Set A

Q.1. Define an embedded system. provide the 3 main components needed to design an embedded system and what are the specific features that characterize an embedded system.

→ Embedded system :- It can be defined as a computing device that does a specific focused job.

- Applicances such as the air-conditioner, VCD player, DVD player, printer, Fax machine, mobile phone etc. are examples of embedded system.
- An Embedded system is a computing device that does a specific job. Both the hardware and software are optimized for the specific job.

* 3 main components needed to design an embedded system

1) Hardware :- Applications such as the air-conditioner, DVD player, printer, Fax Machine, Mobile phone etc.

- Each of this applications will have processor and special hardware.

2) Processor :- To meet the specific requirement of the application along with the embedded software that is executed by the processor for meeting that specific requirement.

3) Application Firmware :- Embedded software is called firmware.

- The desktop/ laptop computer general purpose computer. We can use it for a variety of applications such as playing games, word processing, accounting, software developmend and so on.

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- The software in the embedded system is always fixed.

* Embedded systems are characterized by some special features listed below :-

1) Specific Tasks :- Embedded systems do a very specific task, they cannot be programmed to do different things.

2) Limited Resources :- Embedded systems have very limited resources, particularly the memory Generally, they do not have secondary storage device such as CDROM or the Floppy disk.

3) Deadline specific :- Embedded systems have to work against some deadlines.

- A specific job has to be completed within a specific time.
- In some embedded system, called real-time systems the deadlines are stringent.
- Missing a deadline may cause a catastrophe-loss of life or damage to property.

4) Power Constraint :- Embedded system are constraint for power

- As many embedded system operate through a battery, the power consumption has to be very low.

5) Reliable :- Embedded systems need to be highly reliable

- Once in a while, pressing ALT-CTRL-DEL is OK on your desktop, but you cannot afford to reset your embedded system.

6) Environmental conditions :- Some Embedded systems have to operate in extreme environmental conditions such as very high temperatures and humidity.

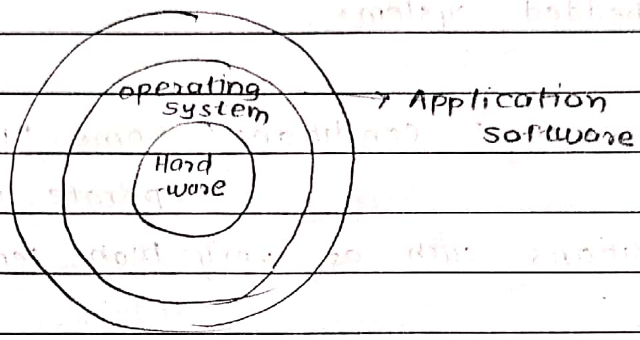
7) cost :- Embedded system ~~comms~~ that address the consumer market are very cost effective.

- Even a reduction of $ 0.1 is lot of cost saving, because thousands or millions systems may be sold.

8) Platform :- Unlike desktop computers in which the hardware platform is dominated by intel and the operating system is dominated by microsoft, there is wide variety of processors and operating systems for the embedded systems.

- So choosing the right platform form it most complex task.

Q.1. Explain the layered architecture of an embedded system, state with example the 4 categori



→ - Every emebedded system consists of custom-built hardware built around a central processing unit.

- This software also contains memory chips onto which the software is loaded.
- The software residing on the memory chip is also called the Firmware.
- The embedded system architecture can be represented as a layered architecture as shown in fig.
  i) Hardware
  ii) Operating system
  iii) Application software
- The operating system run the hardware, and the application software run above the operating system
- The same architecture is applicable to any computer including a desktop computer, However there are significant references.
- It is not compulsory to have any operation system in every embedded system.

For ex. small applicances such as remote control unit, air-conditioners, toys etc, there is no meed for an operating system and you can write only the software specific to that applications.

