

i Eksamen IN1080 - Mekatronikk
Eksamensdag: 27. mai kl 14:30
Tid for eksamen: 4 timer

Hjelpemidler: Alle trykte og skrevne hjelpemidler er tillatt. Kalkulator vil være tilgjengelig digitalt.

Om oppgavene

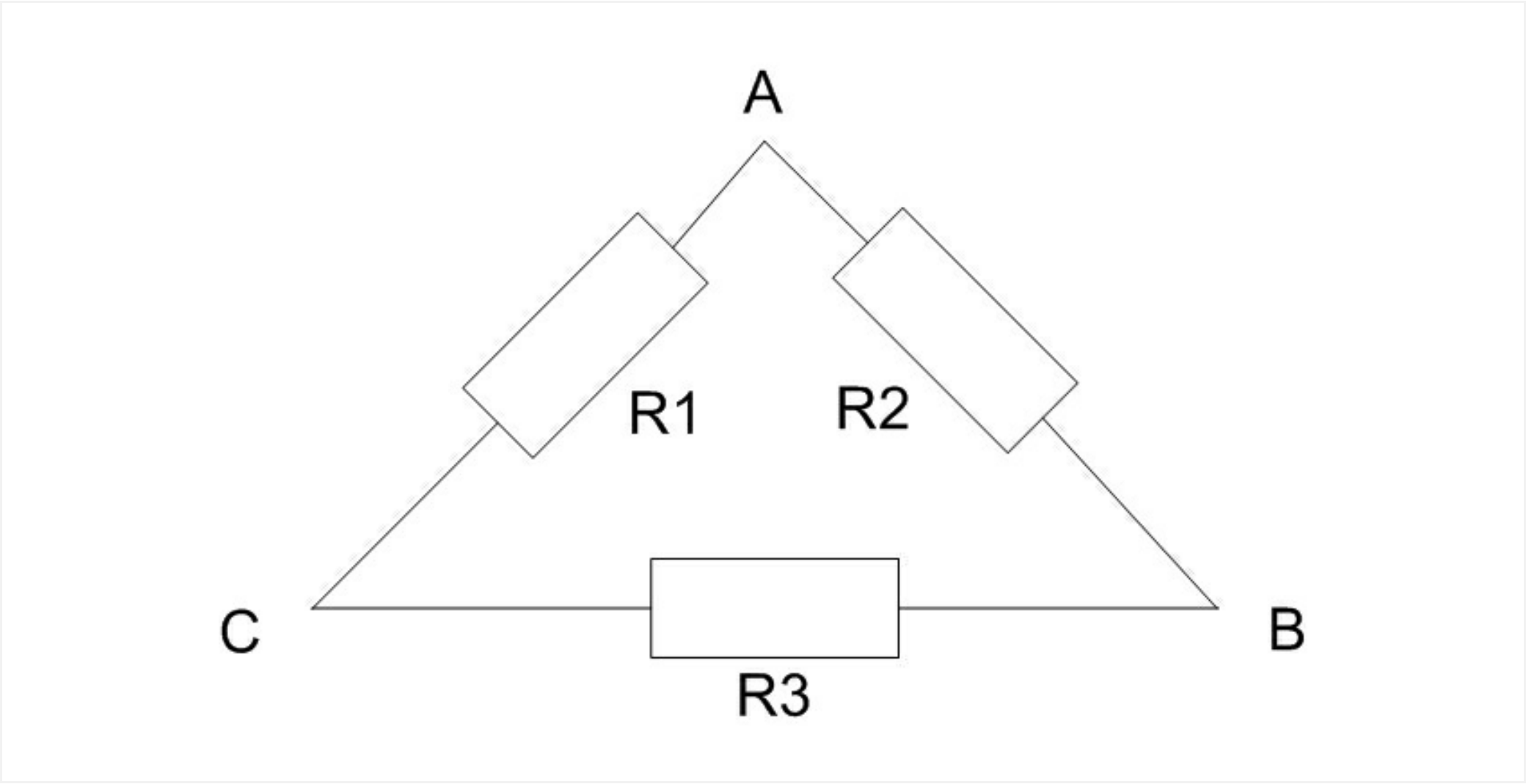
Oppgavesettet består av forskjellige typer oppgaver, både oppgaver der det forventes at du skriver svar og flervalgsoppgaver med ett eller flere riktige valg. Noen oppgaver har flere felter for besvarelse, og noen kan ha vedlegg som er vesentlige for å løse oppgaven. Pass derfor på å sjekke at du har lest og besvart hele oppgaven for hver oppgave, og benytt gjerne rullefeltene (scrollbar) til å kontrollere at du har fått med deg alt. Flervalgsoppgaver med radioknapper kan endres, men ikke skrur av når du har valgt alternativ. Felt med avkrysningsbokser kan ha begrensning i antall kryss som er lov.

Om poeng i dette eksamenssettet

I dette oppgavesettet er det mulig å oppnå inntil 100 poeng totalt. Poengene for hver oppgave er oppgitt på oversiktssiden for å angi vekten av hver oppgave slik at kandidatene kan disponere tiden. Feil i avkrysningsoppgaver kan gi poengtrekk innenfor oppgaven. Poengtrekk tas ikke med fra en oppgave til en annen. Nøyaktig tall på poeng for hver riktige eller gale avkrysning vil ikke oppgis da dette kan gi svar på hvor mange riktige oppgaven har.

Lykke til!

1

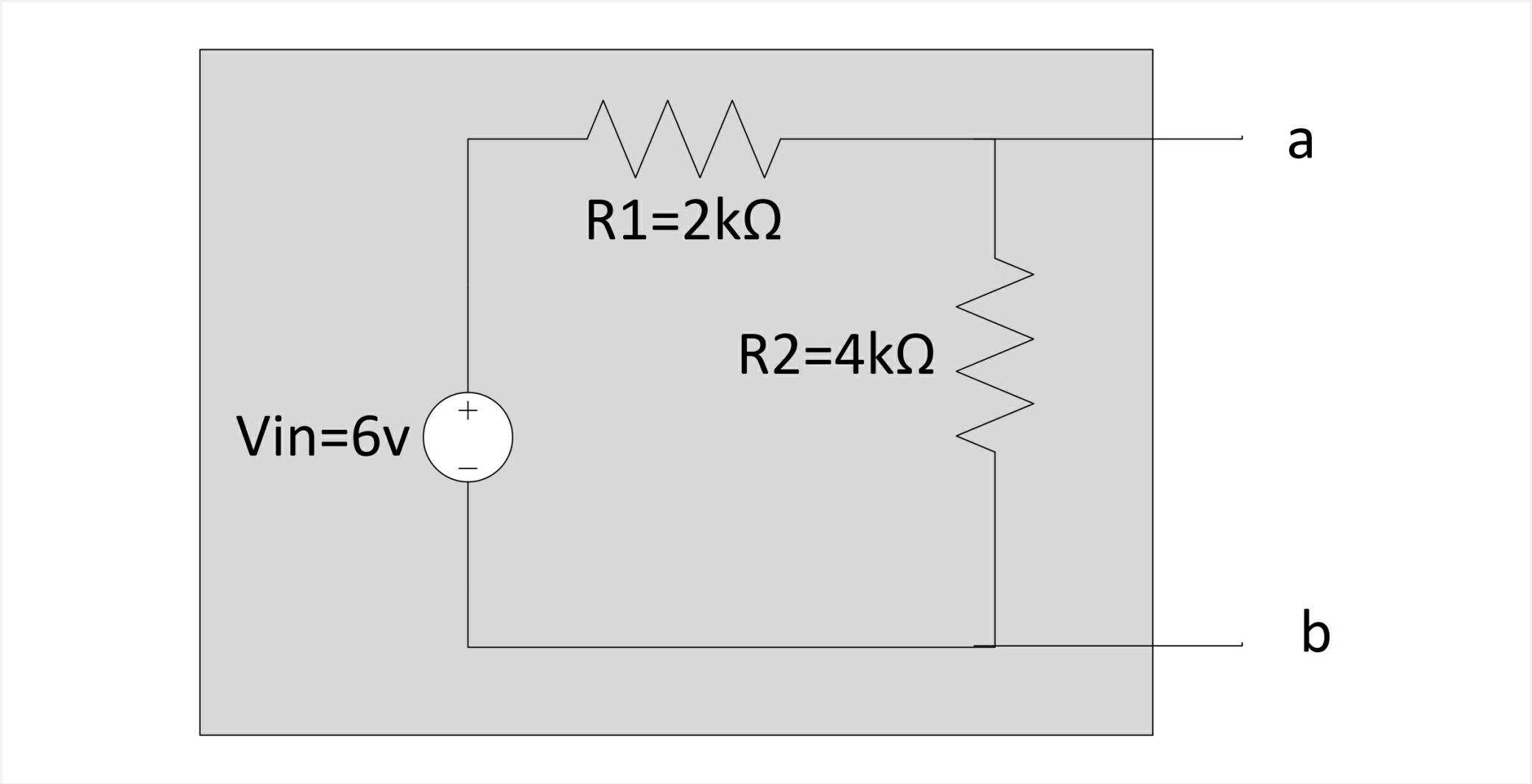


Gitt kretsen i figuren. Anta følgende komponentverdier: $R1=30\text{ k}\Omega$, $R2=50\text{ k}\Omega$ og $R3=20\text{ k}\Omega$. Beregn resistansen mellom nodene A og B, og mellom nodene A og C.

Skriv ditt svar her...

Maks poeng: 5

2



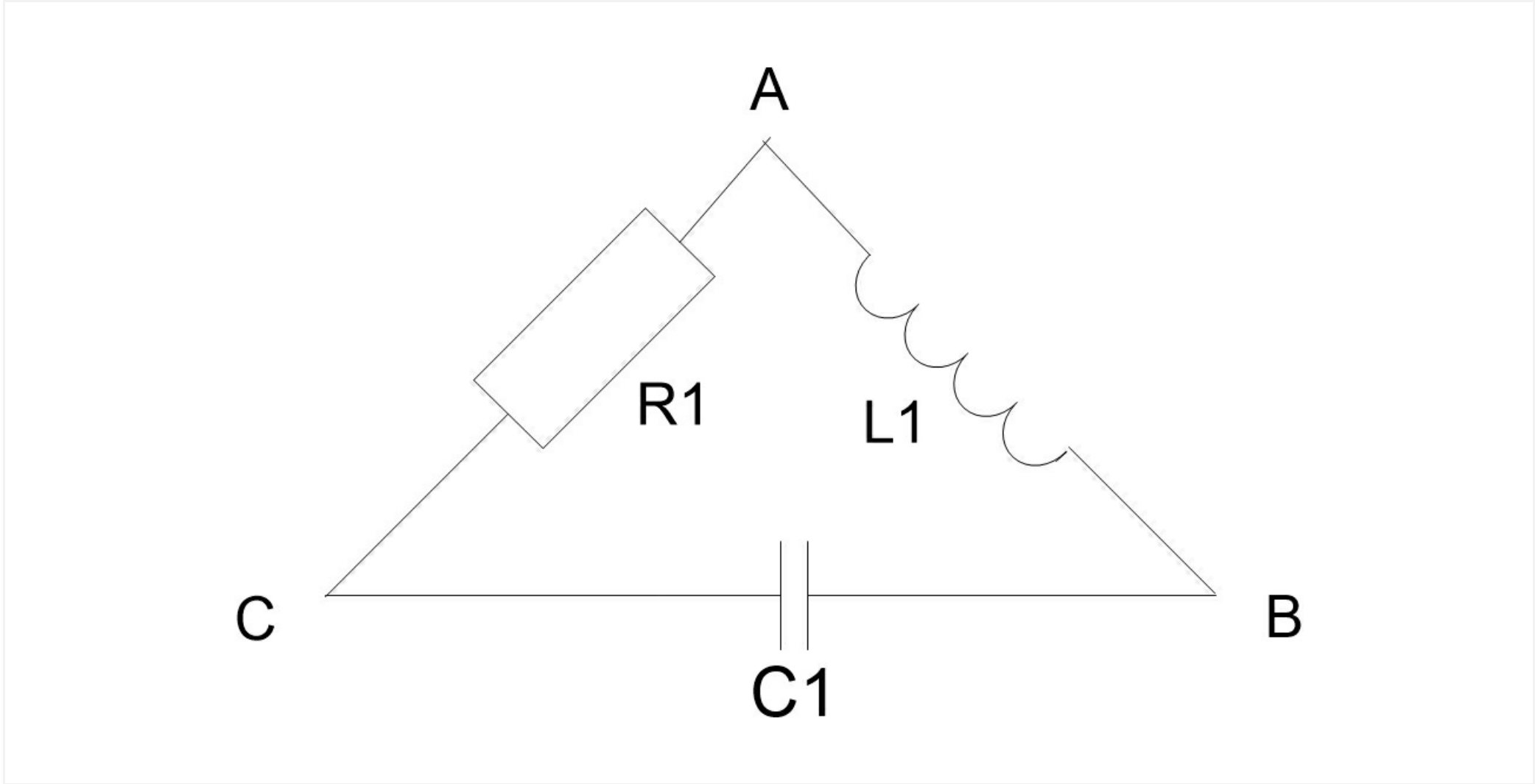
Gitt kretsen i figuren.

- 1. Hva er den Thévenin-ekvivalente resistansen R_{th} sett mellom node **a** og **b**?
- 2. Hva er den tilsvarende Thévenin-ekvivalente spenningen V_{th} ?

Skriv ditt svar her...

Maks poeng: 5

3



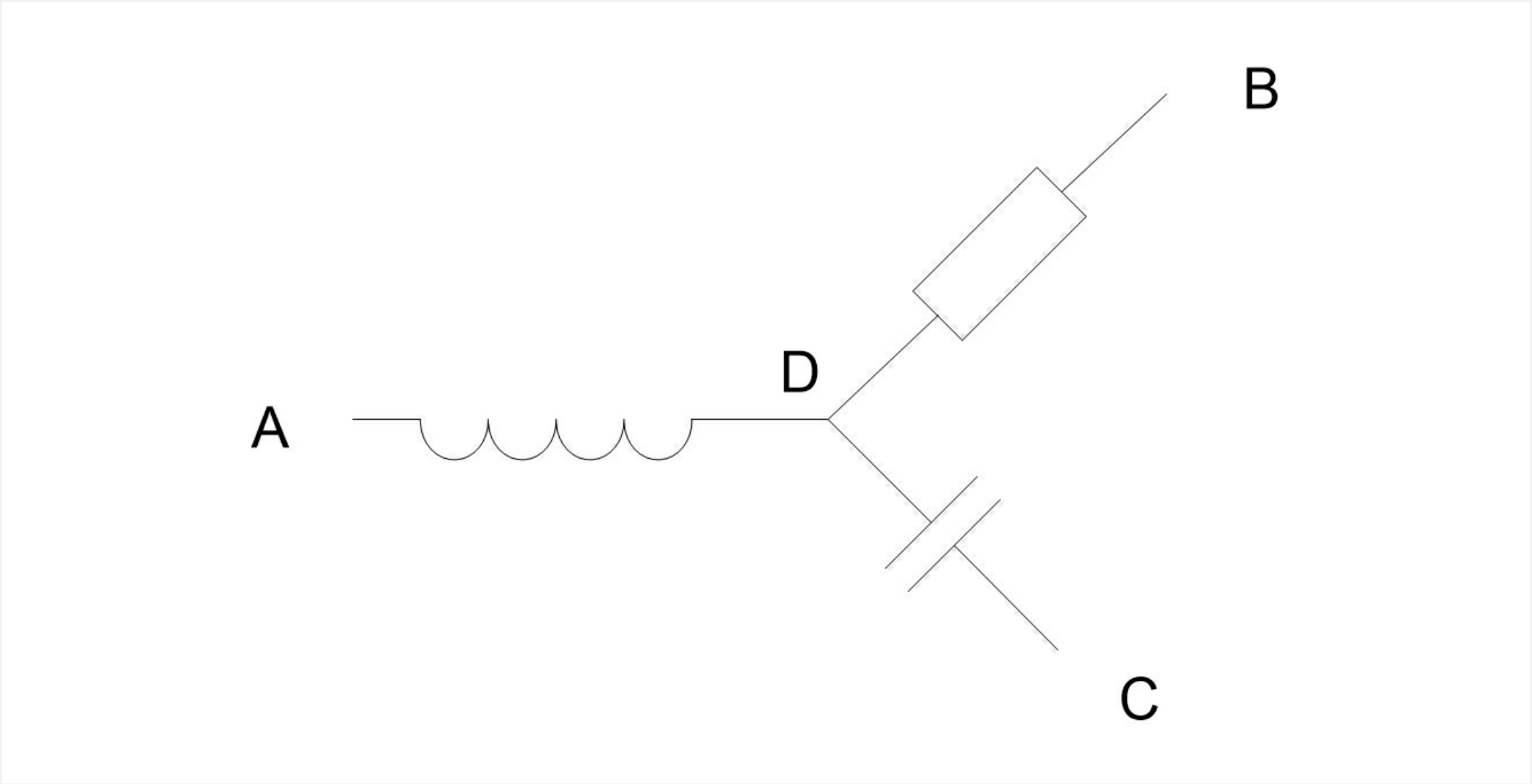
Gitt kretsen i figuren. Anta at alle komponentene er ideelle, og at R1, C1 og L1 kan ha vilkårlige verdier. Hva er den tilnærmede impedansen mellom node C og B i følgende to tilfeller:

- 1. Likestrøm (dc)?
- 2. Vekselstrøm (ac) ved svært høye frekvenser?

