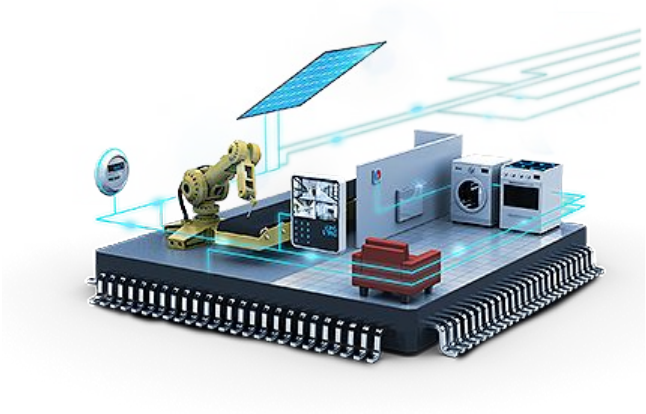
Giris



Suhap SAHIN

Kaynaklar

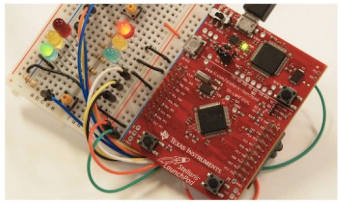
http://users.ece.utexas.edu/~valvano/Volume1/E-Book/

Embedded Systems

users.ece.utexas.edu/~valvano/Volume1/E-Book/

Apps OLASILIK NEDİR CS109-1 Vector intro for l i3: i3 User's Guid Data Structure an Source code bea Enabling multime Double-Ended Q FONKSİYONUN Olasılık ve İstatist PERMÜTASYON Veri Yapıları ve Al AVL Tree | Set 1 Applications of Li How to Calculate Probability Random Event: D

Embedded Systems - Shape The World



Jonathan Valvano and Ramesh Yerraballi

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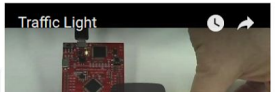
This material is being developed for an online class that is running January 2016 to May 2016 on the EdX platform. This website is meant to supplement not replace the content on edX. This site has been our sandbox where we first built the information before uploading to edX. If you need closed captions, please use the edX site because the captions on edX have been reviewed and edited by Valvano and Yerraballi. When viewing the videos on YouTube you can activate their closed captioning, but these captions have not been reviewed or edited. However, many students have asked for two things: 1) a more linear or book-like resource of the class material; and 2) a list of the video links. This website provides both. All videos are hosted in two places: YouTube and Amazon S3. It is our plan to make the edX pages as accurate as possible and will strive to make corrections as we can. Again, this website contains the material prior to uploading to edX and hence may be more inaccurate. Knowing that however, it is our goal to reach as many people as possible and we hope this site makes the class more accessible for those having technical issues reading and watching the material on edX. All quizzes and labs must be performed on the edX site.

https://www.edx.org/course/embedded-systems-shape-world-utaustinx-ut-6-03x



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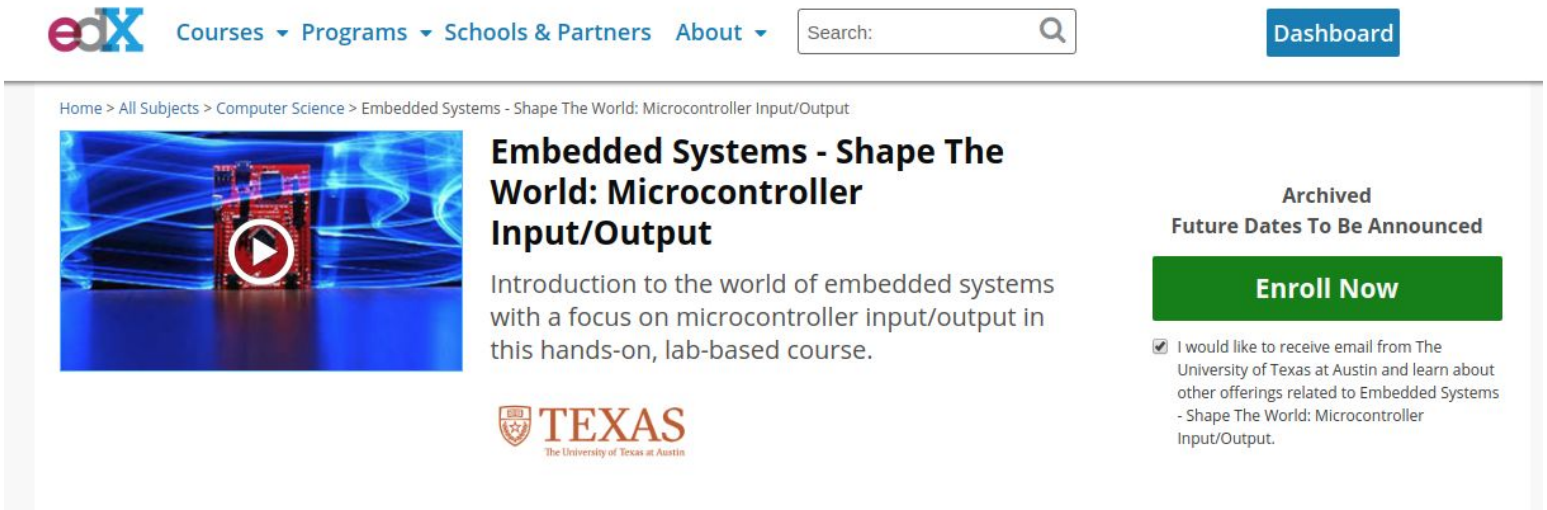
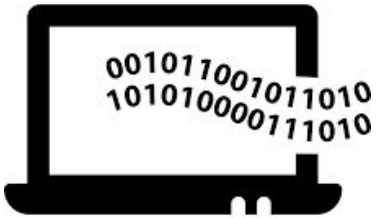


Konular

1. Giris

Konular

1. Giris
2. Temel Kavramlar



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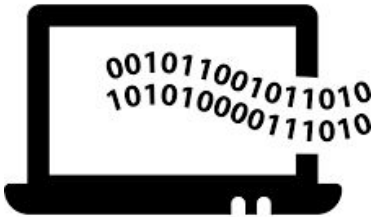
2. Temel Kavramlar



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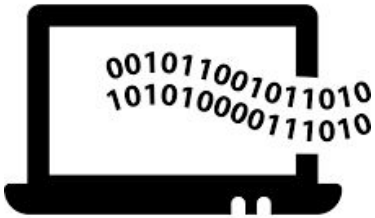

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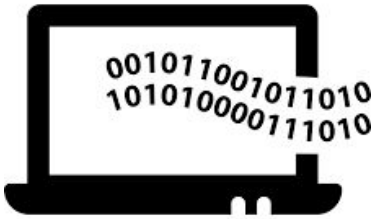

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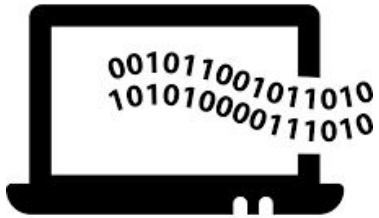

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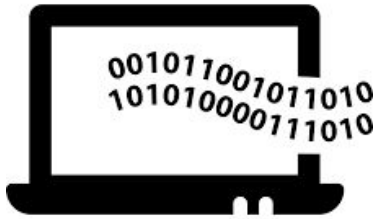

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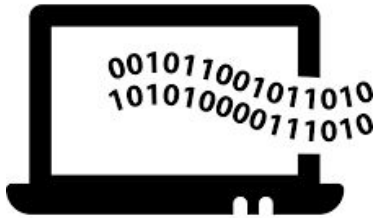

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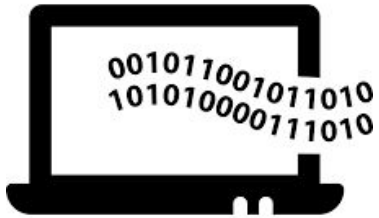

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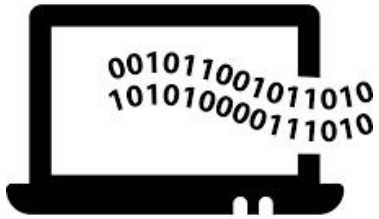

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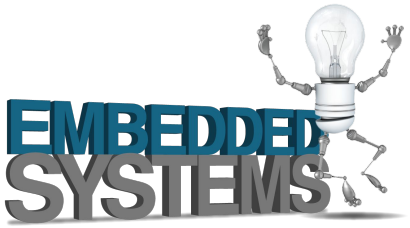

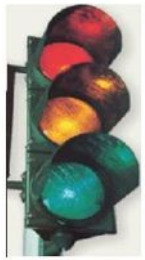

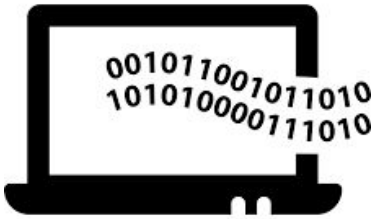

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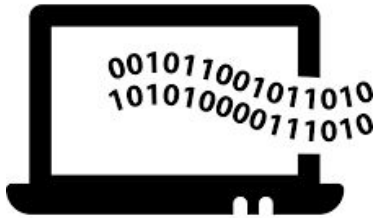

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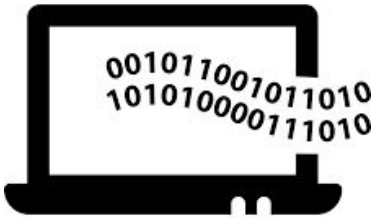

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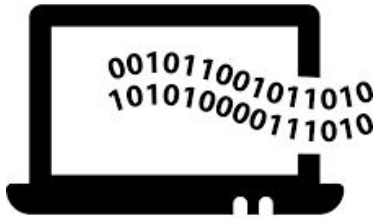

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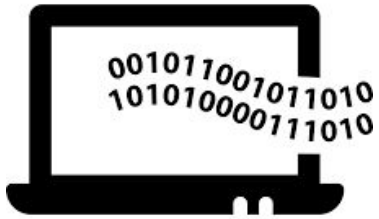

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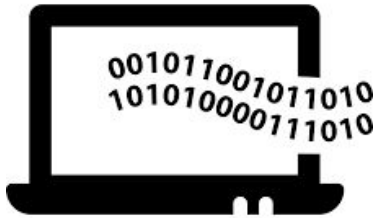

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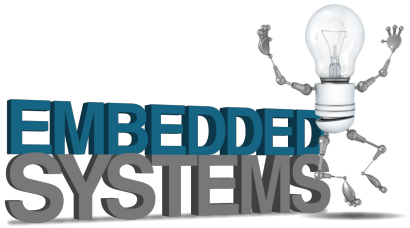
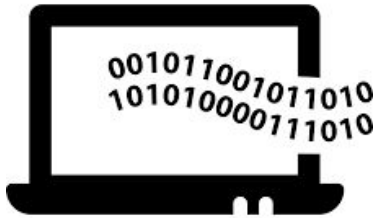
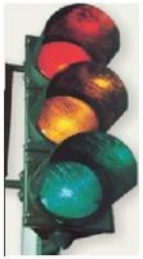






Konular

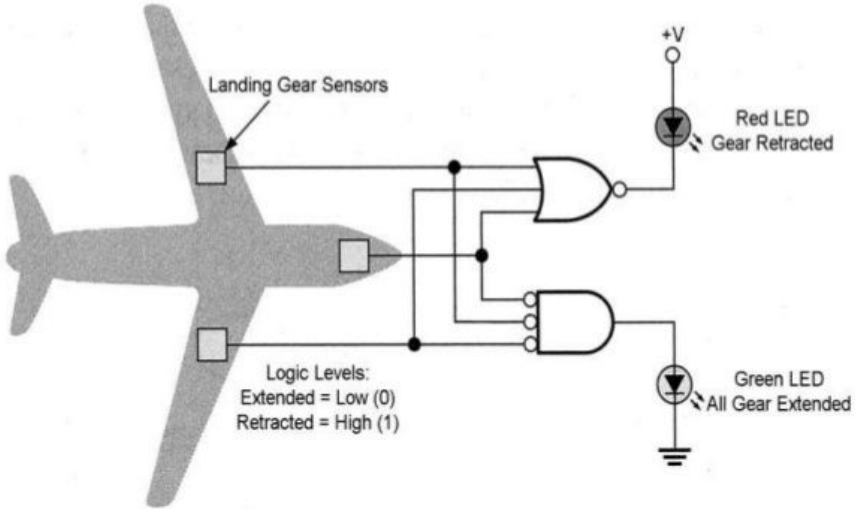
1. Giris
2. Temel Kavramlar
3. Elektronik

Konular

1. Giris
2. Temel Kavramlar
3. Elektronik
4. Lojik

AIRCRAFT LOGIC CIRCUIT

- **LANDING GEAR WARNING CIRCUIT**



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2. Temel Kavramlar
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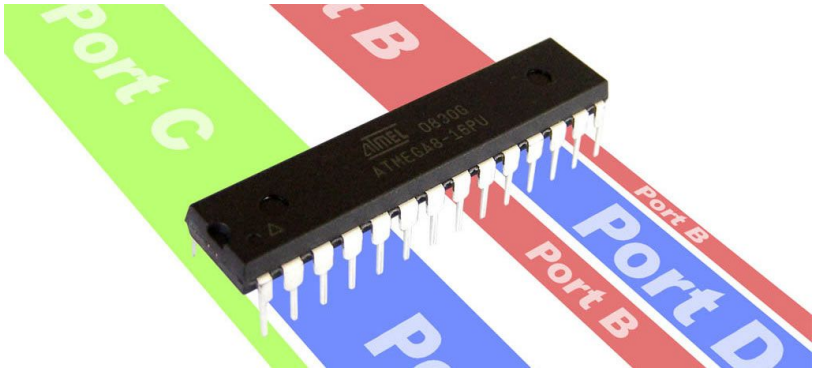
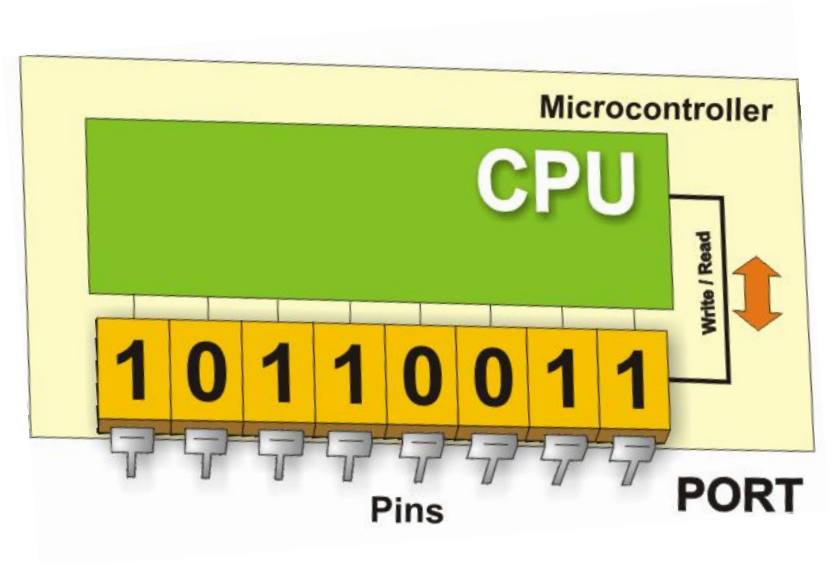
4. Lojik
5. C Diline Giris

Konular

1. Giris
2. Temel Kavramlar
3. Elektronik
4. Lojik
5. C Diline Giris
6. Mikrokontrolcü portları





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1. Giris
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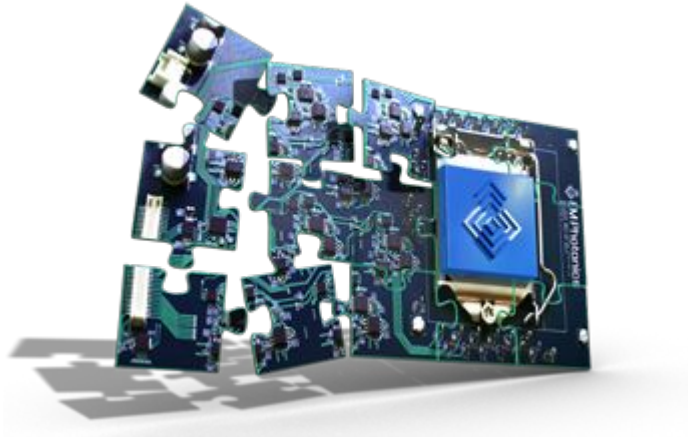
3. Elektronik
4. Lojik
5. C Diline Giris
6. Mikrokontrolcü portları
7. Tasarım ve Gelistirme



