UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 2004/2005

Mac 2005

EEM 351 – REKABENTUK MEKATRONIK II

Masa : 3 Jam

ARAHAN KEPADA CALON:-

Sila pastikan kertas peperiksaan ini mengandungi **EMPAT BELAS (14)** muka surat beserta **(Lampiran 4 muka surat)** bercetak dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan ini.

Jawab **LIMA (5)** soalan.

Agihan markah diberikan di sudut sebelah kanan soalan berkenaan.

Semua soalan hendaklah dijawab di dalam Bahasa Malaysia.

...2/-

1. (a) Anda dikehendaki membina satu sistem pengekod optik digital jenis tokokan yang akan disambung kepada satu motor untuk pengukuran kedudukan putaran motor tersebut. Spesifikasi yang diberikan ialah pengekod tersebut hendaklah berupaya untuk mengukur 16 kedudukan bagi satu putaran motor.

You are required to build an incremental optical encoder which will be connected to a motor for measuring the motor rotational position. The specification is that the encoder has to be able to measure 16 positions in a one motor rotation.

[i] Lukiskan gambarajah skematik yang lengkap bagi sistem pengekod yang akan anda bina menggunakan D flip-flop (dilampirkan). Lukiskan juga litar sumber cahaya, litar pengesan cahaya dan cakera encoder.

Draw the schematic of this encoder using D flip-flop (attached). Also, draw the light source circuit, light detector circuit and the encoder disc.

(25 markah/*marks*)

[ii] Lukiskan isyarat-isyarat kuadratur saluran A dan B dan juga isyarat keluaran bagi litar pengekod tersebut untuk putaran ikut jam dan lawan jam.

Draw the quadrature signal of channel A and B and also the decoder circuit outputs for clockwise and anti-clockwise directions.

(15 markah/*marks*)

...3/-

(b) Terangkan tentang pengekod mutlak mengunakan kod gray dan kod binary asal. Lukiskan corak pada cakera dan isyarat yang dihasilkan untuk membantu penerangan anda.

Explain about absolute encoder using gray and natural binary codes. Draw the disk track patterns and the generated signals to help your explanation.

(20 markah/*marks*)

(c) Anda seterusnya dikehendaki untuk menggabungkan sistem pengekod yang anda bina dalam 1(a) dengan satu pengawal mikro untuk mengawal pergerakan pada paksi x dan y bagi mesin pencontohsulungan. Anda juga dibekalkan dengan satu penderia reed untuk memberikan titik rujukan bagi mesin anda.

You are subsequently required to combine your designed encoder system in 1(a) with a microcontroller in order to control x and y axes of a prototyping machine. You are also provided with a reed sensor to give the machine reference point.

[i] Lukiskan gambarajah skematik yang mengandungi dua IC74193 (dilampirkan) iaitu satu IC 74193 untuk satu motor, satu PIC16F877 (dilampirkan) serta satu penderia reed.

Draw the schematic using two IC 74193 (attached) where one IC 74193 for one motor, satu PIC16F877(attached) and one reed sensor. (30 markah/*marks*)

[ii] Tuliskan satu program dalam bahasa PicBasic Pro bagaimana untuk praset kedua-dua IC74193 apabila penderia reed tersebut diaktifkan.

Write a program in PicBasic Pro on how to preset these IC 74193 when the reed sensor is activated.

(10 markah/*marks*)

...4/-

2. (a) [i] Lukis gambarajah skematik sistem keselamatan bagi satu rumah yang meggunakan sistem berdasarkan kepada mikro pengawal PIC16F84 (dilampirkan). Rujuk Jadual 2(a).

Draw the schematic for a security system for a house using a system based on microcontroller PIC 16F84 (attached). Refer Table 2(a).

(20 markah/*marks*)

Peralatan	Kuantiti
Pintu (dipasang suis sebagai penderia)	2
Tingkap (dipasang suis sebagai penderia	2
Loceng (berbunyi apabila ada pencerobohan)	1
Pengesan pergerakan	1
Suis untuk dipilih oleh penghuni samada (1) Sedang tidur (2) Tiada di rumah (3) Ada di rumah	2

Jadual 2(a)
Table 2(a)

[ii] Bina satu carta alir bagi sistem keselamatan yang akan anda bina dalam [i].

Build a flow chart for the security system that you will build in [i].

