



12 Pages

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1	Student Number	p141924
2	Title of Examination Paper	Embedded Microcontrollers
3	Module Code	MGX8529
4	Date and Time of Examination	16/05/2019
5	Examination Venue	IQ
6	Seat Number	112
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
1	12 ¹ / ₂
2	7
3	7
4	4
Total	30.5

(Gweler yr ochr arall am y fersiwn Cymraeg)

SURNAME: Elder

FORENAME(S): Ashleigh Thomas
George Edwin Robert.

Total	30.5%
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305

Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David



12 Tudalen

Cyfarwyddiadau i Ymgeiswyr

1. Rhwch yr holl wybodaeth y gofynnir amdani yn y blychau isod.
2. Rhwch eich enw yn y lle a ddarparwyd ar y dde, pwygch et a'i selio i lawr (gan dddefnyddio'r label a ddarparwyd i guddio'ch enw.

1. Rhaid i'r atebion fod mewn llawysgriften ddarlennadwy. Gall yr Arholiwy'r naill al anwybyddu sgript annarllennadwy, neu drefnu iddi gael ei theipio a chael yr ymgeisydd i dalu.
2. Ysgrifennwch eich atebion mewn inc.
3. Dechreuwch bob ateb ar dudalen newydd. Gwnewch unrhyw ftras nodiadau yn y llyfr atebion a thynnwch llinell drwyddyn.
4. Ni ddylid rhwngo unrhyw ran o'r llyfr hwn; rhaid ei gyflwyno yn gyfan.
5. Os defnyddir mwy nag un llyfr, rhwymwch hwy gyda'i gilydd gan ddefnyddio'r tagiau sydd ar gael oddi wrth y gwyllwyr/gwylwyr.
6. Rhaid dychwelyd pob llyfr. Ni chaniateir mynd â llyfrau atebion, wedi eu defnyddio neu heb eu defnyddio, allan o'r lleoliad arholi o dan unrhyw amgylchiadau.

CYFENW:

ENW(AU) CYNTAF:

Llenwch, plygwrch a seliwrch
(gweler nodyn 2 isod)

[illegible]

1	Rhif Myfyriwr	
2	Teitl y Papur Arholiad	
3	Cod y Modwl	
4	Dyddiad ac Amser yr Archoliad	
5	Lleoliad yr Arholiad	
6	Rhif Sedd	
7	Nifer y Llyfrau Atebion a gyflwynwyd	

(See the other side for English version)

✓ a) In the AC motor control system outlined in the question the mains power supply is filtered to remove any abnormal signals (voltage spikes, high/low frequency noise etc). The capacitive/resistive power supply is used to limit the ~~voltage~~ mains voltage and to convert the AC voltage input into a DC source that is usable by the PIC (a diagram demonstrating a potential C/R powersupply can be seen at the end of this question). The PIC is used to control the system, it's connected to the VI and output LEDs whilst also being used to activate the gate of the TRIAC to give a cleaner PWM signal that determines the on/off times of the motor. The UART is ~~connected~~ isolated from the system to protect the user from coming into contact with the mains power. The POT is used to control the cycle speed of the PIC.

b) ZCD uses a built in comparator circuit inside the microcontroller to ~~diagram~~ determine when a signal changes from high to low and vice versa, used to count and determine the PIC's phase angle.

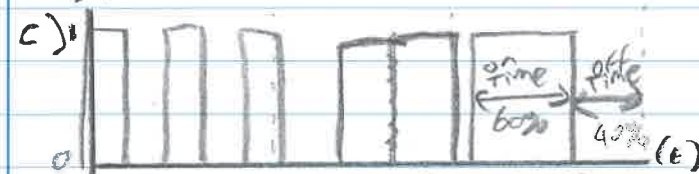


Diagram demonstrating phase-angle control

The above diagram demonstrates phase-angle control of a PWM signal, the on time (in this case 60%) is used to determine the speed or brightness of a system by using its average frequency, even though the pulses are on at different times the average on time of the three blocks above is $\approx 60\%$ on.