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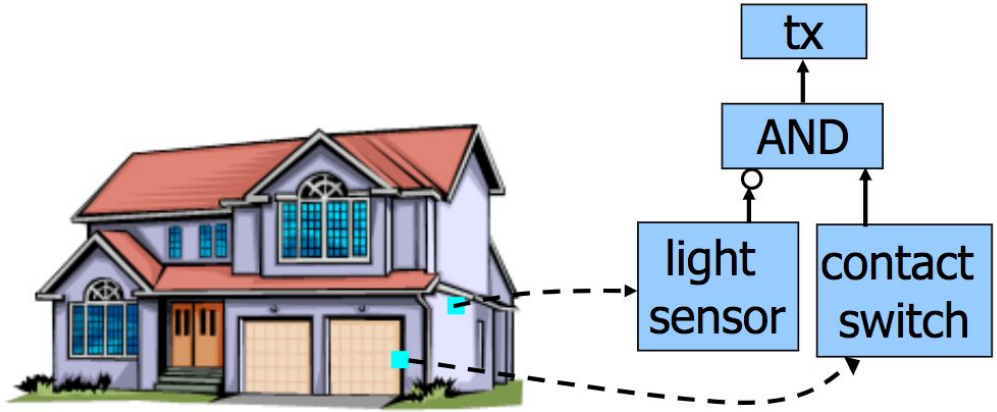

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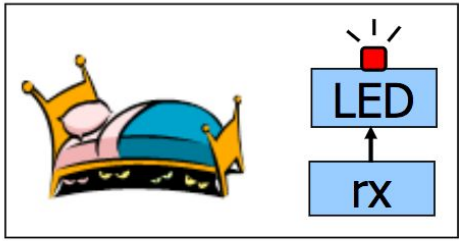

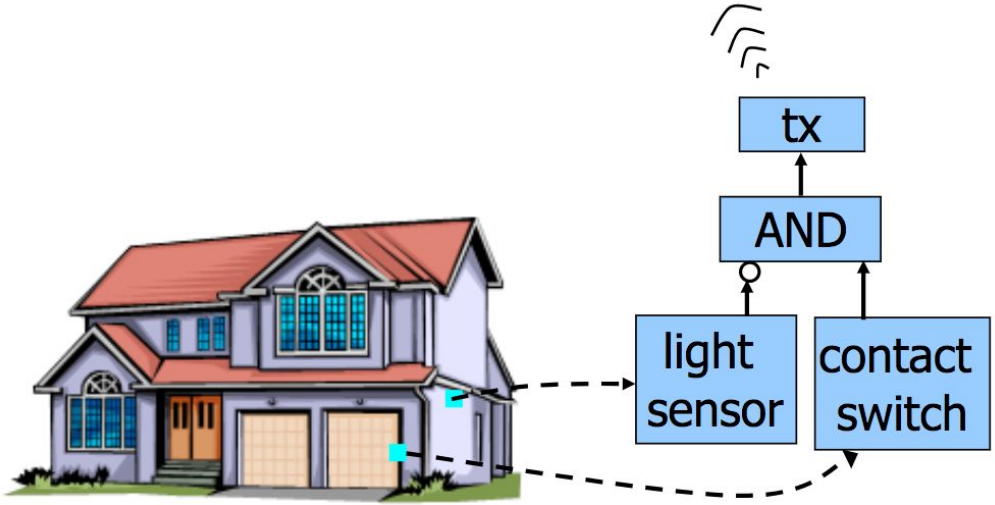

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9. Diziler ve Fonksiyonel Hata Ayıklama

Computer running
external debugger tool

Konular

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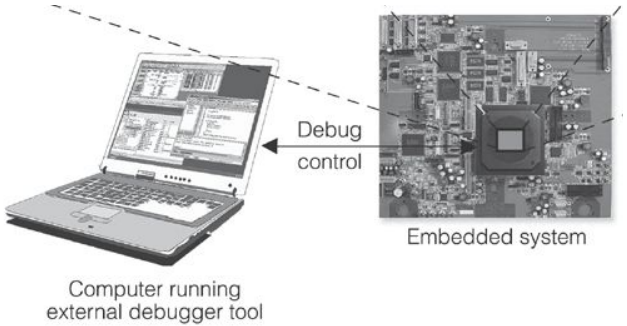

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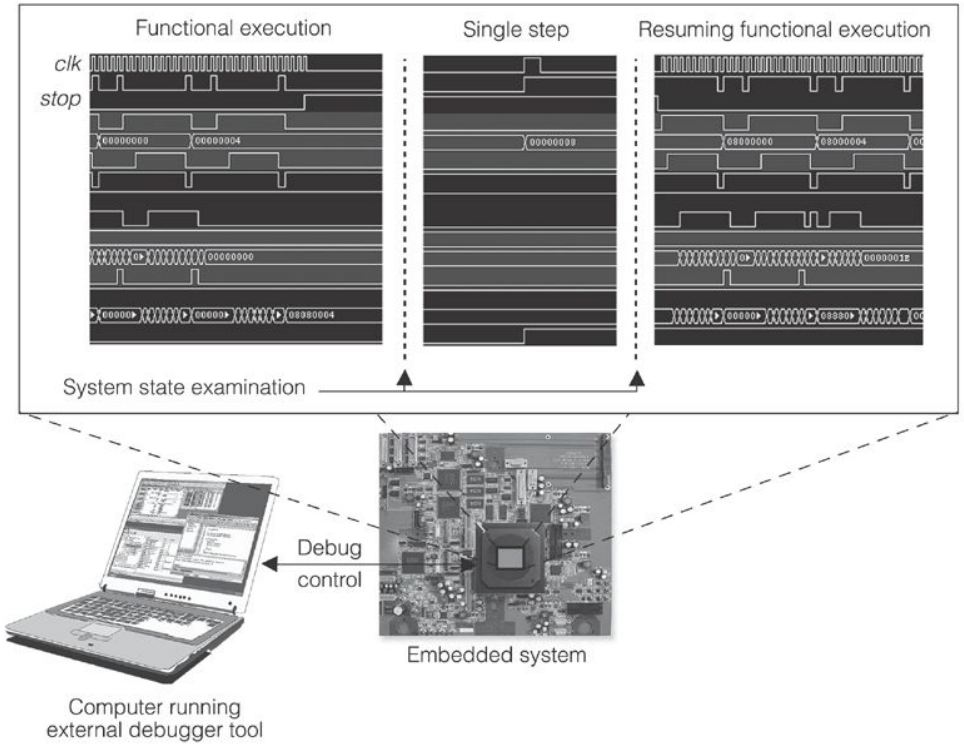

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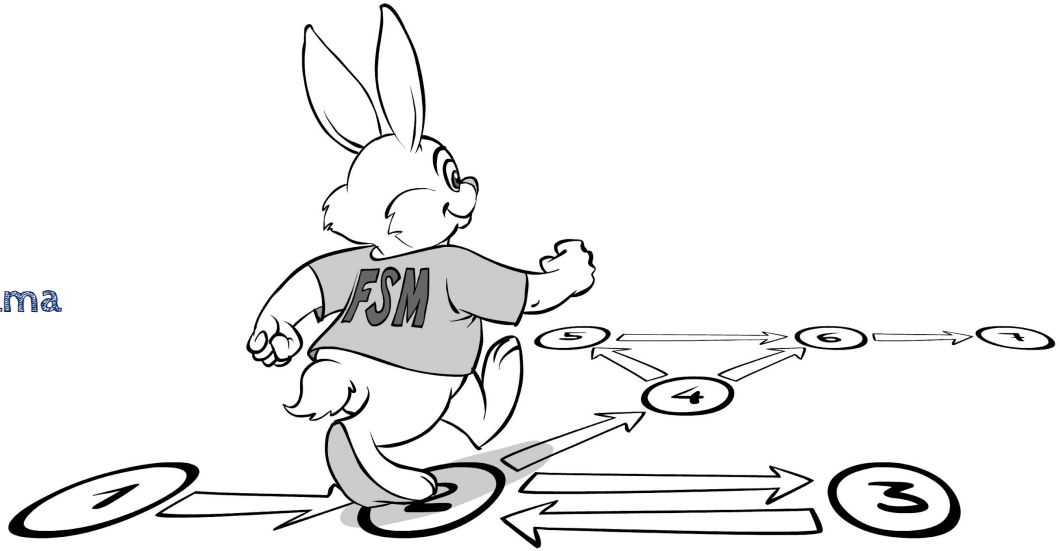
8. Led ve Anahtarlar
9. Diziler ve Fonksiyonel Hata Ayıklama
10. Sonlu Durum Makinaları



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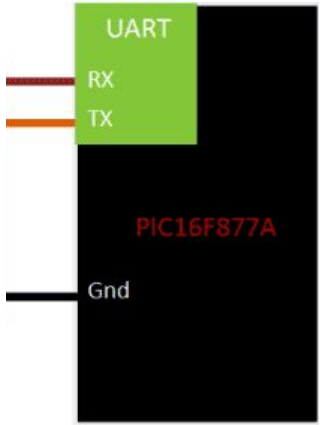
11. UART Seri port



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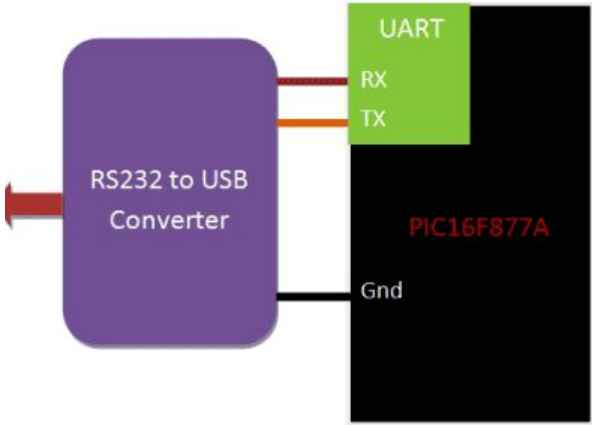

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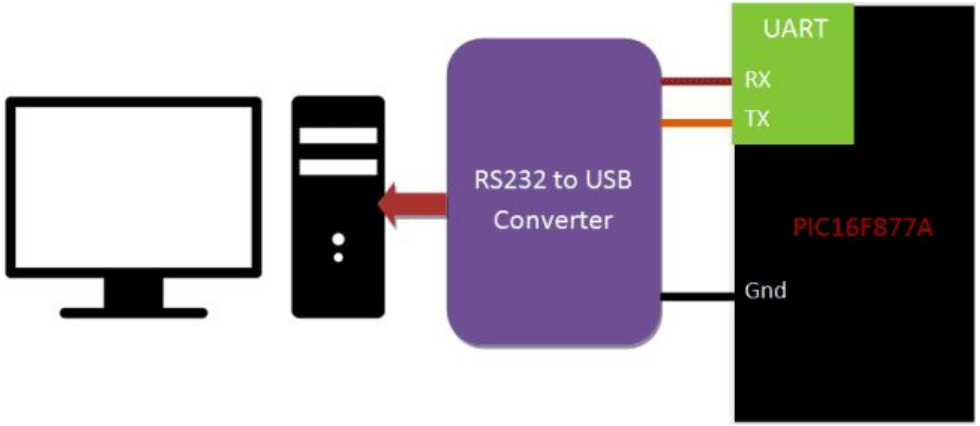

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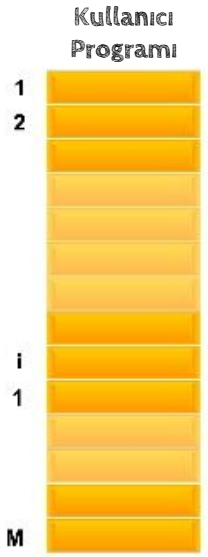

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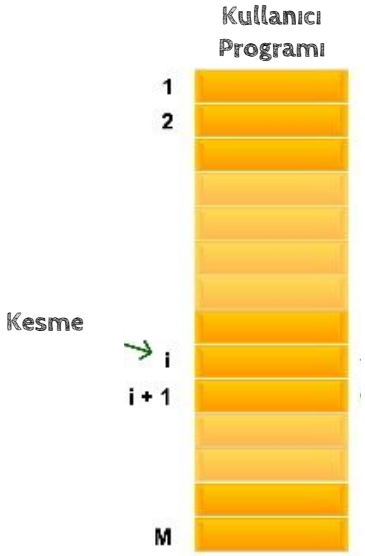

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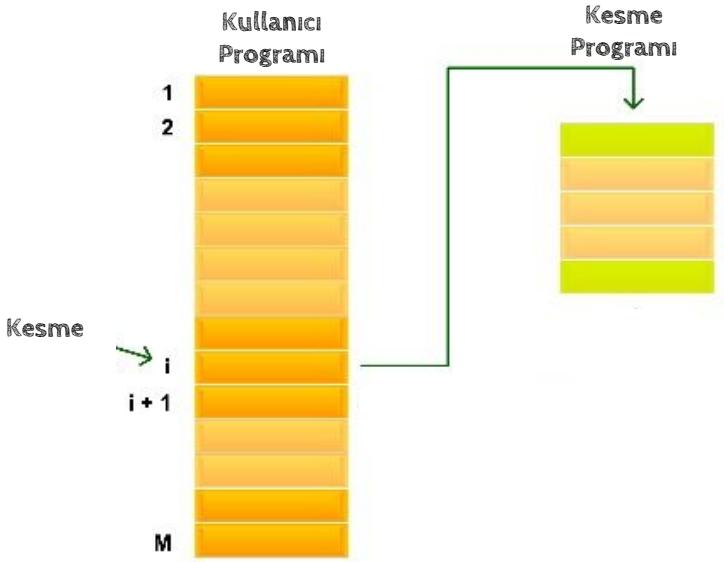

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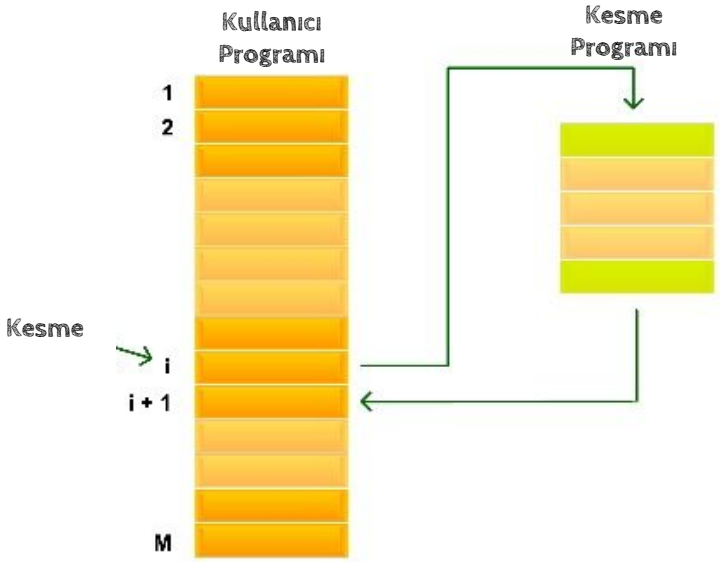

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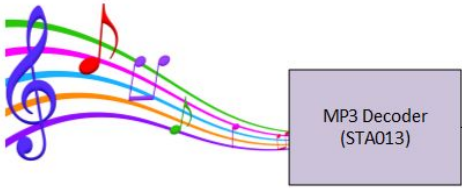
9. Diziler ve Fonksiyonel Hata Ayıklama
10. Sonlu Durum Makinaları
11. UART Seri port
12. Kesmeler
13. DAC ve Ses



Konular

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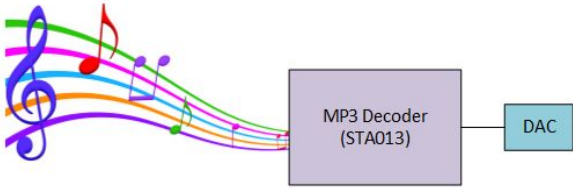

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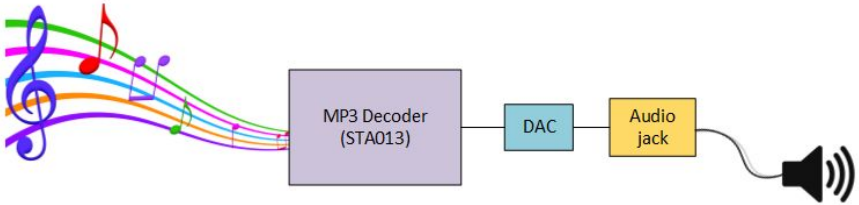