(15 markah/*marks*)

[iii] Berdasarkan carta alir dalam [ii], tuliskan satu program dalam PicBasic Pro yang lengkap.

Based on the flow chart you have drawn in [ii], write a complete program in PicBasic Pro.

(10 markah/*marks*)

(b) [i] Terangkan secara ringkas tentang estetik dan ergonomic.

Explain, in brief, about aesthetics and ergonomic.

(20 markah/marks)

...5/-

[ii] Berikan lima perbezaan antara manusia dan mesin

Give five differences between human and machine.

(10 markah/*marks*)

(c) Dengan bantuan lakaran yang sesuai, berikan:-

With the help of relevant sketches, give

[i] Tiga aplikasi suis mikro

Three applications of micro-switches

[ii] Tiga aplikasi suis reed

Three applications of reed switches

(25 markah/*marks*)

3. (a) Terangkan dengan bantuan gambarajah tentang penukar gerakan yang berikut:-

Explain, with the help of appropriate sketches, the following motion converters:-

[i] Pemacu geseran balutan dawai
Friction wire wrap drive

[ii] Sistem skrew-nut
Screw-nut system

[iii] Pemacu bolehubah kon dan kapi
Cone and pulley variable drive

[iv] Kopp variator
Kopp variator

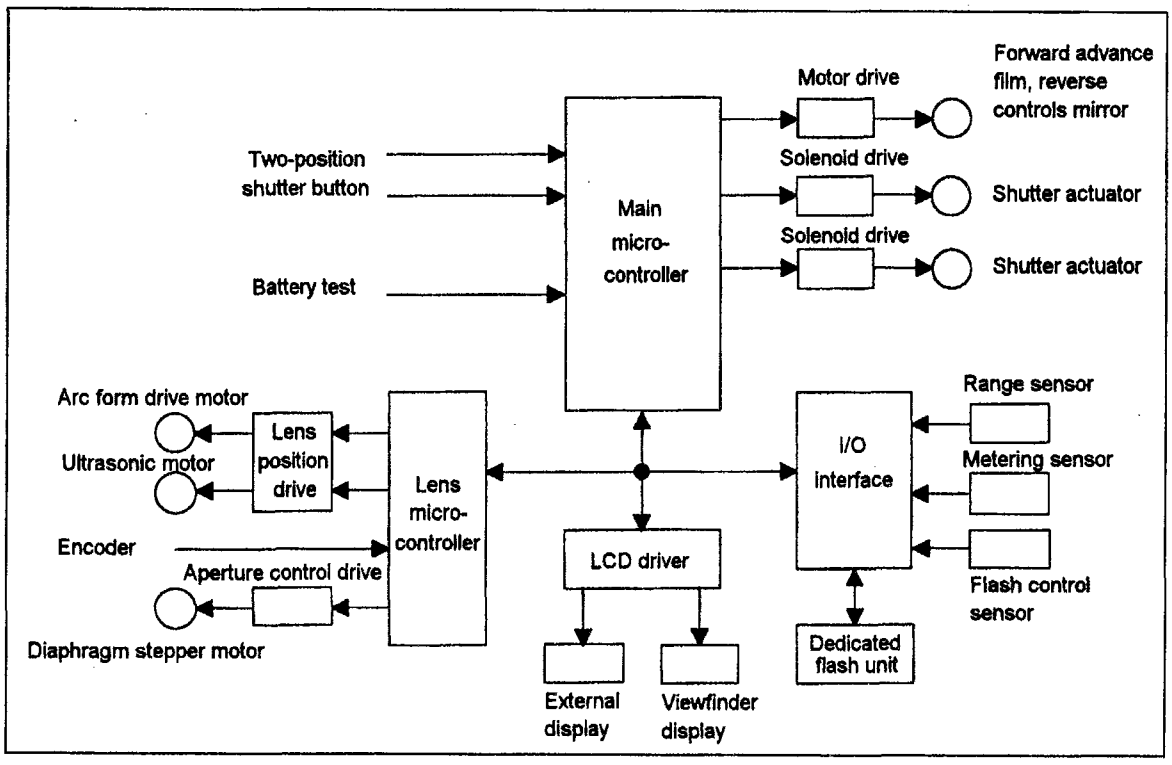
(25 markah/*marks*)

(b) Lukiskan carta alir bagi operasi kamera autofokus berdasarkan Rajah 3(b).