- For example: For applications involving complex processing it is advisable to have an operating system
- In such a case, you need to integrate the application software with the operating system and then transfer the entire software on to the memory ~~device~~ chip.
- Once the software is transferred to the memory chip, the software will continue to run for long time and you don't need to reload new software.
- Now, let us see the block of the hardware of an embedded system.
  i) Central processing unit (CPU)
  ii) Memory (Read-only memory and Random Acess Memory)
  iii) Input Devices
  iv) Output Devices
  v) Communication interfaces
  vi) Application- specific circuitry

Embedded System can be categorized into:
1> Stand-Alone Embedded Systems
2> Real-time Systems
3> Networked information appliances
4> Mobile devices.

1> stand-alone embedded system:-
→ As the name implies, stand-alone system works in standalone system.
- The input can be electrical signals from transdures or commands from a human being such as the pressing of

a button. The output can be electrical signals to drive another system, can LED display or LCD display for displaying of information to the user.

- Embedded systems used in process control, automobiles, consumer electronic items etc. fall in this category.
- Ex. In process control system, the inputs are from sensors that convert a physical entity such as temperature or pressure into its equivalent electrical signal.
- These electrical signal are processed by the system and the appropriote electrical signals are produced using which an action is taken such as opening a valve.

2) Real time systems :-

- Embedded systems in which some specific work has to do done in a specific time period are called real-time systems.
- Example :- consider a system that has to open a valve within 30 miliseconds when the humidity crosses a particular threshold.

IF the valve is not opened within 30 miliseconds, a catastrophe may occur. Such systems with strict deadlines are called hard real-time systems.

* Soft-real time systems :-

→ In some embedded systems, deadlines are imposed but not adhering to them once in a while may do not lead to catastropher.

- Example - Consider a DVD player. suppose you give a command to the DVD player from a remote control and there is a delay of few

miliseconds in executing that command.
But the delay won't lead to a serious implication. Such systems are called the soft real time systems.

→ Example :- Hard real-time embedded system

A missible that has to track and intercept an enemy aircraft. The missile contains an embedded system that tracks the aircraft and generates a control signal that will lunch the missible.

IF there is a delay in tracking the aircraft and if the missile misses the deadlines, the enemy aircraft may drop a bomb and cause loss of many lines. Hence this system is a hard real-time embedded system.

3) Networked Information Appliances :-

- Embedded systems that are provided with network interfaces and accessed by networks such as local area network or the internet are called networked information appliances.
- Such embedded system are connected to a network typically a network running TCP/IP transmission control protocol / internet protocols, Protocol suite, such as the internet or a company's intranet.
- Example :- The door lock of your home can be a small embedded system with TCP/IP and HTTP server software running on it. When your children stand in front of the door lock after they return from school, the web camera in the door lock will send an alert to your desktop over the internet and then you can open the door-lock through a click of the mouse.

4) Mobile Devices

- Mobile devices such as mobile phones, personal digital assitants (PDAs), smart phones etc. are special category of embedded systems.
- Though the PDA do many general purpose task, they need to be designed just like the conventional embedded systems.
- The limitations of the mobile devices memory constraints, small size, lack of good user informatic interfaces such as full-fledged keyboard and display etc.

* Specialities of Embedded system :-

i) Reliability :- When we use a desktop, sometimes the system 'hangs' and we need to reset the computer.
- Generally this does not cause any problem.
- However this is not the case with the embedded systems used in mission-critical applications.
- They must work with high reliability.
- Reliability is of ~~para~~ paramount importance in embedded system.
- They should continue to work for thousands of hours without break. Example :- Embedded systems used in industrial control are inaccessible.
- They are hidden in some other large sized equipment hence there will not be a reset button on such systems. So the design of the embedded system should be such that in case the system has to be reset, the reset should be done automatically.

- Special hardware / software needs to be built into the system to take care of it.
- The special module is known as watchdog timer.

2) Performance :- Many embedded systems have time constraints.
- For example : For instance, in a process control system a constraint can be : "If the temperature exceeds 40 degrees open a valve within 10 milliseconds".
- The systems must meet such deadlines.
- If the deadlines are missed, it may result in a catastrophe.
- You can imagine the damage that can be done if such deadlines are not meet in a safety system of nuclear plant.