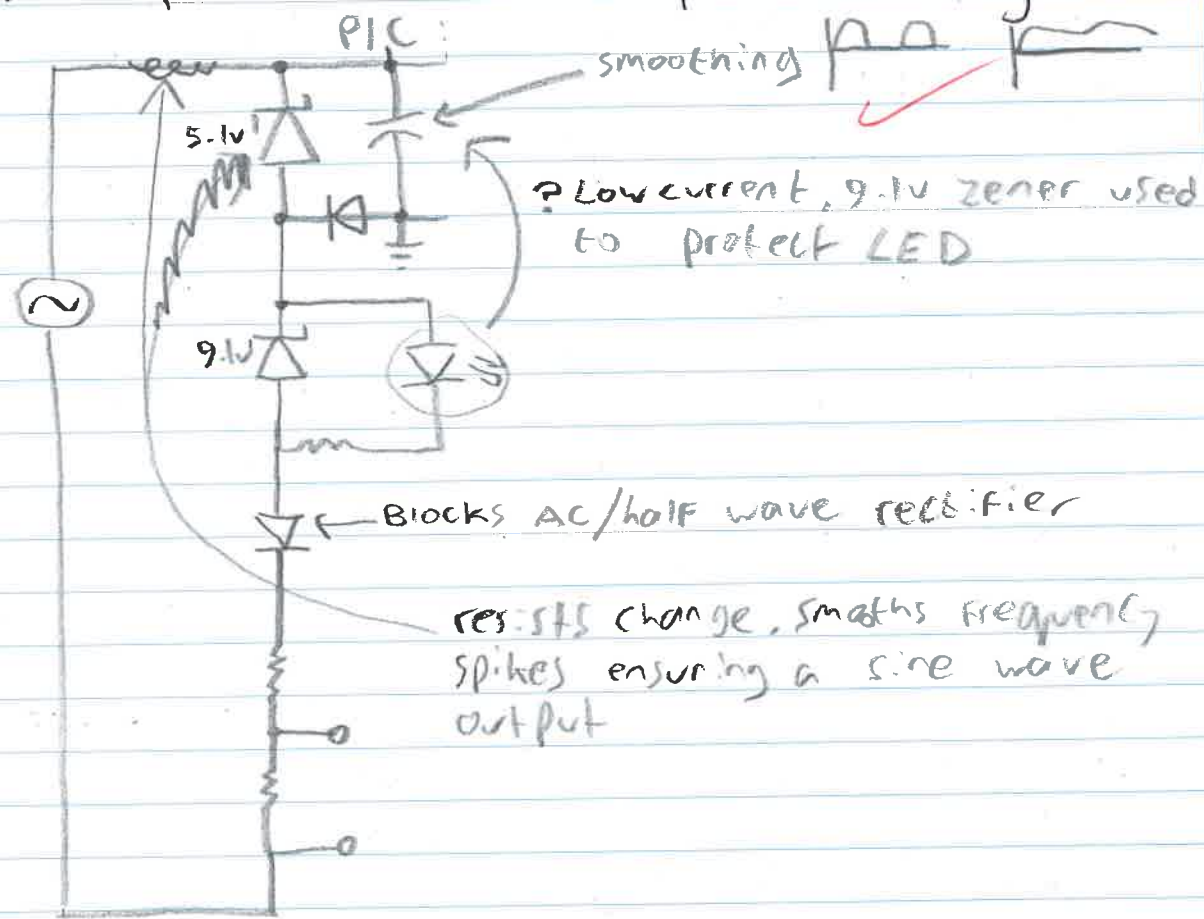
6

2 1/2

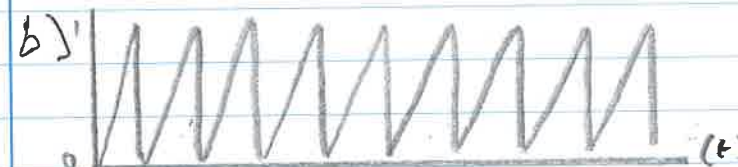
PWM $\neq$ phase angle control

1/ d) an isolation barrier ~~is~~ ~~not~~ (often an opto-isolator) is used to "isolate" part of a system (generally close to the user/VI) from other high power components. This protects the user from electric shocks from the power supply. Often used in heavy user interface based systems like power tools or personal computers.

a) Capacitive/Resistive power supply.



2/ a) R1 is a current limiting resistor used to protect the LED. It is also used as a "pull down" resistor to dissipate any unwanted voltage from pin 3 to ground.



Real output of the timer set by the control system for PWM.