Draw a flow chart for the operation of autofocus camera based on Figure 3(b).

(50 markah/*marks*)

...6/-



Rajah 3(b)
Figure 3(b)

(c) Lakukan penapisan konsep lima meja komputer pelbagai-guna yang diberikan di dalam Rajah 3(c), berdasarkan kepada kriteria-kriteria seperti berikut:-

Perform screening concept for five multi-purpose computer tables given in Figure 3(c), based on the following criterion:-

1. Mudah digunakan
   Ease of use

2. Mudah dipindahkan
   Portable

3. Mudah difabrikasi
   Ease of fabrication

...7/-

4. Mudah dipasang
Ease of Assembly

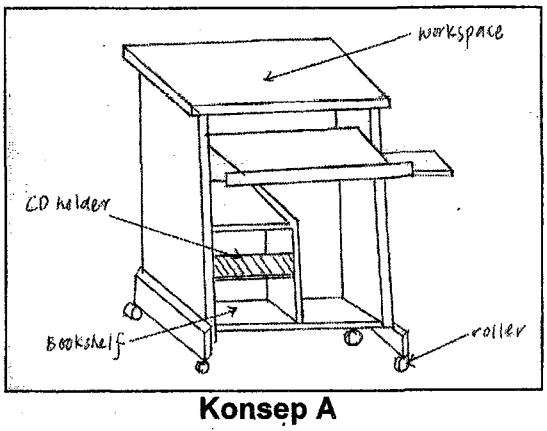
5. Stabil
Stable

6. Kos bahan mentah
Raw material cost

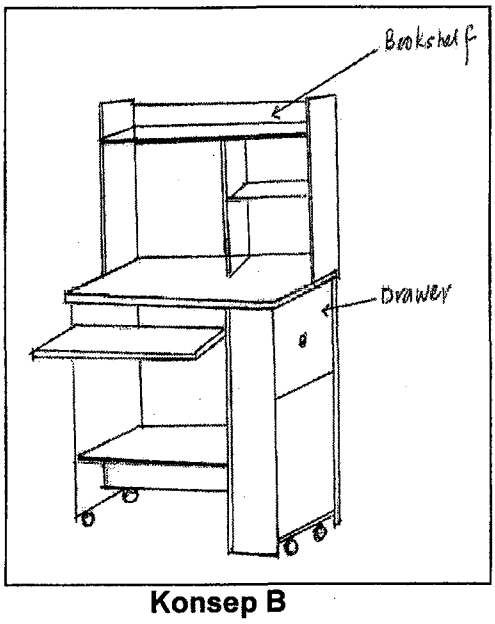
Tujuan soalan ini ialah untuk menilai keupayaan pelajar memahami konsep proses penapisan. Perbandingan kriteria antara meja-meja tersebut terpulang kepada pelajar sendiri.

The purpose of this question is to evaluate the student understanding of concept screening process. The comparison of criterion between the tables is up to the student.

(25 markah/*marks*)