3) Power consumption :-
- Most of the embedded system operate through a battery.
- To reduce the battery drain and avoid frequent recharging of the battery, the power consumption of the embedded system has to be very low.
- To reduce power consumption such hardware components should be used that consume less power. Besides, emphasis should be on reducing the components count of the hardware.

4) Cost :- For embedded systems used in safety applications of a nuclear plant or in a spacecraft, cost may not be a very important factor.
- However, for embedded systems used in consumer electronics or office automation, the cost is of atmost importance.
- For example :- Suppose that you designed a toy in which the electronics will cost \$ 20. By careful analysis of the design if you can find a way to reduce the cost to \$ 19, it will

be a great job. Don't underpay the importance of the one dollar because when you sell 10 million toys, the cost reduction is $10 million. Not suppрrisingly the hardware eneginееrs debate on component selection to reduce even $ 0.1.

5) Size :- size is certainly a factor for many embedded systems.

- We do not like a mobile phone that has to be carried on our back.
- The size and the weight are important parameters in embedded systems used in aircraft, spacecraft, missiles etc. because such cases, every inch and every gram matters.

6) Limited user interface :- Unlike desktops, which have full-fledged input/output devices, embedded systems do not have sophisticated interfaces for input and output.

- Some embedded systems do not have any user interface at all.
- They take electrical signals as input and produce electrical signals as output.
- In many embedded systems the input is through a small function keypad or a set of buttons. The output is displayed either on a set of LEDs, or a small LCD.
- For example :- The mobile phone has a small display of a 4 lines 16 characters. The input is through a keypad and composing a small text message is not and easy task. Developing a user friedly interface with limitations of the input/output devices is a challenging task for firmare developers.

7) Software upgradation capability :- Embedded system are meant for a very specific task.

- Once the software is transferred to the embedded system, the same software will run throughout its life.
- However in some cases, it maybe necessary to upgrade the software.
- For example :- A public call office (PCO). At the PCO an embedded system is used while displays amount to be paid by a telephone user. The amount is calculated by the firmware, based on the calling number and the duration of the call. From time to time, the telecom operator will change the algorithm for the calculation of the bill amount.

Q.2. Consider the typical triangle-shaped revenue model suppose that a product is supposed to enter the market at time 0 with the peak revenue of 3 units at time W, and the product life is 2W. However the launch of the product get delayed by a time D. For W = 24 months, and D = 2 months, Calculate what will be the revenue loss and percentage revenue loss due to the delayed launch of the product.

→ given :- product life cycle is 2W.

$W = 24$ months

$D = 2$ months

Revenue loss $= \frac{D(3W-D)}{2} = \frac{2[3(24)-2]}{2} = 70$

percentage Revenue loss $= \frac{D(3W-D)}{2W^2} \times 100$

$= \frac{2(3(24)-2)}{2 \times 24 \times 24} \times 100 = 12.15\%$

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Q. The cost required to set up a factory in urmorgoan for an automative industry has been given to be 12 lakh. The Factory manufactures seat covers and breakpads for volkwagean Auto at a cost of 18000/- unit. The R and D cost required to design this system by a team of electronics engineers from DJSCE over a period of 01 years of pegged at 8 lakh including the wadges. If 2500 units are to be manufactured per month. Calculate the total cost incurred for the production unit for these units over 1 year and hence Calculate the cost per unit.

→ cost of expenditure = 12 lakhs + 8 lakhs

X = 20 lakhs.

cost per unit = y = 18000

per month manufactured = 2500 units.

For 1 year = $N = 12 \times 2500 = 30{,}000$

Total cost = $X + NY$

$= 20{,}00000 + (30{,}000 \times 18{,}000)$

$= 54.2$ Crore

per unit cost = $\frac{x}{N} + y$

$= \frac{20{,}00000}{30{,}000} + 18{,}000$

$=$ ₹ 18.066

required for ...

