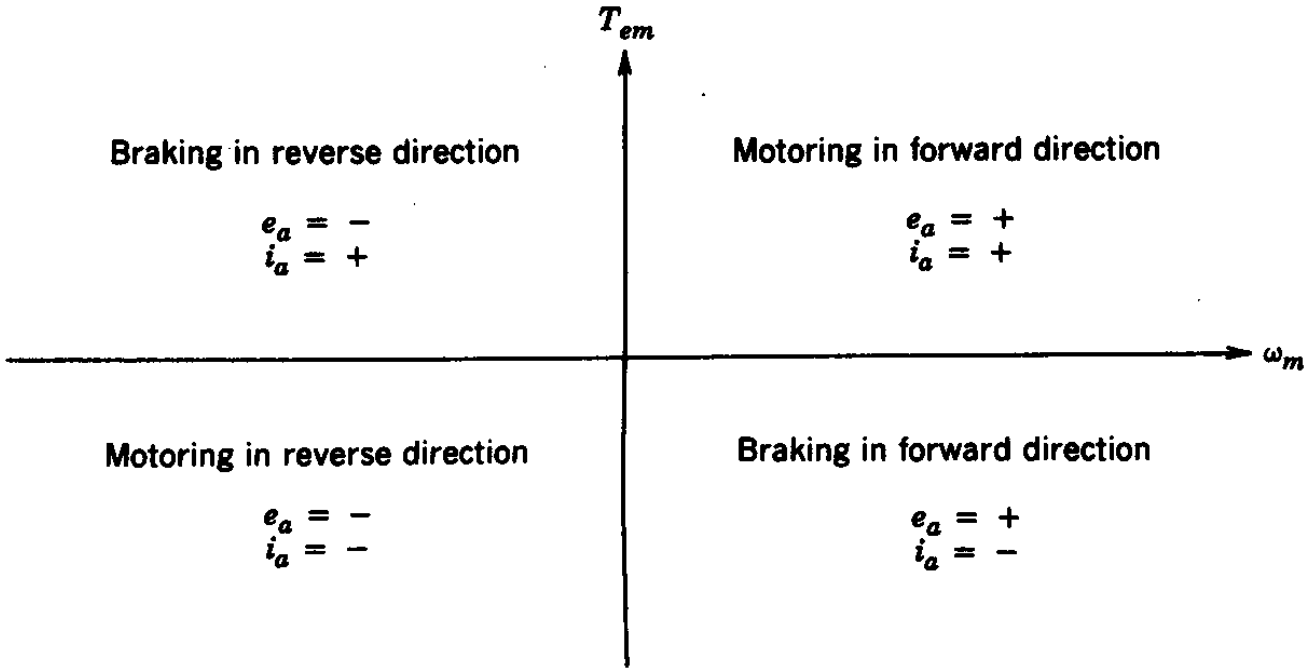
$$v_t = e_a + R_a i_a + L_a \frac{di_a}{dt}$$



$$J_L \frac{d\omega}{dt} = T_{em} - T_{WL}$$

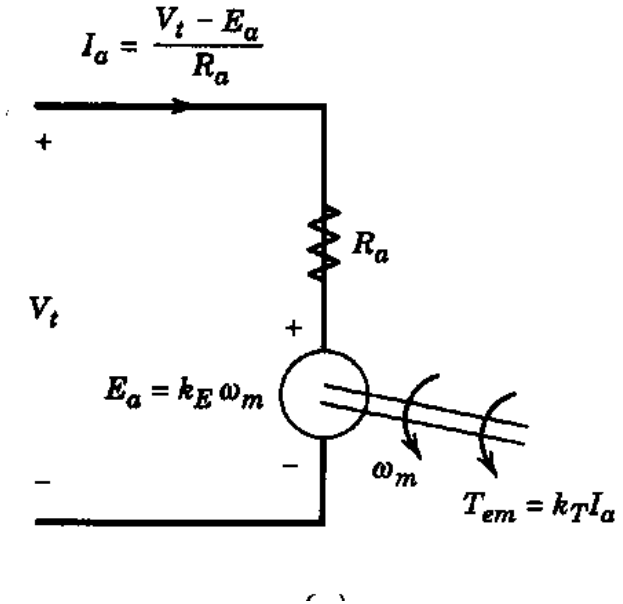
- The mechanical system can also be represented as an electrical circuit

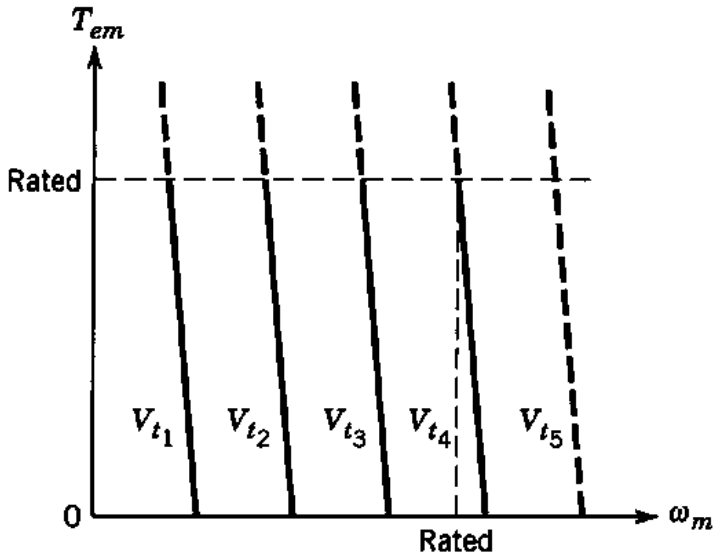
Four-Quadrant Operation of DC-Motor Drives