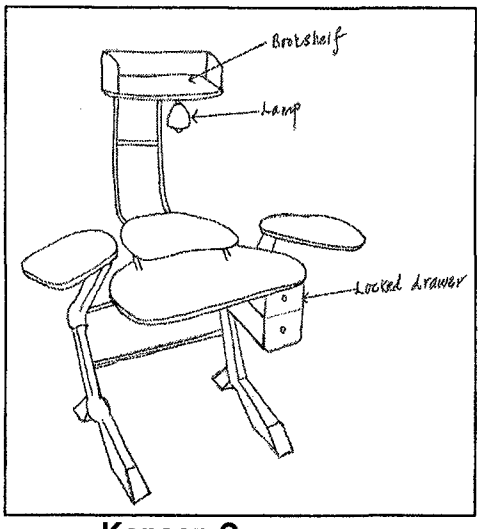


Konsep A
Concept A

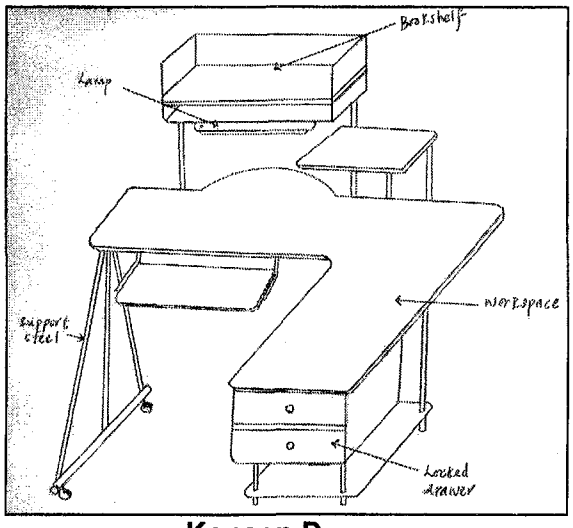


Konsep B
Concept B

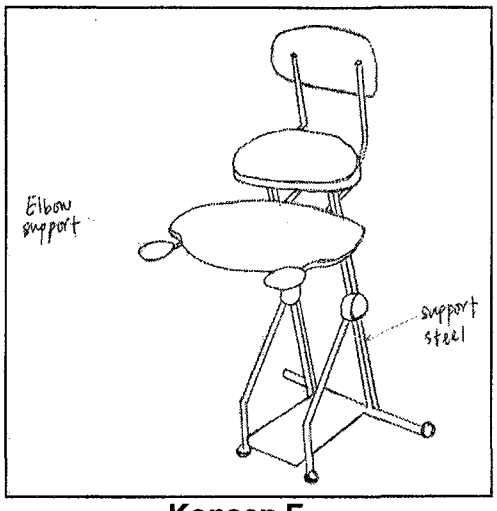
...8/-



Konsep C
Concept C



Konsep D
Concept D



Konsep E
Concept E

Rajah 3(c)
Figure 3(c)

...9/-

4. (a) Jelaskan apakah yang dimaksudkan dengan terma 'signal conditioning' dengan merujuk kepada rekabentuk suatu sistem mekatronik.

Define what is meant by the term signal conditioning with reference to the design of a mechatronic system.

(10 markah/*marks*)

(b) Berikan definisi bagi terma-terma berikut merujuk kepada peranti op-amp: *CMRR*

Define the following terms with reference to an op-amp device:

[i] "CMRR"

[ii] "Slew rate"

[iii] Frekuensi isyarat maksima
Maximum signal frequency

(20 markah/*marks*)

(c) Tentukan voltan keluaran bagi sebuah op-amp dengan voltan masukan, V_{i1} = *150* μV dan V_{i2} = *140* μV. Penguat tersebut mempunyai nilai gandaan bezaan A_d = *4000* dan CMRR dengan nilai:

Determine the voltage output of an op-amp for input voltages of V_{i1} = *150* μV *and* V_{i2} = *140* μV. *The amplifier has a differential gain of* A_d = *4000 and the value of CMRR is:*

[i] 100

[ii] 10^5

(20 markah/*marks*)

...10/-

(d) Dengan merujuk kepada spesifikasi op-amp yang diberi oleh Jadual 4(d) dan Rajah 4(d), tentukan parameter-parameter berikut:

By referring to the specification of an op-amp given in Table 4(d) and Figure 4(d), determine the following parameters:

[i] Voltan Ofset Keseluruhan
Total offset voltage

[ii] Arus masukan pincang bagi setiap masukan
Input bias current at each input

[iii] Untuk masukan $V_1 = 50\ mV$, tentukan frekuensi maksimum yang boleh digunakan, diberi $SR = 0.5\ V/\mu s$.

For an input of V_1=50mV, determine the maximum frequency that may be used, given $SR = 0.5\ V/\mu s$.

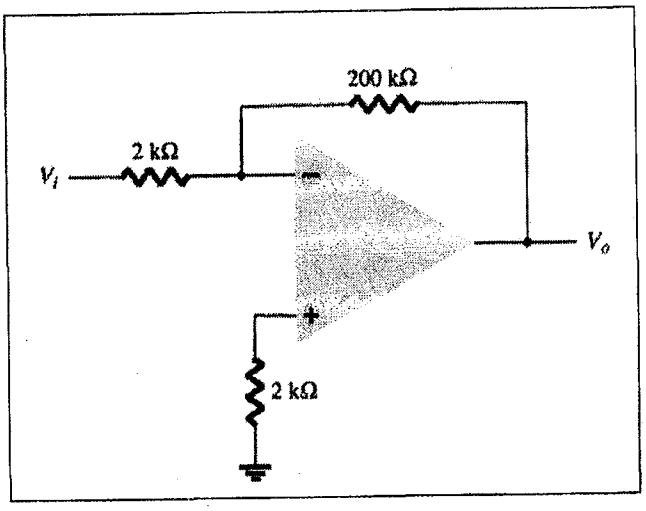
(50 markah/*marks*)