The control program outputs a PWM signal through the timer. This signal is not a perfect square wave thus requiring Q1 to act as a switch giving a wave form closer to a square wave (although a perfect square wave is not feasible for real world development).

c) LED 1 is the light for a torch (or similar lighting system) its brightness is determined by the phase angle of Q1's output. L1 smooths this signal making it closer to a sine wave so that the LED changes on and off relatively gradually instead of hard switching. D1 is a zener that's used as a clamp to protect the diode from unwanted dangerous voltage spikes.

d) an analogue system consumes additional power and is a more "lossy" system due to higher power (see ohms law) causing heat loss as the system is continually at a middling voltage for higher current state. PWM solves this by only using two states (high and low) at high frequencies that cannot be easily perceived by the human eye.

3/ a) boundary scanning used to debug / update code / a circuit by removing and reprogramming the IC originally developed for debugging and repairs in house by the product developer

3

b) doesn't have to be removed, used in micro processors ex. PICkit / PICStarf

c) deterministic RTOS systems have set times for functions and if a function is not complete a check for a higher priority function is conducted. This reduces jitter and is often used in ~~hard~~ soft RTOS systems.

4

4/ a) ~~PC~~ ^{1/2} PC104 is a PC standard used by certain ICs with a specific set of requirements, it's cheap to produce and super fast/efficient (power use/size) although this comes at a greater cost per unit ~~with~~ with little to no upgradability / future implementation. Uses von Neuman architecture and due to limited functionality is faster as it requires less address decoding and time to complete additional background functions (unlike conventional PC standards). This is why it makes it faster.

2

b)



Von Neuman
Harvard

2

* c) Load variable data state (LVDS) signalling uses variable information (stored in RAM) to complete background processes while the CPU controls data flow. This means less operations are required when transferring data in comparison to a conventional parallel bus. It also works in series.

?



SURNAME: RUSSELL

FORENAME(S): Edward

12 Pages

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[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

(See the other side for English version)

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3	Cod y Modwl	
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6	Rhif Sedd	
7	Nifer y Llyfrau Atebion a gyflwynwyd	

Rhestwrch nïau'r cwestiynau a ymgeiswyrd genych	
At Ddlbenion y Swyddfa	

arholi o dan unthw amgylchidau.

8. Rhaid dychwelyd pob llyfr. Ni chaniateir mynd â llyfrau atebion, wedi eu defnyddio neu heb eu defnyddio, allan o'r lleoliad

7. Os defnyddir mwy nag un lliftr, rhwymwch hwy gyda'i gilydd gan ddefnyddio'r tagiau sydd ar gael oddi wrth y gwyliwtr/gwylwyr.

6. Ni ddylid rhwgo unrhyw ran o'r llyfr hwn; rhaid ei gyflwyno yn gyfan.

5. Dechreuwch bob ateb ar dudalen newydd. Gwnewch unrhyw fras nodiadau yn y llyfr atebion a thynnw llinell drwyddyn.

4. Ysgriennwch eich atebion mewn inc.

gael ei theipio a chael yr ymgeisydd i dalu.

3. Rhaid i'r atebion fod mewn llawysgrifen ddarllenadwy. Gall yr Arholwyr naill ai anwybyddu sgrïpt annarllenadwy, neu drefnu iddi!

guddio'ch enw.

2. Rhwch eich enw yn lle a ddarparwyd ar y dde, plygwch et a'i selio i lawr (gan ddefnyddio'r label a ddarparwyd) !

1. Rhowch yr holl wybodaeth y gofynnir amdani yn y blychau isod.

Cyfarwyddiadau i Ymgeiswyr

12 Tudalen

Llyfr Atebion Arholiadau



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
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Lienwch, plygwh a seliwch
(gweler nodyn 2 isod)

CYFENW:

ENW(AU) CYNTAF:

- Q1 a) This system controls the speed of the motor by using a PIC Microcontroller and a potentiometer. The Filter removes the frequencies at the extremes of the AC waveform allowing for a smoother, denser signal. The Capacitive/Resistive ~~transformer~~ power supply takes the 120/240V mains input and reduces it by 5V, this allows the pic to see this ~~lower~~ 5V lower level as a virtual ground. It is better than a standard transformer power supply as it is safer, isolated. This is done later, with isolation between the ~~UART~~ UART and the PIC Microcontroller. This isolation removes risks to personnel as well as the other device as it may not be capable of handling 120/240V. The Potentiometer allows for user control over the speed of the motor by varying the trigger angle of the triac, this trigger angle is displayed using the LEDs. The triac provides AC switching and speed control over the motor via the potentiometer.