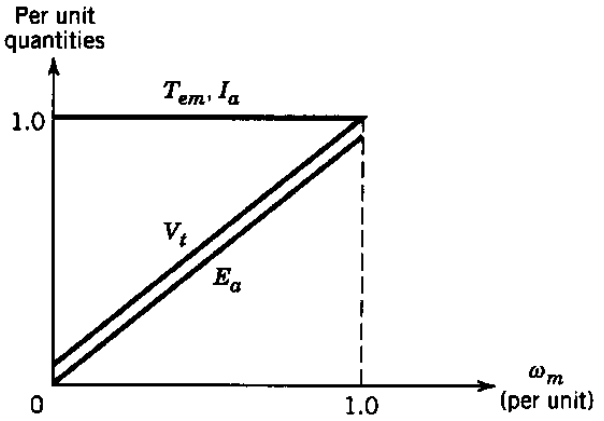


- High performance drives may operate in all four quadrants

DC-Motor Drive Torque-Speed Characteristics and Capabilities

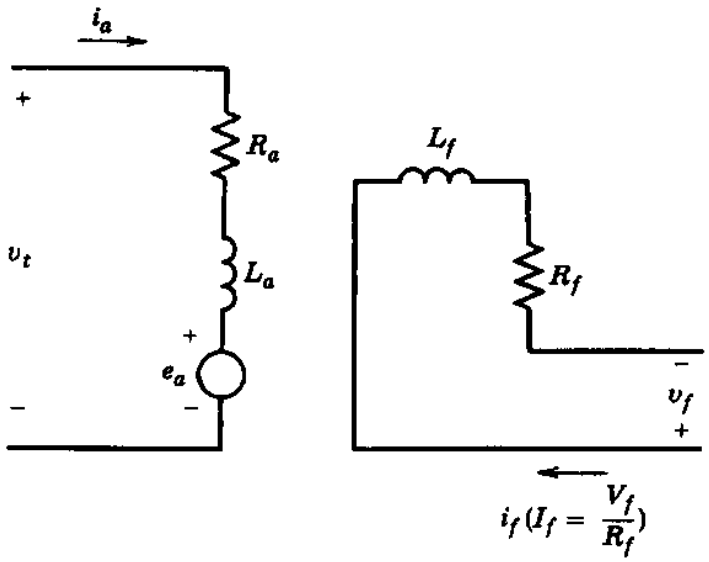


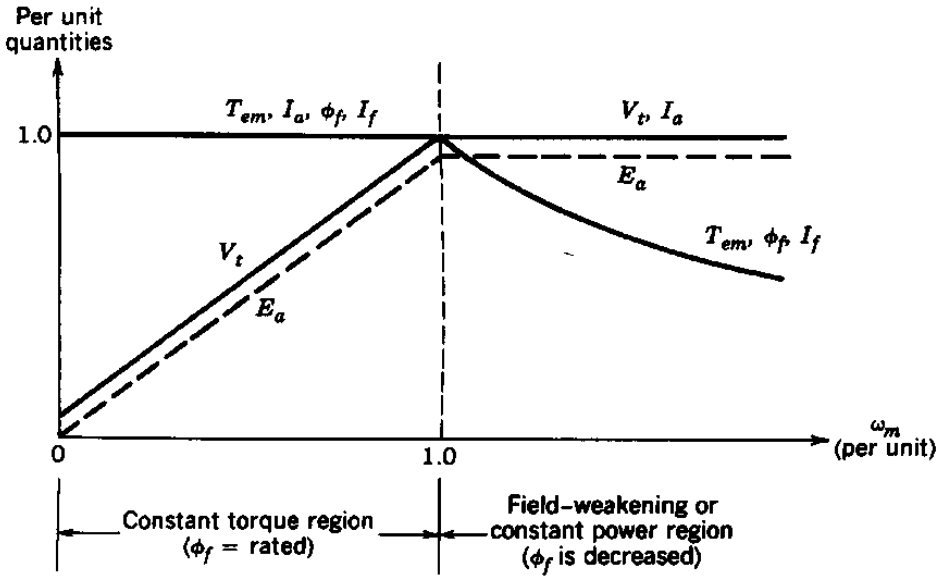




- With permanent magnets

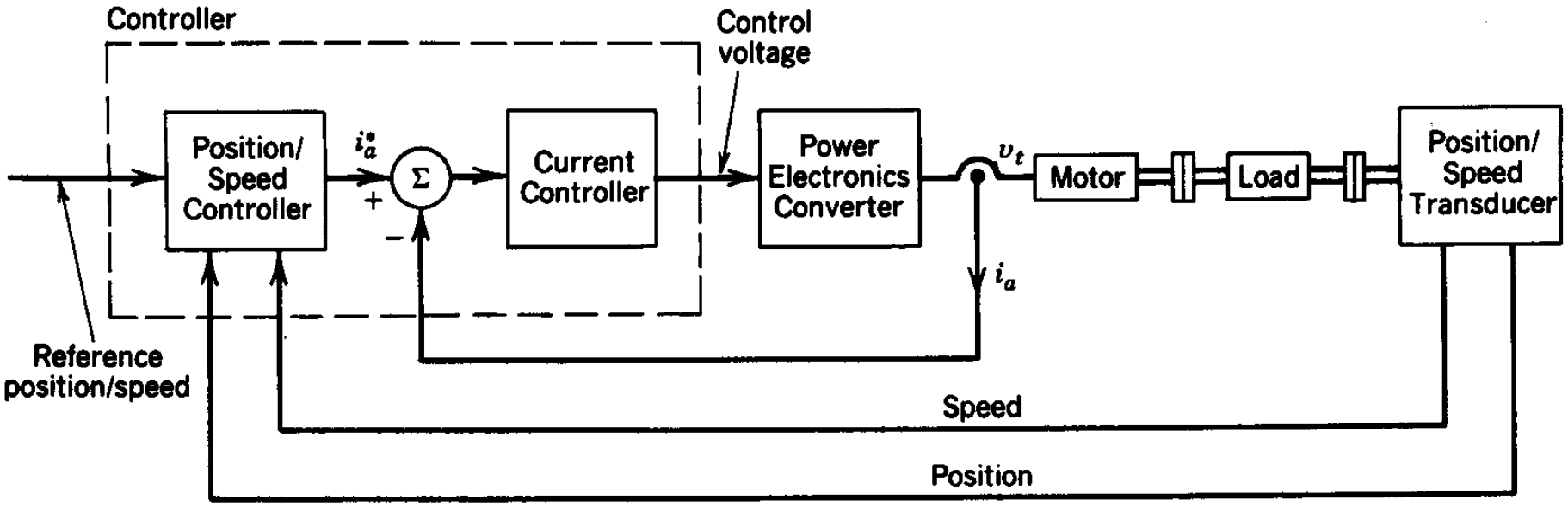
DC-Motor Drive Capabilities





- Separately-Excited field

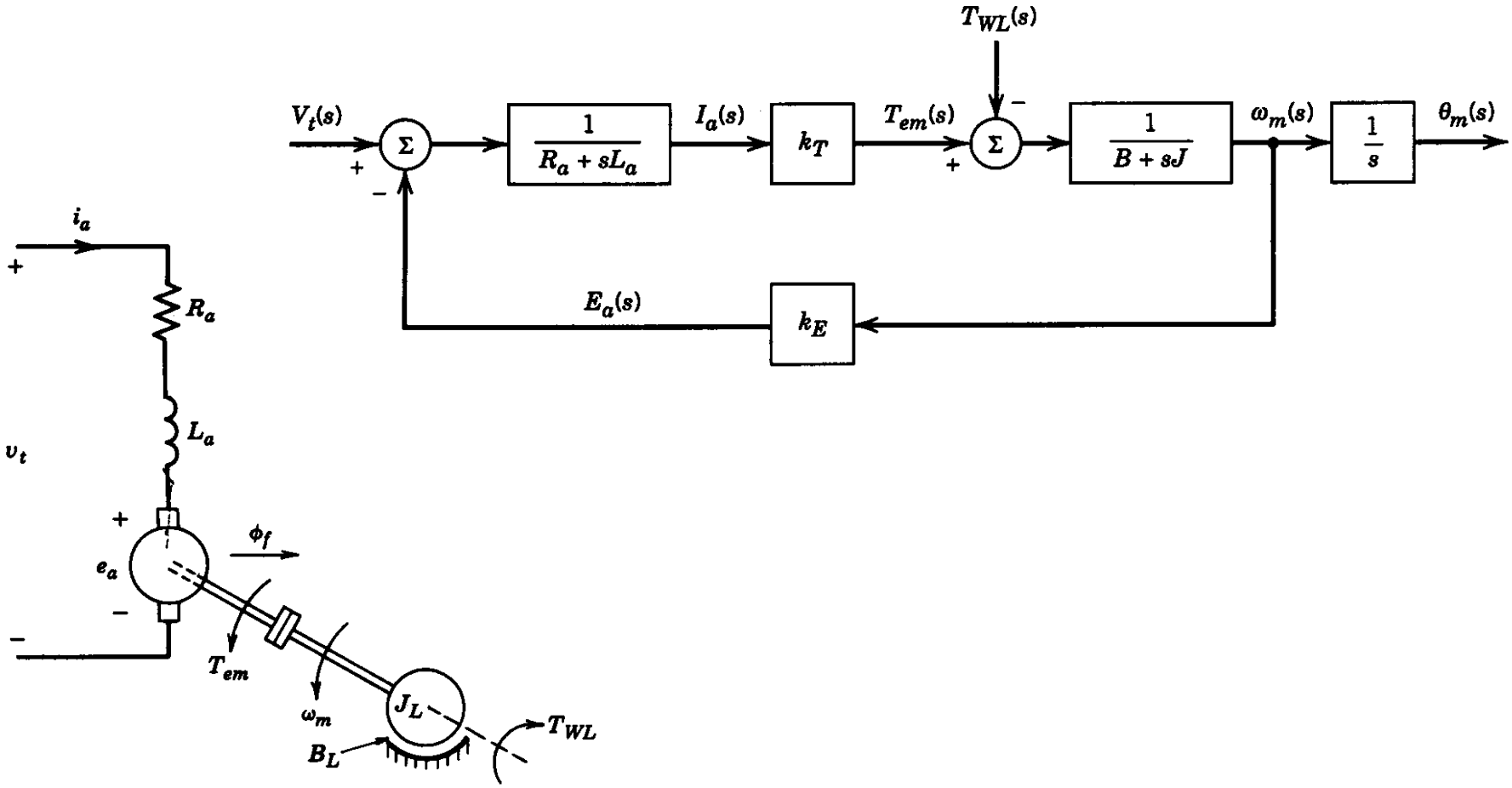
Controlling Torque, Speed and Position



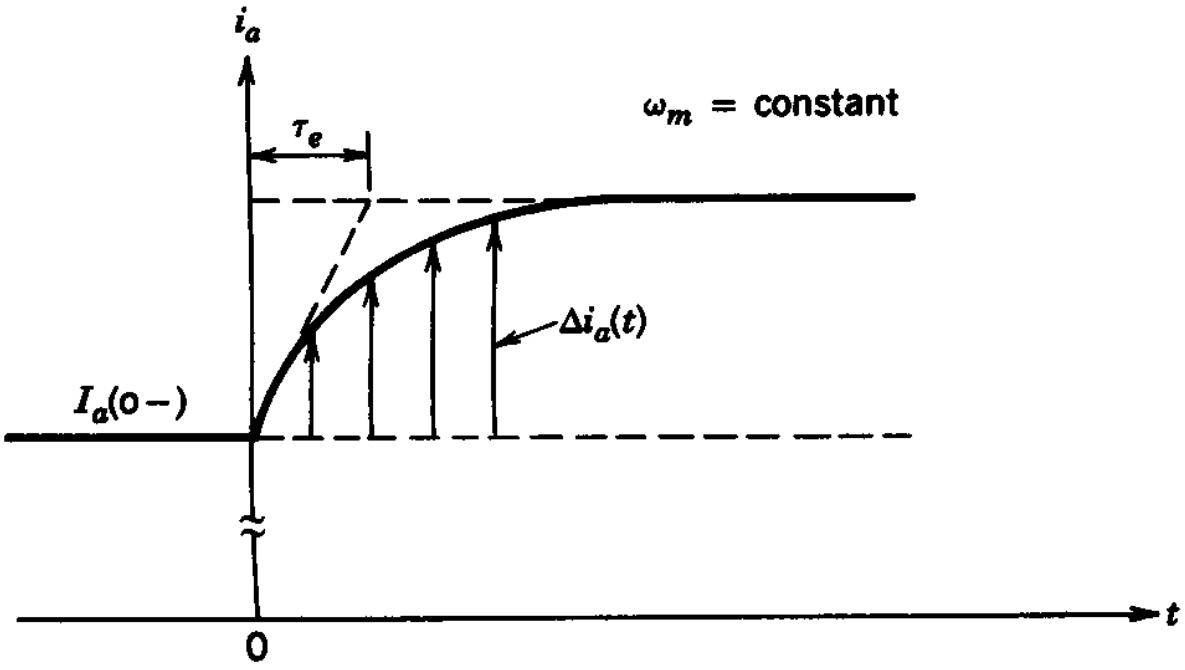
- Cascaded control is commonly used

Small-Signal Representation of DC Machines

- Around a steady state operating point