Skriv ditt svar her...

Maks poeng: 5

4



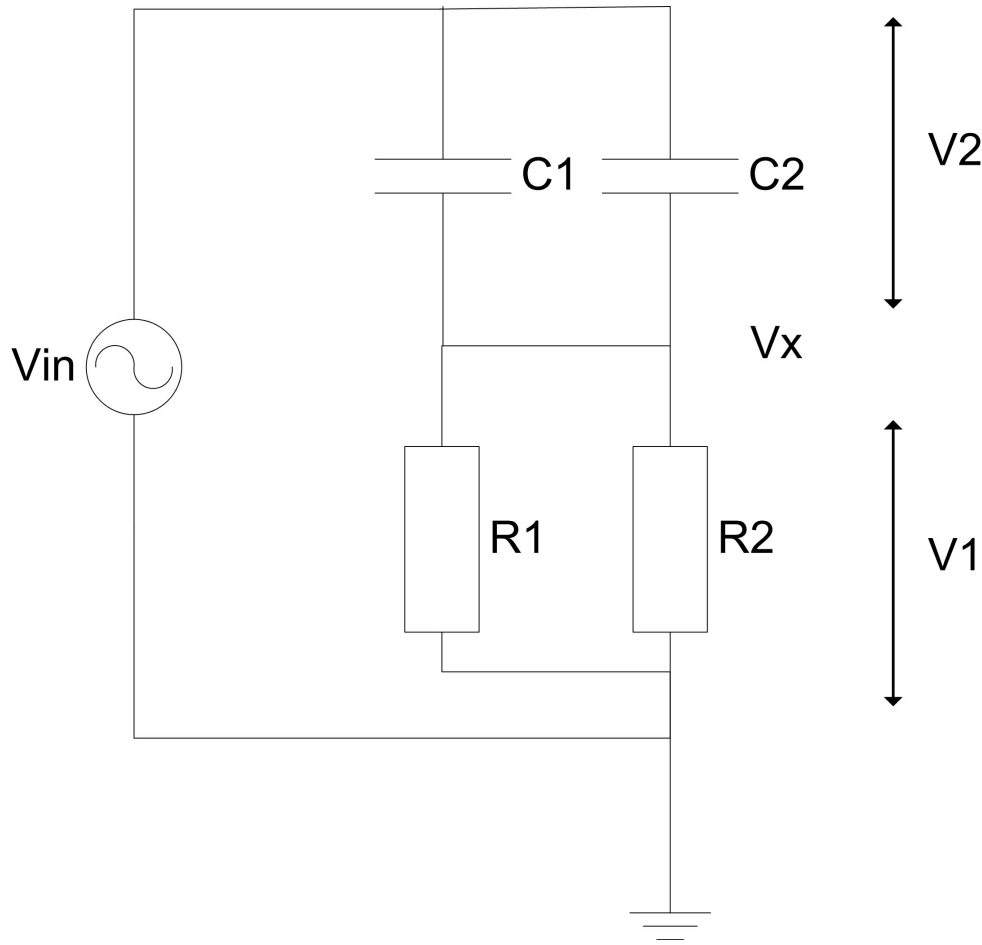
Gitt kretsen i figuren og anta at komponentene er ideelle. Tenk deg videre man kan kortslutte forbindelsen mellom noder (dvs. de kobles sammen med en leder perfekt leder). Hvilke typer impedans får vi i følgende tilfeller:

- 1. Mellom node A og B når forbindelsen mellom node A og C kortsluttes?
- 2. Mellom node C og D når forbindelsen mellom node A og C kortsluttes?

Skriv ditt svar her...

Maks poeng: 5

5



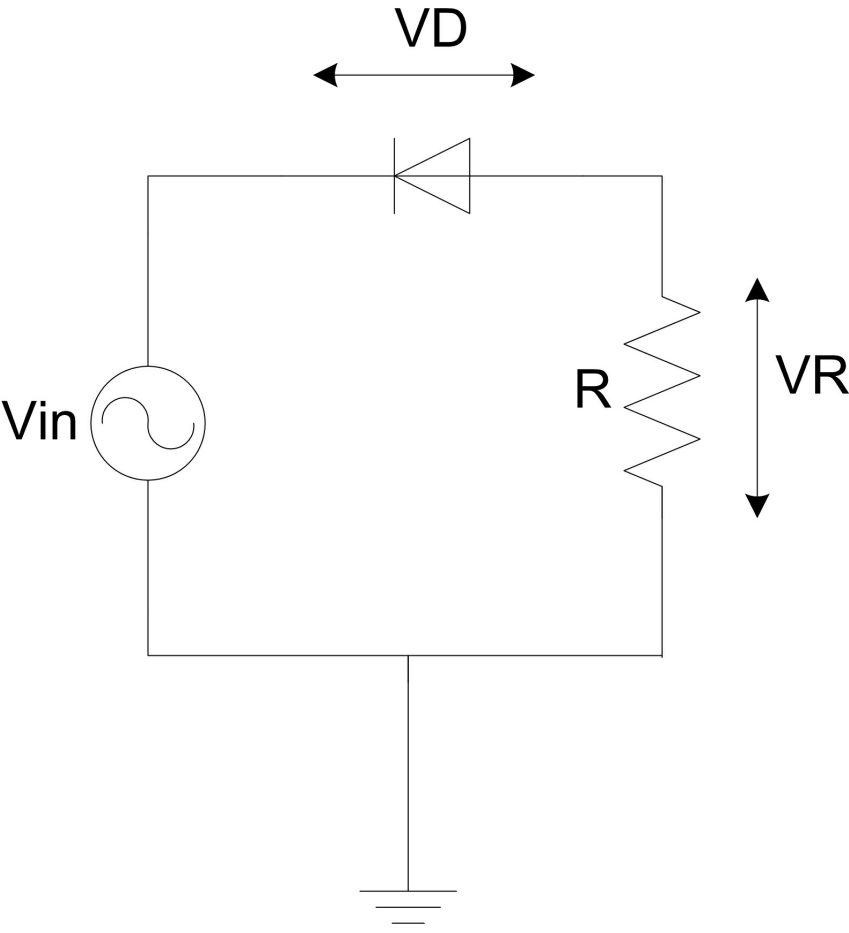
Gitt kretsen i figuren. Besvar følgende spørsmål:

- 1. Finn spenningen V_x uttrykt ved de andre spenningen i kretsen.
- 2. Anta at V_{in} er en likespenning større enn 0: Er da V_1 eller V_2 størst? Begrunn svaret.
- 3. Hva slags filter er denne kretsen hvis spenningen tas ut over resistorene (dvs $V_{out}=V_1$)?
- 4. Hvor må spenningen tas ut hvis vi ønsker et lavpassfilter?

Skriv ditt svar her...

Maks poeng: 10

6



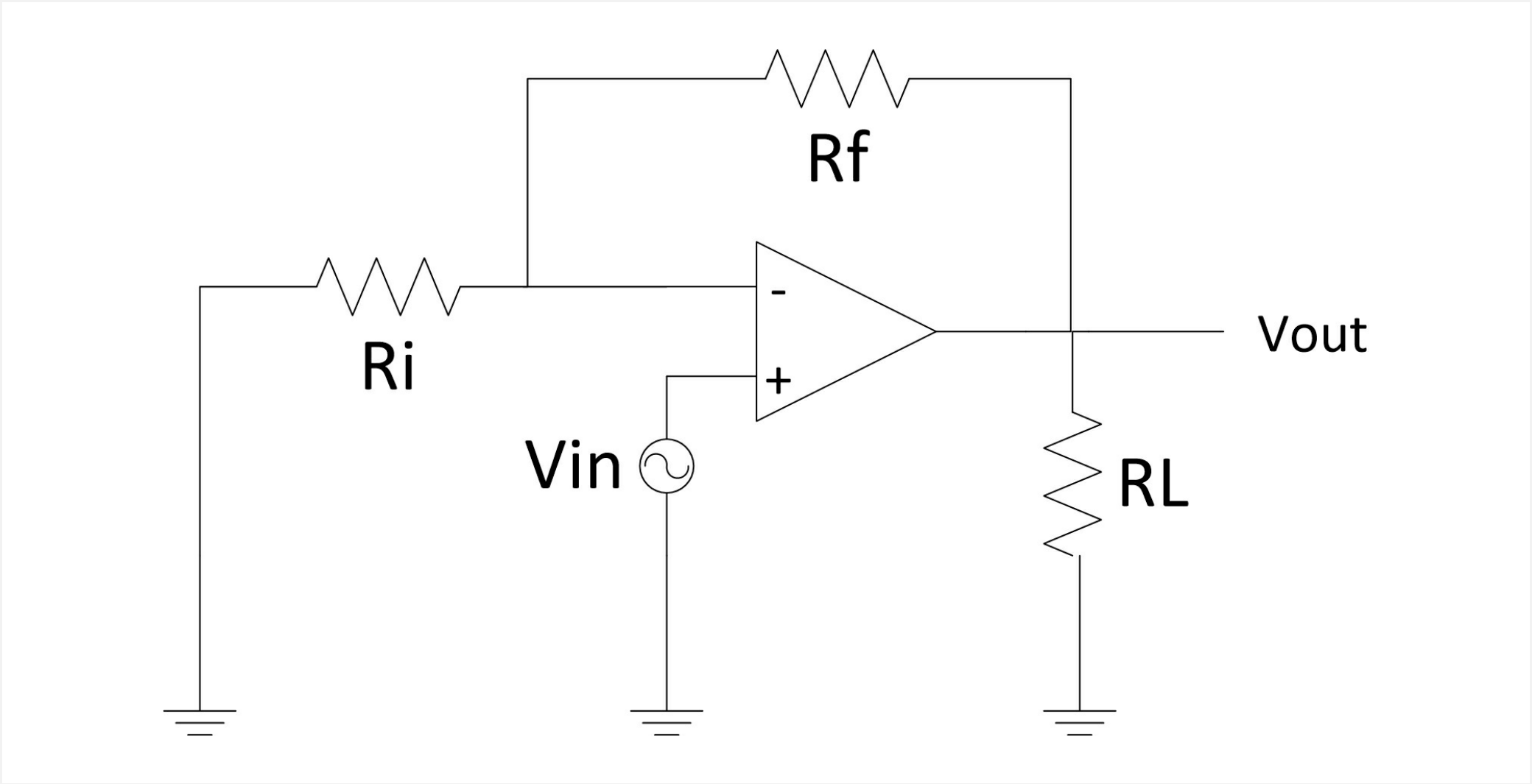
Gitt diodekretsen vist i figuren hvor V_D er spenningen over dioden og V_R spenningen over resistoren R . Anta at dioden er ideell med t barrierespenning $V_f=0.6$ volt, mens breakdown-spenningen er $V_{br}=-50$ volt, og $V_{in} = 5\sin(t)$.

1. Hva er det største spenningefallet målt i absoluttverdi (dvs enten postivt eller negativt) over resistoren R ?
2. Hva er det største spenningefallet målt i absoluttverdi (dvs enten postivt eller negativt) over dioden?
3. Hva er V_R når $V_{in} = 5$ volt?
4. Hva er V_D når $V_{in}=-5$ volt?

Skriv ditt svar her...

Maks poeng: 10

7



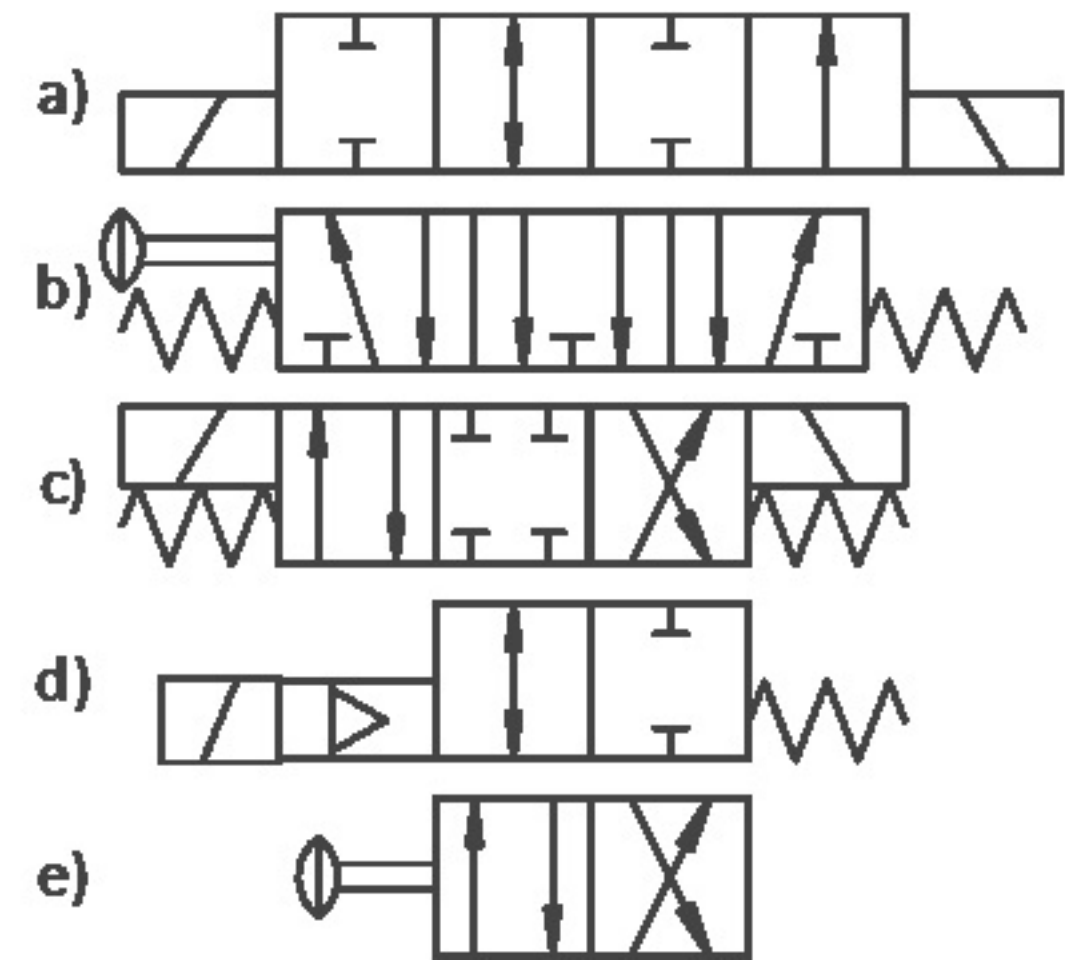
Gitt kretsen i figuren. Anta at opamp'en er ideell hvis ikke annet er angitt, og videre at $R_f = 240\text{ k}\Omega$, $R_L = 25\text{ k}\Omega$ og $V_{in} = 1 + \sin(t)$ volt

- 1. Hva må R_i være for at kretsen skal gi en forsterkning $A = 25$?
- 2. Hva er den maksimale effekten lastmotstanden R_L må tåle for det gitte input-signalet?
- 3. Hva slags krets får vi hvis $R_f = 0$ og $R_i = \infty$?
- 4. Anta nå at opampen ikke lenger er ideell; blant annet er R_{out} ikke lenger lik 0. Hvordan vil dette påvirke hvor mye effekt R_L må tåle?