- b) Zero cross detection occurs when a sine wave crosses the zero point. This is marked in Figure 1 with crosses. When the AC waveform crosses the zero point the PIC detects this and is able to turn off the triac as needed. This allows for more efficiency in the design & removes the need for a DIAC to control the Gate of the triac.

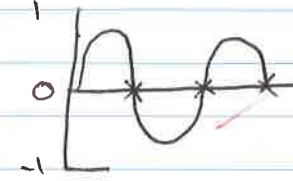


Figure 1

- c) In this system the potentiometer is a ~~other~~ method for the user to adjust the phase angle of the triac, and therefore the speed of the motor. The greater the phase angle the higher the speed on the motor.

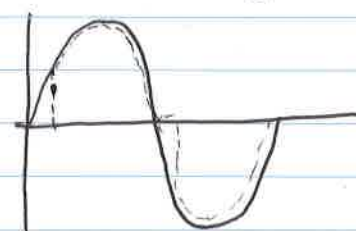
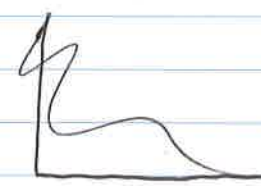


Figure 2

Figure 3

Figure 2 shows an example of a low phase angle as it is almost in phase. This would result in the increased speed of the motor. Figure 3 is nearly out of phase and is a high phase angle, low motor speed.

Q1 d)

The isolation barrier is implemented for two main reasons.

- 1) The AC motor control system is utilizing 120/240 V AC with a virtual ground of 125/116.9/234.9 VAC. The device connected to this system via UART may not be capable of handling such high voltages, as such isolating the system UART will prevent damage to either system.
- 2) As the Capacitive/Inductive power supply is not directly isolated, like a transformer power supply, isolating the system reduces the risk of harm to any users of the system.

The Barrier could be implemented using an optoisolator which allows for the transmission of signals, but not power. A basic optoisolator can be seen in Figure 4r.

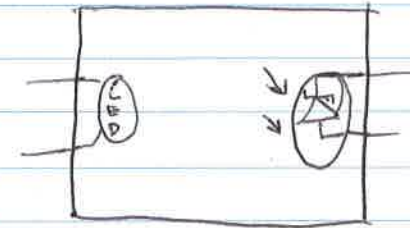


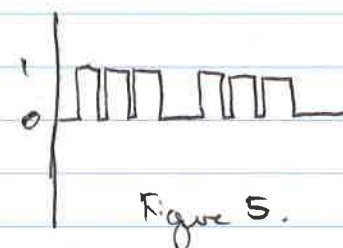
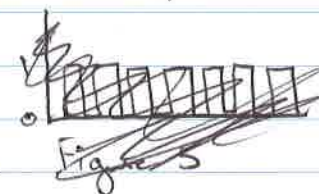
Figure 4r

~~Transmitting signal to system~~

4

Q2 a) The ~~resistor~~ R1 is used to sink the current, as preventing ~~and~~ ^{and} damage to the LED. R1 is used to sink a current, preventing damage to both the LED & the microcontroller. X

b) To drive Q1, pin 2 would be outputting a PWM (Pulse width modulation) signal from the timer module within the microcontroller. ~~the signal is a square wave~~ An example of a PWM can be seen in figure 5.



c) ~~Let's take the AC~~ ~~signal~~ L1 reduces amount of DC ~~power~~ voltage passes through the LED, preventing any damage to it. As an inductor it blocks DC. $\times$
D1, is a Zener diode, ensures that there is a maximum voltage of ~~about 10V~~ ~~being~~ being pulled down to ground, as reducing the load on L1, reducing its size requirement and increasing its efficiency. $\times$

d) By implementing an air embedded microcontroller into the ~~sig~~ flashlight it allows for the optimization of PWM. This ensures the system has greater efficiency than a current limiting resistor which wastes a lot of energy as heat. It also allows for a variety of options regarding flashing patterns.

Q3 a) Boundary Scanning was originally designed as a part of the JTAG Standard. (Joint Testing Action Group) is a test technique method of testing & excluding Printed Circuit Boards.

by sending electrical signals to each component it can determine if there are any faults. how?