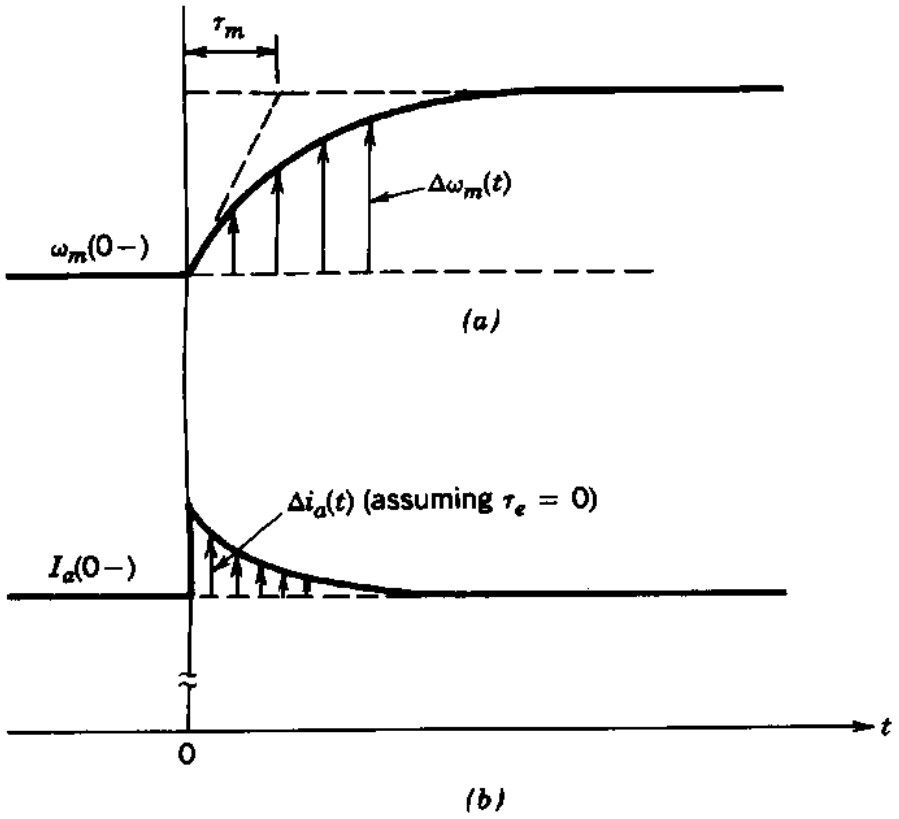


Electrical Time-Constant of the DC Machine



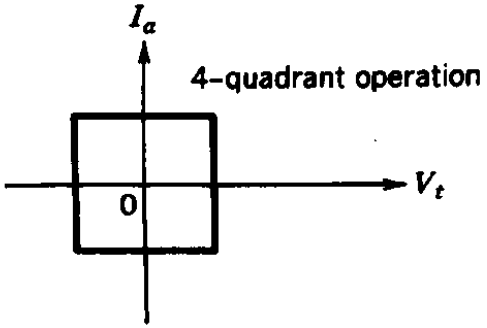
- The speed is assumed constant

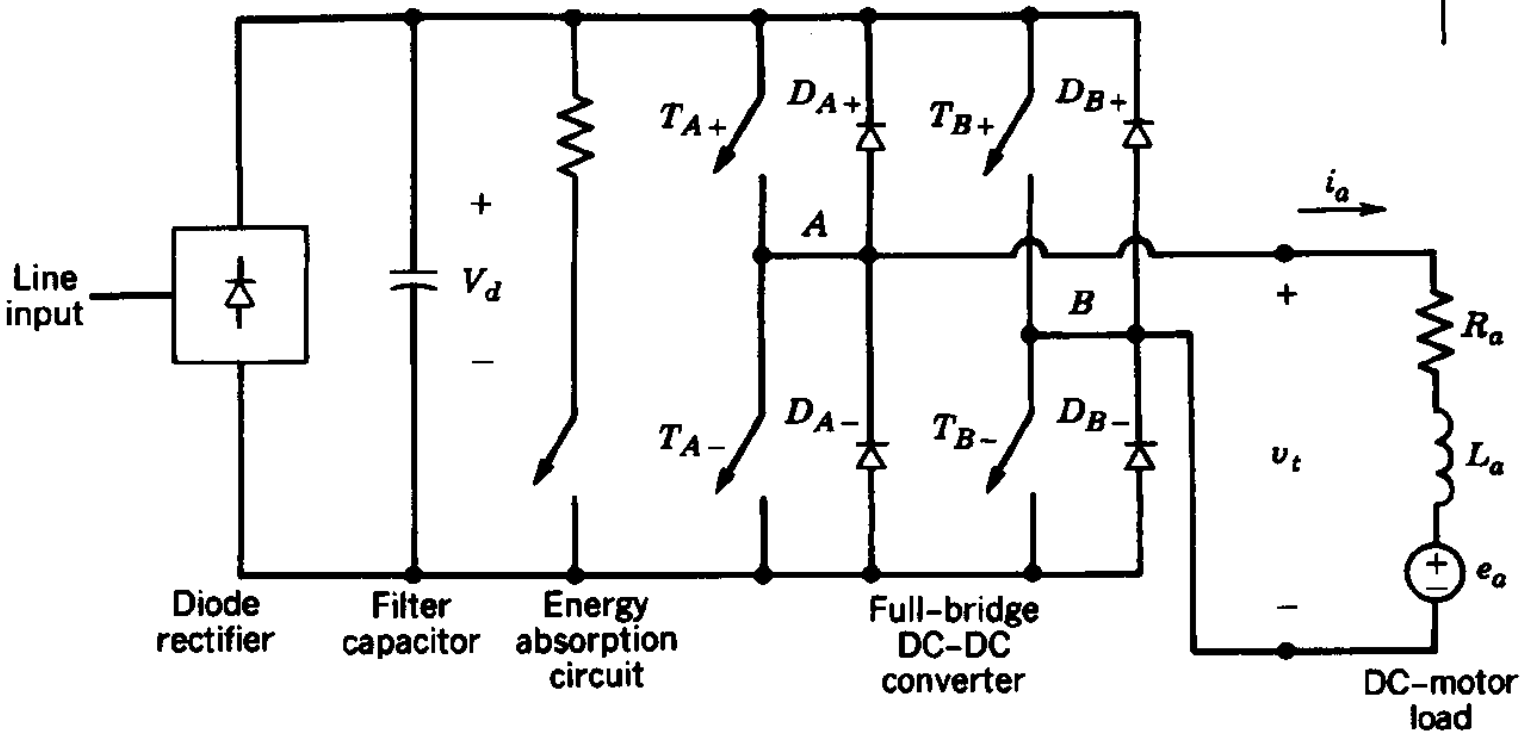
Mechanical Time-Constant of the DC Machine



- The load-torque is assumed constant

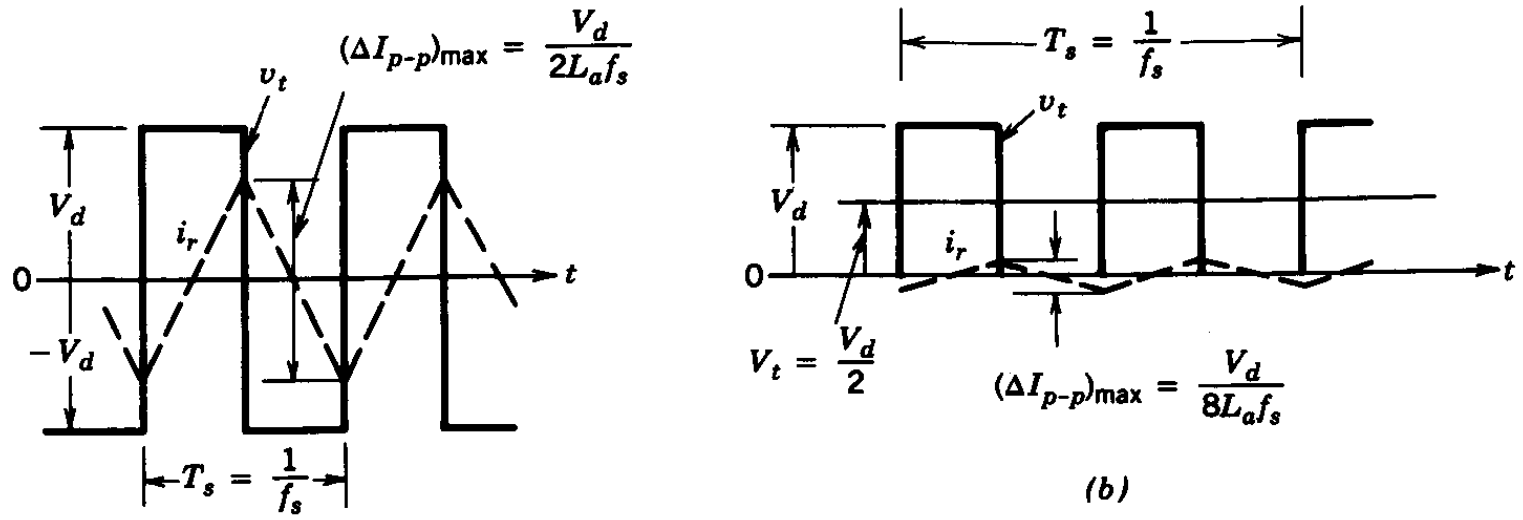
DC-Motor Drive: Four-Quadrant Capability



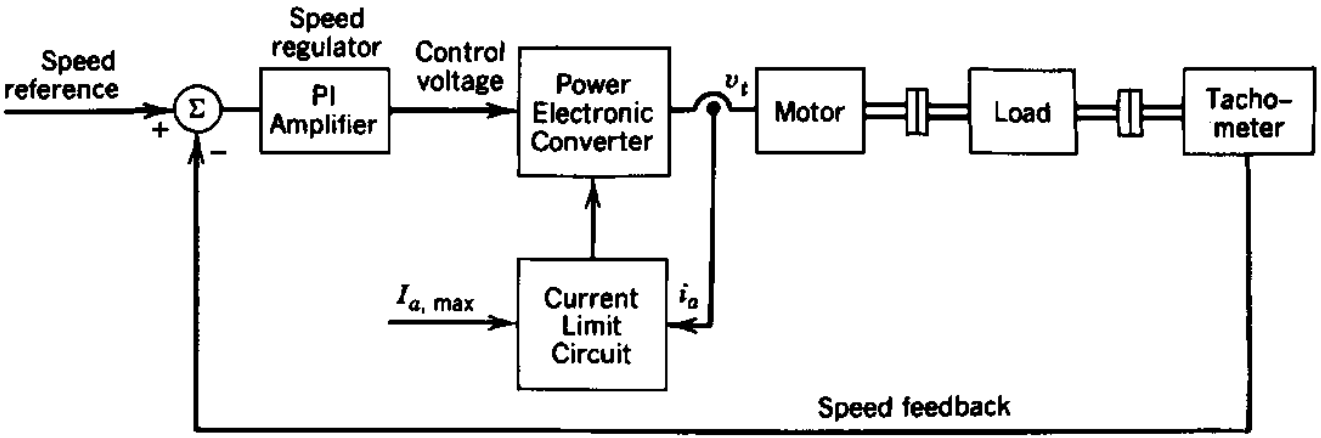


- If a diode-rectifier is used, the energy recovered during regenerative braking is dissipated in a resistor

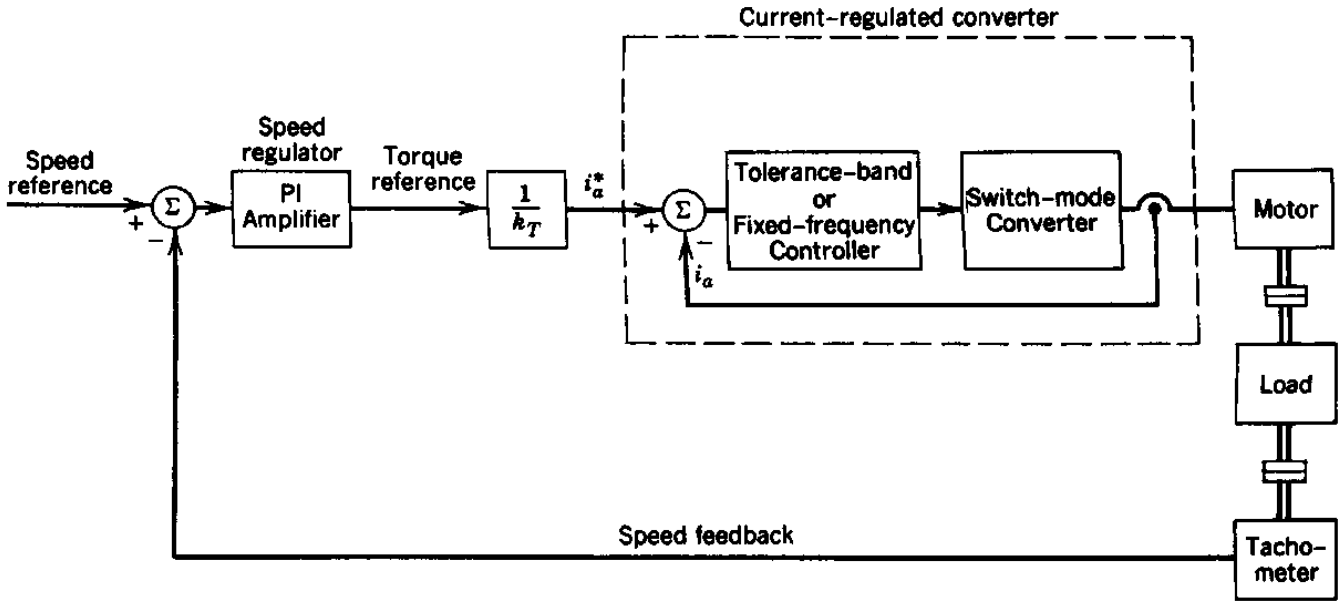
Ripple in the Armature Current bipolar and unipolar voltage switching