Skriv ditt svar her...

Maks poeng: 10

8



Hvilke av disse ventilene har ikke avklart startverdi?

Velg ett eller flere alternativer

- ☐ d)
- ☐ e)
- ☐ a)
- ☐ Ingen
- ☐ b)
- ☐ c)

Hvilke av ventilene er normalt (default) helt lukket?

Velg ett eller flere alternativer

- ☐ a)
- ☐ d)
- ☐ ingen
- ☐ e)
- ☐ b)
- ☐ c)

Hvilke av ventilene kan stilles manuelt?

Velg ett eller flere alternativer

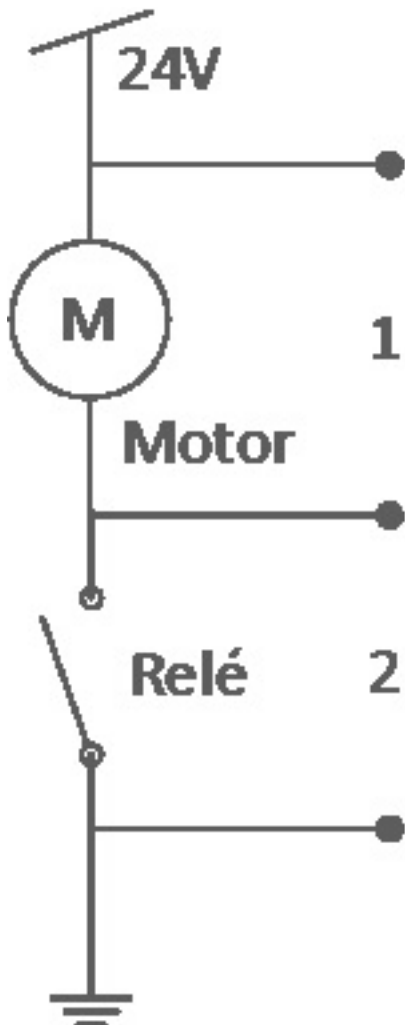
- ☐ c)
- ☐ ingen
- ☐ b)
- ☐ a)
- ☐ e)
- ☐ d)

Pilotbaserte magnetventiler...

- ☐ ... brukes bare til hydraulikk
- ☐ ... er normalt avhengig av trykkforskjeller for å virke
- ☐ ... brukes for å klare seg med mindre solenoider enn rene magnetventiler
- ☐ ... kan brukes i hydrauliske systemer
- ☐ ... kan brukes i pneumatiske systemer
- ☐ ... er raskere enn andre magnetventiler
- ☐ ...er enklere mekanisk enn andre ventiler
- ☐ ... trenger større magneter enn andre magnetventiler
- ☐ ... er uavhengig av trykkforskjeller

Maks poeng: 2.5

9

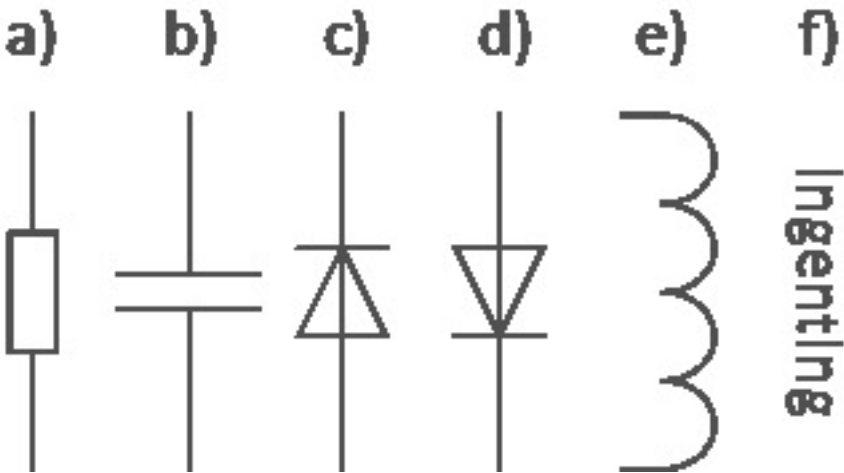


En DC-motor og et relé er koblet som vist på skjemaet over. Reléet brukes til å skru motoren av og på og er koblet til styringslogikk som vi ikke ser på skjemaet.

I det motoren skrur av høres en frese/knitrelyd til motoren stopper, og etterpå lukter det litt svidd. I denne oppgaven skal du sikre at denne kretsen blir trygg og kan fungere over lang tid.

På koblingsbrettet er det plass til én komponent i parallell med motoren (1), og én komponent i parallell med reléet (2). *I denne oppgaven fins det ikke andre koblingsmuligheter.*

Valgene for komponenter (og orientering) er følgende:



Velg hvilken komponent som bør brukes på plass 1.

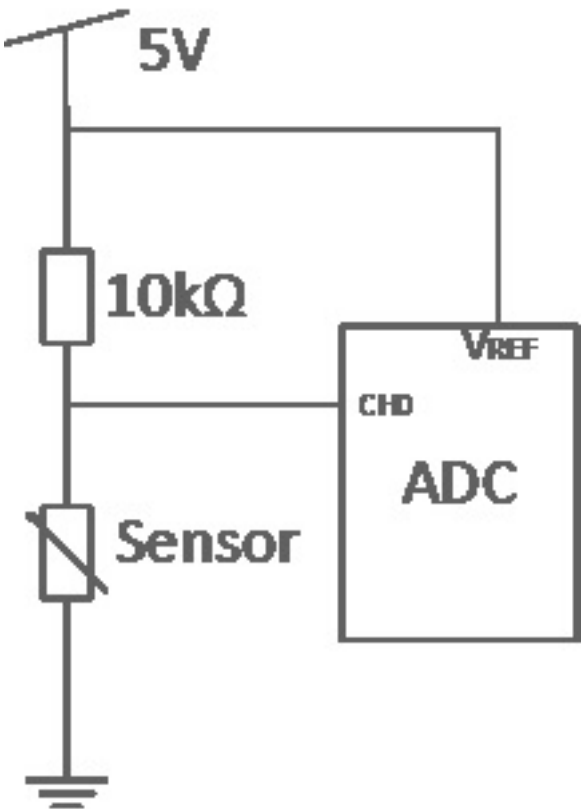
- ☐ a) resistoren
- ☐ e) spolen
- ☐ f) ingenting
- ☐ d) dioden som peker ned
- ☐ b) kondensatoren
- ☐ c) dioden som peker opp

Velg hvilken komponent som bør brukes på plass 2.

- ☐ a) resistoren
- ☐ e) spolen
- ☐ f) ingenting
- ☐ c) dioden som peker opp
- ☐ d) dioden som peker ned
- ☐ b) kondensatoren

Maks poeng: 2

10



I et måleoppsett har vi en motstandsbasert sensor koblet i en spenningsdeler og en analog til digital konverter (ADC) som vist på skjemaet over. Sensoren har en motstand som kan variere fra 5kΩ til 20kΩ. Uten ytre påvirkning har sensoren en motstand på 10kΩ. AD-konverteren er av typen LTC1098 (Se [forkortet] datablad). Forsyningsspenningen til AD-konverteren er 5V , og AD-konverteren er koblet videre til et kontrollsystem som lar oss lese av verdiene den måler (vises ikke på skjema).

Vi tar som utgangspunkt for oppgaven at AD vil gi 0 som digital output for 0 volt på CH0, og maksimal digital verdi for samme spenning som VREF på CH0.

Alle tallsvar i denne oppgaven skal oppgis med titalssystem/ desimaltall.

Hva er den laveste digitale AD-verdien vi kan lese av med dette oppsettet?

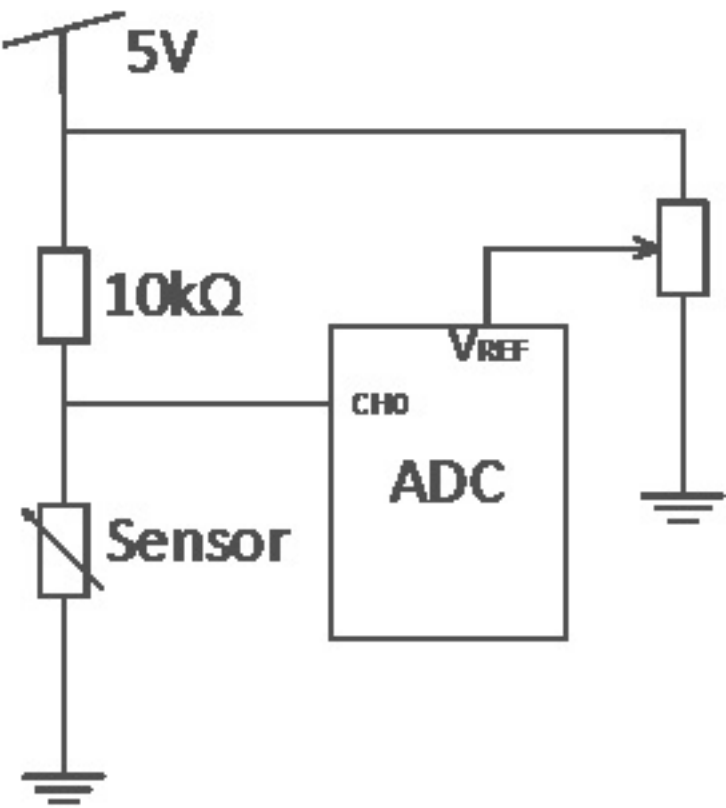
a)

Hva er den høyeste digitale AD-verdien vi kan lese av med dette oppsettet?

b)

Ved hvilket frekvensområde kan vi bruke denne AD-konverteren uten å få aliasing?

- c) Fra kHz
- d) til kHz



Ved å koble et potensiometer til Vref som vist på figuren over, kan vi bestemme måleområdet til AD-konverteren.

Hvilken verdi bør spenningsreferansen (VREF) ha for at vi skal få utnyttet det dynamiske området til sensor og ADC så mye som mulig? (oppgi svar med 0,1V presisjon eller 2 siffer)

- e) V

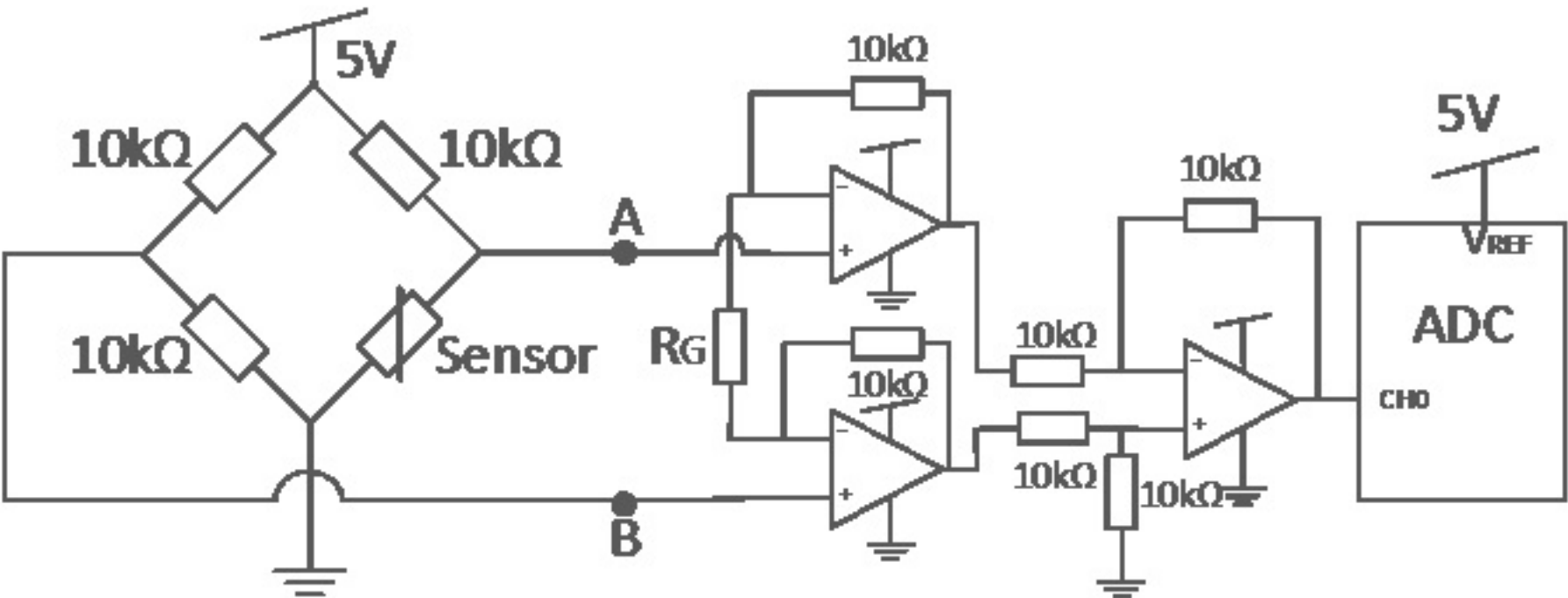
Vi lar sensoren være upåvirket, og bruker de digitale verdiene til AD-konverteren til å hjelpe oss mens vi justerer potensiometeret.

Hvilken verdi bør AD-konverteren vise når vi har optimal spenningsreferanse (VREF)?

- f)

Maks poeng: 7.5

11



I et måleoppsett har vi en motstandsbasert sensor koblet i en wheatstone bru som er koblet til en instrumenteringsforsterker som går til en analog til digital konverter (ADC) som vist på skjemaet over. Sensoren har en motstand som kan variere fra 5kΩ til 20kΩ. Uten ytre påvirkning har sensoren en motstand på 10kΩ. AD-konverteren er av typen LTC1098 (Se datablad). AD-konverteren er koblet videre til et kontrollsystem som lar oss lese av verdiene den måler (vises ikke på skjema).