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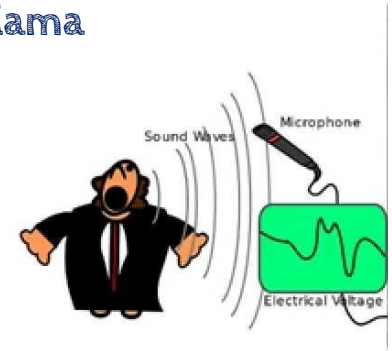

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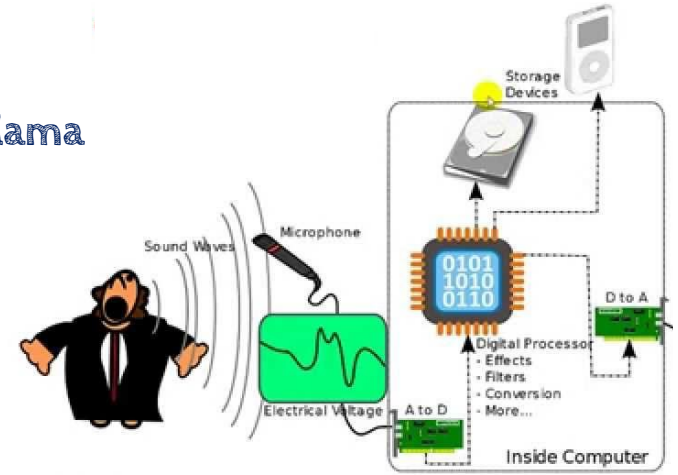

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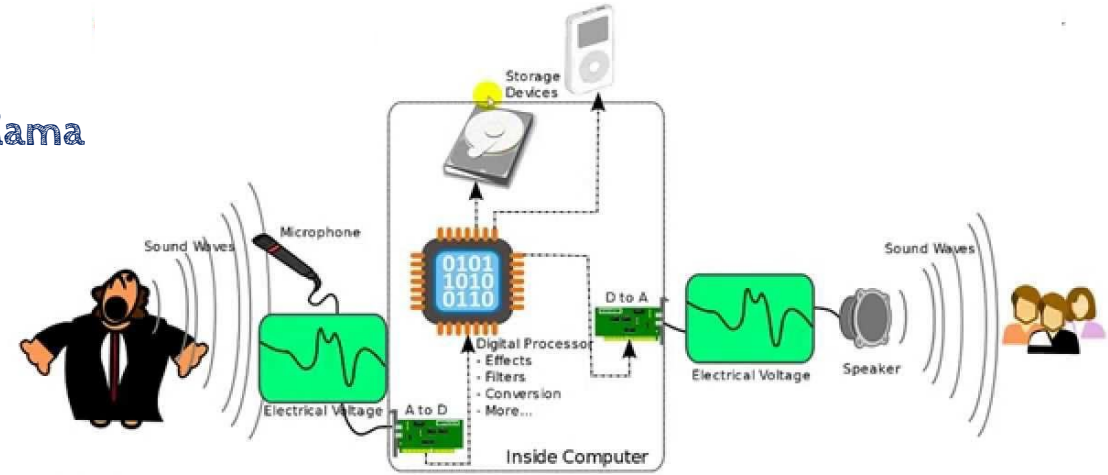

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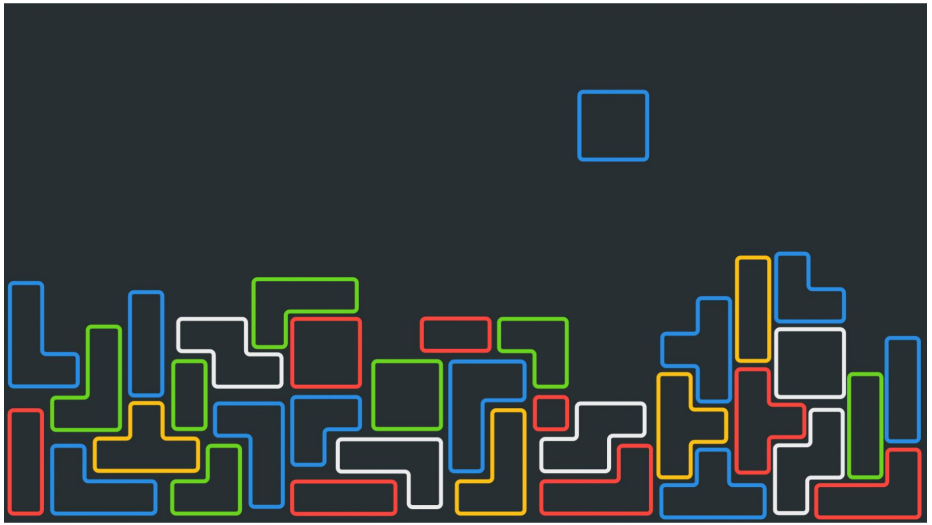
14. ADC ve Veri Alma
15. Sistem Yaklasımı ve Oyun Tasarımı



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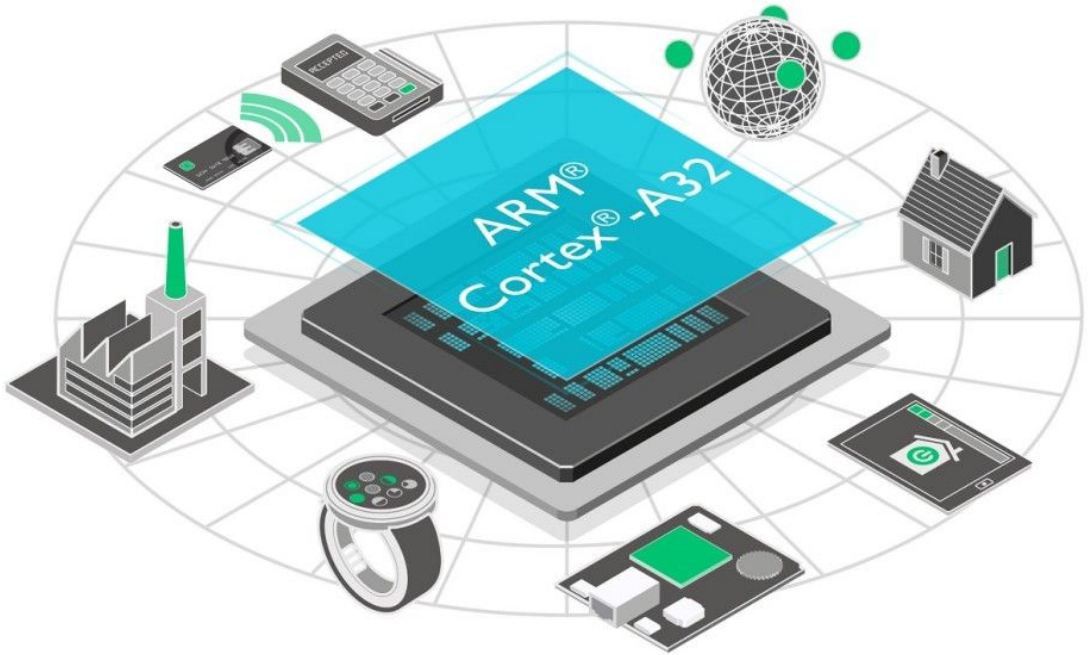
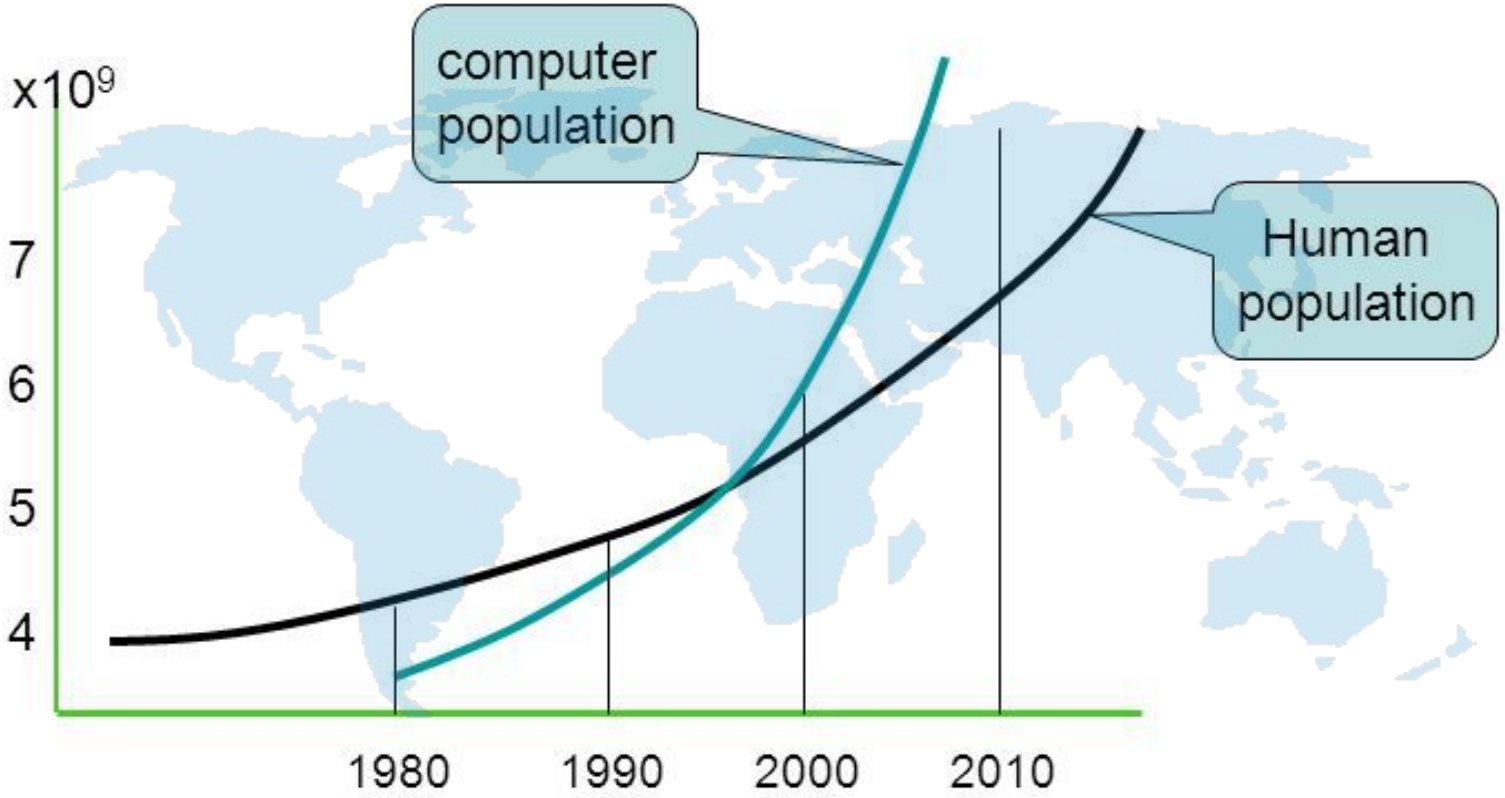
14. ADC ve Veri Alma
15. Sistem Yaklasımı ve Oyun Tasarımı
16. Nesneleri interneti