Characteristic	***MIN***	***TYP***	***MAX***	***Unit***
V_{IO} Input offset voltage		1	6	mV
I_{IO} Input offset current		20	200	nA
I_{IB} Input bias current		80	500	nA
V_{ICR} Common-mode input voltage range	± 12	± 13		V
V_{OM} Maximum peak output voltage swing	± 12	± 14		V
A_{VD} Large-signal differential voltage amplification	20	200		V/mV
r_i Input resistance	0.3	2		MΩ
r_o Output resistance		75		Ω
C_i Input capacitance		1.4		pF
CMRR Common-mode rejection ratio	70	90		dB
I_{CC} Supply current		1.7	2.8	mA
P_D Total power dissipation		50	85	mW

Parameter	***MIN***	***TYP***	***MAX***	***Unit***
B_1 Unity gain bandwidth		1		MHz
T_r Rise time		0.3		μs

Jadual 4(d)
Table 4(d)

...11/-



Rajah 4(d)
Figure 4(d)

5. (a) Huraikan jenis-jenis penuras yang boleh digunakan untuk suatu proses pembaikian isyarat, sebelum ia boleh dimanfaatkan sebaiknya untuk litar.

Describe the different types of filters which are available to be used in a signal conditioning process, before the signal can be properly utilized in the circuit.

(20 markah/*marks*)

(b) Huraikan perbezaan ciri-ciri dan prestasi penuras jenis Butterworth dan Chebyshev.

Describe the differences in terms of characteristics and performance of a Butterworth and Chebyshev filters.

(20 markah/*marks*)

...12/-

(c) Rekabentuk sebuah penuras Butterworth yang memenuhi spesikasi berikut: f_p = *10 kHz*, A_{max} = *2 dB*, f_s = *15 kHz*, dan A_{min} = *15 dB*. Tentukan *N*, mod tabie, dan *T(s)*. Apakah nilai lesapan pada *20 kHz* ? Lakarkan plot Bode bagi penuras tersebut dan implementasi litar penuras menggunakan Op-amp.

Design a Butterworth filter that meets the following low-pass specifications: f_p = *10 kHz*, A_{max} = *2 dB*, f_s = *15 kHz, and* A_{min} = *15 dB. Find N, the natural modes, and T(s). What is the attenuation provided at 20 kHz ? Sketch the Bode plot for the filter and its circuit implementation using Op-amp.*

(60 markah/*marks*)

6. (a) Apakah yang dimaksudkan dengan penukar analog ke digital secara berturut ? Terangkan litar penukar analog ke digital jenis ini dengan rajah yang bersesuaian.

What is a Successive-Approximation ADC ? Please describe this type of ADC circuit with relevant diagrams.

(25 markah/*marks*)

(b) Sebuah penukar digital ke analog jenis lapan bit menghasilkan keluaran voltan 2.0 V bagi kod masukan 01100100. Apakah nilai keluaran V_{out} bagi kod masukan 10110011 ?

An eight-bit DAC produces an output voltage of 2.0V for an input code of 01100100. What will be the value of V_{out} *for an input code of 10110011 ?*

(10 markah/*marks*)

...13/-

(c) Andaikan keluaran sebuah DAC seperti rajah 3a, disambung kepada op-amp di dalam Rajah 6(c).

Assume that the output of the DAC in figure 3a. is connected to the op-amp of Figure 6(c).

[i] Dengan V_{REF}= *5 V, R = 20 kΩ,* dan R_F = *10 kΩ,* tentukan saiz langkah dan voltan skel-penuh di V_{out}.

With V_{REF}= *5 V, R = 20 kΩ, and* R_F = *10 kΩ, determine the step size and the full-scale voltage at* V_{out}.