- a) Hva er maksimal og minimal verdi for spenningsforskjell i A (Amax-Amin) og B (Bmax - Bmin)

Velg ett alternativ

- ☐ A: 0,83V, B: 0,83V
- ☐ A: 2,00V, B: 1,00V
- ☐ A: 0,83V, B: 0V
- ☐ A: 1,67V, B: 0V
- ☐ A: 3,00V, B: -3,00V

b) I denne oppgaven har vi en wheatstone bru istedenfor en enkel spenningsdeler (forrige oppgave). Under står det noen påstander. Kryss av for de som er sanne

Velg ett eller flere alternativer

- ☐ Vi får (minst) like stort dynamisk område med en wheatstone-bru som med en spenningsdeler.
- ☐ Vi får alltid et mindre dynamisk område med wheatstone-bru enn bare én spenningsdeler, men det veies opp med bedre støyegenskaper for målekretsen totalt.
- ☐ En instrumenteringsforsterker er bra fordi den har lav inngangsimpedans.
- ☐ Wheatstone-bru med differensiell forsterkning gir bedre signal-støyforhold enn bare en spenningsdeler når utslaget er lite i forhold til støyen.
- ☐ Vi må ha en instrumenteringsforsterker for å kunne bruke en wheatstone bru.
- ☐ Hvis vi kun bruker én differensiell opamp som forsterker vil forsterkerleddet forstyrre avlesningen mer enn med en instrumenteringsforsterker.

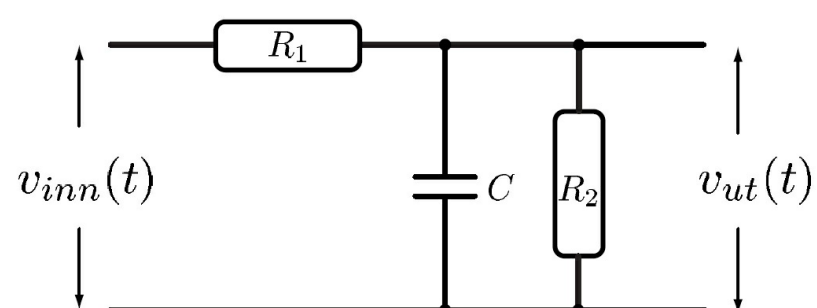
c) Hvilken verdi for RG må vi ha for å utnytte det dynamiske området til AD-konverteren maksimalt?

Velg ett alternativ

- ☐ 20k Ω
- ☐ 36k Ω
- ☐ 33k Ω
- ☐ 30k Ω
- ☐ 10k Ω

Maks poeng: 6

12 For inngangsspenningen $v_{inn}(t) = \cos(\omega t)$, hva blir utgangsspenningen $v_{ut}(t)$?

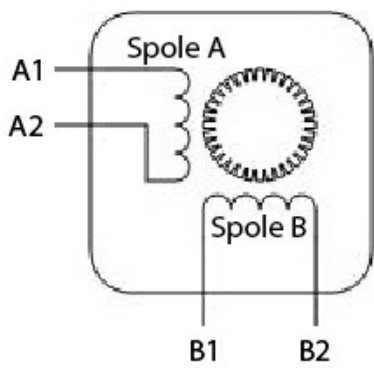


Velg ett svar

- ☐ $v_{ut}(t) = \frac{R_2}{\sqrt{(R_1+R_2)^2 + (R_1 R_2 \omega C)^2}} \cdot e^{j\omega t}$
- ☐ $v_{ut}(t) = \frac{R_2 \omega C}{\sqrt{(R_1+R_2)^2 + (R_1 R_2 \omega C)^2}} \cdot \cos(\omega t + \phi)$
- ☐ $v_{ut}(t) = \frac{R_2}{\sqrt{(R_1+R_2)^2 + (R_1 R_2 \omega C)^2}} \cdot \cos(\omega t + \phi)$
- ☐ $v_{ut}(t) = \frac{R_2}{R_1+R_2+R_1 R_2 \omega C} \cdot \sin(\omega t + \phi)$
- ☐ $v_{ut}(t) = \frac{R_2}{R_1+R_2+R_1 R_2 \omega C} \cdot \cos(\omega t + \phi)$

Maks poeng: 4

- 13
- Vi har en bipolar steppermotor med 2 spoler A og B. Vi tenker oss et arrangement der vi styrer spenningene over spolene fra vår Arduino mikrokontroller. Vi tenker oss at "pinA1" og "pinA2" direkte setter spenningene over spole A (se figuren under) via en motordriver. En HØY verdi på pinne "pinA1" setter 5V på ledning A1, en LAV verdi på pinne "pinA1" setter 0V på ledning A1 osv. Tilsvarende for pinA2, pinB1 og pinB2. Vi trenger ikke tenke på hvordan motordriveren virker. Motoren skal rotere med en jevn stepphastighet i en retning. Under er det vist en liten sekvens av koden som styrer motoren.



```
digitalWrite(pinA1, LOW);
digitalWrite(pinA2, HIGH);
delay(d);
digitalWrite(pinB1, LOW);
digitalWrite(pinB2, HIGH);
delay(d);
digitalWrite(pinA1, HIGH);
digitalWrite(pinA2, LOW);
delay(d);
digitalWrite(pinB1, HIGH);
digitalWrite(pinB2, LOW);
delay(d);
```

Hvilken kommuteringstype produserer Arduinokoden?

Velg ett alternativ

- ☐ Mikrostepp
- ☐ Ingen av delene
- ☐ Wave
- ☐ Fullstepp
- ☐ Halvstepp

Maks poeng: 3

- 14

For en steppermotor som vist i databladet med spesifisert vinkel på 1.8 grader mellom hver fullstep-posisjon, anta at vi wave-kommuterer den med en forsinkelse på 20ms mellom hver wavestep-posisjon, hva blir omdreiningshastigheten?
Velg ett svar

☐ 20 rpm

☐ 48 rpm

☐ 30 rpm

☐ 15 rpm

☐ 24 rpm

Maks poeng: 4

- 15

For en DC motor, hvilket utsagn er riktig for en steady state situasjon? Med belastning mener vi dreiemomentet lasten yter på motoren, og med hastighet mener vi vinkelhastighet. Effekt inn er gitt av spenning ganger strøm. Effekt ut (uten tap) er gitt av dreiemoment*vinkelhastighet.
Velg ett svar

☐ Når belastningen er konstant, er hastigheten omtrent lineært avhengig av påført spenning. Når påført spenning er konstant er hastigheten omtrent lineært avhengig av belastningen

☐ Den induserte spenningen øker med belastningen. Maksimal hastighet er omtrent gitt av spenning delt på motorkonstant

☐ Belastningen er omtrent proposjonal med strømmen. Effekt inn er størst ved maksimal hastighet

☐ Belastningen er omtrent proposjonal med strømmen. Effekt inn og ut er størst ved minimal hastighet, derfor må aldri en DC motor belastes for fullt før den kommer opp i en viss hastighet

☐ Så lenge motoren ikke overbelastes er hastighet for en gitt spenning uavhengig av belastningen. Hastigheten er gitt av motorkonstantene

Maks poeng: 6

- 16

Vi skal lage Arduinokode for å lese av en rotasjons quadraturenkoder. Quadratursignalet skal gjøres om til en variabel som representerer vinkelen. Et eksempel på en rotasjons quadraturenkoder er vist i medfølgende datablad. Koden her er laget for lesbarhet og ikke optimalisert.
Velg ett svar

```
// ----- start kode
```

```
int vinkel;
```

```
void setup() {
```

```
  pinMode(13, INPUT); // fase A
```

```
  pinMode(12, INPUT); // fase B
```

```
}
```

```
void loop() {
```

```
  int a = digitalRead(13);
```

```
  int b = digitalRead(12);
```

```
  if (a==LOW && b==LOW)
```

```
    vinkel = 0;
```

```
  if (a==HIGH && b==LOW)
```

```
    vinkel = 1;
```

```
  if (a==LOW && b==HIGH)
```

```
    vinkel = 2;
```

```
  if (a==HIGH && b==HIGH)
```

```
    vinkel = 3;
```

```
}
```

```
// ----- slutt kode
```

```
// ----- start kode
```

```
int vinkel;
```

```
int currentState, nextState;
```

```
void setup() {
```

```
  pinMode(13, INPUT); // fase A
```

```
  pinMode(12, INPUT); // fase B
```

```
  currentState = 0;
```

```
}
```

```
void loop() {
```

```
  int a = digitalRead(13);
```

```
  int b = digitalRead(12);
```

```
  if (a==LOW && b==LOW)
```

```
    nextState = 0;
```

```
  if (a==HIGH && b==LOW)
```

```
    nextState = 1;
```

```
  if (a==HIGH && b==HIGH)
```

```
    nextState = 2;
```

```
  if (a==LOW && b==HIGH)
```

```
    nextState = 3;
```

```
  if ( (nextState == (currentState+1)) or (nextState==0 and currentState==3) )
```

```
    vinkel++;
```

```
  if ( (nextState== (currentState-1)) or (nextState==3 and currentState==0) )
```

```
    vinkel--;
```

```
  currentState = nextState;
```

```
}
```

```
// ----- slutt kode
```

```
// ----- start kode
```

```
int vinkel;
```

```
void setup() {
```

```
  pinMode(13, INPUT); // fase A
```

```
  pinMode(12, INPUT); // fase B
```

```
}
```

```
void loop() {
```

```
  int a = digitalRead(13);
```

```
  int b = digitalRead(12);
```

```
  if (a==HIGH && b==LOW)
```

```
    vinkel++;
```

```
  if (a==LOW && b==HIGH)
```

```
    vinkel--;
```

```
}
```

```
// ----- slutt kode
```

```
// ----- start kode
int vinkel;
void setup() {
  pinMode(13, INPUT); // fase A
  pinMode(12, INPUT); // fase B
}
void loop() {
  int a = digitalRead(13);
  int b = digitalRead(12);

  if (a==HIGH && b==LOW)
    vinkel--;
  if (a==LOW && b==HIGH)
    vinkel++;
}
// ----- slutt kode

// ----- start kode
int vinkel;
int currentState, nextState;
void setup() {
  pinMode(13, INPUT); // fase A
  pinMode(12, INPUT); // fase B
  currentState = 0;
}
void loop() {
  int a = digitalRead(13);
  int b = digitalRead(12);
  if (a==LOW && b==LOW)
    nextState = 0;
  if (a==LOW && b==HIGH)
    nextState = 1;
  if (a==HIGH&& b==LOW)
    nextState = 2;
  if (a==HIGH && b==HIGH)
    nextState = 3;
  if (nextState>currentState or (nextState==0 and currentState==3) )
    vinkel++;
  if (nextState<currentState or (nextState==3 and currentState==0))
    vinkel--;
  currentState = nextState;
}
// ----- slutt kode
```

Maks poeng: 8

17 Vi ønsker å styre en DC motor med en H-bru av typen TB6612FNG se vedlagte datablad. Vi setter opp og kobler

- TB6612FNG's pinne IN1 (AIN1) til Arduino's pinne 13,
- TB6612FNG's pinne IN2 (AIN2) til Arduino's pinne 12,
- TB6612FNG's pinne PWM (PWMA) til Arduino's pinne 11,
- TB6612FNG's pinne STBY til Arduino's pinne 10
- TB6612FNG's pinner OUT1 (AO1), og OUT2 (AO2) kobles til DC motoren.

Vi tilordner følgende konstanter

```
IN1 = 13;
IN2 = 12;
PWM = 11;
STBY = 10;
```

Hvilke av følgende kodesekvenser vil kjøre motoren med konstant spenning i kun en retning, samt stoppe

IN1080-V19
motoren?

Velg ett alternativ

- ☐

```
// ----- start kode
digitalWrite(STBY, HIGH);
digitalWrite(PWM, HIGH);
digitalWrite(IN1, HIGH);
digitalWrite(IN2, HIGH);
dealy(1000);
digitalWrite(STBY, LOW);
// ----- slutt kode
```
- ☐

```
// ----- start kode
digitalWrite(STBY, HIGH);
digitalWrite(PWM, HIGH);
digitalWrite(IN1, LOW);
digitalWrite(IN2, HIGH);
dealy(1000);
digitalWrite(IN1, HIGH);
// ----- slutt kode
```
- ☐

```
// ----- start kode
digitalWrite(STBY, HIGH);
digitalWrite(PWM, HIGH);
digitalWrite(IN1, HIGH);
digitalWrite(IN2, LOW);
dealy(1000);
digitalWrite(IN1, LOW);
digitalWrite(IN2, HIGH);
// ----- slutt kode
```
- ☐

```
// ----- start kode
digitalWrite(STBY, HIGH);
digitalWrite(PWM, LOW);
digitalWrite(IN1, HIGH);
digitalWrite(IN2, HIGH);
dealy(1000);
digitalWrite(IN1, LOW);
digitalWrite(IN2, LOW);
// ----- slutt kode
```
- ☐

```
// ----- start kode
digitalWrite(STBY, HIGH);
digitalWrite(PWM, HIGH);
digitalWrite(IN1, HIGH);
digitalWrite(IN2, HIGH);
dealy(1000);
digitalWrite(PWM, LOW);
digitalWrite(IN1, LOW);
digitalWrite(IN2, LOW);
// ----- slutt kode
```

Maks poeng: 7

Question 10

Attached



Micropower Sampling 8-Bit Serial I/O A/D Converters

FEATURES

- 80 μ A Maximum Supply Current
- 1nA Typical Supply Current in Shutdown
- 8-Pin SO Plastic Package
- 5V Operation (LTC1096/LTC1098)
- 3V Operation (LTC1096L/LTC1098L) (2.65V Min)
- Sample-and-Hold
- 16 μ s Conversion Time
- 33kHz Sample Rate
- ± 0.5 LSB Total Unadjusted Error Over Temp
- Direct 3-Wire Interface to Most MPU Serial Ports and All MPU Parallel I/O Ports

APPLICATIONS

- Battery-Operated Systems
- Remote Data Acquisition
- Battery Monitoring
- Battery Gas Gauges
- Temperature Measurement
- Isolated Data Acquisition

 LTC and LT are registered trademarks of Linear Technology Corporation.

DESCRIPTION

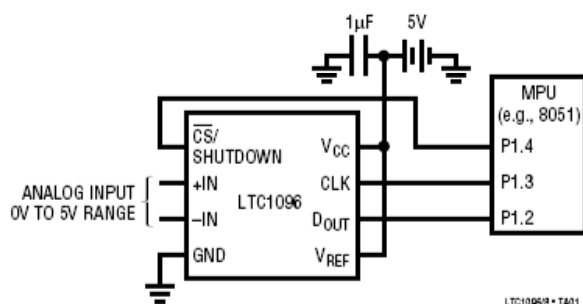
The LTC[®]1096/LTC1096L/LTC1098/LTC1098L are micropower, 8-bit A/D converters that draw only 80 μ A of supply current when converting. They automatically power down to 1nA typical supply current whenever they are not performing conversions. They are packaged in 8-pin SO packages and have both 3V (L) and 5V versions. These 8-bit, switched-capacitor, successive approximation ADCs include sample-and-hold. The LTC1096/LTC1096L have a single differential analog input. The LTC1098/LTC1098L offer a software selectable 2-channel MUX.

On-chip serial ports allow efficient data transfer to a wide range of microprocessors and microcontrollers over three wires. This, coupled with micropower consumption, makes remote location possible and facilitates transmitting data through isolation barriers.

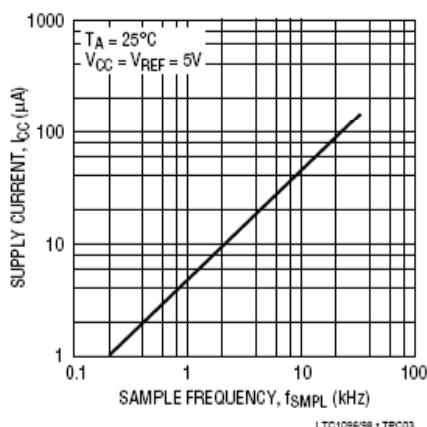
These circuits can be used in ratiometric applications or with an external reference. The high impedance analog inputs and the ability to operate with reduced spans (below 1V full scale) allow direct connection to sensors and transducers in many applications, eliminating the need for gain stages.