Gömülü Sistemler

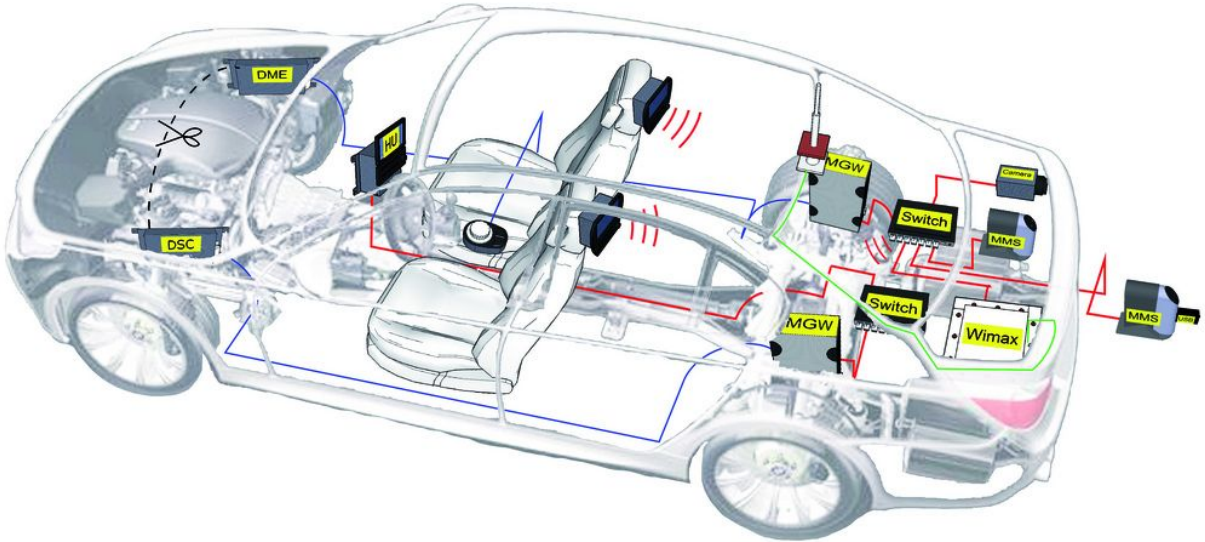


Gömülü Sistemler

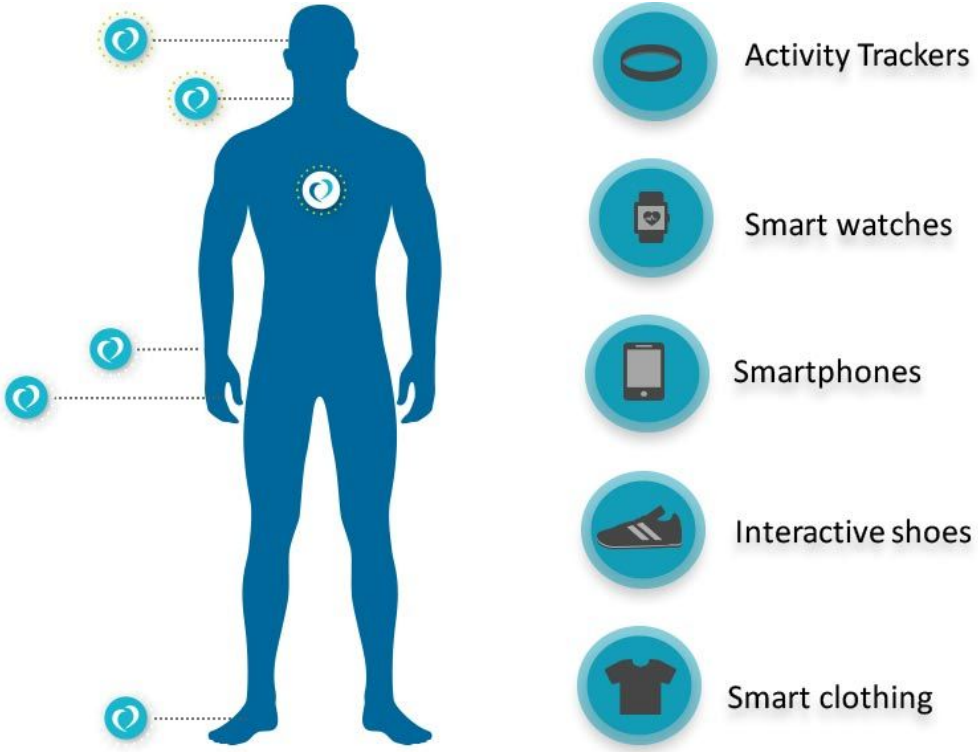


Gömülü Sistemler

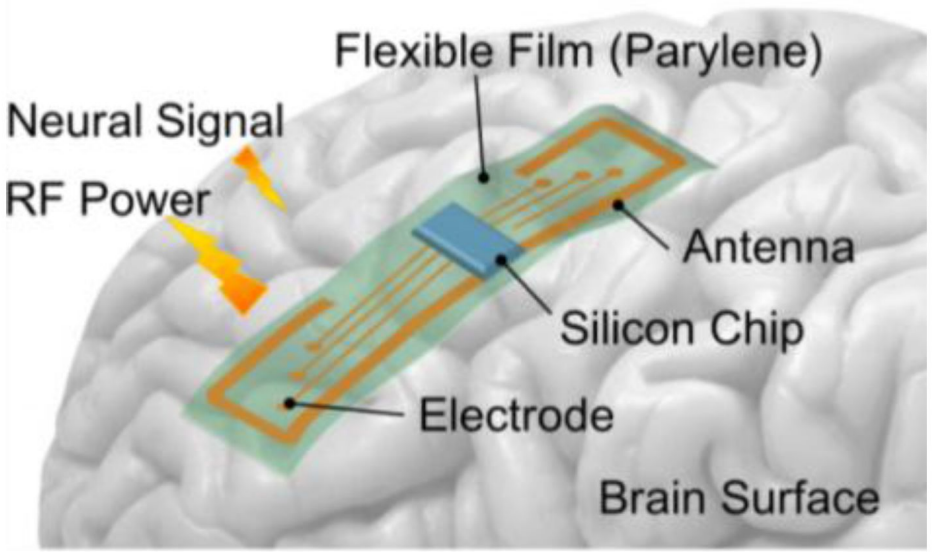
Gömülü Sistemler



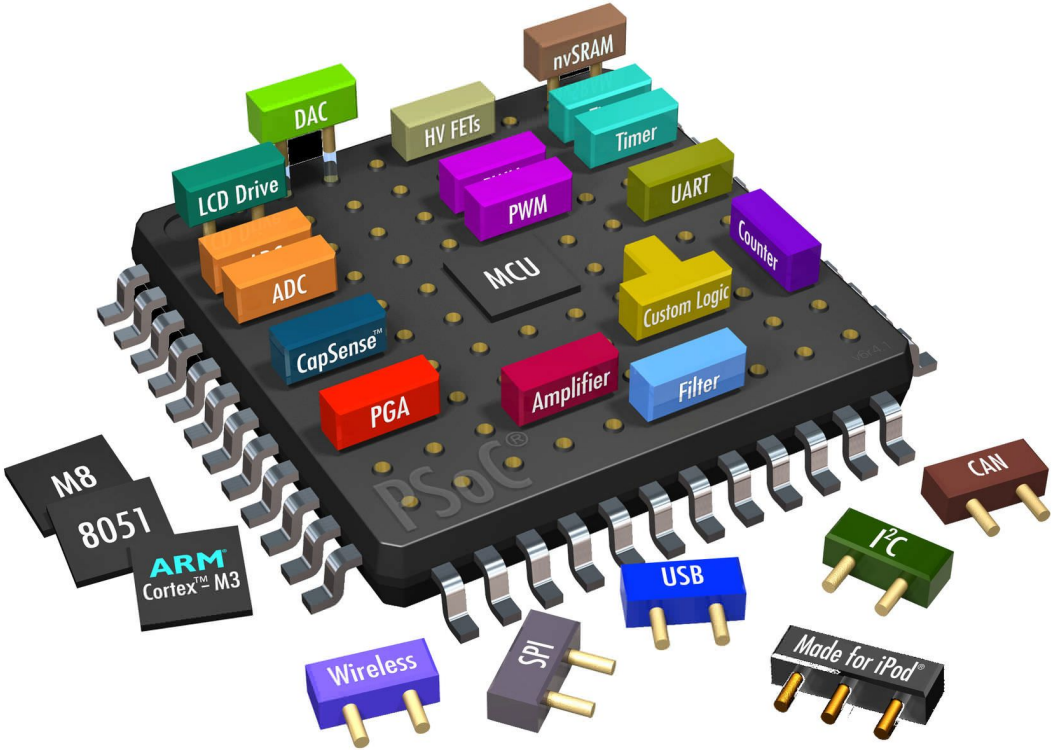
Gömülü Sistemler



Gömülü Sistemler



Develepment



Gereklilikler

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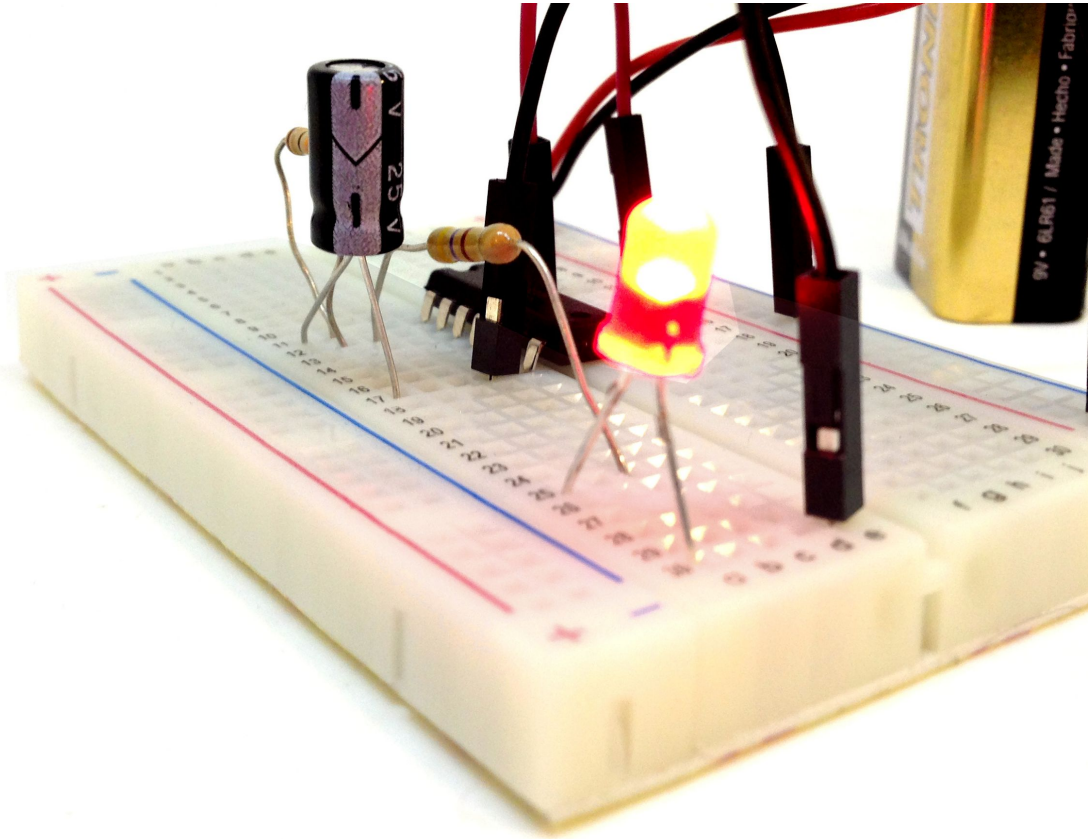
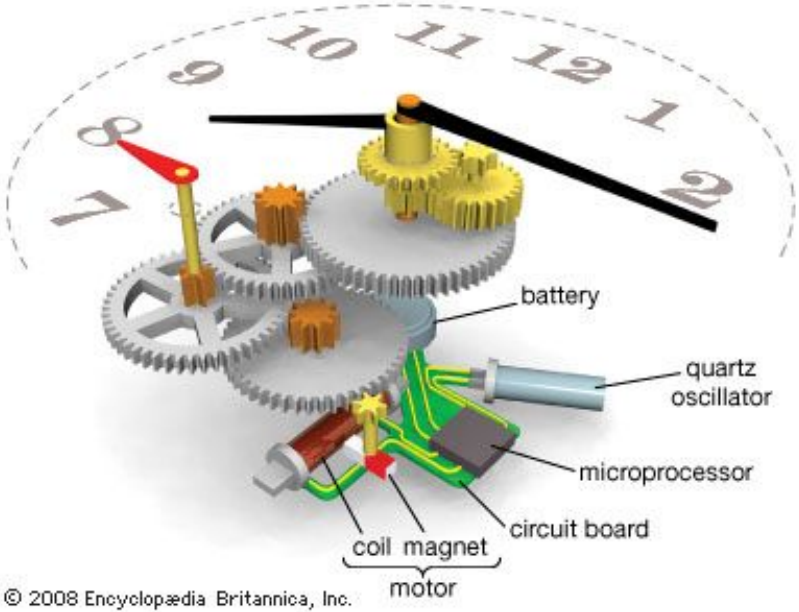


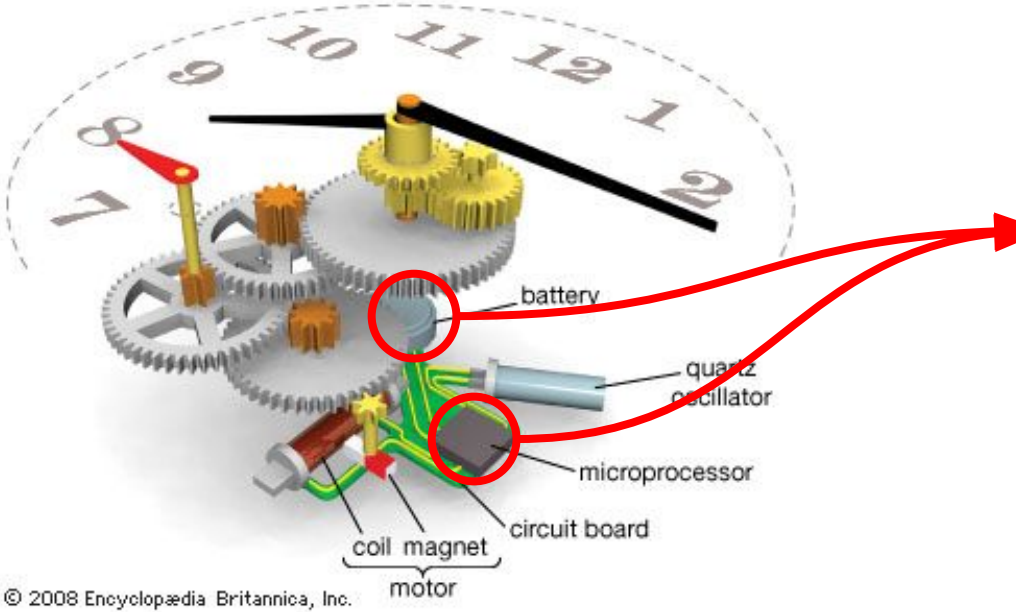
Gömülü Sistem

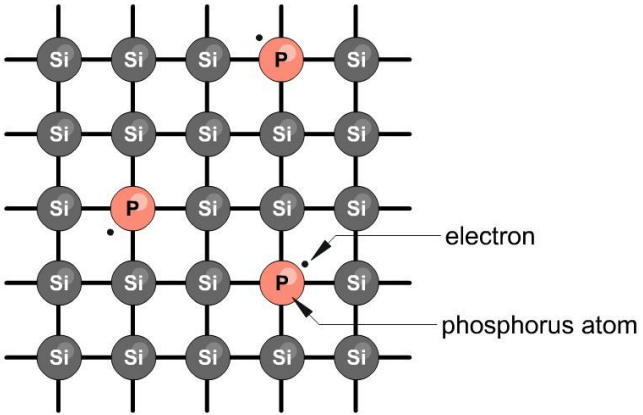


Bir amaç için tasarlanmış

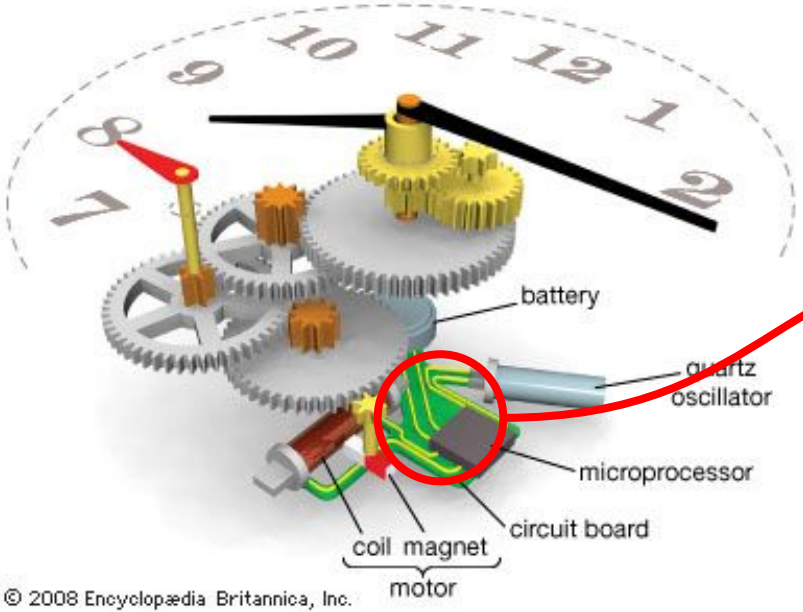
Gömülü Sistem

Kimsal





Gömülü Sistem



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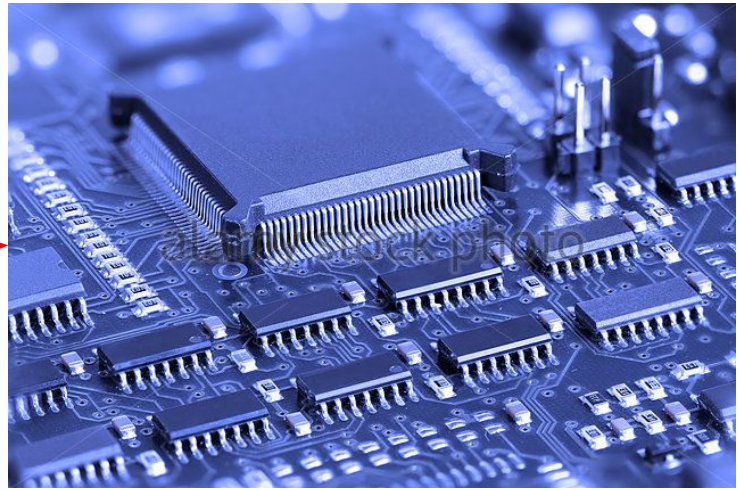
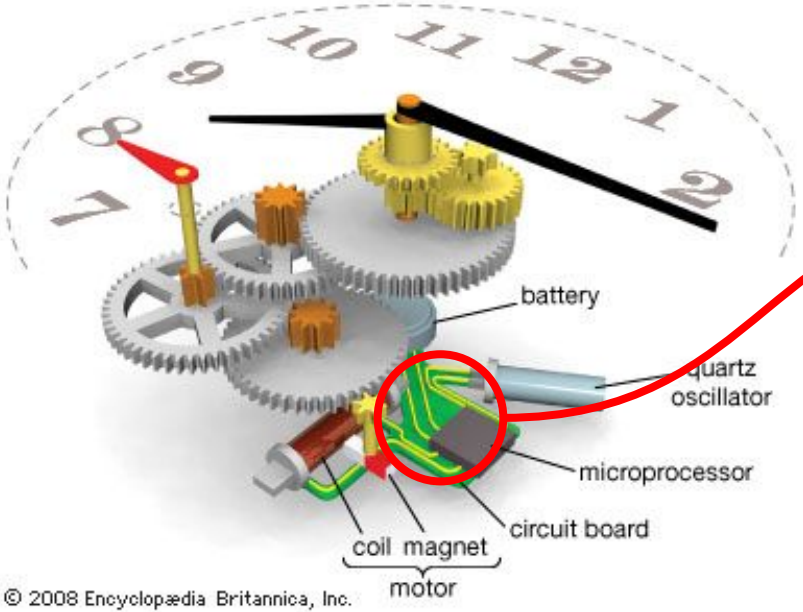
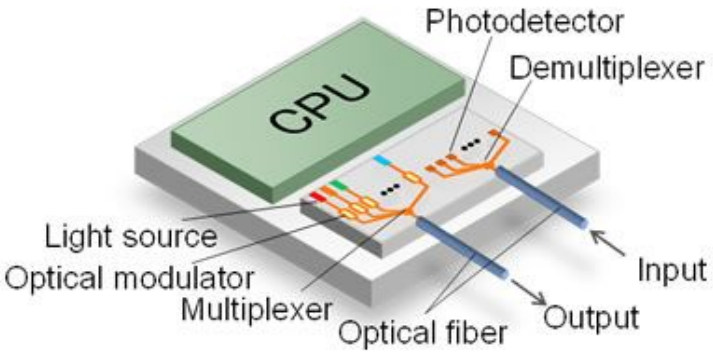