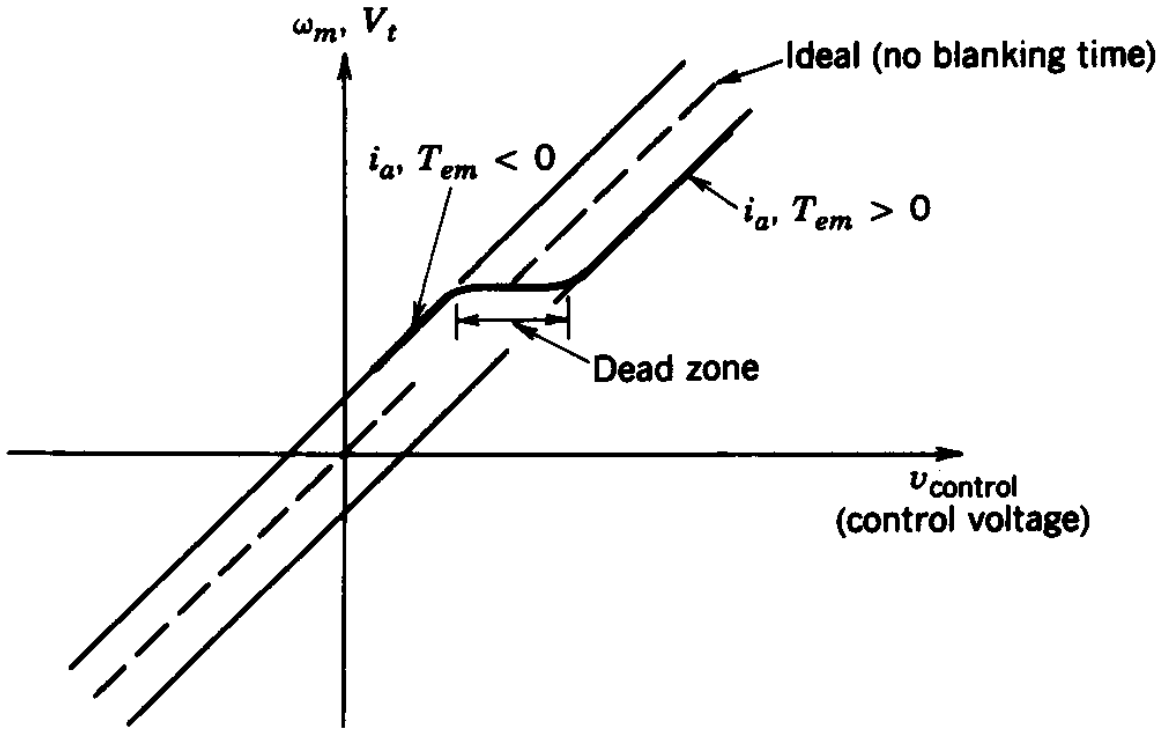
Voltage Control of Servo Drives



Current Control of Servo Drives

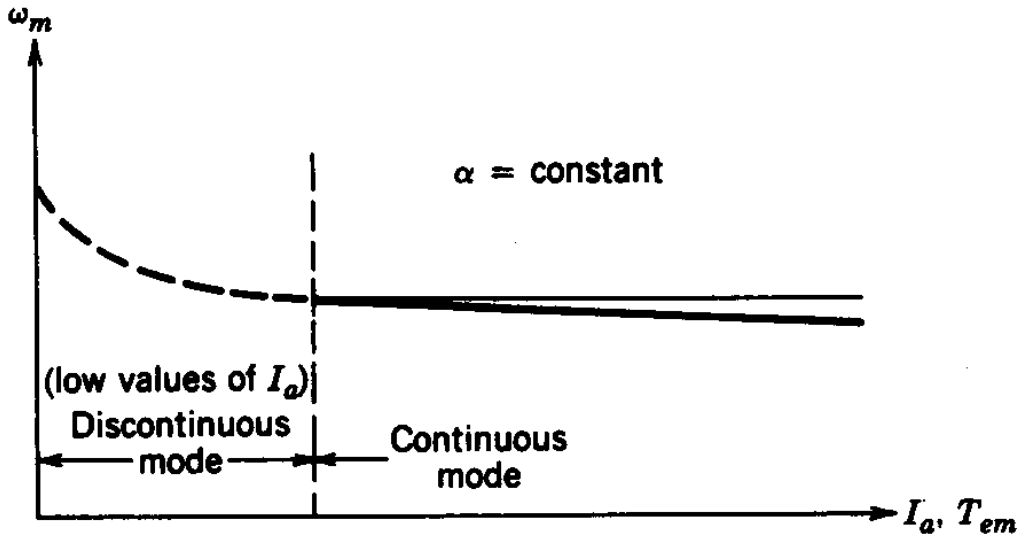


Effect of Blanking Time



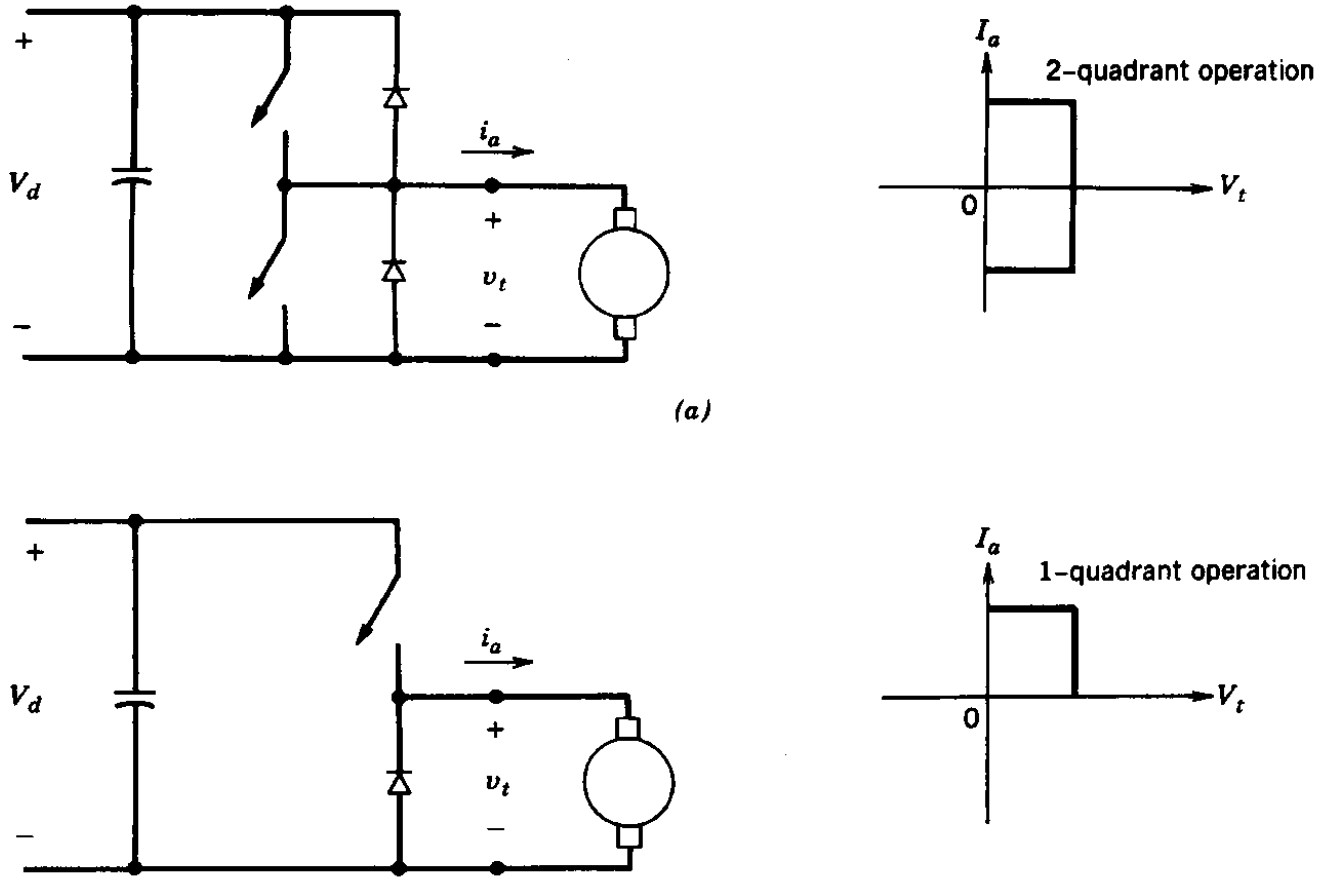
- Non-linearity is introduced

Effect of Discontinuous Current Conduction



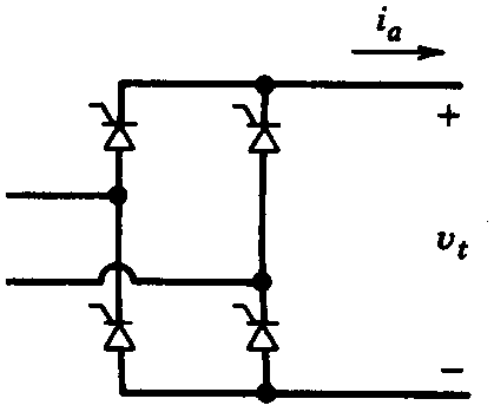
- Speed goes up unless it is controlled!!!

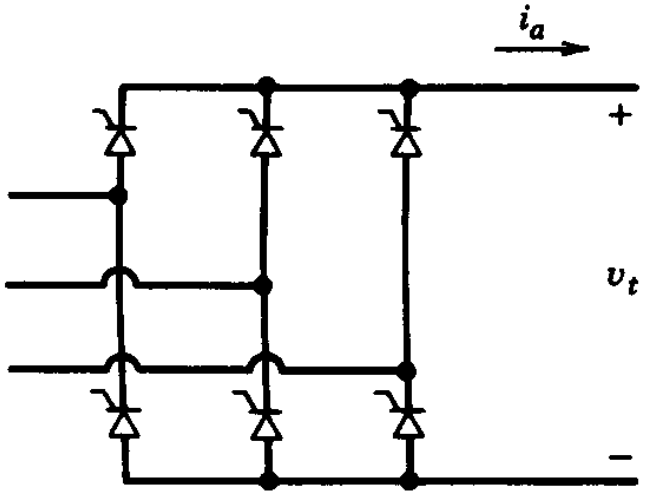
Converters for Limited Operational Capabilities



- Two switches for 2-quadrant operation and only one switch for 1-quadrant operation

Line-Controlled Converters for DC Drives

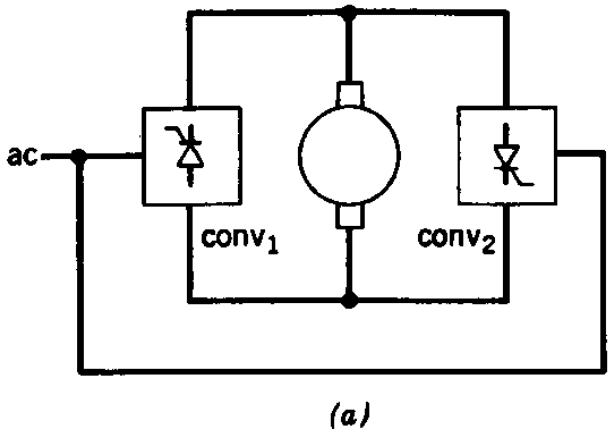




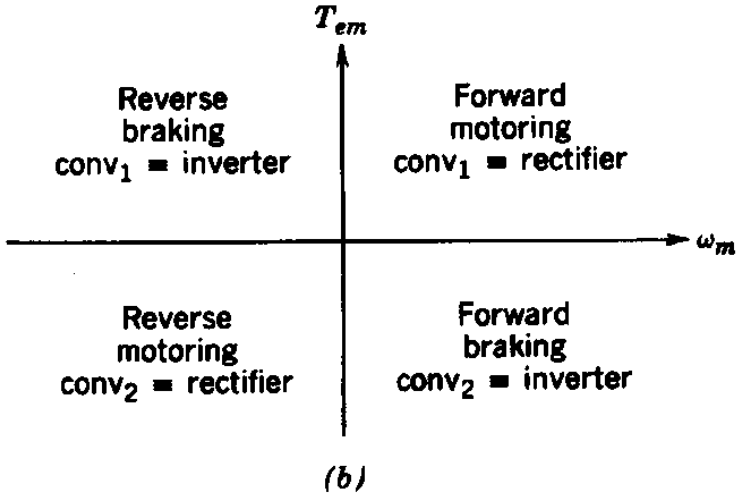
- Large low-frequency ripple in the dc output of converters