TYPICAL APPLICATION

10 μ W, S8 Package, 8-Bit A/D
Samples at 200Hz and Runs Off a 5V Battery



Supply Current vs Sample Rate



ABSOLUTE MAXIMUM RATINGS (Notes 1 and 2)

Supply Voltage (V_{CC}) to GND	12V
Voltage	
Analog and Reference	-0.3V to $V_{CC} + 0.3V$
Digital Inputs	-0.3V to 12V
Digital Outputs	-0.3V to $V_{CC} + 0.3V$
Power Dissipation	500mW
Storage Temperature Range	-65°C to 150°C

Operating Temperature	
LTC1096AC/LTC1096C/LTC1096LC/	
LTC1098AC/LTC1098C/LTC1098LC	0°C to 70°C
LTC1096AI/LTC1096I/LTC1096LI/	
LTC1098AI/LTC1098I/LTC1098LI	-40°C to 85°C
Lead Temperature (Soldering, 10 sec.)	300°C

PACKAGE/ORDER INFORMATION (Notes 3)

TOP VIEW			TOP VIEW		
$\overline{CS}/$ SHUTDOWN	1	8 V_{CC}	$\overline{CS}/$ SHUTDOWN	1	8 V_{CC}
+IN	2	7 CLK	CH0	2	7 CLK
-IN	3	6 D _{OUT}	CH1	3	6 D _{OUT}
GND	4	5 V_{REF}	GND	4	5 V_{REF}
N8 PACKAGE 8-LEAD PLASTIC DIP			S8 PACKAGE 8-LEAD PLASTIC SOIC		
$T_{JMAX} = 150^{\circ}C$, $\theta_{JA} = 130^{\circ}C/W$ (N8) $T_{JMAX} = 150^{\circ}C$, $\theta_{JA} = 175^{\circ}C/W$ (S8)			$T_{JMAX} = 150^{\circ}C$, $\theta_{JA} = 130^{\circ}C/W$ (N8) $T_{JMAX} = 150^{\circ}C$, $\theta_{JA} = 175^{\circ}C/W$ (S8)		
S8 PART MARKING			S8 PART MARKING		
1096	1096I	1096L	1098	1098I	1098L
1096A	1096IA	1096LI	1098A	1098IA	1098LI
ORDER PART NUMBER			ORDER PART NUMBER		
LTC1096ACN8			LTC1098ACN8		
LTC1096ACS8			LTC1098ACS8		
LTC1096AIN8			LTC1098AIN8		
LTC1096AIS8			LTC1098AIS8		
LTC1096CN8			LTC1098CN8		
LTC1096CS8			LTC1098CS8		
LTC1096IN8			LTC1098IN8		
LTC1096IS8			LTC1098IS8		
LTC1096LCS8			LTC1098LCS8		
LTC1096LIS8			LTC1098LIS8		

Consult factory for Military grade parts.

RECOMMENDED OPERATING CONDITIONS

LTC1096/LTC1098

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{CC}	Supply Voltage	LTC1096 LTC1098	3.0 3.0		9 6	V V
$V_{CC} = 5V$ Operation						
f_{CLK}	Clock Frequency	$V_{CC} = 5V$	25	500		kHz
t_{CYC}	Total Cycle Time	LTC1096, $f_{CLK} = 500kHz$ LTC1098, $f_{CLK} = 500kHz$	29 29			μs μs
t_{HDI}	Hold Time, D_{IN} After $CLK\uparrow$	$V_{CC} = 5V$	150			ns
$t_{su\overline{CS}}$	Setup Time $\overline{CS}\downarrow$ Before First $CLK\uparrow$ (See Operating Sequence)	$V_{CC} = 5V$, LTC1096 $V_{CC} = 5V$, LTC1098	500 500			ns ns
t_{WAKEUP}	Wake-Up Time $\overline{CS}\downarrow$ Before First $CLK\downarrow$ After First $CLK\uparrow$ (See Figure 1 LTC1096 Operating Sequence)	$V_{CC} = 5V$, LTC1096	10			μs
	Wake-Up Time $\overline{CS}\downarrow$ Before MSBF Bit $CLK\downarrow$ (See Figure 2 LTC1098 Operating Sequence)	$V_{CC} = 5V$, LTC1098	10			μs
t_{suDI}	Setup Time, D_{IN} Stable Before $CLK\uparrow$	$V_{CC} = 5V$	400			ns
t_{WHCLK}	CLK High Time	$V_{CC} = 5V$	0.8			μs

RECOMMENDED OPERATING CONDITIONS

LTC1096/LTC1098

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
t_{WLCLK}	CLK Low Time	$V_{CC} = 5V$	0.8			μs
t_{WHCS}	$\overline{CS}$ High Time Between Data Transfer Cycles	$V_{CC} = 5V$	1			μs
t_{WLCS}	$\overline{CS}$ Low Time During Data Transfer	LTC1096, $f_{CLK} = 500kHz$ LTC1098, $f_{CLK} = 500kHz$	28 28			μs μs

$V_{CC} = 3V$ Operation

f_{CLK}	Clock Frequency	$V_{CC} = 3V$	25		250	kHz
t_{CYC}	Total Cycle Time	LTC1096, $f_{CLK} = 250kHz$ LTC1098, $f_{CLK} = 250kHz$	58 58			μs μs
t_{HDI}	Hold Time, D_{IN} After $CLK\uparrow$	$V_{CC} = 3V$	450			ns
t_{suCS}	Setup Time $\overline{CS}\downarrow$ Before First $CLK\uparrow$ (See Operating Sequence)	$V_{CC} = 3V$, LTC1096 $V_{CC} = 3V$, LTC1098	1 1			μs μs
t_{WAKEUP}	Wake-Up Time $\overline{CS}\downarrow$ Before First $CLK\downarrow$ After First $CLK\uparrow$ (See Figure 1 LTC1096 Operating Sequence)	$V_{CC} = 3V$, LTC1096	10			μs
	Wake-Up Time $\overline{CS}\downarrow$ Before MSBF Bit $CLK\downarrow$ (See Figure 2 LTC1098 Operating Sequence)	$V_{CC} = 3V$, LTC1098	10			μs
t_{suDI}	Setup Time, D_{IN} Stable Before $CLK\uparrow$	$V_{CC} = 3V$	1			μs
t_{WHCLK}	CLK High Time	$V_{CC} = 3V$	1.6			μs
t_{WLCLK}	CLK Low Time	$V_{CC} = 3V$	1.6			μs
t_{WHCS}	$\overline{CS}$ High Time Between Data Transfer Cycles	$V_{CC} = 3V$	2			μs
t_{WLCS}	$\overline{CS}$ Low Time During Data Transfer	LTC1096, $f_{CLK} = 250kHz$ LTC1098, $f_{CLK} = 250kHz$	56 56			μs μs

LTC1096L/LTC1098L

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{CC}	Supply Voltage		2.65		4.0	V
f_{CLK}	Clock Frequency	$V_{CC} = 2.65V$	25		250	kHz
t_{CYC}	Total Cycle Time	LTC1096L, $f_{CLK} = 250kHz$ LTC1098L, $f_{CLK} = 250kHz$	58 58			μs μs
t_{HDI}	Hold Time, D_{IN} After $CLK\uparrow$	$V_{CC} = 2.65V$	450			ns
t_{suCS}	Setup Time $\overline{CS}\downarrow$ Before First $CLK\uparrow$ (See Operating Sequence)	$V_{CC} = 2.65V$, LTC1096L $V_{CC} = 2.65V$, LTC1098L	1 1			μs μs
t_{WAKEUP}	Wake-Up Time $\overline{CS}\downarrow$ Before First $CLK\downarrow$ After First $CLK\uparrow$ (See Figure 1, LTC1096L Operating Sequence)	$V_{CC} = 2.65V$, LTC1096L	10			μs
	Wake-Up Time $\overline{CS}\downarrow$ Before MSBF Bit $CLK\downarrow$ (See Figure 2, LTC1098L Operating Sequence)	$V_{CC} = 2.65V$, LTC1098L	10			μs
t_{suDI}	Setup Time, D_{IN} Stable Before $CLK\uparrow$	$V_{CC} = 2.65V$	1			μs
t_{WHCLK}	CLK High Time	$V_{CC} = 2.65V$	1.6			μs
t_{WLCLK}	CLK Low Time	$V_{CC} = 2.65V$	1.6			μs
t_{WHCS}	$\overline{CS}$ High Time Between Data Transfer Cycles	$V_{CC} = 2.65V$	2			μs
t_{WLCS}	$\overline{CS}$ Low Time During Data Transfer	LTC1096L, $f_{CLK} = 250kHz$ LTC1098L, $f_{CLK} = 250kHz$	56 56			μs μs

CONVERTER AND MULTIPLEXER CHARACTERISTICS

LTC1096/LTC1098

$V_{CC} = 5V$, $V_{REF} = 5V$, $f_{CLK} = 500kHz$, unless otherwise noted.

PARAMETER	CONDITIONS		LTC1096A/LTC1098A			LTC1096/LTC1098			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Resolution (No Missing Code)		●	8			8			Bits
Offset Error		●	±0.5			±0.5			LSB
Linearity Error	(Note 4)	●	±0.5			±0.5			LSB
Full Scale Error		●	±0.5			±1.0			LSB
Total Unadjusted Error (Note 5)	V _{REF} = 5.000V	●	±0.5			±1.0			LSB
Analog Input Range	(Notes 6, 7)		−0.05V to V _{CC} + 0.05V						V
REF Input Range (Notes 6, 7)	4.5 ≤ V _{CC} ≤ 6V 6V < V _{CC} ≤ 9V, LTC1096		−0.05V to V _{CC} + 0.05V −0.05V to 6V						V V
Analog Input Leakage Current	(Note 8)	●	±1.0			±1.0			μA

LTC1096/LTC1098

$V_{CC} = 3V$, $V_{REF} = 2.5V$, $f_{CLK} = 250kHz$, unless otherwise noted.

PARAMETER	CONDITIONS		LTC1096A/LTC1098A			LTC1096/LTC1098			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Resolution (No Missing Code)		●	8			8			Bits
Offset Error		●	±0.75			±1.0			LSB
Linearity Error	(Notes 4, 9)	●	±0.5			±1.0			LSB
Full-Scale Error		●	±1.0			±1.0			LSB
Total Unadjusted Error (Notes 5, 9)	V _{REF} = 2.500V	●	±1.0			±1.5			LSB
Analog Input Range	(Notes 6, 7)		−0.05V to V _{CC} + 0.05V						V
REF Input Range (Notes 6, 7, 9)	3V ≤ V _{CC} ≤ 6V		−0.05V to V _{CC} + 0.05V						V
Analog Input Leakage Current	(Notes 8, 9)	●	±1.0			±1.0			μA

LTC1096L/LTC1098L

$V_{CC} = 2.65V$, $V_{REF} = 2.5V$, $f_{CLK} = 250kHz$, unless otherwise noted.

PARAMETER	CONDITIONS		LTC1096L/LTC1098L			UNITS
			MIN	TYP	MAX	
Resolution (No Missing Code)		●	8			Bits
Offset Error		●	± 1.0			LSB
Linearity Error	(Note 4)	●	± 1.0			LSB
Full-Scale Error		●	± 1.0			LSB
Total Unadjusted Error (Notes 5)	$V_{REF} = 2.5V$	●	± 1.5			LSB
Analog Input Range	(Notes 6, 7)		$-0.05V$ to $V_{CC} + 0.05V$			V
REF Input Range (Note 6)	$2.65V \leq V_{CC} \leq 4.0V$		$-0.05V$ to $V_{CC} + 0.05V$			V
Analog Input Leakage Current	(Note 8)	●	± 1.0			μA

DIGITAL AND DC ELECTRICAL CHARACTERISTICS

LTC1096/LTC1098

$V_{CC} = 5V$, $V_{REF} = 5V$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IH}	High Level Input Voltage	$V_{CC} = 5.25V$	●	2.0		V
V_{IL}	Low Level Input Voltage	$V_{CC} = 4.75V$	●		0.8	V
I_{IH}	High Level Input Current	$V_{IN} = V_{CC}$	●		2.5	μA
I_{IL}	Low Level Input Current	$V_{IN} = 0V$	●		-2.5	μA
V_{OH}	High Level Output Voltage	$V_{CC} = 4.75V$, $I_O = 10\mu A$ $V_{CC} = 4.75V$, $I_O = 360\mu A$	● ●	4.5 2.4	4.74 4.72	V V
V_{OL}	Low Level Output Voltage	$V_{CC} = 4.75V$, $I_O = 1.6mA$	●		0.4	V
I_{OZ}	Hi-Z Output Leakage	$\overline{CS} \geq V_{IH}$	●		± 3.0	μA
I_{SOURCE}	Output Source Current	$V_{OUT} = 0V$		-25		mA
I_{SINK}	Output Sink Current	$V_{OUT} = V_{CC}$		45		mA
I_{REF}	Reference Current	$\overline{CS} = V_{CC}$ $t_{CYC} \geq 200\mu s$, $f_{CLK} \leq 50kHz$ $t_{CYC} = 29\mu s$, $f_{CLK} = 500kHz$	● ● ●	0.001 3.500 35.000	2.5 7.5 50.0	μA μA μA
I_{CC}	Supply Current	$\overline{CS} = V_{CC}$	●	0.001	3.0	μA
		LTC1096, $t_{CYC} \geq 200\mu s$, $f_{CLK} \leq 50kHz$	●	40	80	μA
		LTC1096, $t_{CYC} = 29\mu s$, $f_{CLK} = 500kHz$	●	120	180	μA
		LTC1098, $t_{CYC} \geq 200\mu s$, $f_{CLK} \leq 50kHz$	●	44	88	μA
		LTC1098, $t_{CYC} = 29\mu s$, $f_{CLK} = 500kHz$	●	155	230	μA

LTC1096/LTC1098

$V_{CC} = 3V$, $V_{REF} = 2.5V$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IH}	High Level Input Voltage	$V_{CC} = 3.6V$	●	1.9		V
V_{IL}	Low Level Input Voltage	$V_{CC} = 3V$	●		0.45	V
I_{IH}	High Level Input Current (Note 9)	$V_{IN} = V_{CC}$	●		2.5	μA
I_{IL}	Low Level Input Current (Note 9)	$V_{IN} = 0V$	●		-2.5	μA
V_{OH}	High Level Output Voltage	$V_{CC} = 3V$, $I_O = 10\mu A$ $V_{CC} = 3V$, $I_O = 360\mu A$	● ●	2.3 2.1	2.69 2.64	V V
V_{OL}	Low Level Output Voltage	$V_{CC} = 3V$, $I_O = 400\mu A$	●		0.3	V
I_{OZ}	Hi-Z Output Leakage (Note 9)	$\overline{CS} \geq V_{IH}$	●		± 3.0	μA
I_{SOURCE}	Output Source Current (Note 9)	$V_{OUT} = 0V$		-10		mA
I_{SINK}	Output Sink Current (Note 9)	$V_{OUT} = V_{CC}$		15		mA
I_{REF}	Reference Current (Note 9)	$\overline{CS} = V_{CC}$ $t_{CYC} \geq 200\mu s$, $f_{CLK} \leq 50kHz$ $t_{CYC} = 58\mu s$, $f_{CLK} = 250kHz$	● ● ●	0.001 3.500 35.000	2.5 7.5 50.0	μA μA μA
I_{CC}	Supply Current (Note 9)	$\overline{CS} = V_{CC}$	●	0.001	3.0	μA
		LTC1096, $t_{CYC} \geq 200\mu s$, $f_{CLK} \leq 50kHz$	●	40	80	μA
		LTC1096, $t_{CYC} = 58\mu s$, $f_{CLK} = 250kHz$	●	120	180	μA
		LTC1098, $t_{CYC} \geq 200\mu s$, $f_{CLK} \leq 50kHz$	●	44	88	μA
		LTC1098, $t_{CYC} = 58\mu s$, $f_{CLK} = 250kHz$	●	155	230	μA