2

b) JTAG is used in testing faulty products on ~~parting~~ PCB's. ?
it is also used ?

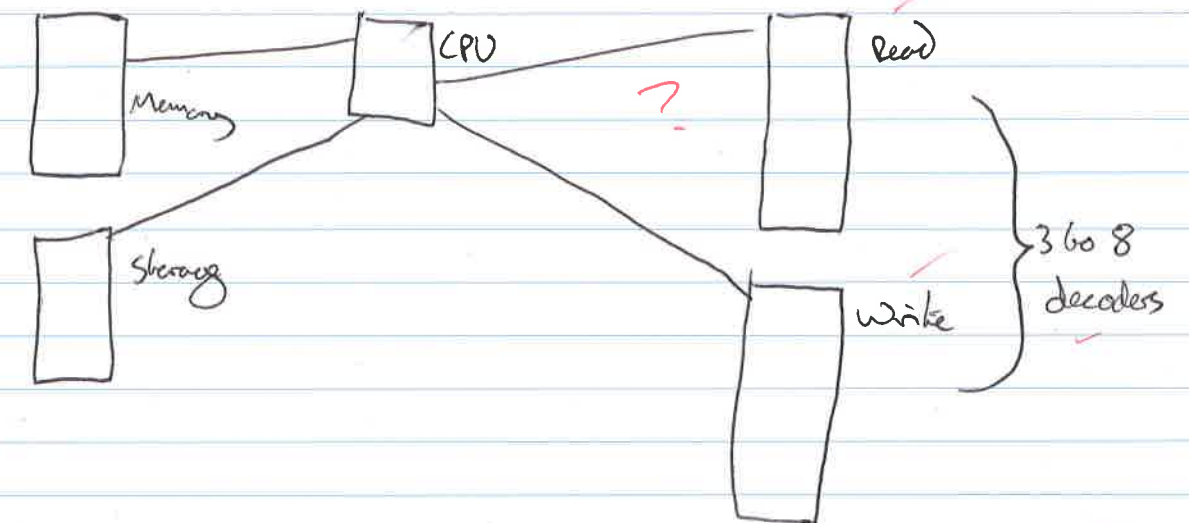
c) When an RTOS is said to be deterministic it is ensuring that the critical tasks will always be done within a given, predetermined time period, this will be the case every time with ~~no~~ little to no variation.

5

- Q4a) The PC104 Standard is a smaller, nestling only 90mm by 96mm. It is rugged, allowing it to be built into and be designed for specialised environments. It is also highly customisable with a huge selection of boards available on the market. Some examples being Ethernet LAN or Power supply boards. The PC104 Standard is flexible allowing for customisable boards that can be designed for any requirement a designer could require. Due to being an industry Standard design much of the board design is already available, drastically reducing development costs. They ~~are~~ also have the potential for cost processing with a variety of processor options including Intel i7.

6 ✓

b)



3 ✓

- c) LVDS Signalling is a low power, high speed Serial data transfer. by using multiple serial buffers it allows for greater speeds than parallel with lower requirements. It also allows for multiple streams of data to be sent ~~at~~ simultaneously ~~low~~.

3 ✓



SURNAME: KRISTIANSEN

FORENAME(S): T HORBJØRN
RAVNAAS

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2	Title of Examination Paper	EMBEDDED MICROCONTROLLER
3	Module Code	M3X8529
4	Date and Time of Examination	16/5-19
5	Examination Venue	ROOM 310 1Q-BUILDING
6	Seat Number	G009
7	Number of Answer Books handed in	

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)



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Llyfr Atebion Arholiadau

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[illegible]

(See the other side for English version)

Llenwch, plygwrch a selwch
(gweler nodyn 2 isod)

CYFENN:

ENW(AU) CYNTAF:

- 1 a) The system depicted in the diagram works on the principle of powering a digital device such as a PLC directly from the power lines. This removes the need for clunky components like a step-down transformer.

Going from left to right:

The symbol on the far left is the mains AC voltage, at either 120V or 240V. The filter is in place both to protect the circuit from mains noise and to protect the mains from noise made by the system. This noise is mainly produced by the motor, where its collapsing fields produce back-EMF (voltage spikes).