Four Quadrant Operation using Line Converters

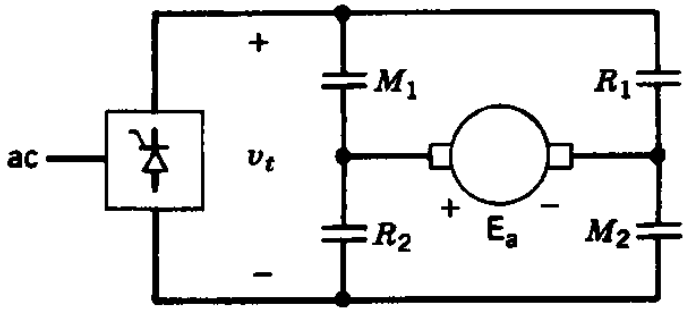
- Two options to achieve 4-quadrant operation



(a)

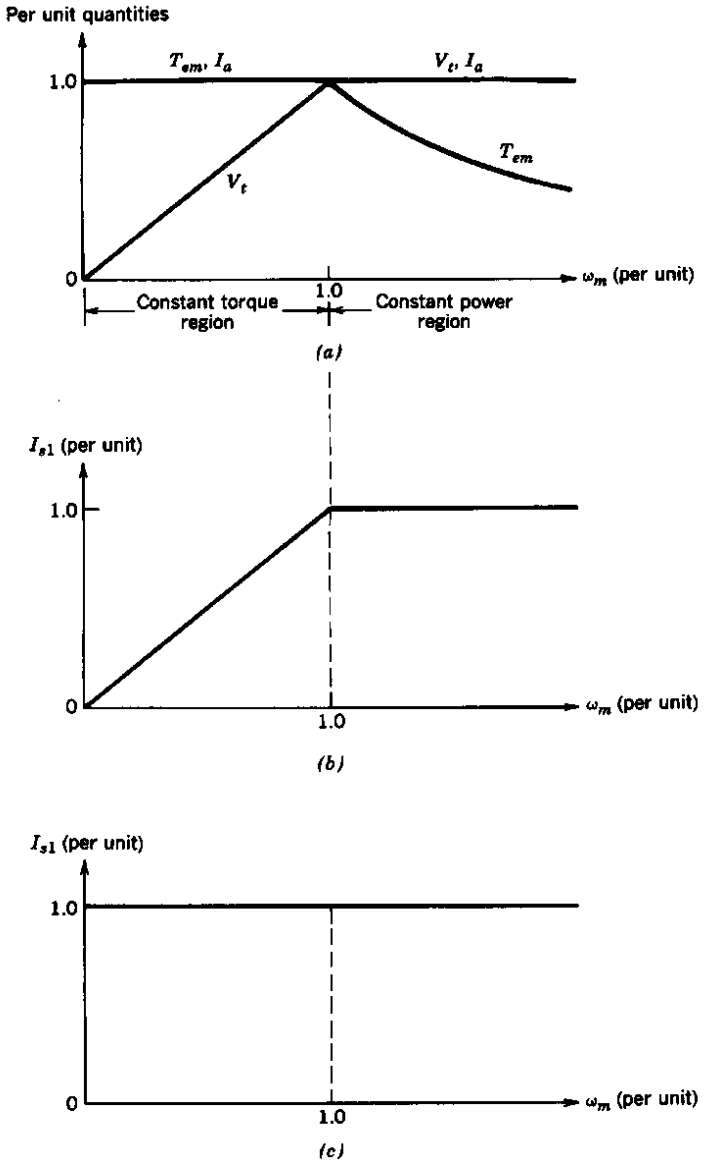


(b)

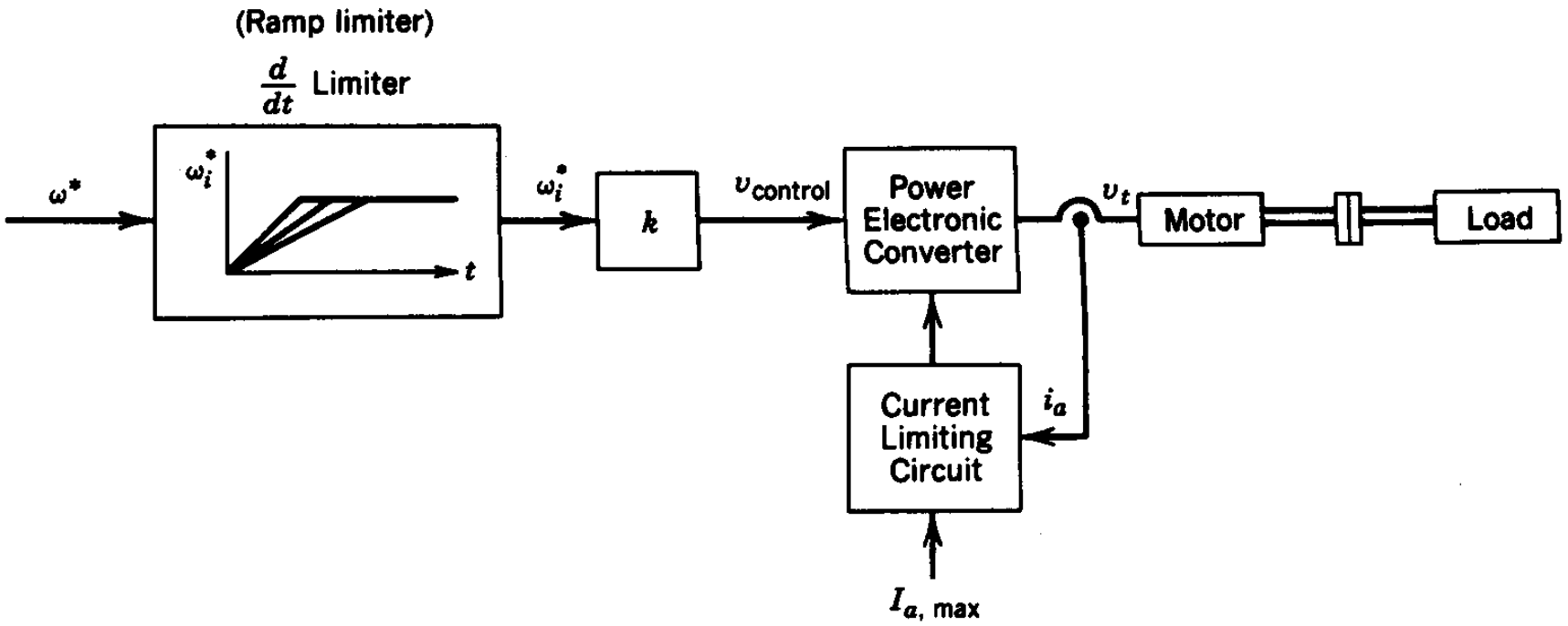


DC Drive Characteristics and Capabilities

- Line current (fund freq.) in switch-mode (b) line-converter drives (c)



Open-Loop Speed Control



- Adequate for general-purpose student applications

TI DRV8848

Dual H-Bridge Motor Driver
- Single/Dual Brushed DC
- Stepper

PWM Control Interface

Optional Current Regulation With 20-µs Fixed Off-Time

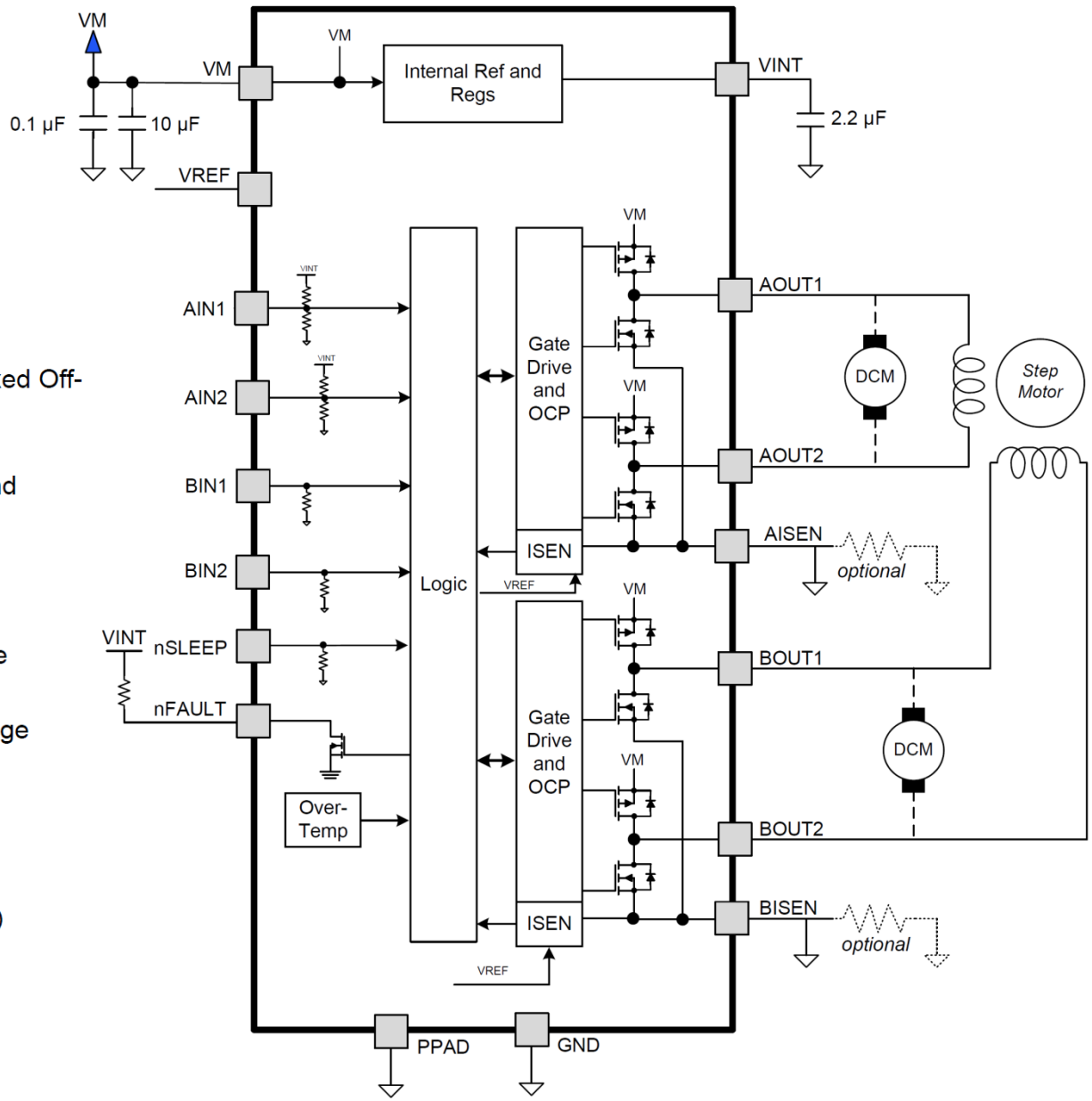
High Output Current per H-Bridge
- 2-A Maximum Driver Current at 12 V and T_A = 25°C
- Parallel Mode Available Capable of 4-A Maximum Driver Current at 12 V and T_A = 25°C