DIGITAL AND DC ELECTRICAL CHARACTERISTICS

LTC1096L/LTC1098L

$V_{CC} = 2.65V$, $V_{REF} = 2.5V$, $f_{CLK} = 250kHz$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IH}	High Level Input Voltage	$V_{CC} = 3.6V$	●	1.9		V
V_{IL}	Low Level Input Voltage	$V_{CC} = 2.65V$	●		0.45	V
I_{IH}	High Level Input Current	$V_{IN} = V_{CC}$	●		2.5	μA
I_{IL}	Low Level Input Current	$V_{IN} = 0V$	●		-2.5	μA
V_{OH}	High Level Output Voltage	$V_{CC} = 2.65V$, $I_O = 10\mu A$ $V_{CC} = 2.65V$, $I_O = 360\mu A$	● ●	2.3 2.1	2.64 2.50	V V
V_{OL}	Low Level Output Voltage	$V_{CC} = 2.65V$, $I_O = 400\mu A$	●		0.3	V
I_{OZ}	Hi-Z Output Leakage	$\overline{CS} = \text{High}$	●		± 3.0	μA
I_{SOURCE}	Output Source Current	$V_{OUT} = 0V$		-10		mA
I_{SINK}	Output Sink Current	$V_{OUT} = V_{CC}$		15		mA
I_{REF}	Reference Current	$\overline{CS} = V_{CC}$ $t_{CYC} \geq 200\mu s$, $f_{CLK} \leq 50kHz$ $t_{CYC} = 58\mu s$, $f_{CLK} = 250kHz$	● ● ●	0.001 3.500 35.000	2.5 7.5 50.0	μA μA μA
I_{CC}	Supply Current	$\overline{CS} = V_{CC}$	●	0.001	3.0	μA
		LTC1096L, $t_{CYC} \geq 200\mu s$, $f_{CLK} \leq 50kHz$	●	40	80	μA
		LTC1096L, $t_{CYC} = 58\mu s$, $f_{CLK} = 250kHz$	●	120	180	μA
		LTC1098L, $t_{CYC} \geq 200\mu s$, $f_{CLK} \leq 50kHz$	●	44	88	μA
		LTC1098L, $t_{CYC} = 58\mu s$, $f_{CLK} = 250kHz$	●	155	230	μA

AC CHARACTERISTICS

LTC1096/LTC1098

$V_{CC} = 5V$, $V_{REF} = 5V$, $f_{CLK} = 500kHz$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
t_{SMPL}	Analog Input Sample Time	See Operating Sequence		1.5		CLK Cycles
$f_{SMPL(MAX)}$	Maximum Sampling Frequency	●	33			kHz
t_{CONV}	Conversion Time	See Operating Sequence		8		CLK Cycles
t_{DDO}	Delay Time, $CLK\downarrow$ to D_{OUT} Data Valid	See Test Circuits	●	200	450	ns
t_{dis}	Delay Time, $\overline{CS}\uparrow$ to D_{OUT} Hi-Z	See Test Circuits	●	170	450	ns
t_{en}	Delay Time, $CLK\downarrow$ to D_{OUT} Enable	See Test Circuits	●	60	250	ns
t_{hDO}	Time Output Data Remains Valid After $CLK\downarrow$	$C_{LOAD} = 100pF$		180		ns
t_f	D_{OUT} Fall Time	See Test Circuits	●	70	250	ns
t_r	D_{OUT} Rise Time	See Test Circuits	●	25	100	ns
C_{IN}	Input Capacitance	Analog Inputs On Channel Analog Inputs Off Channel		25 5		pF pF
		Digital Input		5		pF

AC CHARACTERISTICS

LTC1096/LTC1098

$V_{CC} = 3V$, $V_{REF} = 2.5V$, $f_{CLK} = 250kHz$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
t_{SMPL}	Analog Input Sample Time	See Operating Sequence		1.5		CLK Cycles
$f_{SMPL(MAX)}$	Maximum Sampling Frequency		●	16.5		kHz
t_{CONV}	Conversion Time	See Operating Sequence		8		CLK Cycles
t_{dDO}	Delay Time, $CLK\downarrow$ to D_{OUT} Data Valid	See Test Circuits (Note 9)	●	500	1000	ns
t_{dis}	Delay Time, $\overline{CS}\uparrow$ to D_{OUT} Hi-Z	See Test Circuits (Note 9)	●	220	800	ns
t_{en}	Delay Time, $CLK\downarrow$ to D_{OUT} Enable	See Test Circuits (Note 9)	●	160	480	ns
t_{hDO}	Time Output Data Remains Valid After $CLK\downarrow$	$C_{LOAD} = 100pF$		400		ns
t_f	D_{OUT} Fall Time	See Test Circuits (Note 9)	●	70	250	ns
t_r	D_{OUT} Rise Time	See Test Circuits (Note 9)	●	50	150	ns
C_{IN}	Input Capacitance	Analog Inputs On Channel		25		pF
		Analog Inputs Off Channel		5		pF
		Digital Input		5		pF

LTC1096L/LTC1098L

$V_{CC} = 2.65V$, $V_{REF} = 2.5V$, $f_{CLK} = 250kHz$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
t_{SMPL}	Analog Input Sample Time	See Operating Sequence		1.5		CLK Cycles
$f_{SMPL(MAX)}$	Maximum Sampling Frequency		●	16.5		kHz
t_{CONV}	Conversion Time	See Operating Sequence		8		CLK Cycles
t_{dDO}	Delay Time, $CLK\downarrow$ to D_{OUT} Data Valid	See Test Circuits	●	500	1000	ns
t_{dis}	Delay Time, $\overline{CS}\uparrow$ to D_{OUT} Hi-Z	See Test Circuits	●	220	800	ns
t_{en}	Delay Time, $CLK\downarrow$ to D_{OUT} Enable	See Test Circuits	●	160	480	ns
t_{hDO}	Time Output Data Remains Valid After $CLK\downarrow$	$C_{LOAD} = 100pF$		400		ns
t_f	D_{OUT} Fall Time	See Test Circuits	●	70	250	ns
t_r	D_{OUT} Rise Time	See Test Circuits	●	50	200	ns
C_{IN}	Input Capacitance	Analog Inputs On Channel		25		pF
		Analog Inputs Off Channel		5		pF
		Digital Input		5		pF

The ● denotes specifications which apply over the operating temperature range.

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: All voltage values are with respect to GND.

Note 3: For the 8-lead PDIP, consult the factory.

Note 4: Linearity error is specified between the actual and points of the A/D transfer curve.

Note 5: Total unadjusted error includes offset, full scale, linearity, multiplexer and hold step errors.

Note 6: Two on-chip diodes are tied to each reference and analog input which will conduct for reference or analog input voltages one diode drop below GND or one diode drop above V_{CC} . This spec allows 50mV forward bias of either diode. This means that as long as the reference or analog

input does not exceed the supply voltage by more than 50mV, the output code will be correct. To achieve an absolute 0V to 5V input voltage range will therefore require a minimum supply voltage of 4.950V over initial tolerance, temperature variations and loading. For $5.5V < V_{CC} \leq 9V$, reference and analog input range cannot exceed 5.55V. If reference and analog input range are greater than 5.55V, the output code will not be guaranteed to be correct.

Note 7: The supply voltage range for the LTC1096L/LTC1098L is from 2.65V to 4V. The supply voltage range for the LTC1096 is from 3V to 9V, but the supply voltage range for the LTC1098 is only from 3V to 6V.

Note 8: Channel leakage current is measured after the channel selection.

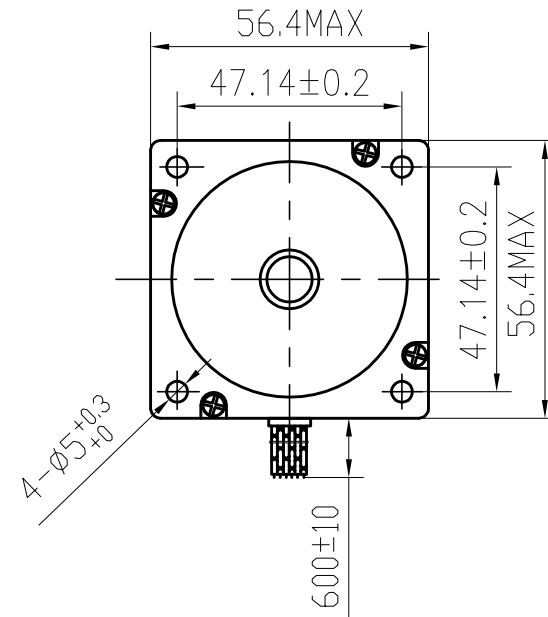
Note 9: These specifications are either correlated from 5V specifications or guaranteed by design.

Question 14

Attached

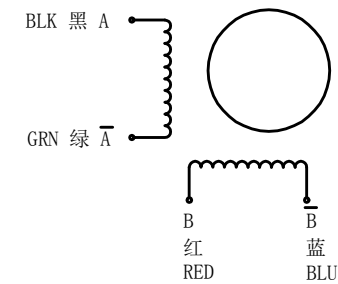


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SPECIFICATIONS *unit=mm*

PHASE	相数	2 PHASE	COMMENT
STEP ANGLE	步距角	1.8± 5 % ° /STEP	
VOLTAGE	静电压	3.2V	
CURRENT	电流	2.0 A/PHASE	
RESISTANCE	电阻	1.6± 10 % Ω/PHASE	
INDUCTANCE	电感	5.5± 20 % mH/PHASE	
HOLDING TORQUE	静转矩	120 N.cm Min	
DETENT TORQUE	定位转矩	3.5 N.cm Max	
INSULATION CLASS	绝缘等级	B	
LEAD STYLE	引出线规格	AWG22 UL1007	
ROTOR TORQUE	转动惯量	280 g.cm ²	



					57BYGH420-2	WANTAI MOTOR		
A								
更改 标记		更改单号	签 名	日 期		等级标记	重 量	比 例
设 计		ANDY	2015.5.7					
审 核					技术规格书			
工 艺						1	共 张	
标准化						www.wantmotor.com		
批 准								

Question 16

Attached



CHINA YUMO ELECTRIC CO.,LIMITED
YUEQING YING'S IMPORT & EXPORT CO.,LTD

ADD: ZHAOYANG INDUSTRIAL ZONE, LIUSHI TOWN, YUEQING CITY, ZHEJIANG, 325604 CHINA

TEL: 0086-577-62791815 FAX: 0086-577-62791825

Http://www.yumoelectric.com E-mail:sales@yingselectric.com

A6A2 series

Incremental Rotary Encoder

YUMO®



◆ **Substitute: E6A2**

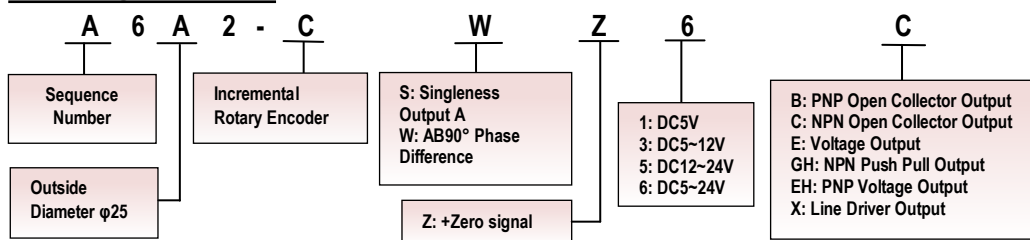
- Mini type encoder
- Outside Diameter $\phi 25$ Model: A6A2

◆ **Features**

Miniature rotary encoder for positioning in space-confined areas

- Wide variety of supply voltages and output forms to match input devices
- Models with zero index function ideal for position applications
- High resolution models (300 or 360 pulses per revolution) substantially improve measuring accuracy
- High response frequency and noise immunity make encoders ideal for factory automation applications

◆ **Ordering Information**



◆ **Note:**

- 1, Please contact sales representative to confirm the correctness and availability of the part number

◆ **Technical Specifications**

Output Phases	Power Supply Voltage	Output Configuration	Substitution	Resolution (pulses/rotation)
Phase A	5 to 12 VDC	Voltage Output	A6A2-CS3E	10, 20, 60, 100, 200, 300, 360
				500
	12 to 24 VDC	Open-collector Output (NPN Output)	A6A2-CS3C	10, 20, 60, 100, 200, 300, 360
			A6A2-CS5C	500
Phase A and B	5 to 12 VDC	Voltage Output	A6A2-CW3E	100 200 360
				500
	12 to 24 VDC	Open-collector Output (NPN Output)	A6A2-CW3C	100 200 360
			A6A2-CW5C	500
Phase A, B, and Z	5 to 12 VDC	Voltage Output	A6A2-CWZ3E	100 200 360
				500
	12 to 24 VDC	Open-collector Output (NPN Output)	A6A2-CWZ3C	100 200 360
			A6A2-CWZ5C	500

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Incremental Rotary Encoder

YUMO®

◆ Ratings and Specifications

Model Item	A6A2- CS3E	A6A2- CS3C	A6A2- CS5C	A6A2- CW3E	A6A2- CW3C	A6A2-CW5C	A6A2- CWZ3E	A6A2- CWZ3 C	A6A2- CWZ5C
Power supply Voltage	5 VDC-5% to 12 V+10%, ripple (p-p): 5% max.		12 VDC- 10% to 24 V+15%, ripple (p-p): 5% max.	5 VDC-5% to 12 V+10%, ripple (p-p): 5% max.		12 VDC-10% to 24 V+15%, ripple (p-p): 5% max.	5 VDC-5% to 12 V+10%, ripple (p-p): 5% max.		12 VDC- 10% to 24 V+15%, ripple (p-p): 5% max.
Current Consumption	30mA max	20mA max		30mA max	20mA max				30mA max
Resolution (See Note1)	10, 20, 60, 100, 200, 300, 360, 500			10, 200, 360, 500					
Output Phases	Phase A			Phase A and B			Phase A, B, and Z		
Output Form	Voltage Output	NPN Open- collector Output		Voltage Output	NPN Open- collector Output		Voltage Output	NPN Open- collector Output	
Output Capacity	Output Resistance: 2KΩ	Applied Voltage: 30VDC max. Sink Current: 30mA max. Residual Voltage: 0.4Vmax (at sink current of 30mA)		Output Resistance: 2KΩ	Applied Voltage: 30VDC max. Sink Current: 30mA max. Residual Voltage: 0.4Vmax (at sink current of 30mA)		Output Resistance: 2KΩ	Applied Voltage: 30VDC max. Sink Current: 30mA max. Residual Voltage: 0.4Vmax (at sink current of 30mA)	
	Output Current: 20mA max.			Output Current: 20mA max.			Output Current: 20mA max.		
	Residual Voltage:0.4V max (Output current: 20mA max.)			Residual Voltage:0.4V max (Output current: 20mA max.)			Residual Voltage:0.4V max (Output current: 20mA max.)		
Maximum Response Frequency	30KHZ								
Phase Difference of Output	---			Phase difference between phases A and B: 90°±45°					
Output Waveform Percentage	50±25%			---					
Output Rise And Fall Times	1.0μs max. (Cable length: 2m, Sink current: 10 mA)	1.0μs max. (Cable length: 2m, Control output voltage: 5V, Load resistance 1kΩ)		1.0μs max. (Cable length: 2m, Sink current: 10 mA)	1.0μs max. (Cable length: 2m, Control output voltage: 5V, Load resistance 1kΩ)		1.0μs max. (Cable length: 2m, Sink current: 10 mA)	1.0μs max. (Cable length: 2m, Control output voltage: 5V, Load resistance 1kΩ)	

◆ Note:

*1. An inrush current of approximately 9A will flow for approximately 0.3ms when the power is turned ON.