Q.3. Compare the wifi 802.11 b standard with 802.11 a g Standard on the basis of following:

	Parameters	802.11.b	802.11.a/g
1)	Frequency Band	2.4 GHz - 15 MHz	2.6 GHz - 15 MHz
2)	Channel Bandwidth	25 MHz	20 MHz
3)	Half/Full duplex	Half	Half
4)	Radio Technology	Direct sequence spread sequence	OFDM (64-channels)
5)	Speed / B/W	< 0.44 bps/Hz	≤ 2.7 bps/Hz
6)	Modulation	QPSK	BPSK, QPSK, 64-QAM
7)	FEC	None	convolution code checking
8)	Encryption	Optional - RC-4M (RES in 802.11)	optional RCS (RES 802.11)
9)	Access protocol	CSMA/CA	CSMAC/A

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Q. Explain Bluetooth wrt following parameters : frequency range and channels, Data Rate, RF Hoping, security, transmit o/p power and hence compare Bluetooth version 1-4.

→ Frequency range and channels :- 2402-2480 MHz (total 79 MHz band)
23 MHz in some countries i.e. spain

Data rate :- 1 Mbps using 1 MHz (Nominal)
720 kbps (user)

Radio Frequency Hopping :- 1600 times/s → 625 us/hop

Security :- challenge / Response authentication
128 b encryption

Transmit o/p power :- i) Class 1. 20 dBm max (0.1W) - 100m
ii) class 2. 4 dBm (2.5 mW)
iii) class 3. 0 dBm (1 mW) - 10 m

Compare Bluetooth version : 1-4

1) Bluetooth 1.1 → IEEE 802.15.1 - 2002

2) Bluetooth 1.2 → IEEE 802.15.1 - 2005
i) completed Nov 2003
ii) Extended SCO, Higher, variable rate retransmission for SCO
iii) Adaptive frequency hoping to avoid interferences.

3) Bluetooth 2.0 → i) Enhanced data Rate (EDR) (NOV 2004)
ii) 3 Mbps using DPSK
iii) For video application
iv) Reduced power due to reduced duty cycle.

4) Bluetooth 2.1 → i) Secure simple pairing to speed up pairing
EDR (July 2007) ; Interperability with wifi

5) Bluetooth 3.0 → i) High speed (HS)

ii) 24mbps using wifi PHY + Bluetooth PHY for lower rates.

6) Bluetooth 4.0 → i) low energy

ii) Smallerdevices requiring longer battery life

iii) New incompatible PHY.

iv) Bluetooth smarter BLE

7) Bluetooth 4.1 → Core specification Amendments (CSA) . 1, 2, 3, 4

Q.4. Explain ARM architecture processor mode and hence explain the frame format of a program status register.

→

	Processor mode	code	Description
i)	User	Usr	Normal program execution mode.
ii)	FIQ	Fiq	Entered when a high priority (Fast interrupt) is raised.
iii)	IRQ	irq	Entered when a low priority (normal) interrupt is raised.
iv)	supervisory	svc	A protected mode for the operating system (entered on reset and when software interrupt instruction is executed)
v)	Abort	abt	Used to handle memory access violations

vi)	undefined	und	used to handle undefined instructions.
vii)	system	sys	Runs priviledged operating system tasks.

→ Registers :- ARM has 37 registers all of which are 32-bits long.

i) 1 dedicated program counter (PC)
ii) 1 dedicated current program status register (CPSR)
iii) 5 dedicated saved program status register (SPSR)
iv) 30 general-purpose register (GPR) which supports 6 datatypes (sign/unsigned)
→ 8 bit-byte, 16 half word, 32-word.

→ register organization

USR, SYS	FIQ	IRQ	SVC	UNDEF	ABT
r0					
r1					
r2	USER modero r7, r15 and CPSR	USER modero r13, r15 and CPSR	User mode r0 r12, r15 and CPSR	User modero r12, r15 and CPSR	User mode r0 r12, r15 and CPSR
r3					
r4					
r5					
r6					
r7					
r8	r8				
r9	r9				
r10	r10				
r11	r11				
r12	r12				
r13 (SP)	r13 (SP)	r13 (SP)	r13 (SP)	r13 (SP)	r13 (SP)
r14 (LR)	r14 (LR)	r14 (LR)	r14 (LR)	r14 (LR)	r14 (LR)
r15 (PC)					
CPSR	SPSR	SPSR	SPSR	SPSR	SPSR

→ Current processor mode governs which registers are accessible.