4- to 18-V Operating Supply Voltage Range

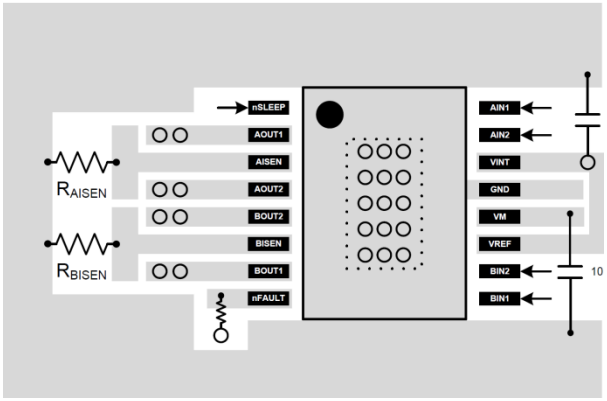
Low-Current 3-µA Sleep Mode

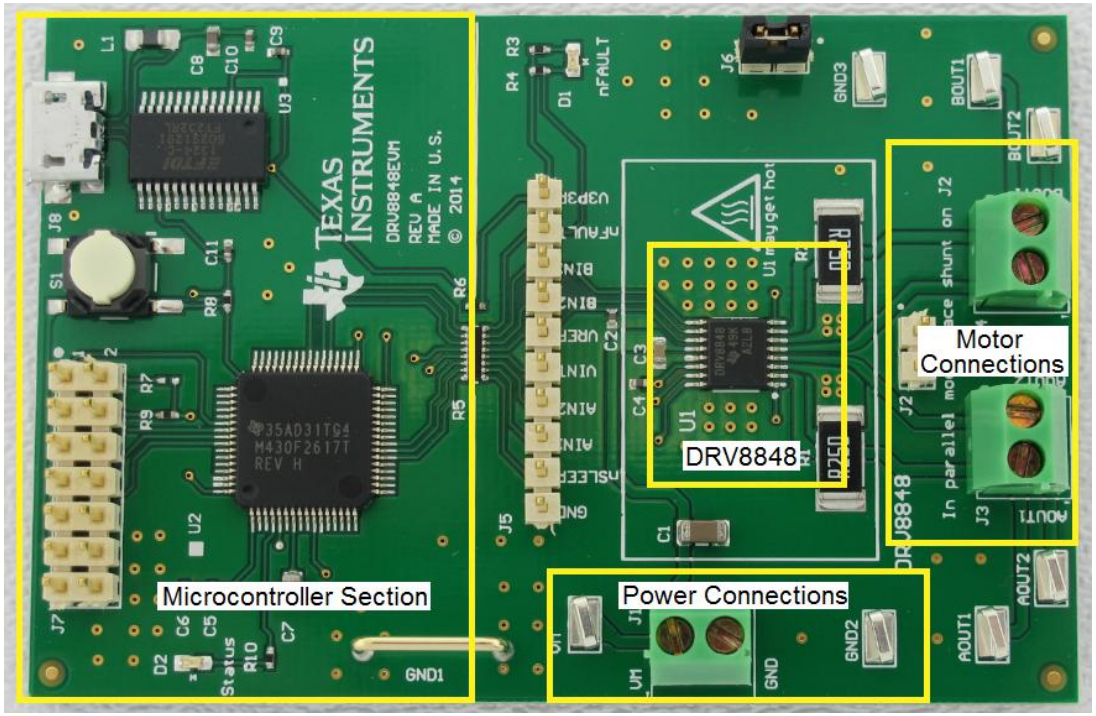
Thermally-Enhanced Surface Mount Package

Protection Features
- VM Undervoltage Lockout (UVLO)
- Overcurrent Protection (OCP)
- Thermal Shutdown (TSD)
- Fault Condition Indication Pin (nFAULT)



TI DRV8848


nSLEEP
AOUT1
AISEN
AOUT2
BOUT2
BISEN
BOUT1
nFAULT
RAISEN
RBISEN
AIN1
AIN2
VINT
GND
VM
VREF
BIN2
BIN1


Microcontroller Section
DRV8848
Motor Connections
Power Connections
GND1
GND2
VM
GND
AOUT1
AOUT2
BOUT1
BOUT2
Status

TI DRV 8808

Three DC Motor Drivers
- Up to 2.5-A Current Chopping
- Low Typical ON Resistance (R_{DSON} = 0.5 Ω at T_J = 25°C)

Three Integrated DC-DC Converters
- ON/OFF Selectable Using CSELECT Pin and Serial Interface
- Outputs Configurable With External Resistor Network From 1 V to 90% of V_M Capability for All Three Channels
- 1.35-A Output Capability for All Three Channels

One Integrated LDO Regulator
- Output Configurable With External Resistor Network from 1 V to 2.5 V
- 550-mA Output Capability

7-V to 40-V Operating Range

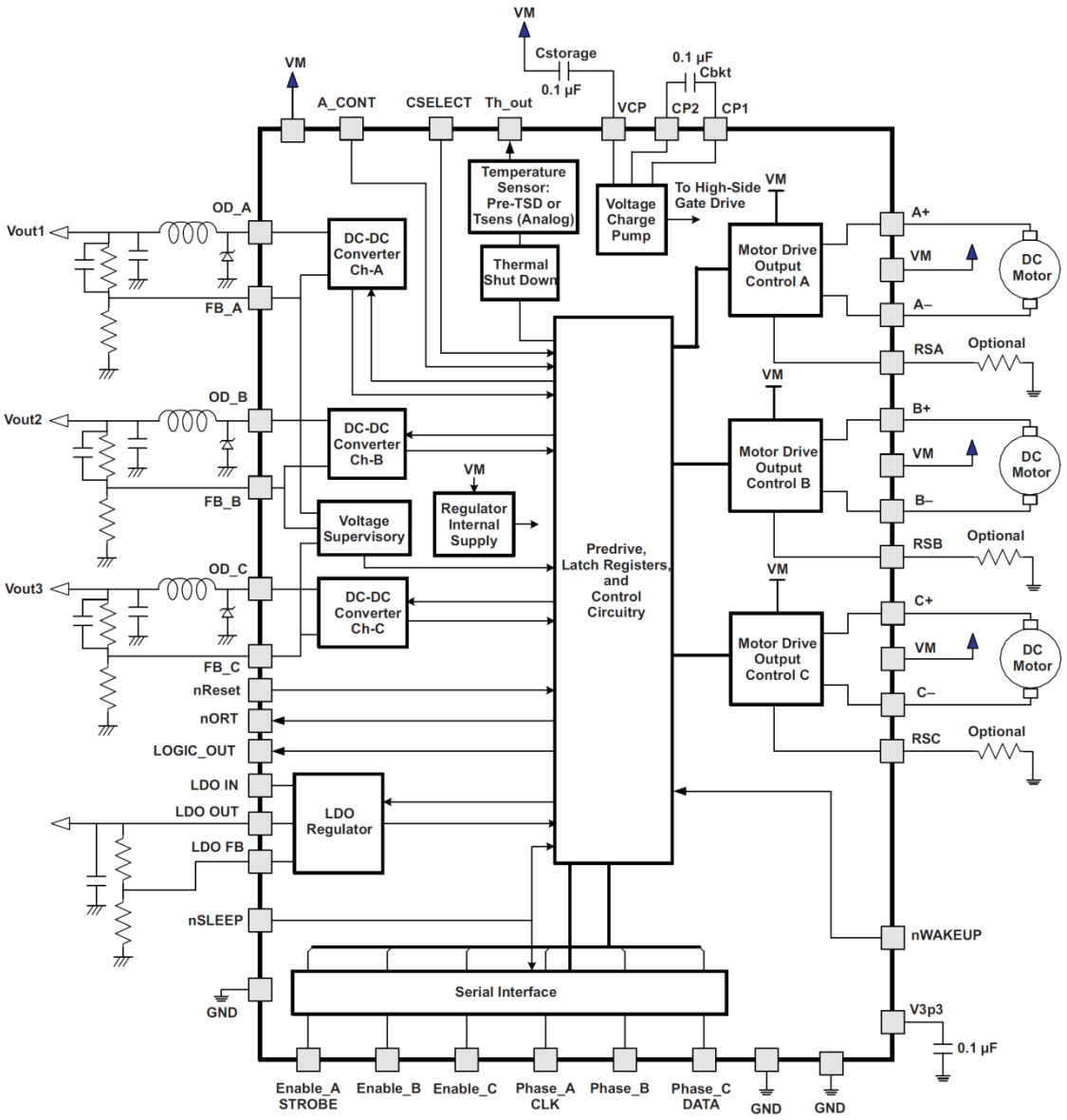
Serial Interface for Communications

Thermally-Enhanced Surface-Mount Package
48-Pin HTSSOP With PowerPAD™
(Eco-Friendly: RoHS and No Sb/Br)

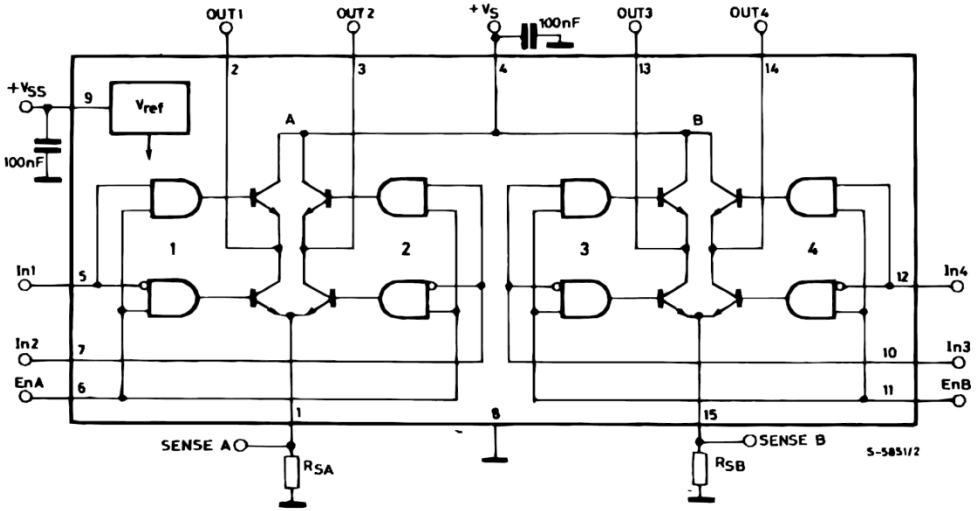
Power-Down Function (Deep-Sleep Mode)

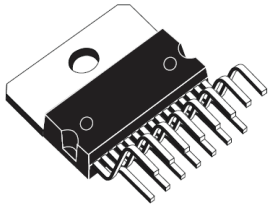
Reset Signal Output (Active Low)