The motor is connected directly to the live mains wire, and through ground via a Triac. A Triac is comprised of two thyristors back-to-back. A gate-terminal is energised, stimulating the PNP-configuration inside, allowing current to flow. Once triggered, it will continue conducting while there still is a current draw. Normally, a Triac is triggered with a Diac, to provide an effective and solid trigger pulse due to the avalanche effect of a Diac.

The capacitive/reactive power supply decreases the voltage potential by the means of Zener diodes and smoothes the AC by means of capacitors and diodes. If $V_{in} = 240V_{AC}$, the PSU extracts 5V out of this due to the voltage drop of a Zener diode, making the ground reference ("virtual ground") 235V, ~~which is the 240V mark~~

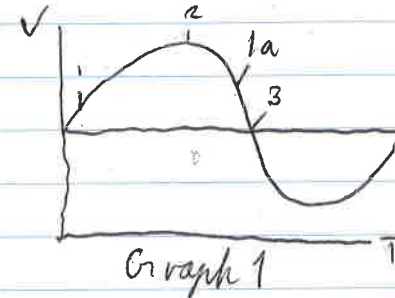
The MCU is seen as "PIC16F1618". It has a potentiometer coupled to an ADC, to adjust the phase angle control of the motor.

1a) cont. The LEDs are in place to provide info on system operation and to warn that it's live.
The user interface could be buttons and screens.

An isolation barrier (e.g. an optoisolator) sits between the live 235-240VAC system and the serial UART connection for safety and to protect controlling equipment from high-voltage.

1

b) A ZCD - module ~~exists~~ exists to enable efficient motor control. By controlling when the Triac conducts on the AC-waveform, speed control and ramp-control is possible.



By triggering at point 3 in graph 1, on the ac-waveform, the motor can be started smoothly, without a large inrush of current. This puts less stress on power components.

Timing?

1

c) By triggering at point 1, maximum power is transferred to the motor, and it receives the entire waveform. The Point 1a is the opposite of, where only part of the waveform is used, decreasing speed and torque.

Diagrams?

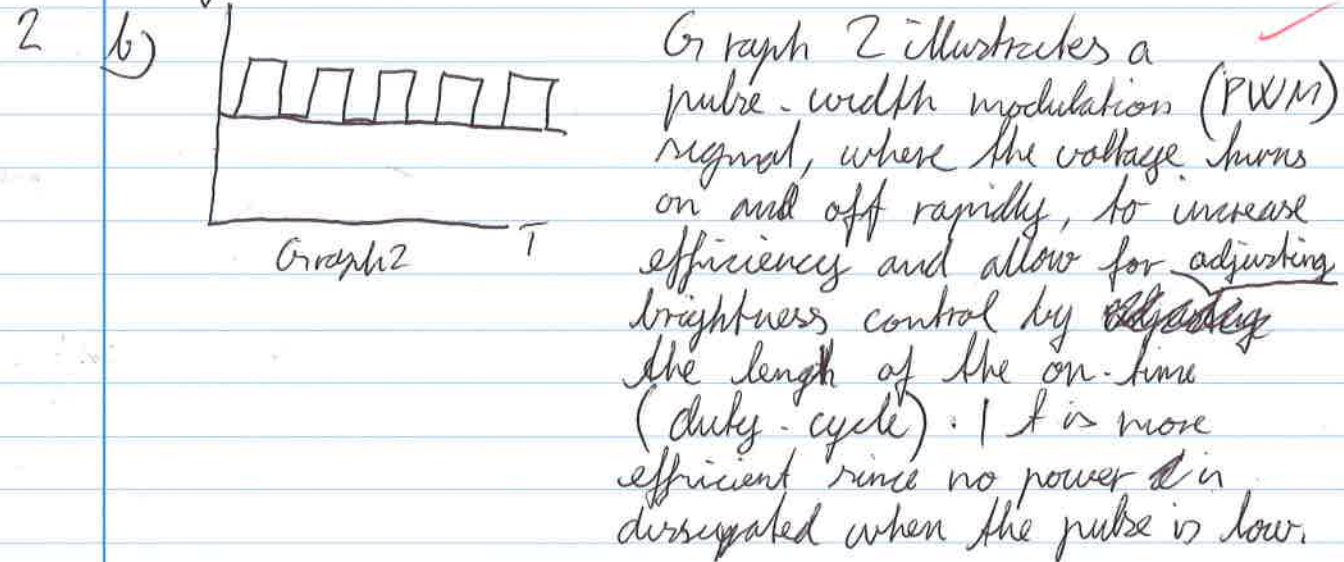
1 d) Since the system left of the barrier sits at 235-240V, it's dangerous to touch. Therefore, the serial connection (to a computer for example) must be isolated from the rest. These systems also operates at a lower voltage.