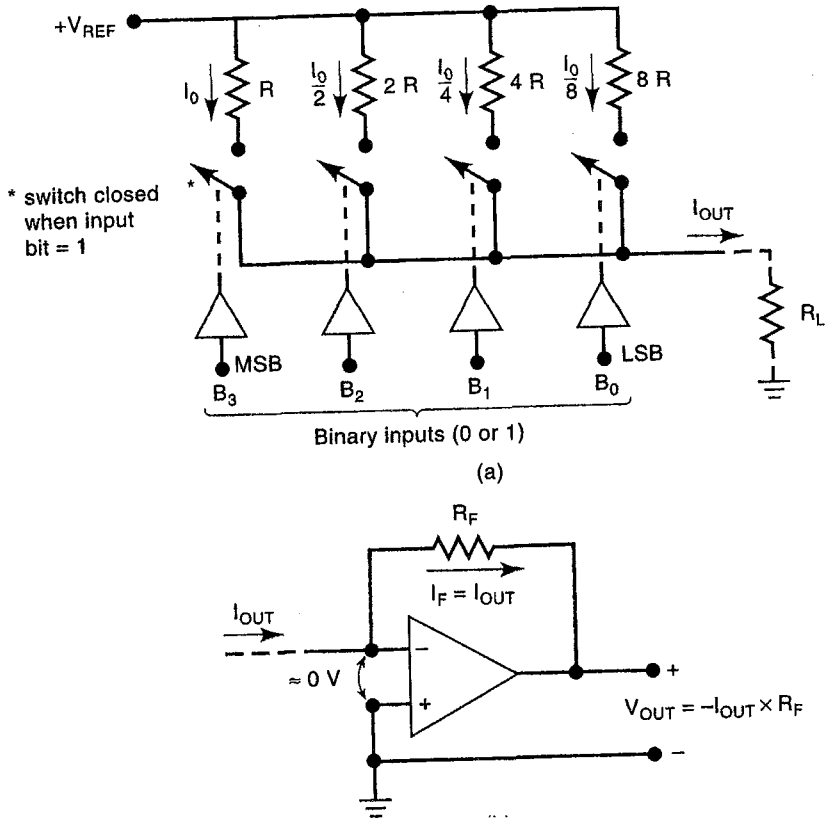
[ii] Tukar nilai R_F supaya voltan skel-penuh di V_{out} adalah -2 V.
Change the value of R_F *so that the full-scale voltage at* V_{out} *is -2 V.*

[iii] Gunakan nilai R_F yang baru ini, dan tentukan nilai *K*, iaitu faktor kadaran.

Use this new value of R_F, *and determine the proportionality factor, K.*

(35 markah/*marks*)

...14/-



Rajah 6(c)
Figure 6(c)

(d) Sebuah ADC mempunyai ciri-ciri berikut: 12 bits; ralat skel-penuh, 0.03% F.S; Voltan skel-penuh, +5 V.

An ADC has the following characteristics: resolution, 12 bits; full-scale error, 0.03% F.S; full-scale output, +5 V.

[i] Apakah ralat kuantisasi di dalam nilai volt?

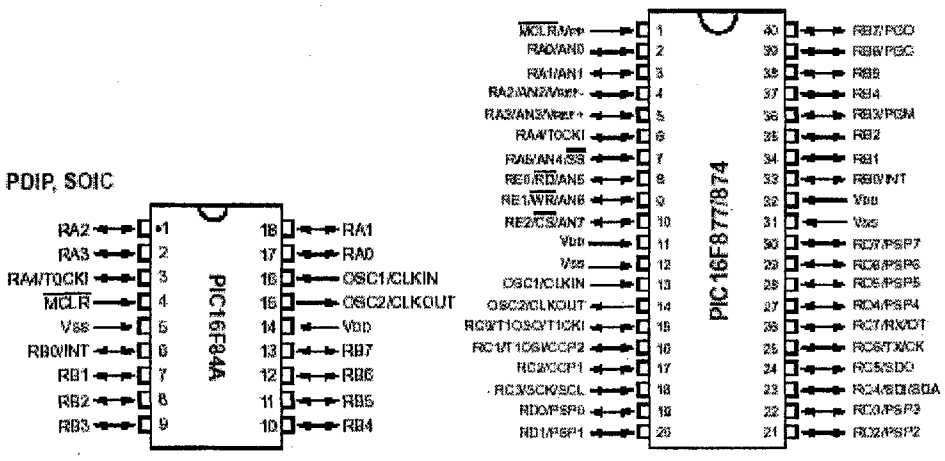
What is the quantization error in volts ?

[ii] Apakah ralat penuh yang boleh terhasil di dalam nilai volt?

What is the total possible errors in volts ?