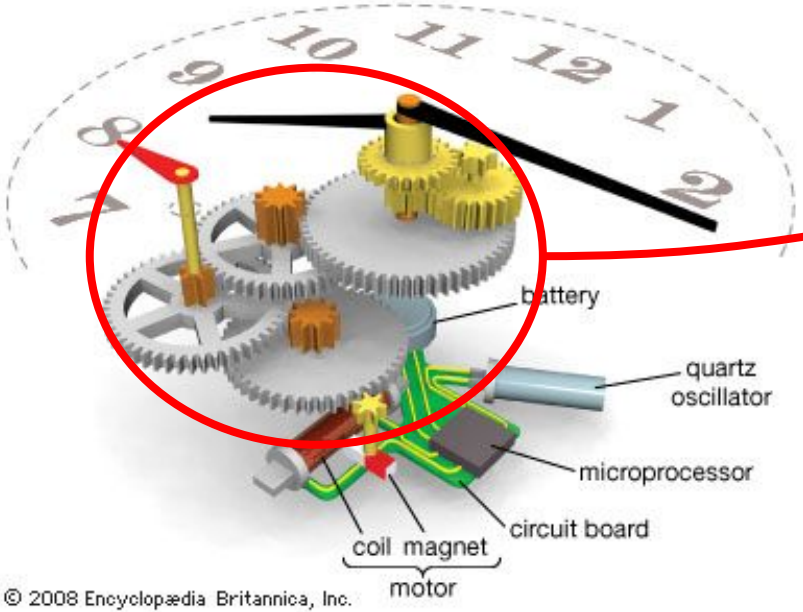
Gömülü Sistem



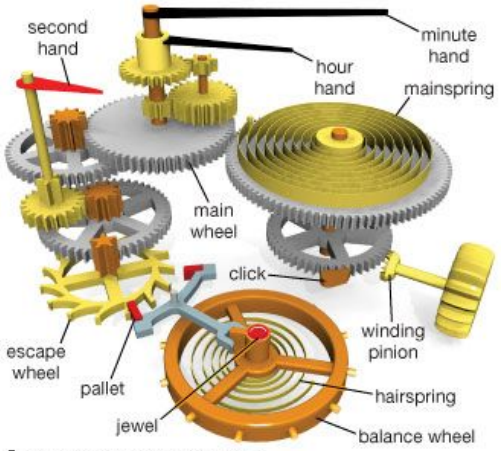
Optik



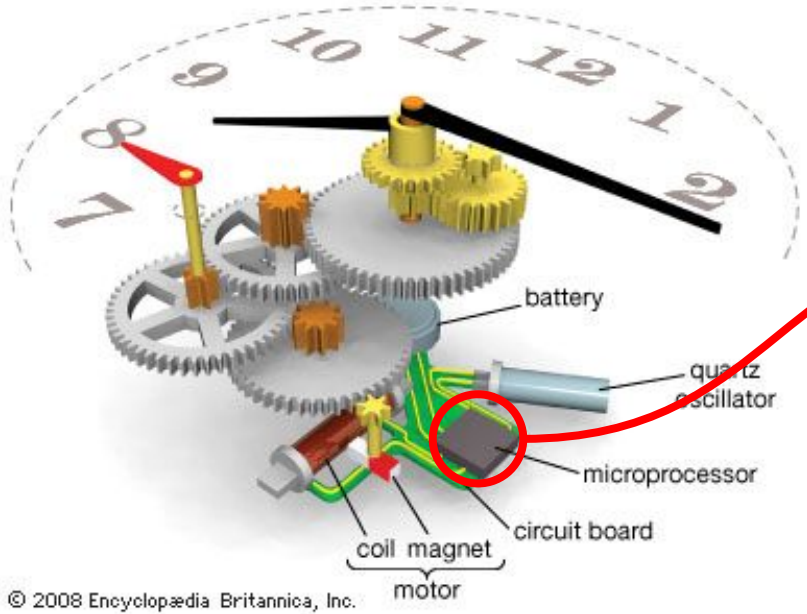
Gömülü Sistem



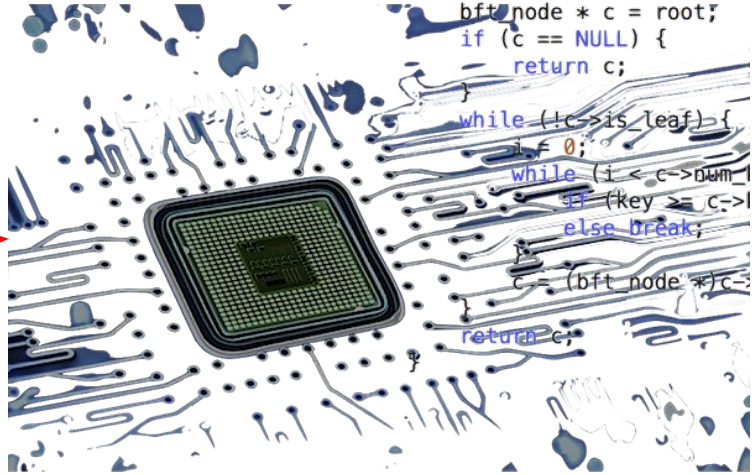
Mekanik



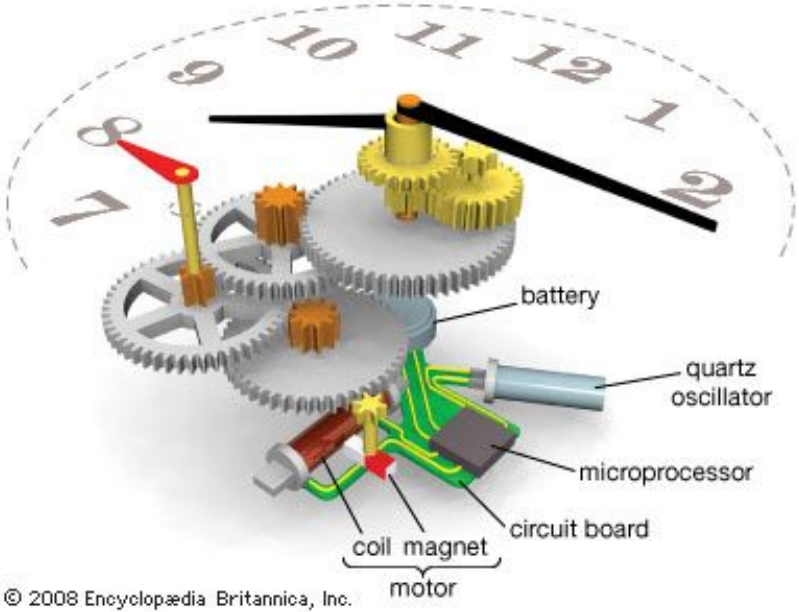
Gömülü Sistem



Yazılım



Gömülü Sistem



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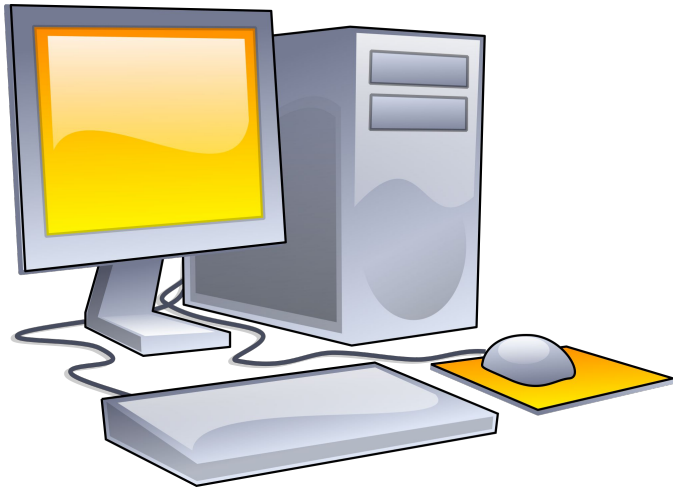
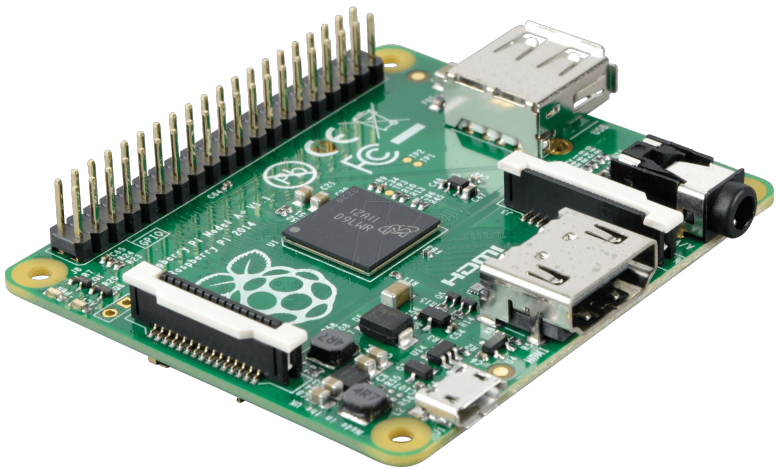
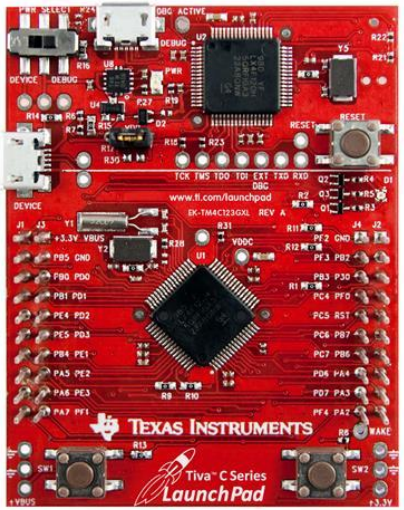


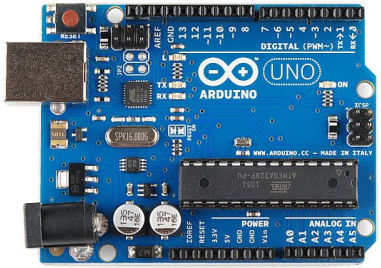
Gömülü Sistem Tipleri

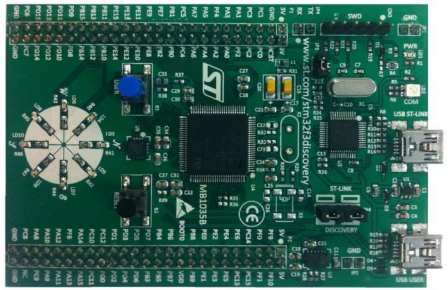
Mikroislemci tabanlı gömülü sistem



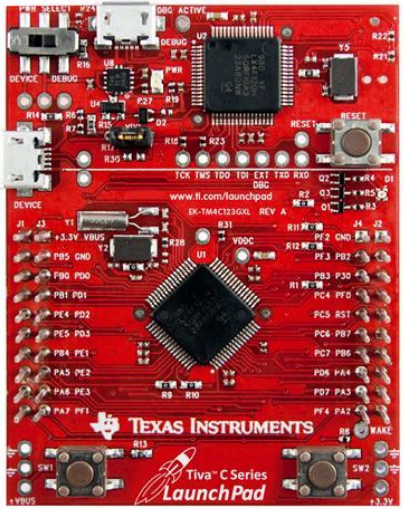
Mikrokontrolcü tabanlı gömülü sistem

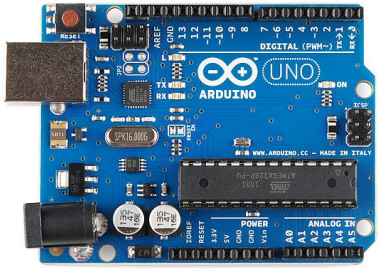






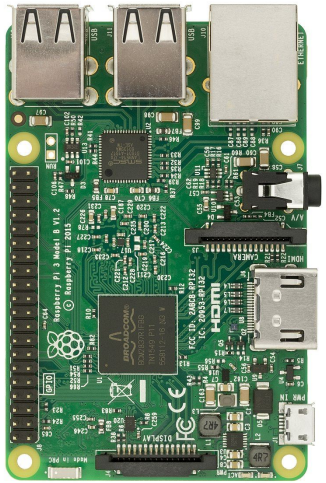
Mikrokontrolcü Tabanlı GS





- Küçük islem gücüne sahip islemci(PIC, AVR, ARM Coretx M)
- 8 veya 16 bitlik basit komut seti
- 10-50 Mhz saat sinyali
- isletim sistemi destegi yok
- C veya assembly ile programlama
- Düsük maliyet

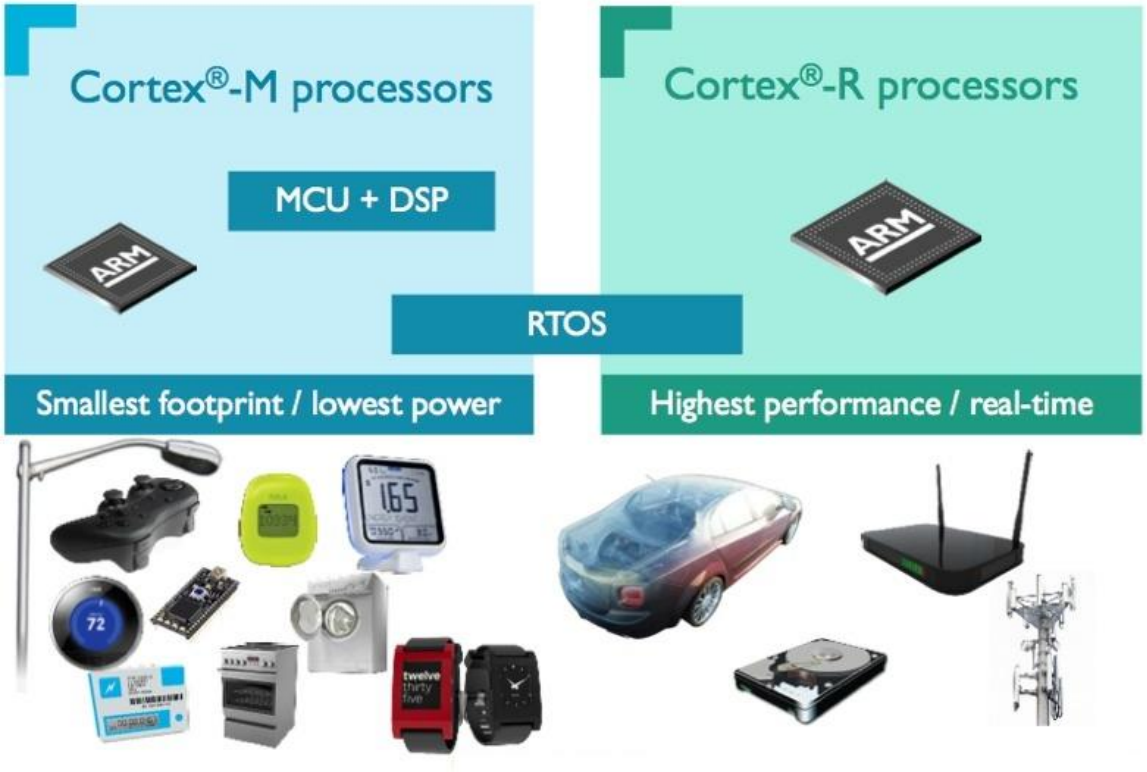
Mikroislemci Tabanlı GS



- Güçlü islemci: Intel Atom, PowerPC,
  ARM Cortex A ve üst versiyonlar
- 32 veya 64 bitlik basit komut seti
- 1000MHz -2 GHz veya üstü saat sinyali
- isletim sistemine destegi (Linux, Windows ...)
- C/C++, Python, Java v.b. ile programlama
- Karmasık sistemler: Image/Video isleme
  Haberlesme sistemleri ....