~~Since it is not safe~~

The isolation-line could also (hopefully) mean a physical isolation, like a plastic chassis. This circuit has no ground, so the chassis must be doubly-isolated.

How?

- 2 a) R1 is a small resistor used to create a voltage drop, by which the MCU can read this voltage because of the potential divider action created by the LED and resistor. This is used to calculate the current through the LED, allowing for ^{LED} protection and brightness control. It is small to ensure it doesn't dissipate too much power in the process.



- 2 c) L1 is an inductor, which resists changes in current. Therefore, it will "average" out the PWM signal, providing near-DC to the LED. When the voltage is removed from the inductor, its magnetic field collapses, creating a large voltage spike. The D1 Schottky-diode is a fast-acting diode which drops this overvoltage straight to ground, protecting the MCU and LED.

This collapse happens every time the PWM goes low, further adding to the necessity of the diode. This diode should be beefy, since it hasn't got a current limiting resistor. The collapsing field can produce voltages much larger than the input voltage, which is why inductors are scary.

~~2~~

- 2 d) An embedded system allows for greater efficiency due to PWM capabilities. It also provides flexibility, with programmable modes, battery information etc.

By being more efficient than its analogue counterpart, it also dissipates less heat.

The system can also be altered with tiny tweaks in software, which enables the seller to sell an entirely new flashlight with "new features", with almost no effort. *like what?*

3 a) The boundary scan method is a quick way of verifying the functionality of complex micro-architectures and electronic circuits. In a system with wires going to key components of the system, standardized by JTAG (Joint Test Action Group).

3 b) JTAG can also be used for programming/debugging, diagnostics and real-time extraction of system data by ~~proposed~~ proprietary software from vendors. This means that the JTAG standard has multiple variations, all building upon the principles of the boundary scan standard.

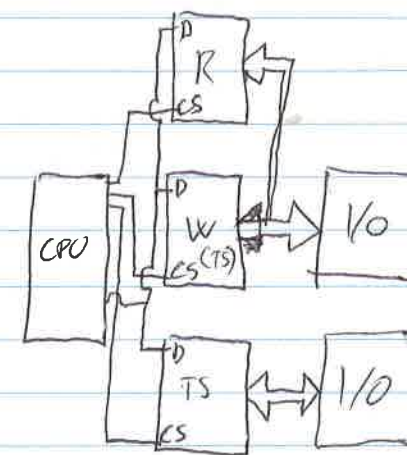
3 c) A deterministic RTOS is an RTOS where all its instructions and functions ~~are~~ have a predictable and ^{repeatably} repeatable instructions time. This is important to reduce jitter in time-critical systems like air-bags and other safety loops.

~~RTOS~~

An analogy for a hard RTOS is the spinal reflex: If you touch a hot plate, the spinal reflex will always have priority, and will pull your hand away regardless of what your brain is doing.

4 a) The PC104 standard was developed to provide a robust, modular hardware platform built on the common PC architecture. It is more powerful than an MCU, but a lot smaller than its full-size brethren. Its main advantage is its modular design, where entire systems can be removed or added quickly, allowing for a customisable system fitting most industrial applications.

4 b)



R = Read
W = Write
I/O = Inputs/outputs
TS = Tri-state buffer
CPU = Central processing unit.
CS = Chip select
D = Data bus

A n ISA system is a standardized approach to system customisation, where chip-select signals are used to enable different components to share the same data bus. Tri-state buffering is included to isolate components when needed.

Common chips are tri-state buffers, 3:8 (or other configs) - decoders and DIP-switches to assign addresses to components.

Address decoding ??

41

c) LVDS (low voltage differential signaling) is a technique used to achieve extremely high data frequencies, by sending data through two wires with opposite polarity. This reduces noise, as it acts like its own error-correction system.

It is a lot faster than parallel, due to the possible clock speeds in the modern world. Our systems have become faster, not more parallel.

It also uses lower voltages, partly due to the extremely short bursts of voltage. It is less susceptible to noise, and thereby errors.

Its principle is similar to twisted-pair cables.

SCRAP