(30 markah/*marks*)

- ooo0ooo -



PIC16F84 PIC16F877

Table 7.5 PicBasic Pro statement summary

Statement	Description
@ assembly statement	Insert one line of assembly language code
ADCIN channel, var	Read the on-chip analog to digital converter (if there is one)
ASM . . . ENDASM	Insert an assembly language code section consisting of one or more statements
BRANCH index, [label1{, label2, . . .}]	Computed goto that jumps to a label based on index
BRANCHL index, [label1{, label2, . . .}]	Branch to a label that can be outside of the current page of code memory (for PICs with more than 2 k of program ROM)
BUTTON pin, down_state, auto_repeat_delay, auto_repeat_rate, countdown_variable, action_state, label	Read the state of a pin and perform debounce (by use of a delay) and autorepeat (if used within a loop)
CALL assembly_label	Call an assembly language subroutine
CLEAR	Zero all variables
CLEARWDT	Clear the watch-dog timer
COUNT pin, period, var	Count the number of pulses occurring on a pin during a period
DATA {@ location,} constant1{, constant2, . . .}	Define initial contents of the on-chip EEPROM (same as the EEPROM statement)
DEBUG item1{, item2, . . .}	Asynchronous serial output to a pin at a fixed baud rate
DEBUGIN {timeout, label,} {item1{,{item2, . . .}]	Asynchronous serial input from a pin at a fixed baud rate
DISABLE	Disable ON INTERRUPT and ON DEBUG processing
DISABLE DEBUG	Disable ON DEBUG processing
DISABLE INTERRUPT	Disable ON INTERRUPT processing
DTMFOUT pin, {on_ms, off_ms,} {tone1{, tone2. . . .}]	Produce touch tones on a pin
{EEPROM {@ location,} constant1{, constant2, . . .}}	Define initial contents of on-chip EEPROM (same as the DATA statement)
ENABLE	Enable ON INTERRUPT and ON DEBUG processing
ENABLE DEBUG	Enable ON DEBUG processing
ENABLE INTERRUPT	Enable ON INTERRUPT processing
END	Stop execution and enter low power mode
FOR count = start TO end {STEP {-} inc} {body statements} NEXT {count}	Repeatedly execute statements as count goes from start to end in fixed increment
FREQOUT pin, on_ms, freq1{, freq2}	Produce up to two frequencies on a pin
GOSUB label	Call a PicBasic subroutine at the specified label
GOTO label	Continue execution at the specified label
HIGH pin	Make pin output high
HSERIN {parity_label,} {time_out, label,} [item1{, item2, . . .}]	Hardware asynchronous serial input (if there is a hardware serial port)
HSEROUT [item1{, item2, . . .}]	Hardware asynchronous serial output (if there is a hardware serial port)
I2CREAD data_pin, clock_pin, control,{ address,} [var1{, var2, . . .}]{, label}	Read bytes from an external I^2C serial EEPROM device
I2CWRITE data_pin, clock_pin, control,{ address,} [var1{, var2, . . .}]{, label}	Write bytes to an external I^2C serial EEPROM device
IF log_comp THEN label	Conditionally jump to a label
IF log_comp THEN true_statements ELSE false_statements ENDIF	Conditional execution of statements
INPUT pin	Make pin an input
LCDIN {address,} [var1{, var2, . . .}]	Read RAM on a liquid crystal display (LCD)
LCDOUT item1{, item2, . . .}	Display characters on LCD
{LET} var = value	Assignment statement (assigns a value to a variable)