ARM Cortex Ailesi

ARM Cortex Ailesi



ARM Cortex Ailesi

Cortex®-M processors

MCU + DSP

RTOS

Smallest footprint / lowest power

Cortex®-R processors

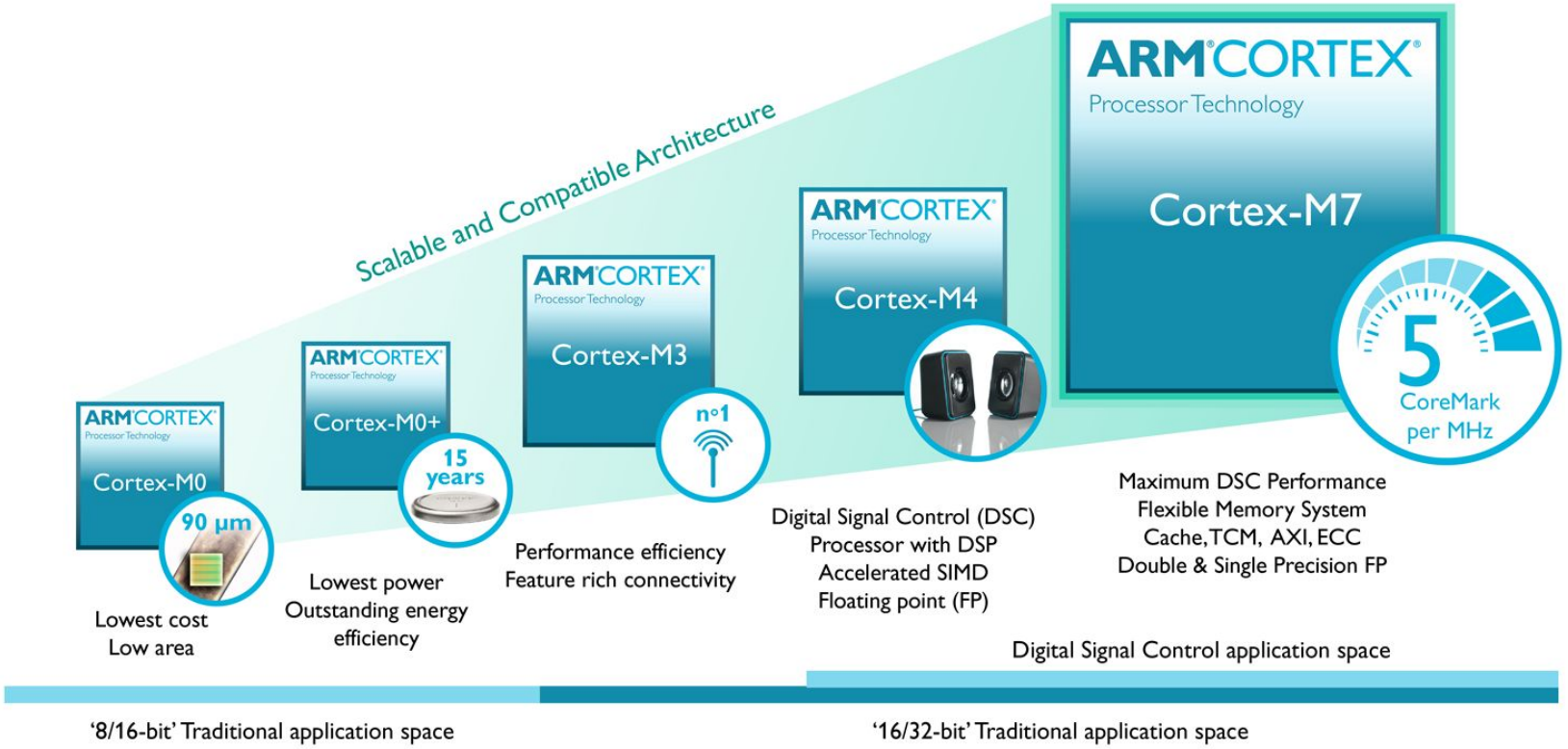
Highest performance / real-time

Cortex®-A processors

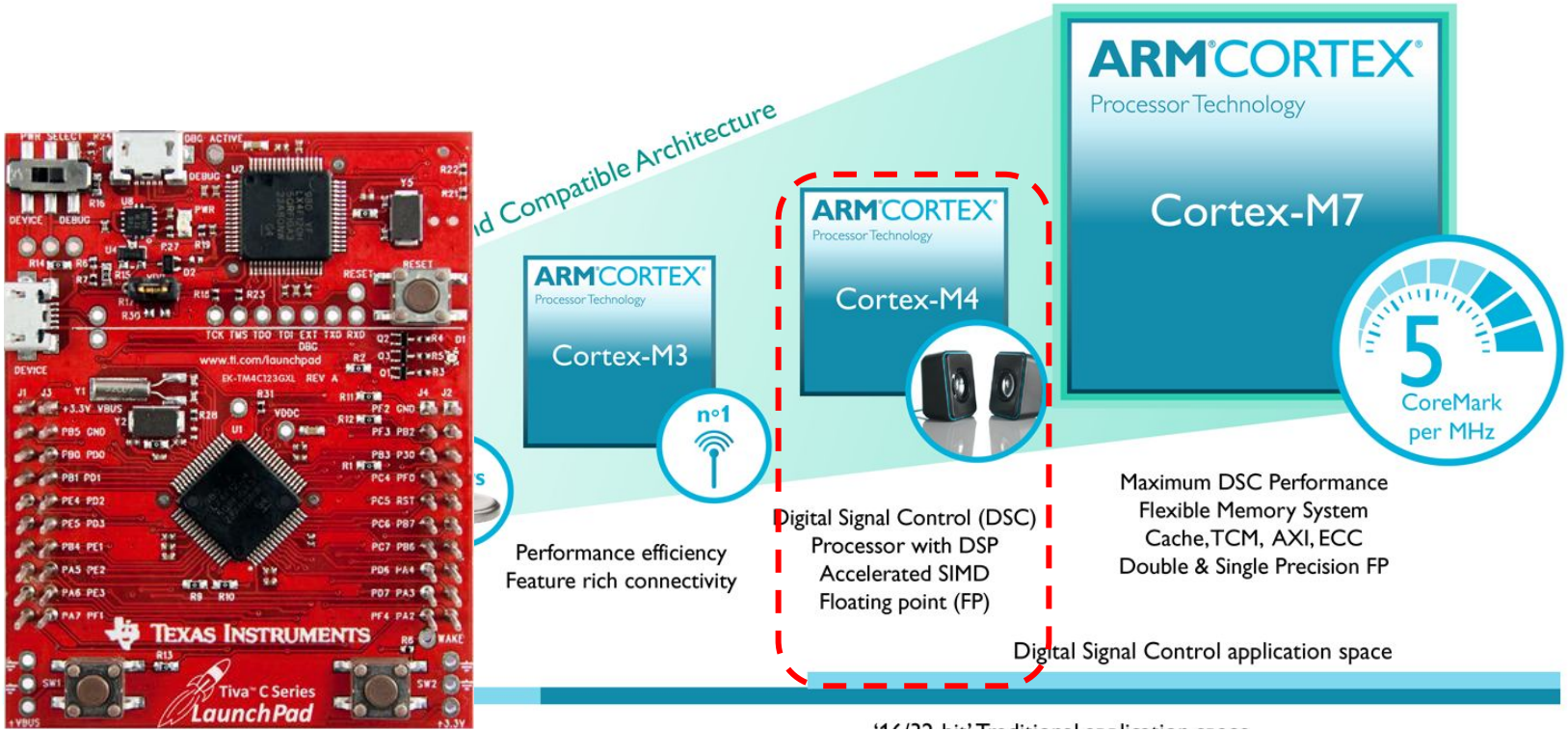
Rich OS

Highest performance

ARM Cortex M

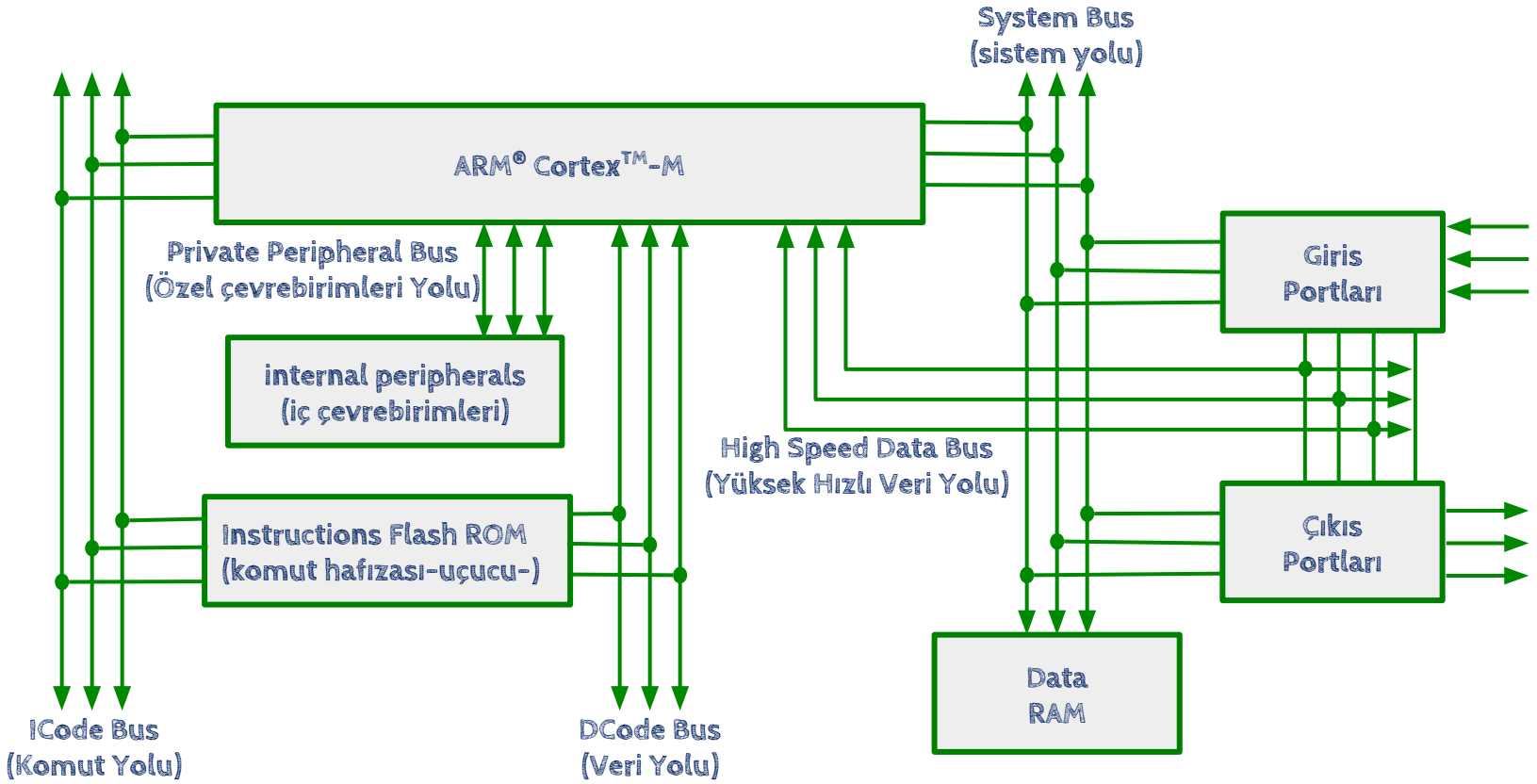

Scalable and Compatible Architecture
ARM CORTEX
Processor Technology
Cortex-M0
90 µm
Lowest cost
Low area
Cortex-M0+
15 years
Lowest power
Outstanding energy efficiency
Cortex-M3
n°1
Performance efficiency
Feature rich connectivity
Cortex-M4
Digital Signal Control (DSC)
Processor with DSP
Accelerated SIMD
Floating point (FP)
Cortex-M7
5
CoreMark per MHz
Maximum DSC Performance
Flexible Memory System
Cache, TCM, AXI, ECC
Double & Single Precision FP
Digital Signal Control application space
'8/16-bit' Traditional application space
'16/32-bit' Traditional application space

Texas Stelaris ve Tiva

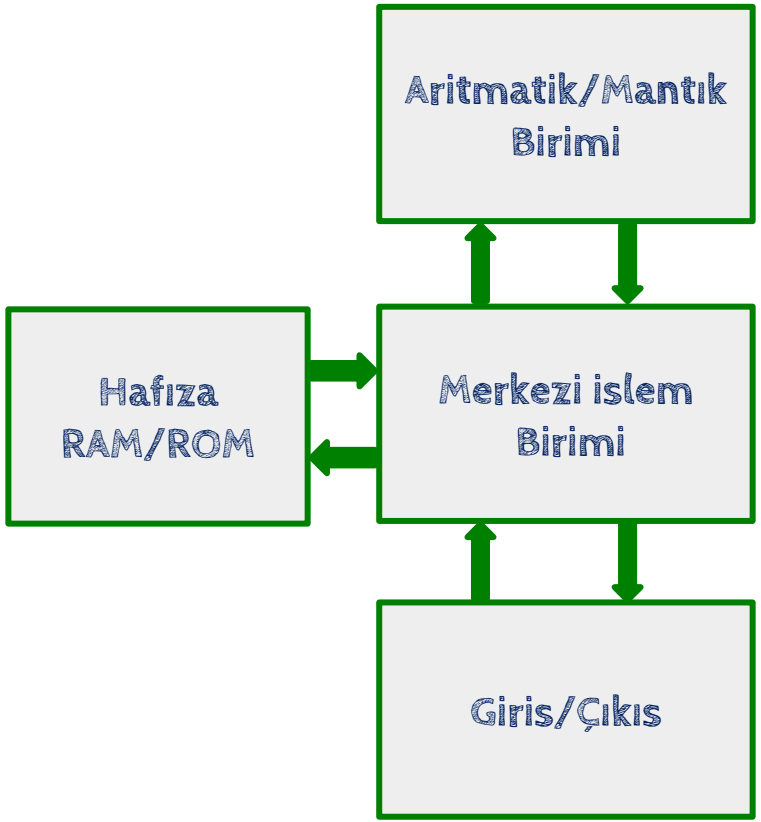


TM4C Series MCU - 80 MHz ARM Cortex-M4 CPU w/ Floating Point

ARM® Cortex-M


System Bus
(sistem yolu)
ARM® Cortex™-M
Private Peripheral Bus
(Özel çevrebirimleri Yolu)
internal peripherals
(iç çevrebirimleri)
Instructions Flash ROM
(komut hafızası-uçucu-)
High Speed Data Bus
(Yüksek Hızlı Veri Yolu)
Giris
Portları
Çıkıs
Portları
Data
RAM
ICode Bus
(Komut Yolu)
DCode Bus
(Veri Yolu)

Bilgisayar mimarisi



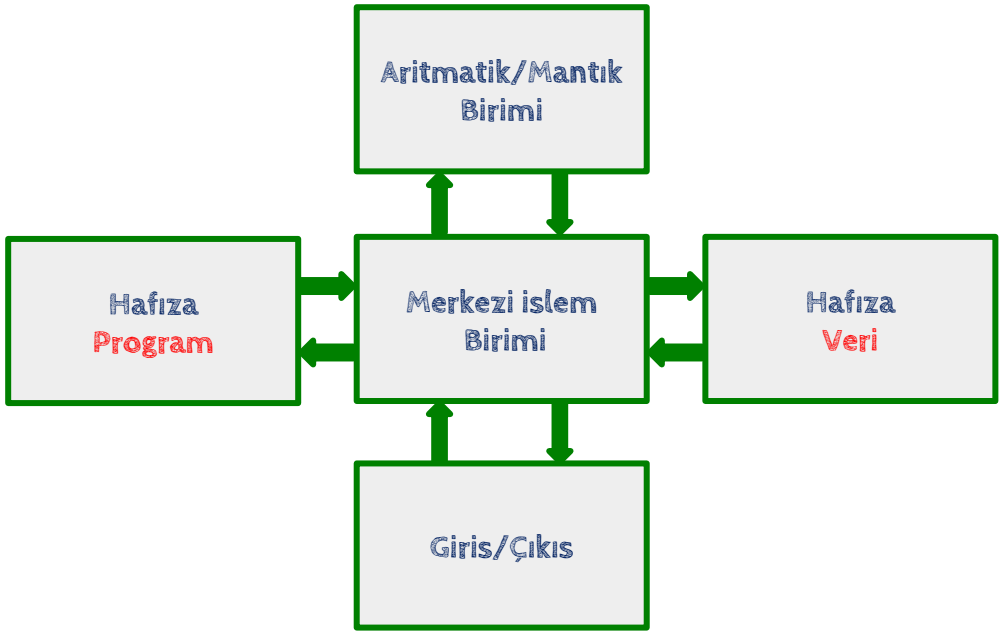
Donanım Mimarisi
(Hardware System Architecture - HSA)

Komut Seti Mimarisi
(Instruction Set Architecture - ISA)