→ Only 16 registers and visible to specific mode of operation each mode can access.

i) A particular set of register r0-r12

ii) r13 (SP stack pointer)

iii) r14 (LR Link Register)

iv) r15 (PC program counter)

v) current program status register (CPSR)

Program status register :-

31 28 27 24 23 16 15 8 7 6 5 4 0

N	Z	C	V	undefined	I	F	T	mode

← F → ← S → ← X → ← C →

codition code flags

→ N: negative result from ALU

→ Z: zero result from ALU

→ C: ALU operation carried out

→ V: ALU operation overflowed

Interrupt Disable bits

→ I: 1 :- Disables the IRQ

F: 1 :- Disables the FIQ:

Mode bits	Mode selected
10000	user
10001	FIQ
10010	IRQ
10011	supervisor
10111	Abort
11011	undefined
11111	system

Q. Explain the concept of Exception Handling using PC & Link register and provide results based on following instructions to complete the task:

- LDR r0, [r1, #12]!

  What will be the contents of r0 & to what location will be r1 pointing to if PC started at 1000

  contents at 1000-10, 1004-20, 1008-30, 100C-40

- STMIA r9!, {r0, r1, r5} & STMDB r9!, {r0, r1, r5}

  If the current location of r9 is 100C what will be the location of the PC after execution of the above instructions and explain the instructions.

→ When any exception occurs in the ARM processor, the up/uc follows the following steps:-

i) copies the status of CPSR into SPSR-mode.

ii) After copying, sets the required bits in CPSR i.e,

  - it changes from thumb state to ARM state [T=0]
  - it changes to related mode [mode bits are altered]
  - it disables FIQ and IRQ [T=1, F=1]

iii) Stores return to address in the LR mode, i.e. it stores in the link register.

iv) sets the PC (program counter) to vector address obtained by calculating using vector table.

v) After execution it restores CPSR from SPSR-mode.

vi) Later, it returns PC (program counter) from LR mode.

i) LDR r0, [r1, #12] !

contents : 1000 - 10

1004 - 20

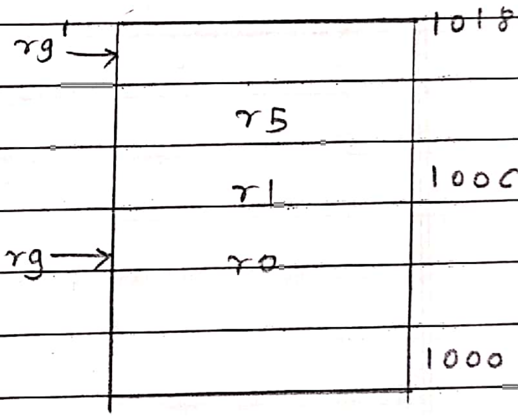
1008 - 30

100C - 40

- contents of r0 = 40
- If the PC started at 1000, r1 is pointing to 1004.

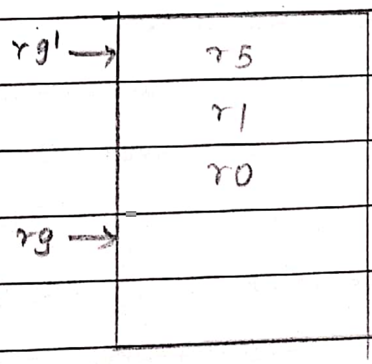
ii) STMIA r9! {r0, r1, r5}

→ location of r9 = 100C



STMIA : The IA instruction stands for increment after. r9 first points at 1000C and value of 10 is stored 100C and r9 is incremented and its value is 1010 and then next value is stored in r9. Location of r9 will be 1014.

STMDB r9! {r0, r1, r5}



STMDB : the instruction stands for increment before. The value of r9 is 1st incremented and then, r0 is stored in r9 and location of r9 will be 1018H.