Statement	Description
LOOKDOWN value, [const1{, const2, . . .}], var	Search constant table for a value
LOOKDOWN2 value, {test} [value1{, value2, . . .}], var	Search constant/variable table for a value
LOOKUP index, [const1{, const2, . . .}], var	Fetch constant value from a table
LOOKUP2 index, [value1{, value2, . . .}], var	Fetch constant/variable value from a table
LOW pin	Make pin output low
NAP period	Power down processor for a selected period of time
ON DEBUG GOTO label	Execute PicBasic debug subroutine at label after every statement if debug is enabled
ON INTERRUPT GOTO label	Execute PicBasic subroutine at label when an interrupt is detected
OUTPUT pin	Make pin an output
PAUSE period	Delay a given number of milliseconds
PAUSEUS period	Delay a given number of microseconds
{PEEK address, var}	Read byte from a register
{POKE address, var}	Write byte to a register
POT pin, scale, var	Read resistance of a potentiometer, or other variable resistance device, connected to a pin with a series capacitor to ground
PULSIN pin, state, var	Measure the width of a pulse on a pin
PULSOUT pin, period	Generate a pulse on a pin
PWM pin, duty, cycles	Output a pulse width modulated (PWM) pulse train to pin
RANDOM var	Generate a pseudo-random number
RCTIME pin, state, var	Measure pulse width on a pin
READ address, var	Read a byte from on-chip EEPROM
READCODE address, var	Read a word from code memory
RESUME {label}	Continue execution after interrupt handling
RETURN	Continue execution at the statement following last executed GOSUB
REVERSE pin	Make output pin an input or an input pin an output
SERIN pin, mode,{ timeout, label,} {[qual1, qual2, . . .],}{ item1{, item2, . . .}}	Asynchronous serial input (Basic Stamp 1 style)
SERIN2 data_pin{\flow_pin}, mode, {parity_label,} {timeout, label,} [item1{, item2, . . .}]	Asynchronous serial input (Basic Stamp 2 style)
SEROUT pin, mode, [item1{, item2, . . .}]	Asynchronous serial output (Basic Stamp 1 style)
SEROUT2 data_pin{\flow_pin}, mode, {pace,} {timeout, label,} [item1{, item2, . . .}]	Asynchronous serial output (Basic Stamp 2 style)
SHIFTIN data_pin, clock_pin, mode, [var1{\bits1} {, var2{\bits2}, . . .}]	Synchronous serial input
SHIFTOUT data_pin, clock_pin, mode, [var1{\bits1} {, var2{\bits2}, . . .}]	Synchronous serial output
SLEEP period	Power down the processor for a given number of seconds
SOUND pin, [note1, duration1{, note2, duration2, . . .}]	Generate a tone or white noise on a specified pin
STOP	Stop program execution
SWAP var1, var2	Exchange the values of two variables
TOGGLE pin	Change the state of an output pin
WHILE logical_comp statements WEND	Execute code while condition is true
WRITE address, value	Write a byte to on-chip EEPROM
WRITECODE address, value	Write a word to code memory
XIN data_pin, zero_pin, {timeout, label,} [var1{, var2, . . .}]]	Receive data from an external X-10 type device
XOUT data_pin, zero_pin, [house_code1\key_code1{\repeat1}{, house_code2\key_code2{\repeat2, . . .}]	Send data to an external X-10 type device

PicBasic Pro commands

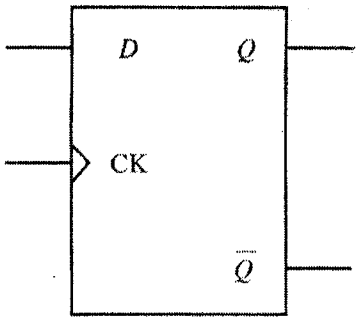
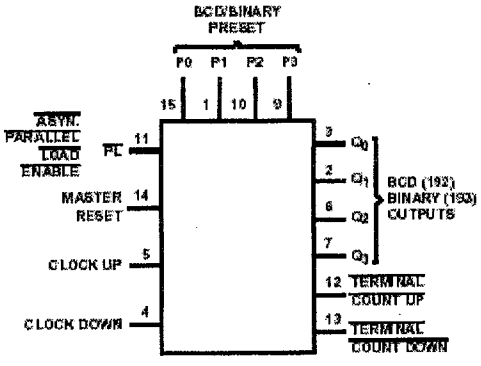


Figure 6.13 Positive edge-triggered D flip-flop.

Table 6.7 Positive edge-triggered D flip-flop truth table

D	CK	Q	$\overline{Q}$
0	↑	0	1
1	↑	1	0
X	0	Q_0	$\overline{Q_0}$
X	1	Q_0	$\overline{Q_0}$

D Flip-flop



TRUTH TABLE

CLOCK UP	CLOCK DOWN	RESET	PARALLEL LOAD	FUNCTION
↑	H	L	H	Count Up
H	↑	L	H	Count Down
X	X	H	X	Reset
X	X	L	L	Load Preset Inputs

NOTE: H = High Voltage Level, L = Low Voltage Level, X = Don't Care, ↑ = Transition from Low to High Level

IC 74193: PRESETTABLE SYNCHRONOUS 4-BIT BINARY UP/DOWN COUNTERS