Reset (All Clear) Control Input

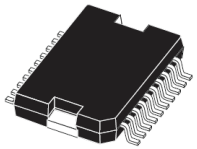


L298



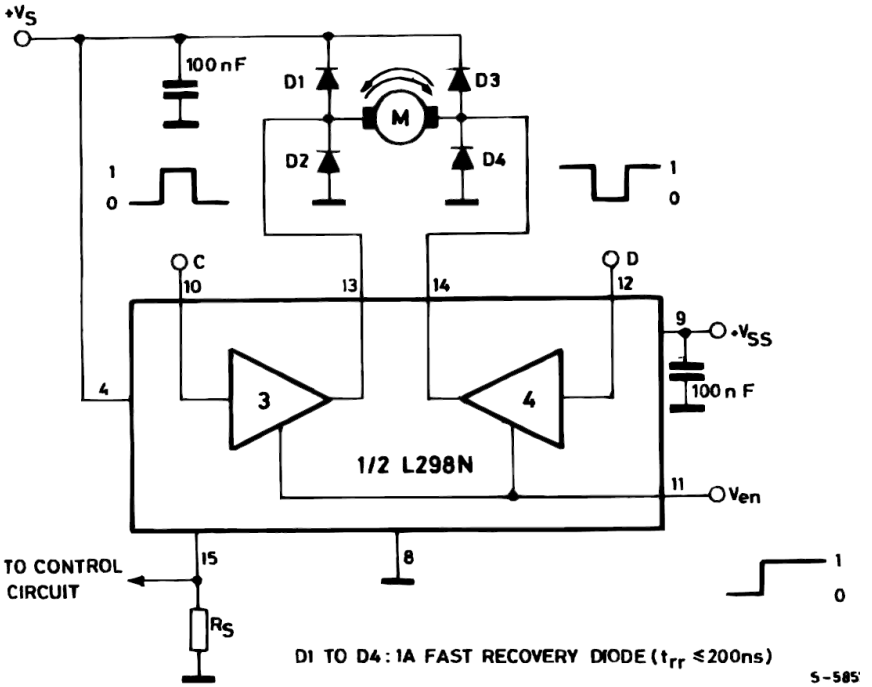


Multiwatt15

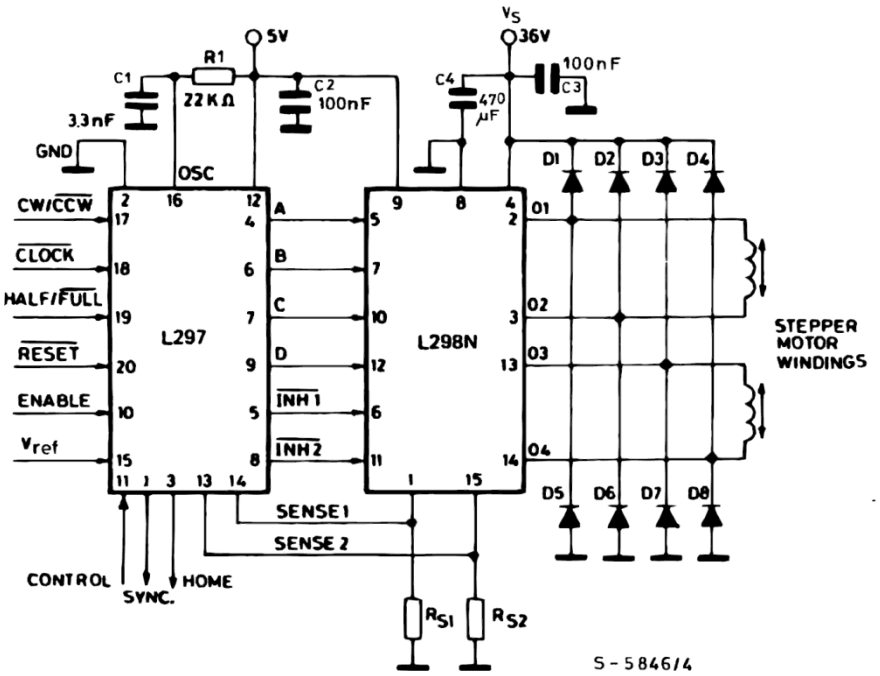


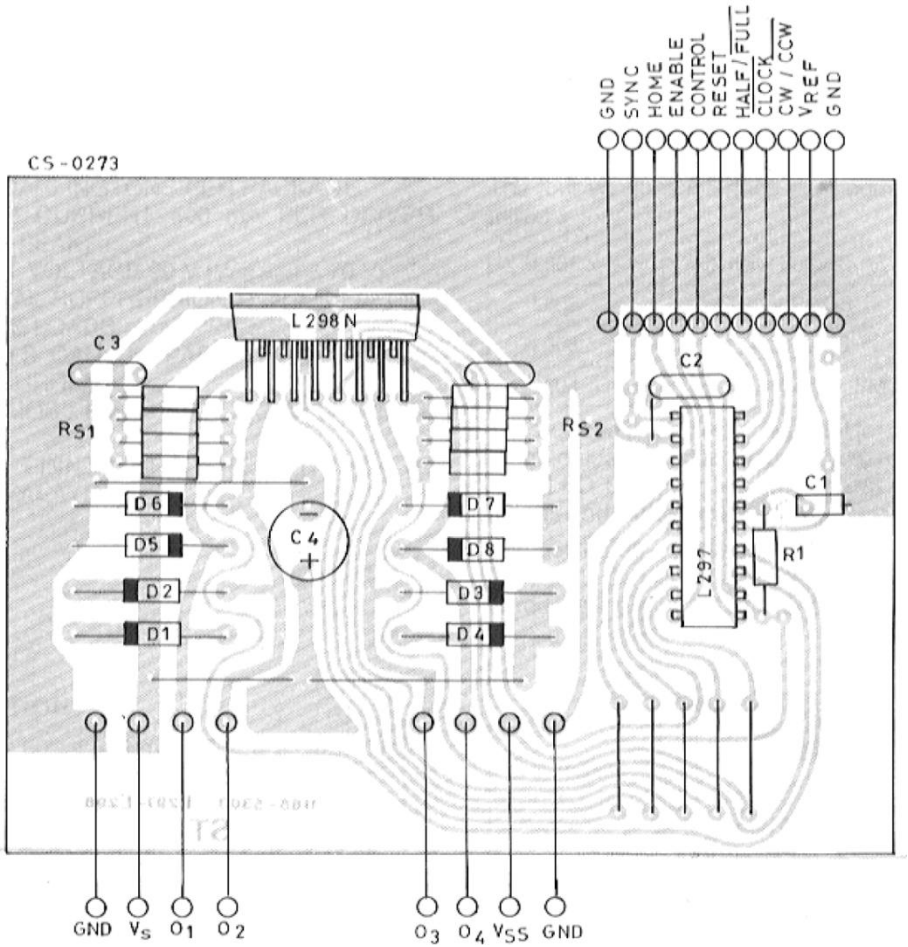
PowerSO20

- OPERATING SUPPLY VOLTAGE UP TO 46 V
- TOTAL DC CURRENT UP TO 4 A
- LOW SATURATION VOLTAGE
- OVERTEMPERATURE PROTECTION
- LOGICAL "0" INPUT VOLTAGE UP TO 1.5 V (HIGH NOISE IMMUNITY)



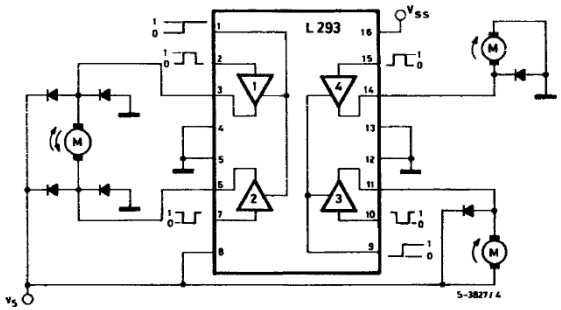
L298

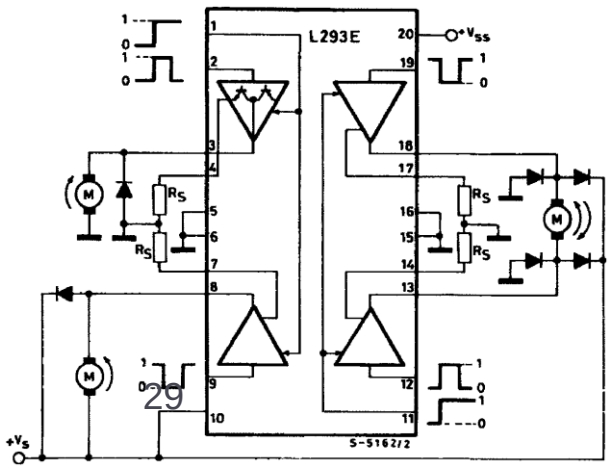

5V
VS
36V
R1
22KΩ
C1
3.3nF
C2
100nF
C4
470 µF
100nF
C3
GND
OSC
CW/CCW
CLOCK
HALF/FULL
RESET
ENABLE
Vref
L297
A
B
C
D
INH1
INH2
L298N
D1
D2
D3
D4
O1
O2
O3
O4
D5
D6
D7
D8
STEPPER MOTOR WINDINGS
SENSE1
SENSE 2
CONTROL
SYNC.
HOME
RS1
RS2
S-5846/4

