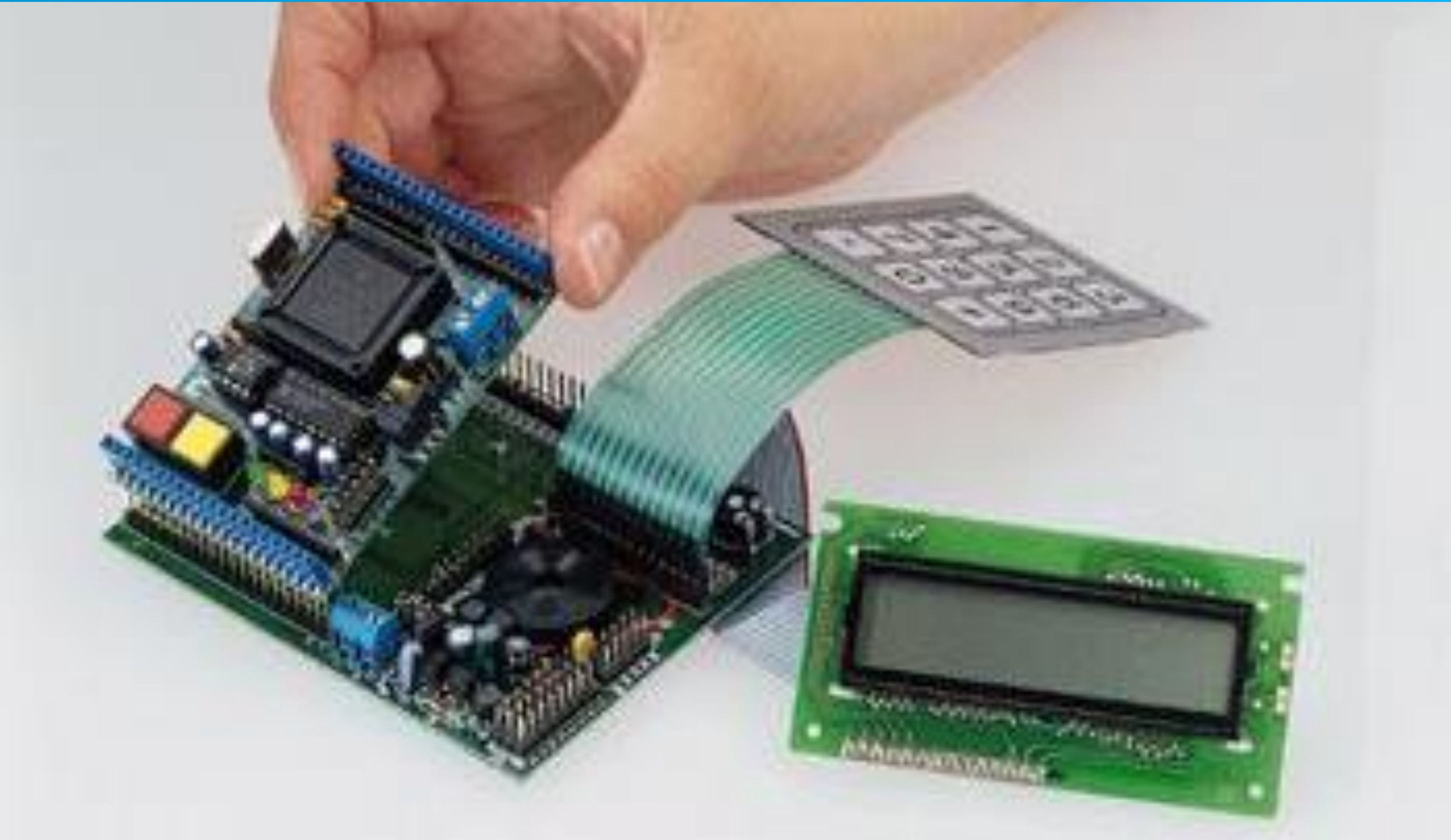
Tópicos em Sistemas Embarcados

Eletrônica para Computação

Prof. José Paulo G. de Oliveira

Sistemas Embarcados



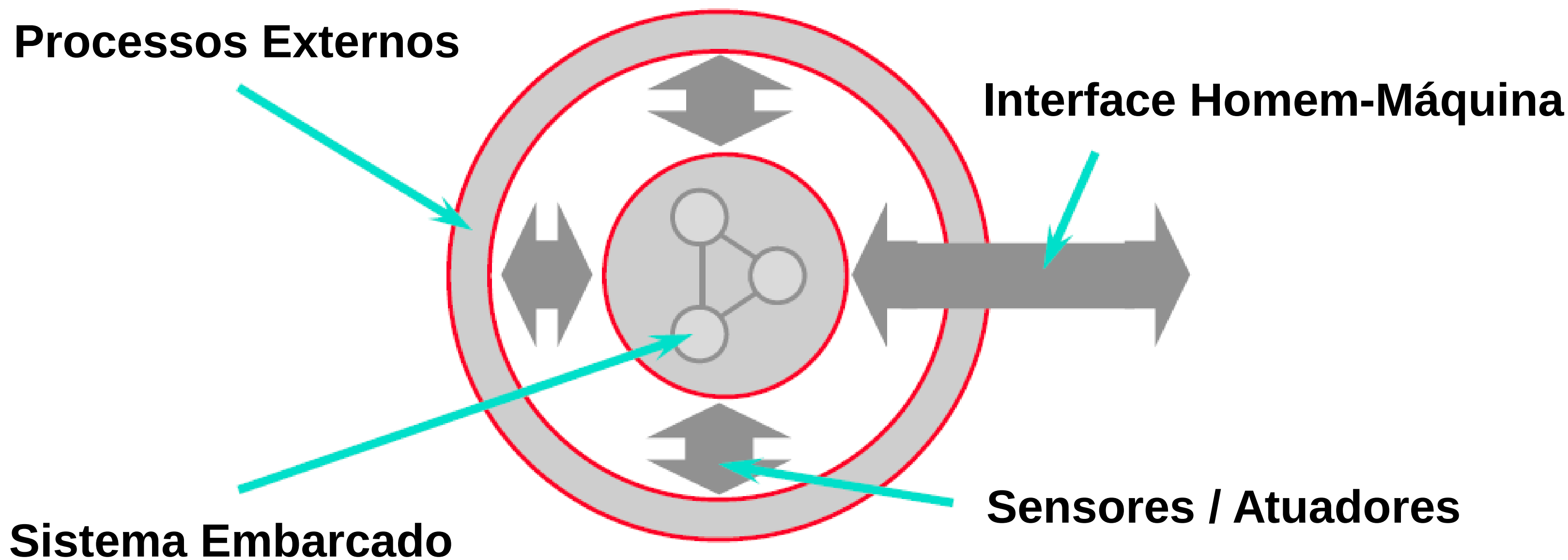
Tiva C Launchpad

Kit de desenvolvimento com microcontrolador

Definições

- *Embedded*
- Sistemas computacionais embutidos em um produto maior
- Hardware com “pouca” capacidade de processamento
  - Celulares, calculadores, tocadores de mp3
- Função específica*
- Sistemas reativos