*2. The maximum electrical response revolution is determined by the resolution and maximum response frequency as follows :

Maximum Electrical Response Frequency (Rpm) = Maximum Response Frequency/ Resolution*60

This means that the A6A2 encoder will not operate electrically if its shaft speed exceeds the maximum electrical response revolution

*3. No protection is provided against water or oil.

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A6A2 series

Incremental Rotary Encoder

YUMO®

Mechanical Specifications		
Starting Torque	1mN.m max	
Moment Of Inertia	$1 \times 10^{-7} \text{kg.m}^2$ max.	
Shaft Loading	Radial	10N
	Thrust	50N
Mounting Tolerance	Radial: 0.03mm TIR Max; Axial:0.2mm Max; Shaft Runout: 0.1° Max	
Allowable Shaft Load	Radial: 5N; Axial: 3N	
Maximum Rotating Speed	5000 rpm	
Ambient Temperature Range	Operating: -10 to 55°C (with no icing), Storage: -25 to 80°C (with no icing)	
Ambient Humidity Range	Operating/storage:35% to 85% (with no condensation)	
Insulation Resistance	20 MΩ min. (at 500 VDC) between current-carrying parts and case	
Dielectric Strength	500 VAC, 50/60 Hz for 1 min between current-carrying parts and case	
Vibration Resistance	Destruction: 10 to 55 Hz, 1.5-mm double amplitude for 2 hours each in X, Y, and Z directions	
Shock Resistance	Destruction: 500m/s ² 3 times each in X, Y, and Z directions	
Degree Of Protection	IEC 60529 IP50	
Connection Method	Pre-wired Models (Standard cable length: 2 m)	
Weight	Approx. 60g	
Accessories	Coupling, Servo Mounting Bracket (provided with the E6A2-CWZ□), Hexagonal wrench, Instruction manual	

I/O Circuit Diagrams

Model	Output circuits	Output mode	Connection	
A6A2-CS3C A6A2-CS5C	A6A2 main circuit Brown Vcc A6A2-CS3C: +5 to 12 V A6A2-CS5C: +12 to 24V Black, white, orange Output (Black: phase A, White: phase B, Orange: phase Z) 30 VDC 30 mA max. Blue 0 V	Output transistor		
A6A2-CW3C A6A2-CW5C		Direction of rotation: CW (as viewed from end of shaft)	Output transistor	
A6A2-CWZ3C A6A2-CWZ5C		Direction of rotation: CCW (as viewed from end of shaft)	Output transistor	
A6A2-CW3E	A6A2 main circuit Brown Vcc (+5 to 12 V) 2 kΩ Black, white, orange Output (Black: phase A, White: phase B, Orange: phase Z) 20 mA max. Blue 0 V	Direction of rotation: CCW (as viewed from end of shaft)	Output transistor	
A6A2-CWZ3E		Output transistor		
A6A2-CS3E		Output transistor		

Color	Signal
Brown	Vcc
Black	Phase A
White	Phase B
Orange	Phase Z
Blue	0 V (common)

Note: 1. The white and orange wires of Single Models (A6A2-CS□□) do not output signals (no connection).
2. The white and orange wires of Single Models (A6A2-CS□□) do not output signals (no connection).
3. Voltage Output Models are capable of sinking a maximum current of 20 mA.

Note: 1. *(H) and (L) indicate the output levels of Voltage Output Models.
2. Output A leads B by $1/4 T \pm 1/8 T$ when the shaft revolves clockwise, while A lags behind B by $1/4 T \pm 1/8 T$ when the shaft revolves counterclockwise.

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TEL: 0086-577-62791815 FAX: 0086-577-62791825

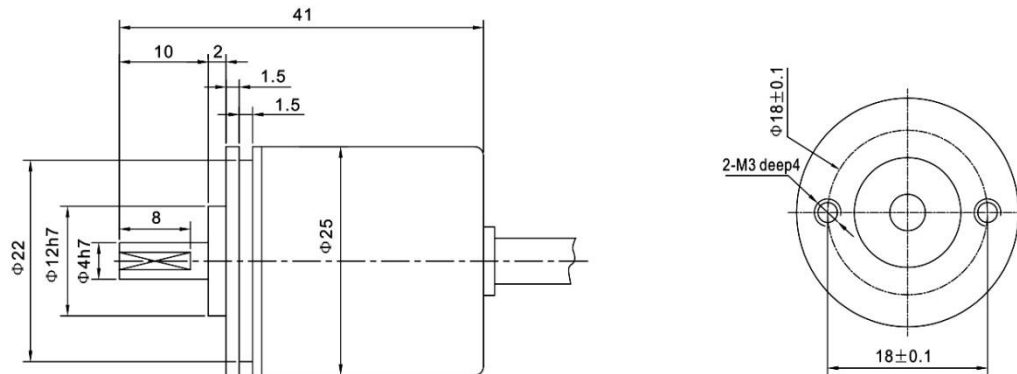
Http://www.yumoelectric.com E-mail:sales@yingselectric.com

A6A2 series

Incremental Rotary Encoder

YUMO®

◆ Dimensions(mm)



Question 17

Attached



Toshiba Bi-CD Integrated Circuit Silicon Monolithic

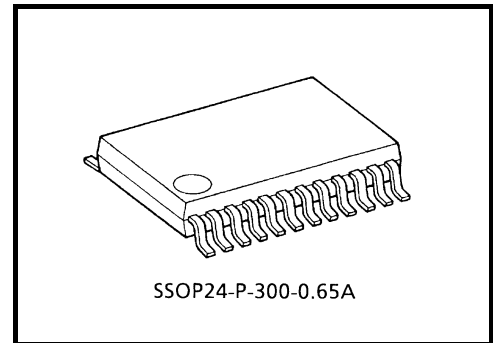
TB6612FNG

Driver IC for Dual DC motor

TB6612FNG is a driver IC for DC motor with output transistor in LD MOS structure with low ON-resistor. Two input signals, IN1 and IN2, can choose one of four modes such as CW, CCW, short brake, and stop mode.

Features

- Power supply voltage; $V_M = 15 \text{ V(Max)}$
- Output current; $I_{OUT}=1.2 \text{ A(ave)} / 3.2 \text{ A (peak)}$
- Output low ON resistor; 0.5Ω (upper+lower Typ. @ $V_M \geq 5 \text{ V}$)
- Standby (Power save) system
- CW / CCW / short brake / stop function modes
- Built-in thermal shutdown circuit and low voltage detecting circuit
- Small faced package(SSOP24: 0.65 mm Lead pitch)
- Response to Pb free packaging



質量: 0.14 g (標準)

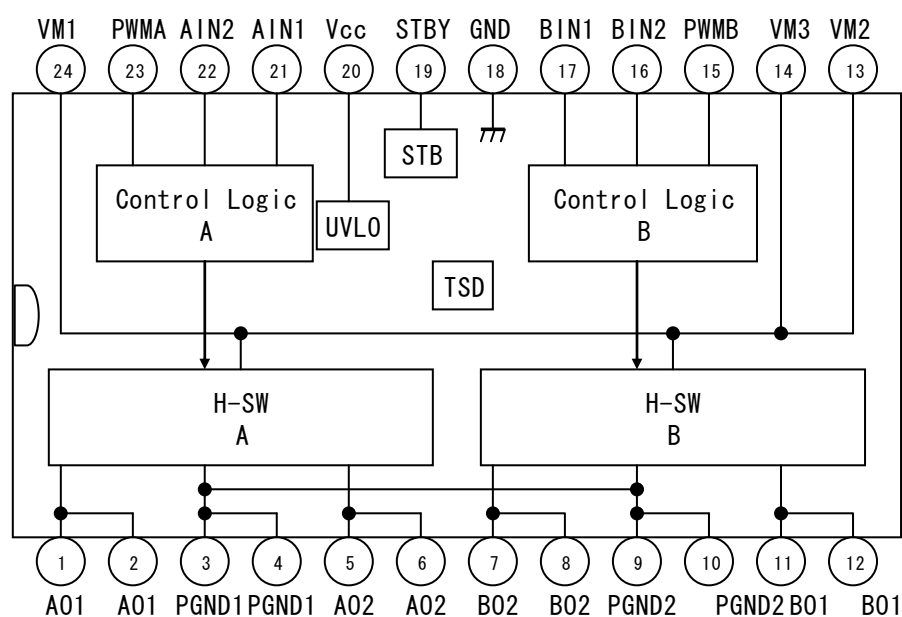
- * This product has a MOS structure and is sensitive to electrostatic discharge. When handling this product, ensure that the environment is protected against electrostatic discharge by using an earth strap, a conductive mat and an ionizer. Ensure also that the ambient temperature and relative humidity are maintained at reasonable levels.

The TB6612FNG is a Pb-free product.
The following conditions apply to solderability:

*Solderability

1. Use of Sn-37Pb solder bath
*solder bath temperature = 230°C
*dipping time = 5 seconds
*number of times = once
*use of R-type flux
2. Use of Sn-3.0Ag-0.5Cu solder bath
*solder bath temperature = 245°C
*dipping time = 5 seconds

Block Diagram



Pin Functions

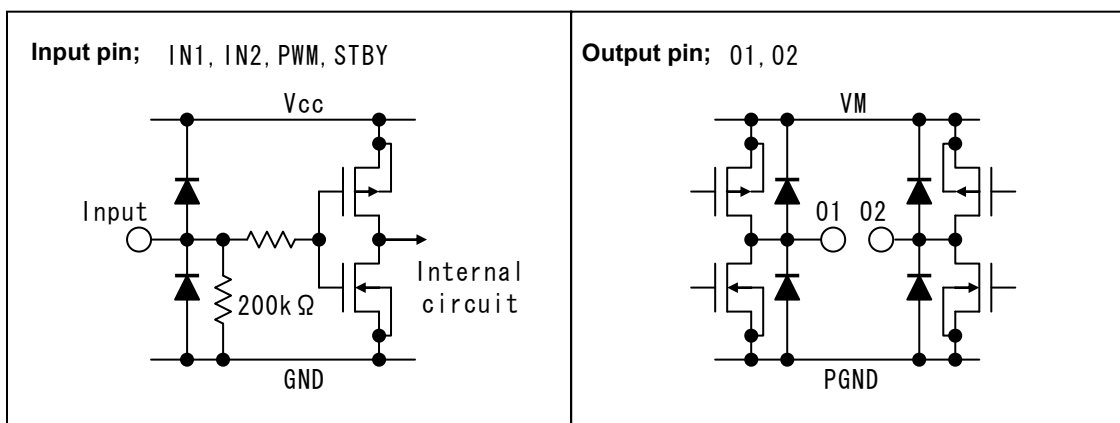
No.	Pin Name	I/O	Function
1	AO1	O	ch A output1
2	AO1		
3	PGND1	—	Power GND 1
4	PGND1		
5	AO2	O	ch A output2
6	AO2		
7	BO2	O	ch B output2
8	BO2		
9	PGND2	—	Power GND 2
10	PGND2		
11	BO1	O	ch B output1
12	BO1		
13	VM2	—	Motor supply (2.5 V to 13.5 V)
14	VM3		
15	PWMB	I	ch B PWM input / 200 kΩ pull-down at internal
16	BIN2	I	ch B input 2 / 200 kΩ pull-down at internal
17	BIN1	I	ch B input 1 / 200 kΩ pull-down at internal
18	GND	—	Small signal GND
19	STBY	I	"L"=standby / 200 kΩ pull-down at internal
20	Vcc	—	Small signal supply
21	AIN1	I	ch A input 1 / 200 kΩ pull-down at internal
22	AIN2	I	ch A input 2 / 200 kΩ pull-down at internal
23	PWMA	I	ch A PWM input / 200 kΩ pull-down at internal
24	VM1	—	Motor supply (2.5 V~13.5 V)

Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit	Remarks
Supply voltage	V _M	15	V	
	V _{CC}	6		
Input voltage	V _{IN}	-0.2 to 6	V	IN1,IN2,STBY,PWM pins
Output voltage	V _{OUT}	15	V	O1,O2 pins
Output current	I _{OUT}	1.2	A	Per 1 ch
	I _{OUT} (peak)	2		tw = 20 ms Continuous pulse, Duty ≤ 20%
		3.2		tw = 10 ms Single pulse
Power dissipation	P _D	0.78	W	IC only
		0.89		50 mm × 50 mm t=1.6 mm Cu ≥ 40% in PCB mounting
		1.36		76.2 mm × 114.3 mm t=1.6 mm Cu ≥ 30% in PCB mounting
Operating temperature	T _{opr}	-20 to 85	°C	
Storage temperature	T _{stg}	-55 to 150	°C	

Operating Range (Ta=-20~85°C)

Characteristics	Symbol	Min	Typ.	Max	Unit	Remarks
Supply voltage	V _{CC}	2.7	3	5.5	V	
	V _M	2.5	5	13.5	V	
Output current (H-SW)	I _{OUT}	—	—	1.0	A	V _M ≥ 4.5 V
		—	—	0.4		4.5 V > V _M ≥ 2.5 V Without PWM Operation
Switching frequency	f _{PWM}	—	—	100	kHz	