Donanım Mimarisi

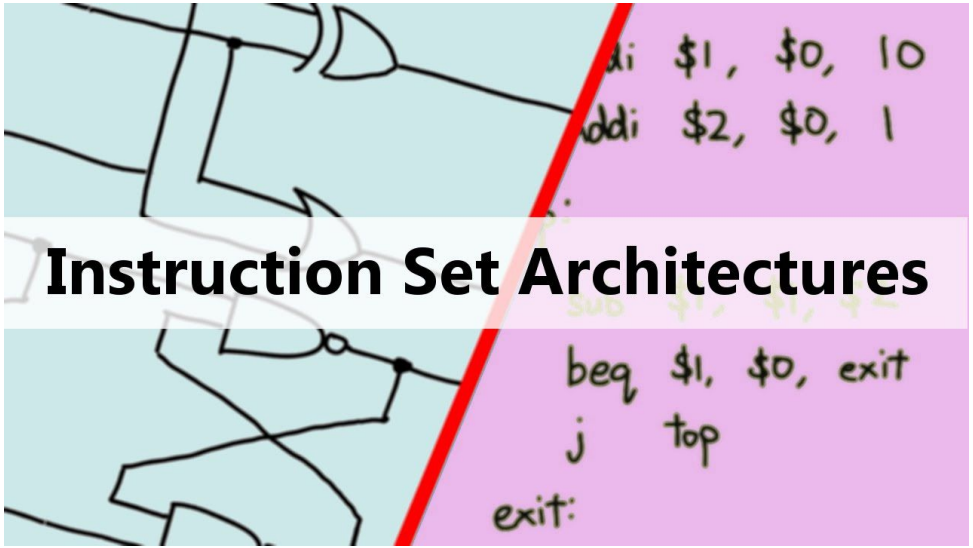
von-Neuman

Harward



Komut Seti Mimarisi ISA

- Hangi komut setini destekledigi
  - CISC Mimarisi (Complex Instruction Set Computer)
  - RISC Mimarisi (Reduce Instruction Set Computer)
- Veri Tipleri
  - “char” veri tipi
  - “int” veri tipi
  - “floating point” veri tipi
- Saklayıcılar
  - Genel amaçlı saklayıcılar
  - Özel amaçlı saklayıcılar
- Adres Alanı



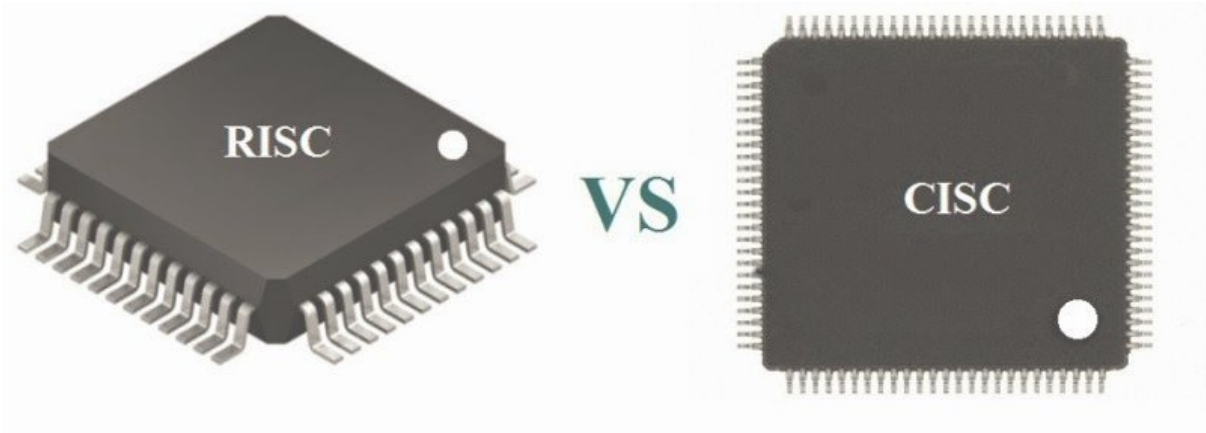
RISC VS CISC

RISC

```
LW      A, 2:3
LW      B, 5:2
MULT    A,B
SW      2:3,A
```

CISC

```
MULT    2:3, 5:2
```



Veri Tipleri

Sayı sistemleri

$$1984 = 1x10^{3} + 9x10^{2} + 8x10^{1} + 4x10^{0}$$

$$273.15 = 2x10^{2} + 7x10^{1} + 3x10^{0} + 1x10^{-1} + 5x10^{-2}$$

ikilik sayı sistemi

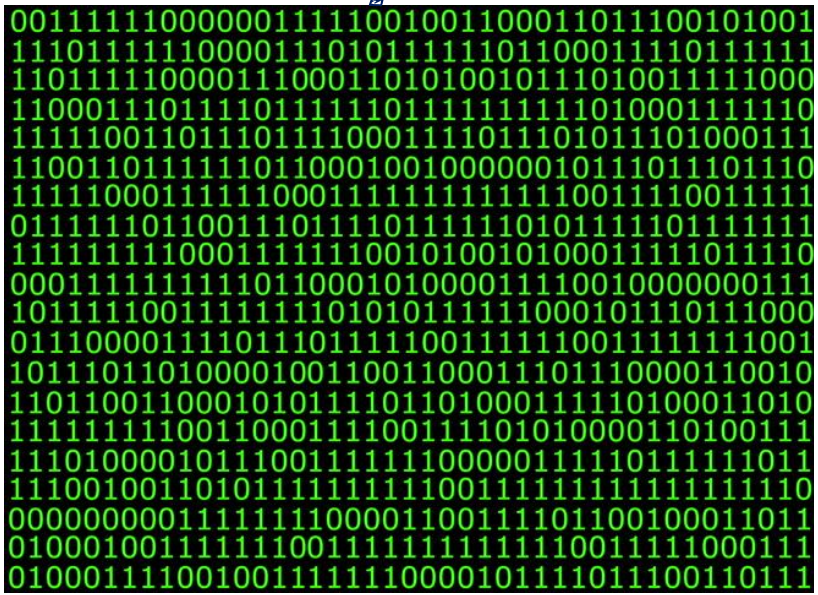
$$01101010_2 = 0x2^7 + 1x2^6 + 1x2^5 + 0x2^4 + 1x2^3 + 0x2^2 + 1x2^1 + 0x2^0$$

$$= 64 + 32 + 8 + 2$$

$$= 106$$

Onaltılık sayı sistemi

ikilik sayı sistemi



Onaltılık sayı sistemi

Onaltılık sayı sistemi

Binary 0011011011001101

Hexadecimal	Decimal	Binary
0	0	0
1	1	1
2	2	10
3	3	11
.	.	.
.	.	.
.	.	.
9	9	1001
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

Onaltılık sayı sistemi

Binary 0011011011001101

Nibbles 0011 0110 1100 1101

Hexadecimal 36CD

Hexadecimal	Decimal	Binary
0	0	0
1	1	1
2	2	10
3	3	11
.	.	.
.	.	.
.	.	.
9	9	1001
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

Onaltılık sayı sistemi

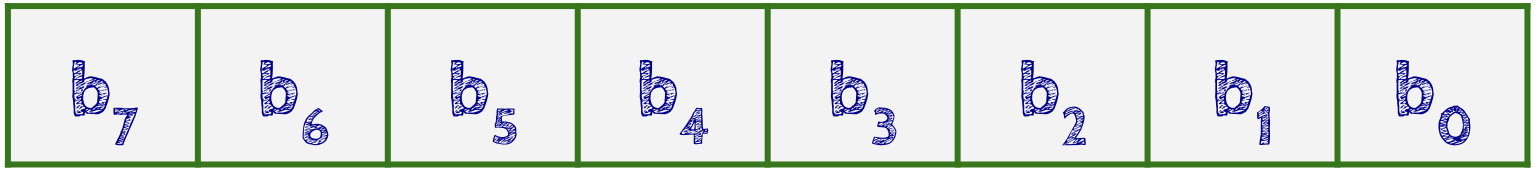
0011011011001101_2 = 0x36CD

0011011011001101_2 = 36CDh

0011011011001101_2 = $36CD

Byte

MSB LSB



$$N = 128*b_7 + 64*b_6 + 32*b_5 + 16*b_4 + 8*b_3 + 4*b_2 + 2*b_1 + 1*b_0$$

Byte

Binary	Hex	Ondalık
0 0 0 0 0 0 0 0	0x00	0
0 0 1 0 0 0 0 1	0x21	33
0 1 0 0 0 1 1 0	0x46	70
1 0 0 0 1 0 1 1	0x8B	139
1 1 1 1 1 1 1 1	0xFF	255

Taban Dönüsümleri

Sayı	Taban	Sınır	Bit	islem
100	128	-	bit 7 = 0	-
100	64	astı	bit 6 = 1	100 - 64
36	32	astı	bit 5 = 1	36 - 32
4	16	-	bit 4 = 0	-
4	8	-	bit 3 = 0	-
4	4	esit	bit 2 = 1	4 - 4
0	2	-	bit 1 = 0	-
0	1	-	bit 0 = 0	-

Negatif Sayılar(8 bit)

bir'e tümleyen
one's complement

$(0)_{10} = (00000000)_2$
$(1)_{10} = (00000001)_2$

...

$(126)_{10} = (01111110)_2$
$(127)_{10} = (01111111)_2$
$(-127)_{10} = (10000000)_2$
$(-126)_{10} = (10000001)_2$

...

$(-2)_{10} = (11111110)_2$
$(-0)_{10} = (11111111)_2$

Negatif Sayılar(8 bit)

bir'e tümleyen
one's complement

$(0)_{10}$ = (00000000

iki tane sıfır var

$(25)_{10}$
$(00011001)_2$

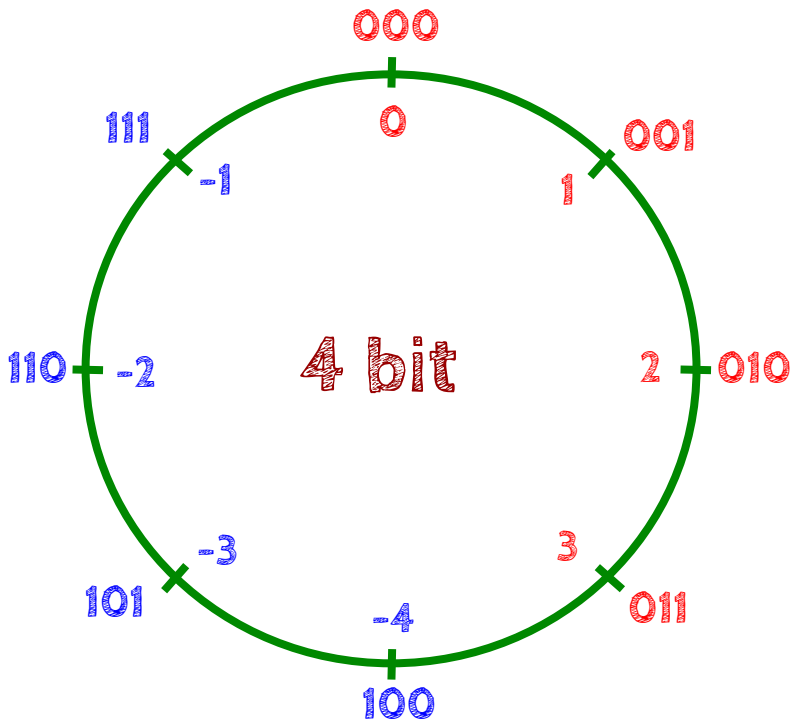
$(-25)_{10}$ = (1

Taban ?

$(-0)_{10}$ = $(11111111)_2$

Negatif Sayılar(4 bit)

iki'ye tümleyen
two's complement



$(25)_{10} = (00011001)_2 \Rightarrow$

$(1\ 1\ 1\ 00\ 1\ 10)_2$

$+ \quad (00000001)_2$

$(-25)_{10} = (1\ 1\ 1\ 00\ 1\ 1\ 1)_2$

Negatif Sayılar

iki'ye tümleyen
two's complement

Binary	Hex	Hesaplama	Ondalık
00000000	0x00		0
00010010	0x12	16+2	18
00100110	0x26	32+4+2	38
11000111	0xC7	128+64+4+2+1	-57
11111111	0xFF	-128+64+32+16+8+4+2+1	-1

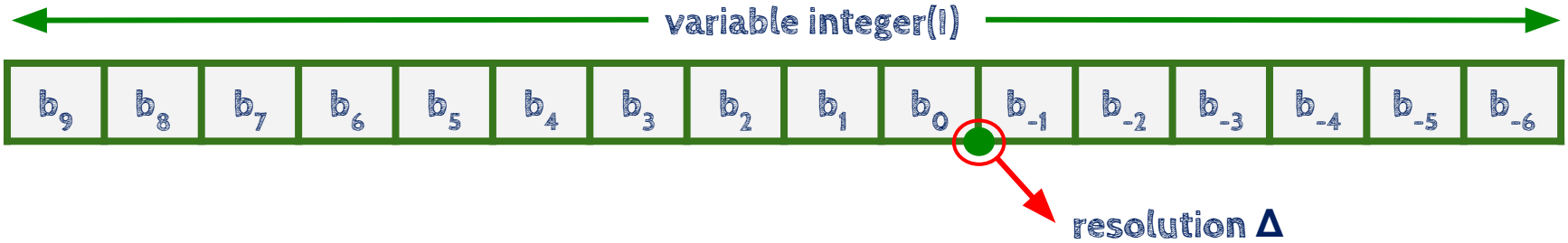
Negatif Sayılar

Sayı	Taban	Sınır	Bit	islem
-100	-128	astı	bit 7 = 1	-100 - (-128)
28	64	-	bit 6 = 0	-
28	32	-	bit 5 = 0	-
28	16	astı	bit 4 = 1	28 - 16
12	8	astı	bit 3 = 1	12 - 8
4	4	esit	bit 2 = 1	4 - 4
0	2	-	bit 1 = 0	-
0	1	-	bit 0 = 0	-

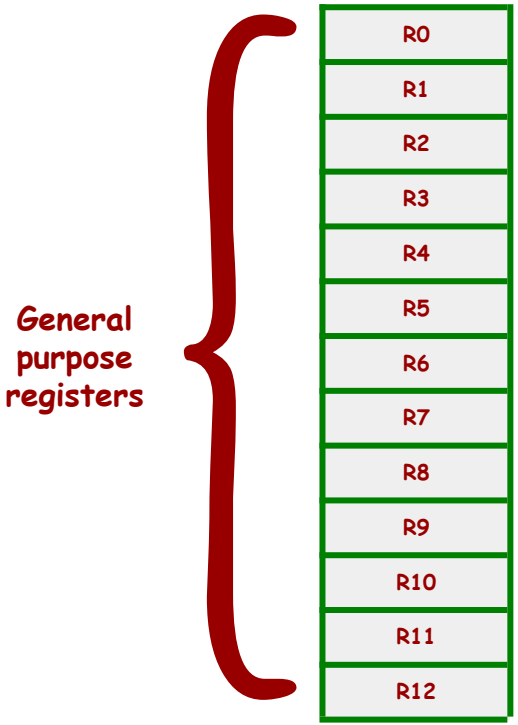
Fixed-Point Nunbers

Precision (hassasiyet): temsil edilebilen degerlerin toplam sayısıdır.