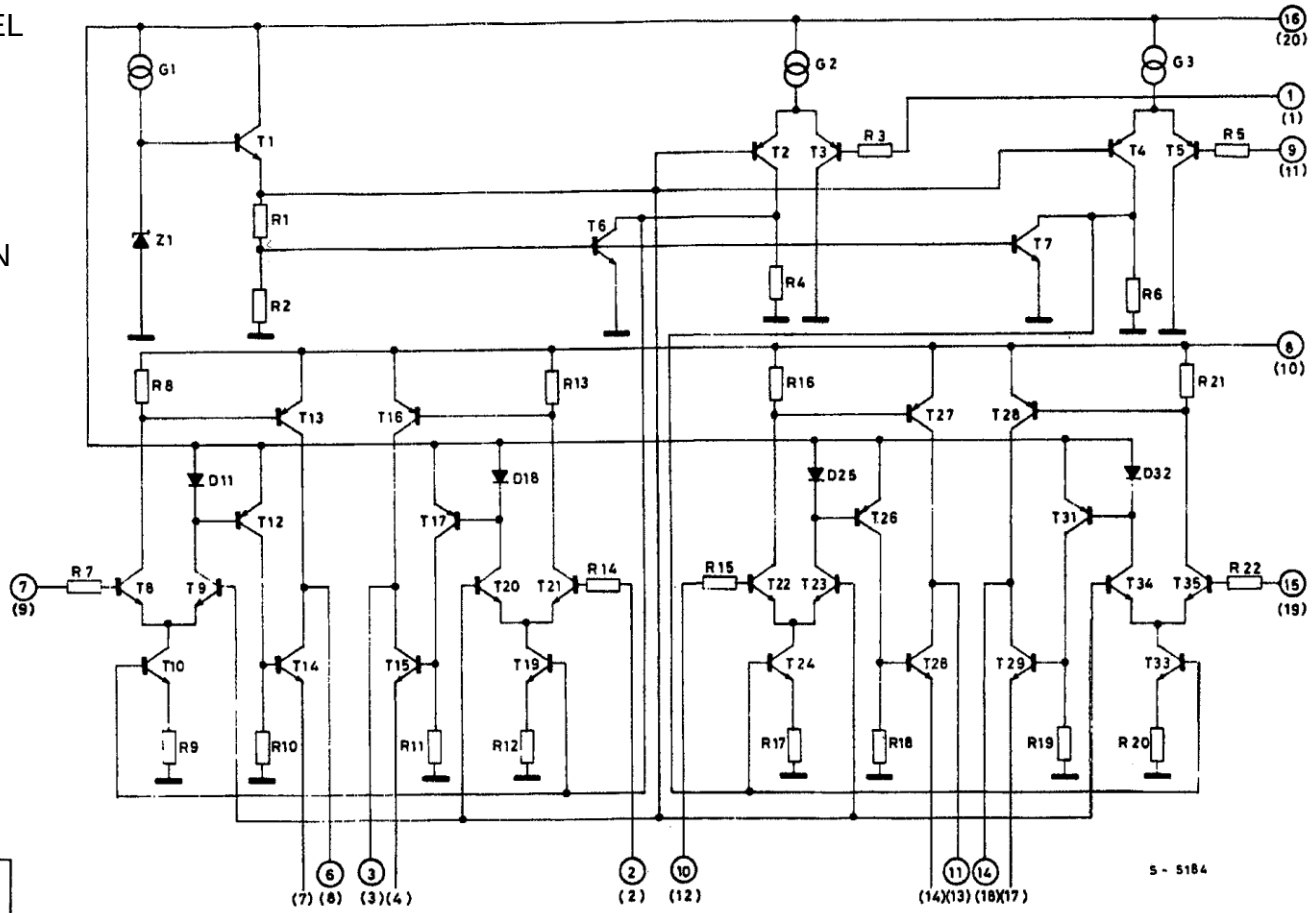

GND
SYNC
HOME
ENABLE
CONTROL
RESET
HALF/FULL
CLOCK
CW / CCW
VREF
GND
CS-0273
L298N
C3
C2
C1
RS1
RS2
D6
D5
D2
D1
C4
D7
D8
D3
D4
L297
R1
GND
Vs
O1
O2
O3
O4
VSS
GND

L293

- OUTPUT CURRENT 1A PER CHANNEL
- PEAK OUTPUT CURRENT 2A PER CHANNEL(non repetitive)
- INHIBIT FACILITY
- HIGH NOISE IMMUNITY
- SEPARATE LOGIC SUPPLY
- OVERTEMPERATURE PROTECTION

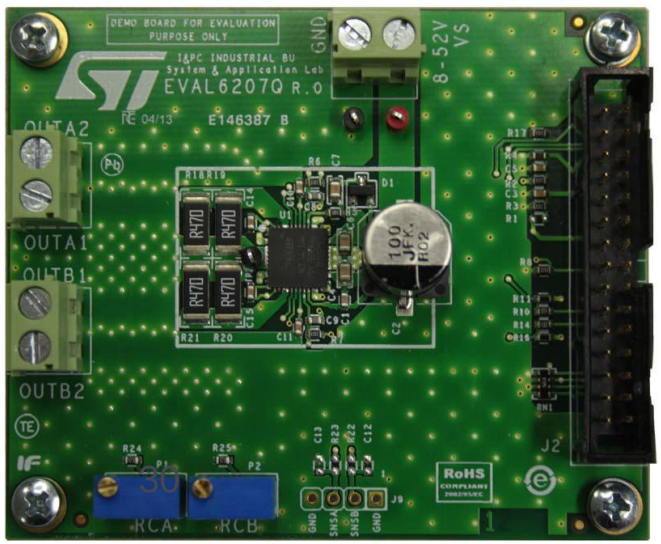


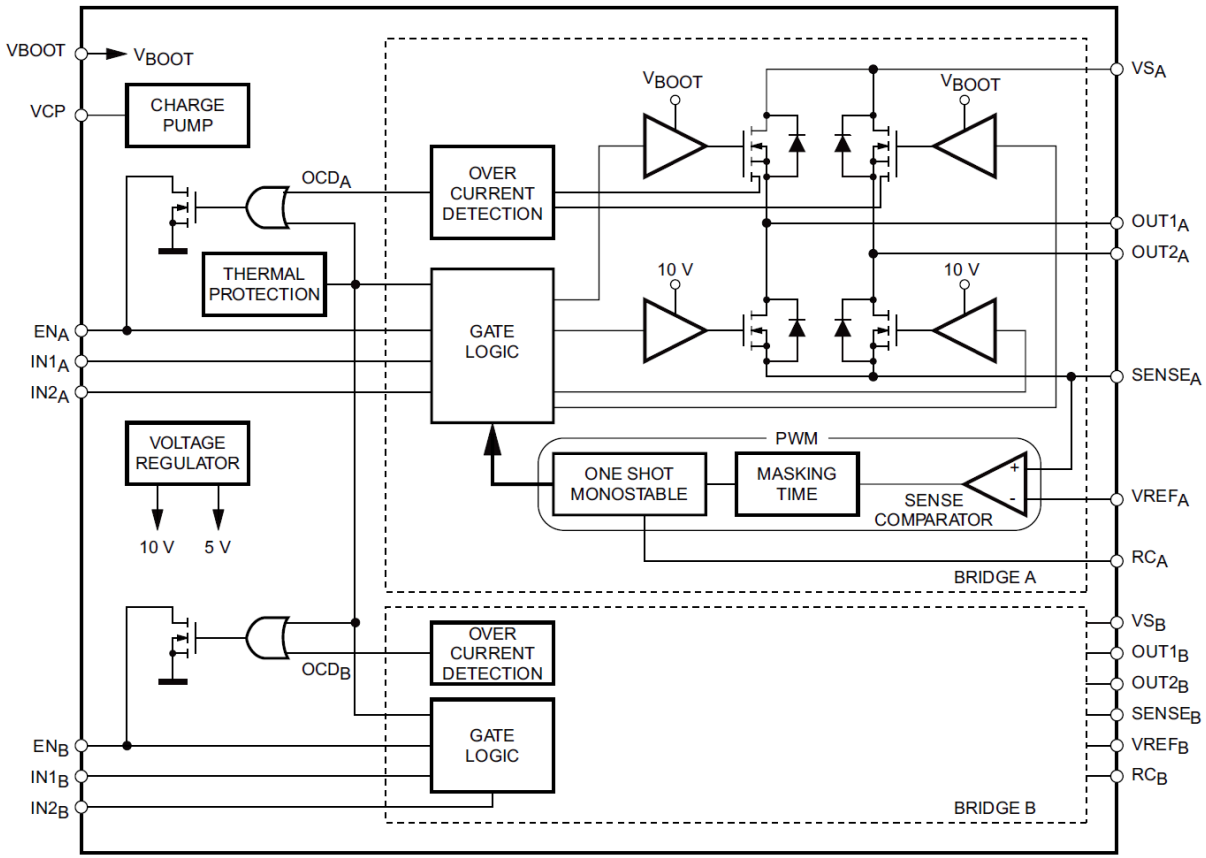




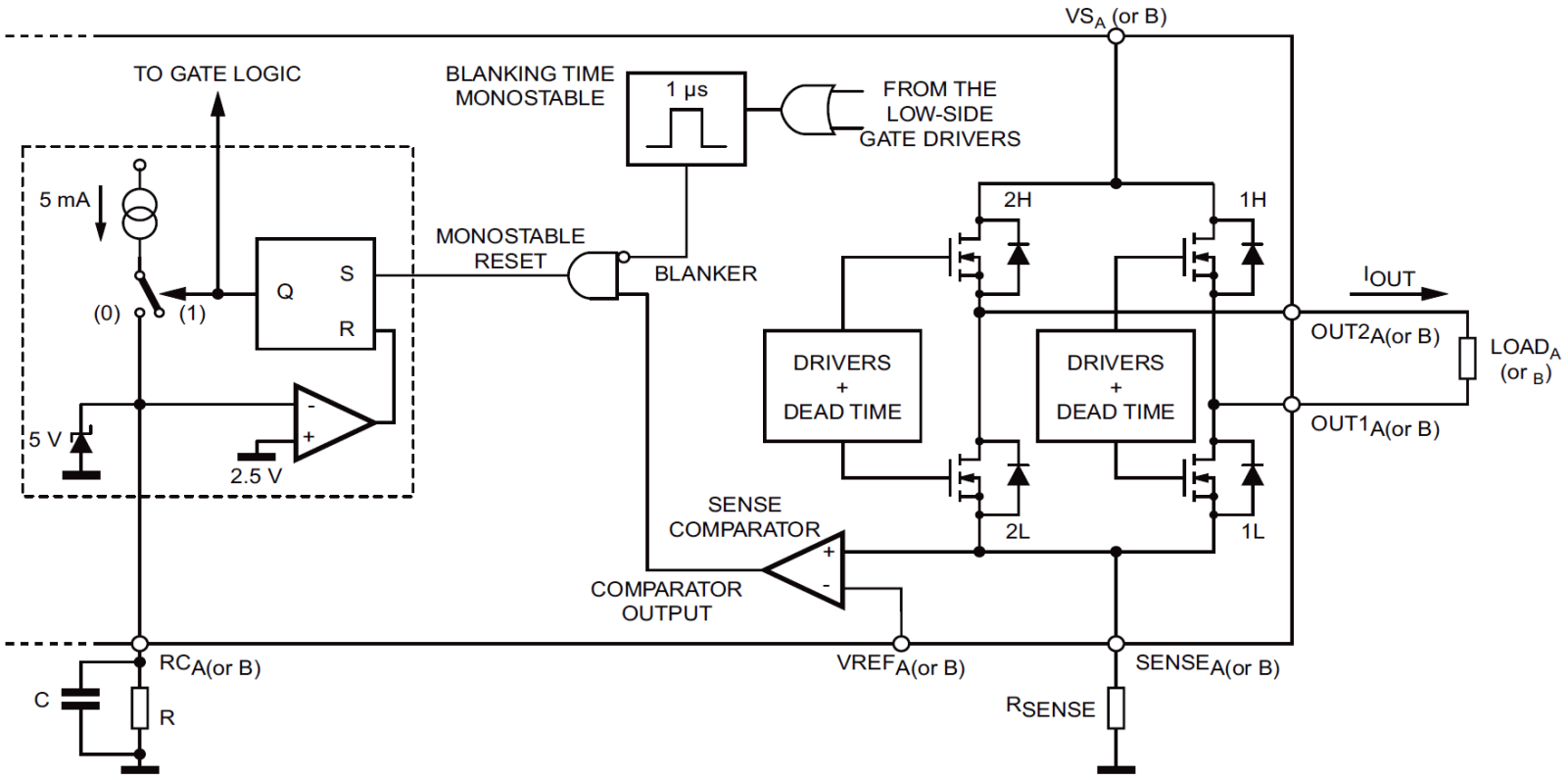
ST L6207

- Operating supply voltage from 8 to 52 V
- 5.6 A output peak current
- $R_{DS(on)}$ 0.3 Ω typ. value at T_j = 25 °C
- Operating frequency up to 100 kHz
- Non-dissipative overcurrent protection
- Dual independent constant t_{OFF} PWM current controllers
- Slow decay synchronous rectification
- Cross conduction protection
- Thermal shutdown
- Undervoltage lockout
- Integrated fast freewheeling diodes





ST L6207
PWM current controller



Homework

- L298 microcontrollers applications
- …