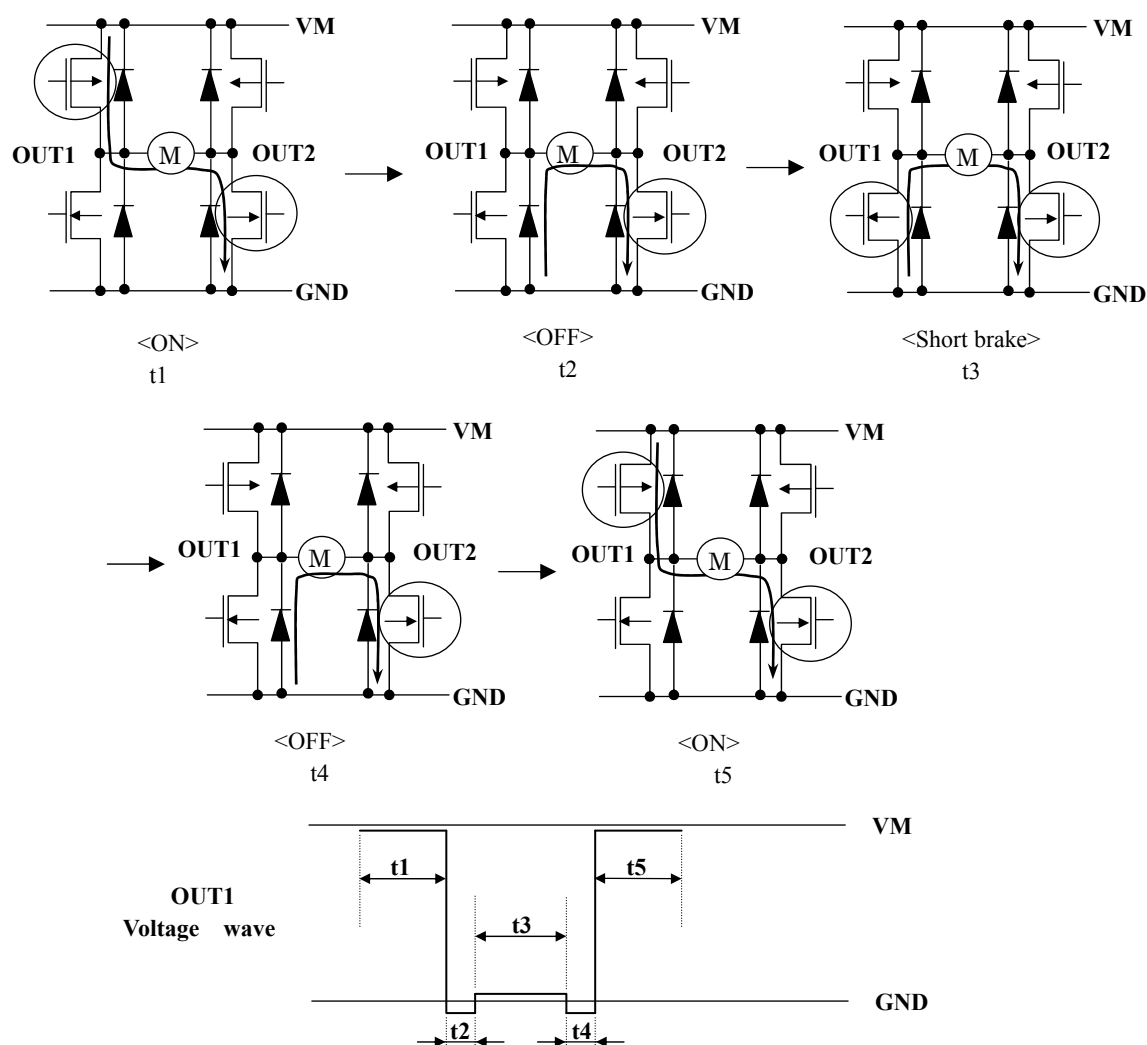


H-SW Control Function

Input				Output		
IN1	IN2	PWM	STBY	OUT1	OUT2	Mode
H	H	H/L	H	L	L	Short brake
L	H	H	H	L	H	CCW
		L	H	L	L	Short brake
H	L	H	H	H	L	CW
		L	H	L	L	Short brake
L	L	H	H	OFF (High impedance)		Stop
H/L	H/L	H/L	L	OFF (High impedance)		Standby

H-SW Operating Description

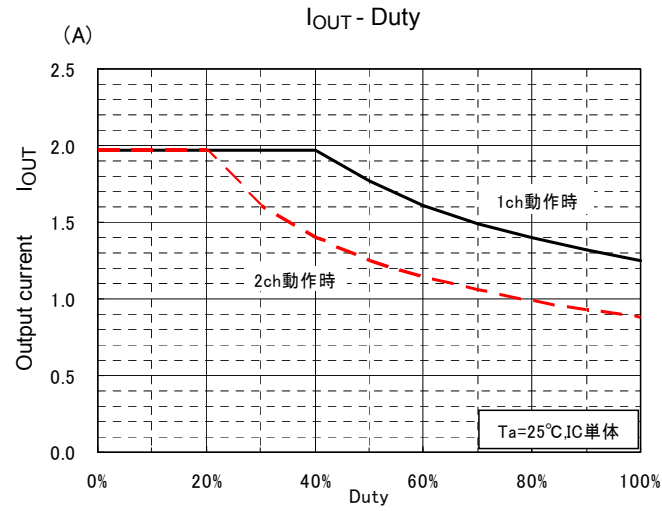
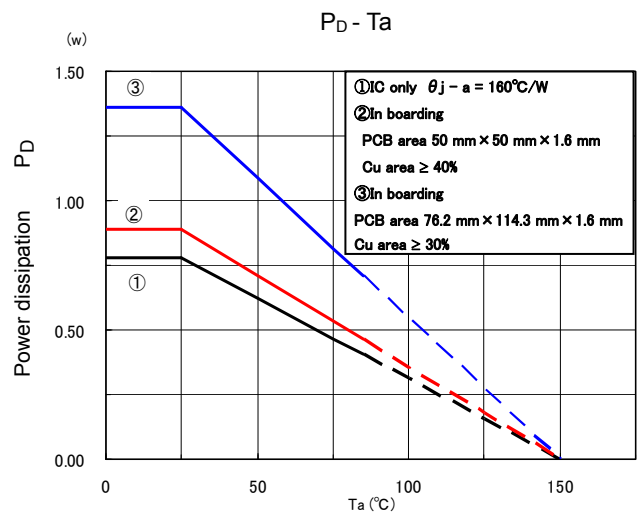
- To prevent penetrating current, dead time t_2 and t_4 is provided in switching to each mode in the IC.



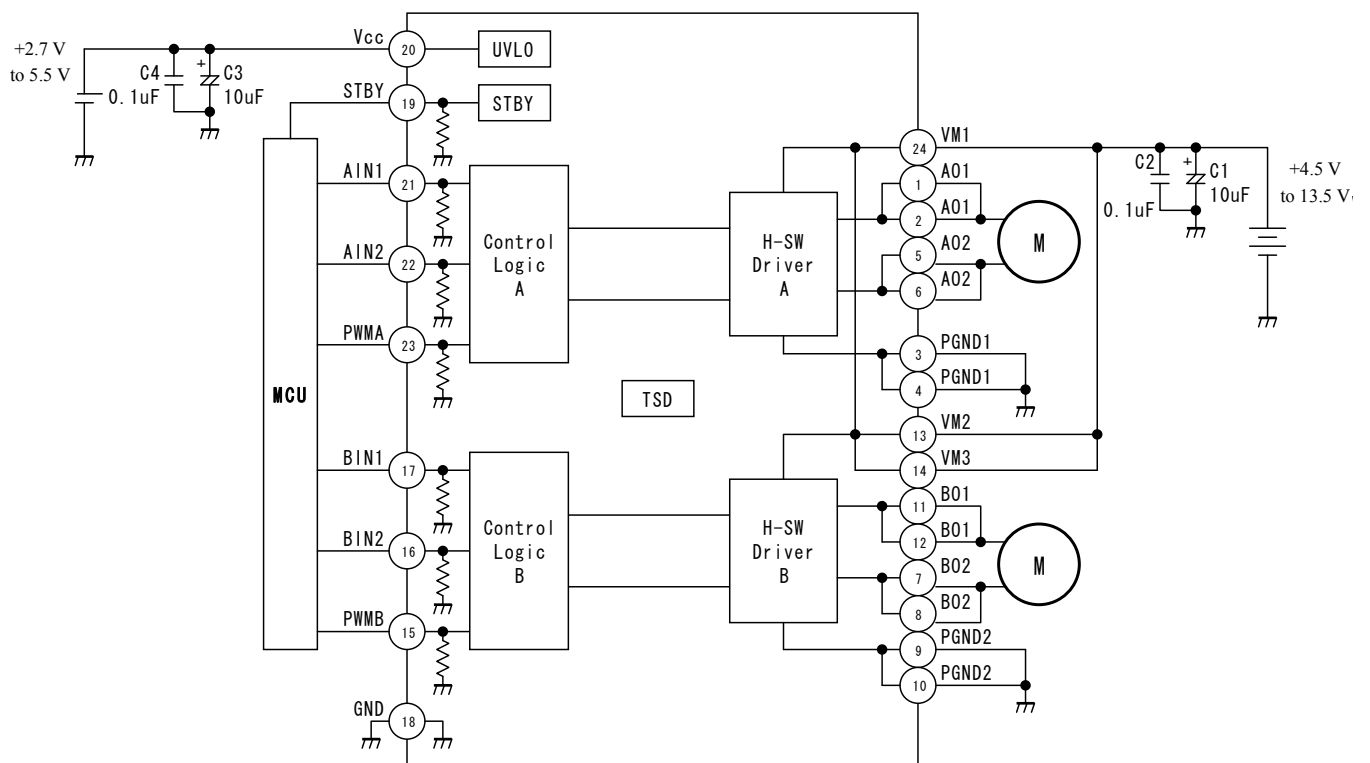
Electrical Characteristics (unless otherwise specified, $T_a = 25^\circ\text{C}$, $V_{CC} = 3\text{ V}$, $V_M = 5\text{ V}$)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Supply current	$I_{CC(3V)}$	STBY = $V_{CC} = 3\text{ V}$, $V_M = 5\text{ V}$	—	1.1	1.8	mA
	$I_{CC(5.5V)}$	STBY = $V_{CC} = 5.5\text{ V}$, $V_M = 5\text{ V}$	—	1.5	2.2	
	$I_{CC(STB)}$	STBY = 0 V	—	—	1	μA
	$I_M(STB)$		—	—	1	
Control input voltage	V_{IH}		$V_{CC} \times 0.7$	—	$V_{CC} + 0.2$	V
	V_{IL}		-0.2	—	$V_{CC} \times 0.3$	
Control input current	I_{IH}	$V_{IN} = 3\text{ V}$	5	15	25	μA
	I_{IL}	$V_{IN} = 0\text{ V}$	—	—	1	
Standby input voltage	$V_{IH(STB)}$		$V_{CC} \times 0.7$	—	$V_{CC} + 0.2$	V
	$V_{IL(STB)}$		-0.2	—	$V_{CC} \times 0.3$	
Standby input current	$I_{IH(STB)}$	$V_{IN} = 3\text{ V}$	5	15	25	μA
	$I_{IL(STB)}$	$V_{IN} = 0\text{ V}$	—	—	1	
Output saturating voltage	$V_{sat(U+L)1}$	$I_O = 1\text{ A}$, $V_{CC} = V_M = 5\text{ V}$	—	0.5	0.7	V
	$V_{sat(U+L)2}$	$I_O = 0.3\text{ A}$, $V_{CC} = V_M = 5\text{ V}$	—	0.15	0.21	
Output leakage current	$I_{L(U)}$	$V_M = V_{OUT} = 15\text{ V}$	—	—	1	μA
	$I_{L(L)}$	$V_M = 15\text{ V}$, $V_{OUT} = 0\text{ V}$	-1	—	—	
Regenerative diode VF	$V_{F(U)}$	$I_F = 1\text{ A}$	—	1	1.1	V
	$V_{F(L)}$		—	1	1.1	
Low voltage detecting voltage	UVLD	(Designed value)	—	1.9	—	V
Recovering voltage	UVLC		—	2.2	—	
Response speed	t_r	(Designed value)	—	24	—	ns
	t_f		—	41	—	
	Dead time	H to L	—	50	—	
		L to H	—	230	—	
Thermal shutdown circuit operating temperature	TSD	(Designed value)	—	175	—	$^\circ\text{C}$
Thermal shutdown hysteresis	ΔTSD		—	20	—	

Target characteristics



Typical Application Diagram

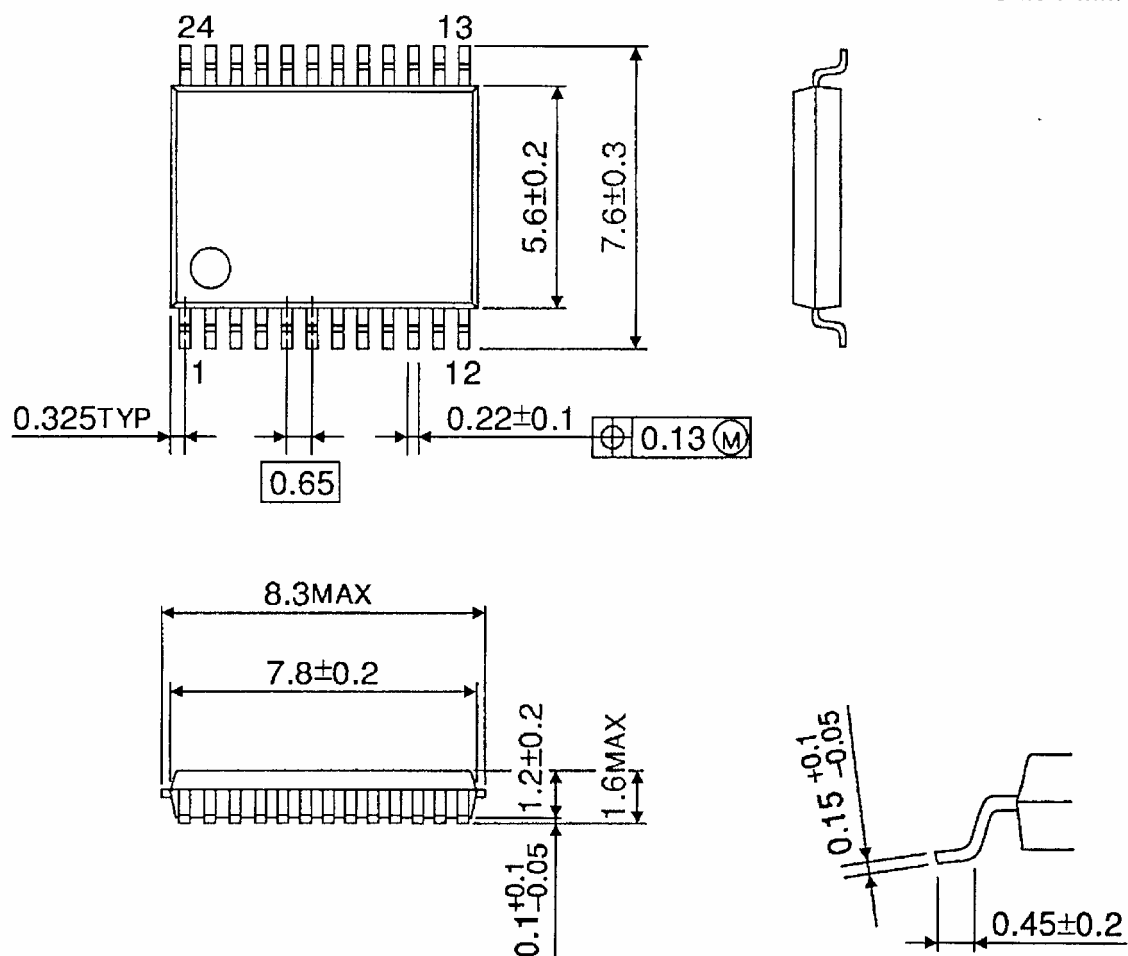


Note: Condensers for noise absorption (C1, C2, C3, and C4) should be connected as close as possible to the IC.

Package Dimennsions

SSOP24-P-300-0.65A

Unit : mm



Weght: 0.14 g (typ)

Notes on Contents**1. Block Diagrams**

Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

2. Equivalent Circuits

The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

3. Timing Charts

Timing charts may be simplified for explanatory purposes.

4. Application Circuits

The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass production design stage.

Toshiba does not grant any license to any industrial property rights by providing these examples of application circuits.

5. Test Circuits

Components in the test circuits are used only to obtain and confirm the device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure from occurring in the application equipment.

IC Usage Considerations**Notes on handling of ICs**

- [1] The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.
Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.
- [2] Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.
- [3] If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. IC breakdown may cause injury, smoke or ignition.
Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.
- [4] Do not insert devices in the wrong orientation or incorrectly.
Make sure that the positive and negative terminals of power supplies are connected properly.
Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.
In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.

Points to remember on handling of ICs**(1) Thermal Shutdown Circuit**

Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately.

Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.

(2) Heat Radiation Design

In using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature (T_J) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into consideration the effect of IC heat radiation with peripheral components.

(3) Back-EMF

When a motor rotates in the reverse direction, stops or slows down abruptly, a current flows back to the motor's power supply due to the effect of back-EMF. If the current sink capability of the power supply is small, the device's motor power supply and output pins might be exposed to conditions beyond maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

RESTRICTIONS ON PRODUCT USE

070122EBA_R6

- The information contained herein is subject to change without notice. 021023_D
- TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property.
In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc. 021023_A
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