16-bit binary fixed-point format with $\Delta=2^{-6}$

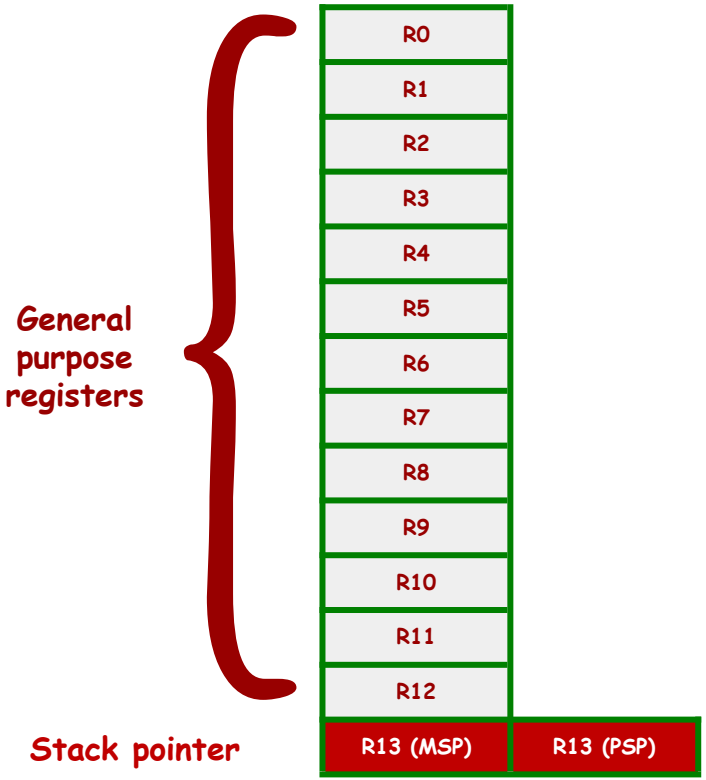


Saklayıcılar



Genel amaçlı saklayıcılar
veri veya adres tutabilirler

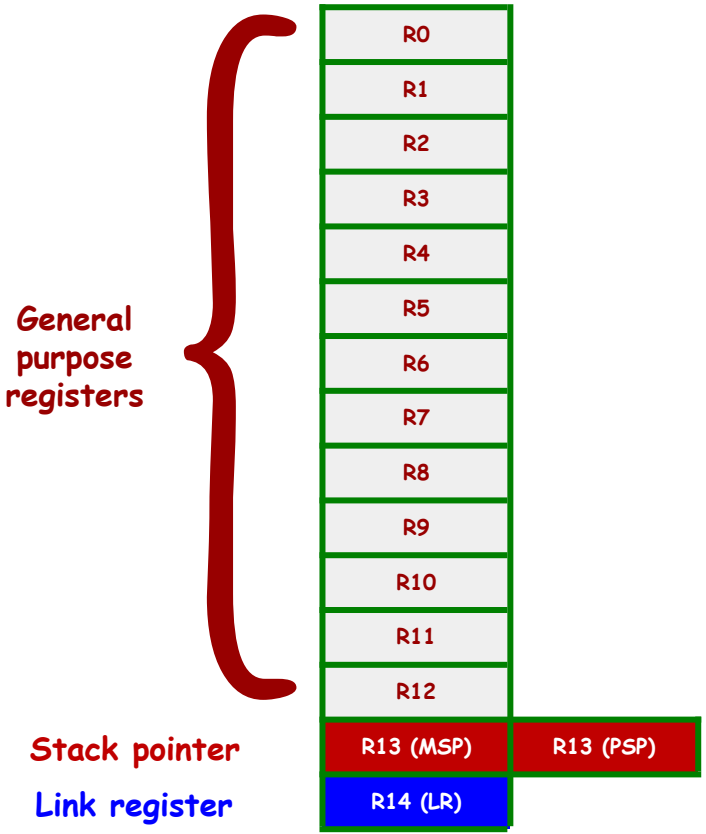
Saklayıcılar



Genel amaçlı saklayıcılar
veri veya adres tutabilirler

Yığın saklayıcılar
main stack pointer, process stack pointer

Saklayıcılar

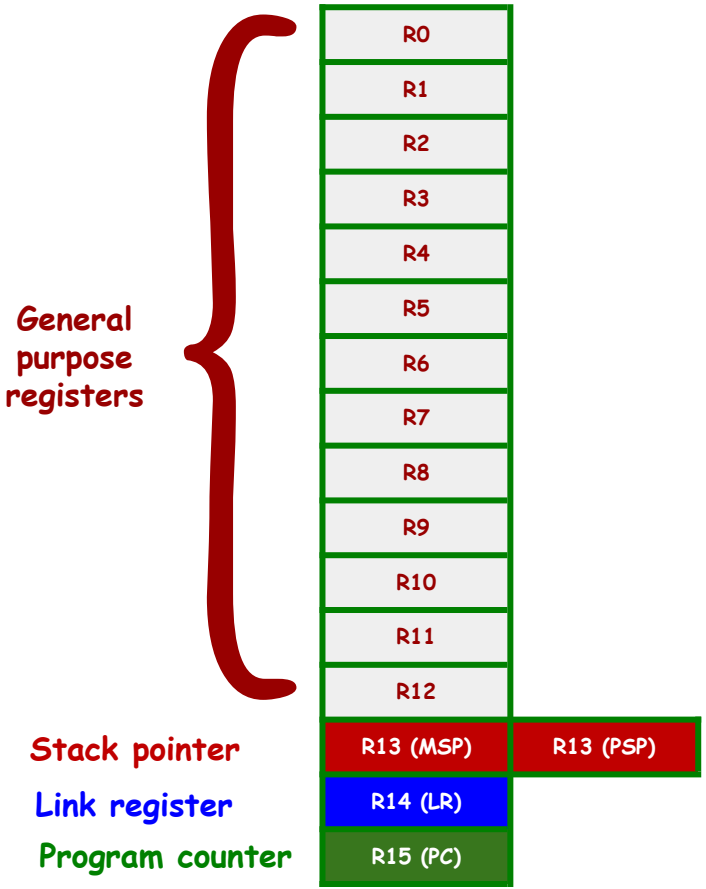


Genel amaçlı saklayıcılar
veri veya adres tutabilirler

Yığın saklayıcılar
main stack pointer, process stack pointer

Link(Bag) saklayıcısı
Fonksiyonlardan dönüs adreslerini saklar
Kesme gibi ekstra durumlar için kullanılır

Saklayıcılar



Genel amaçlı saklayıcılar
veri veya adres tutabilirler

Yığın saklayıcılar
main stack pointer, process stack pointer

Link(Bag) saklayıcısı
Fonksiyonlardan dönüs adreslerini saklar
Kesme gibi ekstra durumlar için kullanılır

Program sayacı saklayıcıs
islemcinin bir sonraki adımda hangi komutu
isleyecegini belirler

Program Durum Saklayıcıları

APSR: Application Program Status Register

ALU islemleri

N: islem sonucu negatif

Z: islem sonucu sıfır

C: islem sonucu tasma (isaretsiz) var

V: islem sonucu tasma (isaretli) var

Q: islem sonucu tasma doyma var

Program Durum Saklayıcıları

IPSR: Interrupt Program Status Register

Kesme islemleri

ISR_NUMBER: Kesme islem numarası

Program Durum Saklayıcıları

EPSR: Execution Program Status Register

Çalısma islemleri

T=1: islemci Thumb komut setini kullanır

ICI/IT: Kesmeye ugramıs çoklu islemlerin devam edebilmesini saglar

IT: Programdaki if-then komutlarının yürütme sayısı ve durumunu tutar

Program Durum Saklayıcıları

PSR: Program Status Register

N: islem sonucu negatif

Z: islem sonucu sıfır

C: islem sonucu tasma (isaretsiz) var

V: islem sonucu tasma (isaretli) var

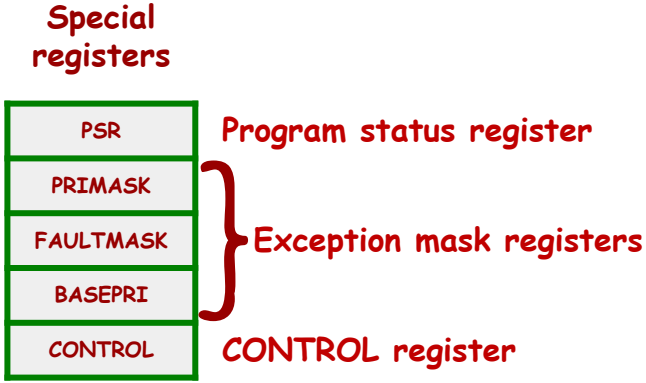
Q: islem sonucu tasma doyma var

ICI/IT: Kesmeye ugramıs çoklu islemlerin devam edebilmesini saglar

T=1: islemci Thumb komut setini kullanır

ISR_NUMBER: Kesme islem numarası

Özel Saklayıcılar



PRIMASK(Bit 0): interrupt mask bit
bit_0=1 bir çok kesmeye izin verilmez

FAULTMASK(Bit 0): fault mask bit
bit_0=1 tüm kesmelere ve hatalarına izin verilmez

BASEPRI: kesme önceligi
BASEORI=3 ise 0,1,2 sevyesindeki kesmeler çalısır

Adres Alanı

1K	1024 Byte	0x400

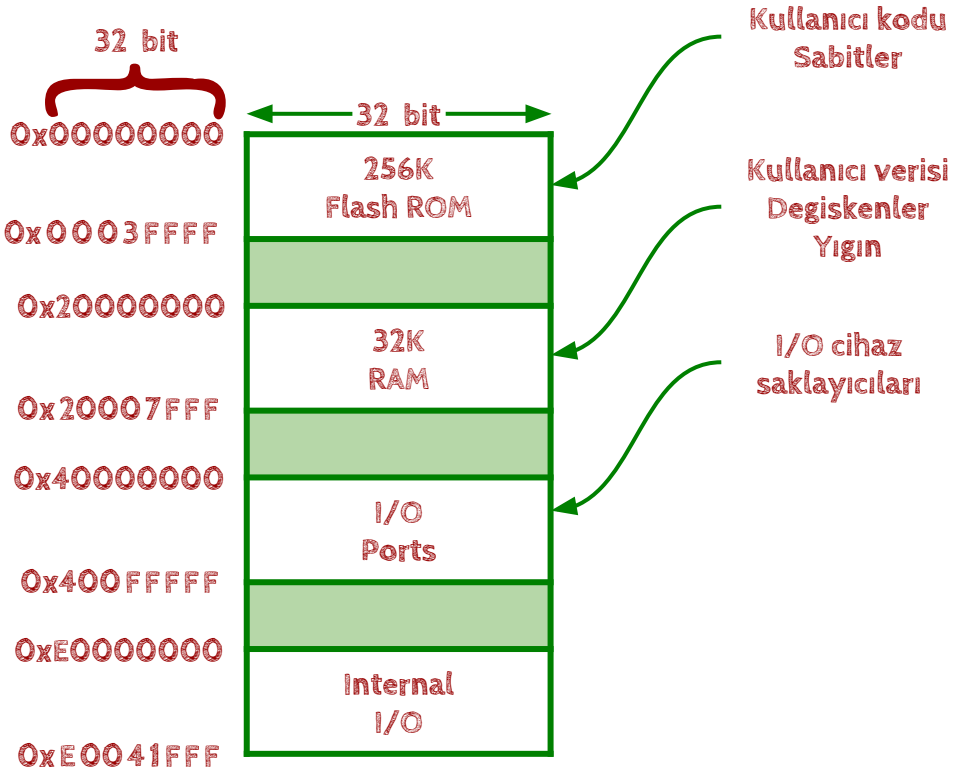
Adres Alanı

1K	1024 Byte	0x400
2K	2048 Byte	0x800

Adres Alanı

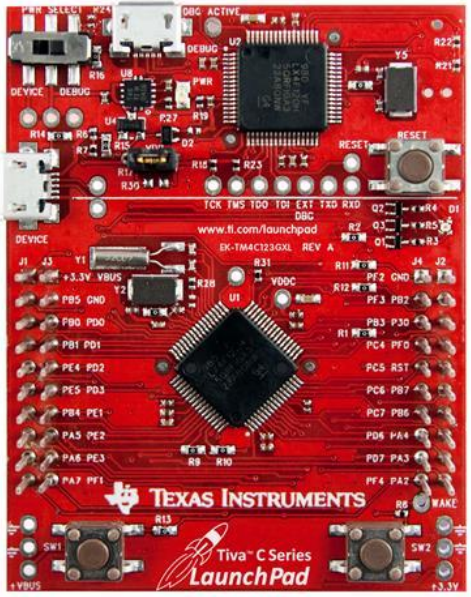
1K	1024 Byte	0x400
2K	2048 Byte	0x800
4K	4096 Byte	0x1000
8K	8192 Byte	0x2000
16K	16384 Byte	0x4000
32K	32768 Byte	0x8000
64K	65536 Byte	0x10000
128K	131072 Byte	0x20000
256K	262144 Byte	0x40000

Adres Alanı

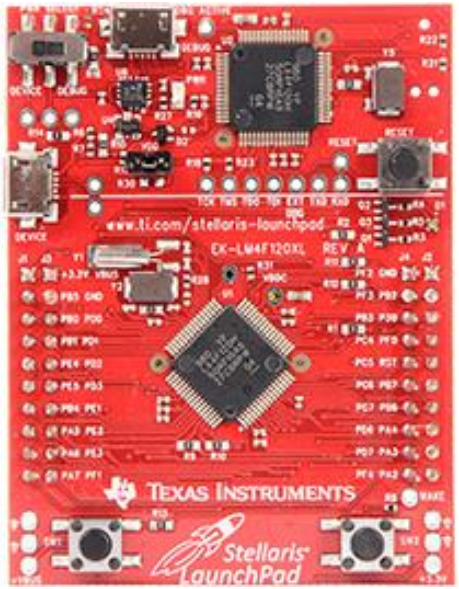

32 bit
32 bit
0x00000000
256K
Flash ROM
0x0003FFFF
0x20000000
32K
RAM
0x20007FFF
0x40000000
I/O
Ports
0x400FFFFF
0xE0000000
Internal
I/O
0xE0041FFF
Kullanıcı kodu
Sabitler
Kullanıcı verisi
Degiskenler
Yıgın
I/O cihaz
saklayıcıları

Gelistirme Kartları

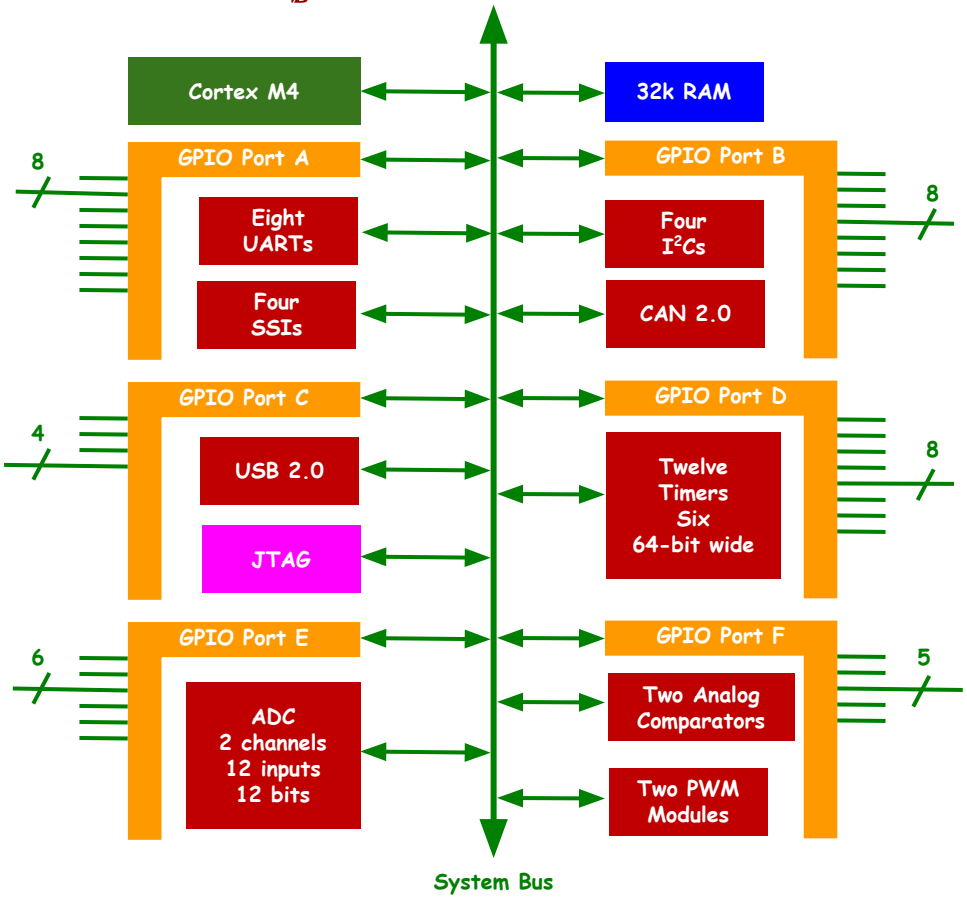
Tiva C Series EK-TM4C123GXL
http://www.ti.com/litv/pdf/spmu296



Stellaris EK-LM4F120XL
http://www.ti.com/lit/ug/spmu289c/spmu289c



I/O Portları


Cortex M4
32k RAM
GPIO Port A
GPIO Port B
8
Eight UARTs
Four I²Cs
8
Four SSIs
CAN 2.0
GPIO Port C
GPIO Port D
4
USB 2.0
Twelve Timers Six 64-bit wide
8
JTAG
GPIO Port E
GPIO Port F
6
ADC 2 channels 12 inputs 12 bits
Two Analog Comparators
5
Two PWM Modules
System Bus

Sorular