- Sistemas de Tempo Real

Sistemas Reativos



Comparação

Sistemas Embarcados

- Poucas aplicações
- Não programável pelo usuário final
- Requisitos de execução fixos

- Critérios:
  - Custo
  - Consumo de energia
  - Previsibilidade(tempo de execução)

Sistema de Propósito Geral

- Ampla classe de aplicações
- Programável pelo usuário final
- Mais rápido é melhor

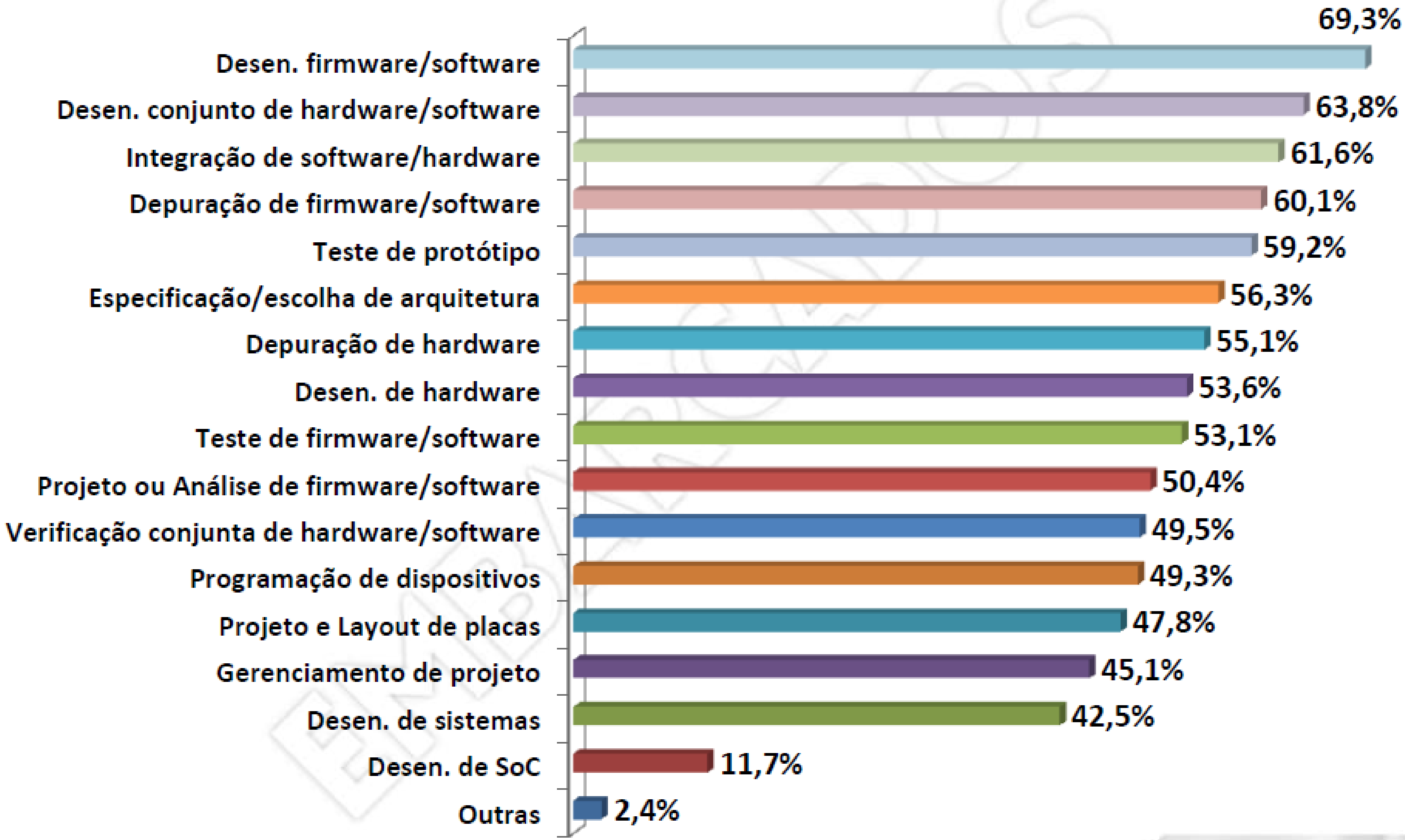
- Critérios :
  - Custo
  - Consumo de energia
  - Velocidade média de execução

Tempo Real

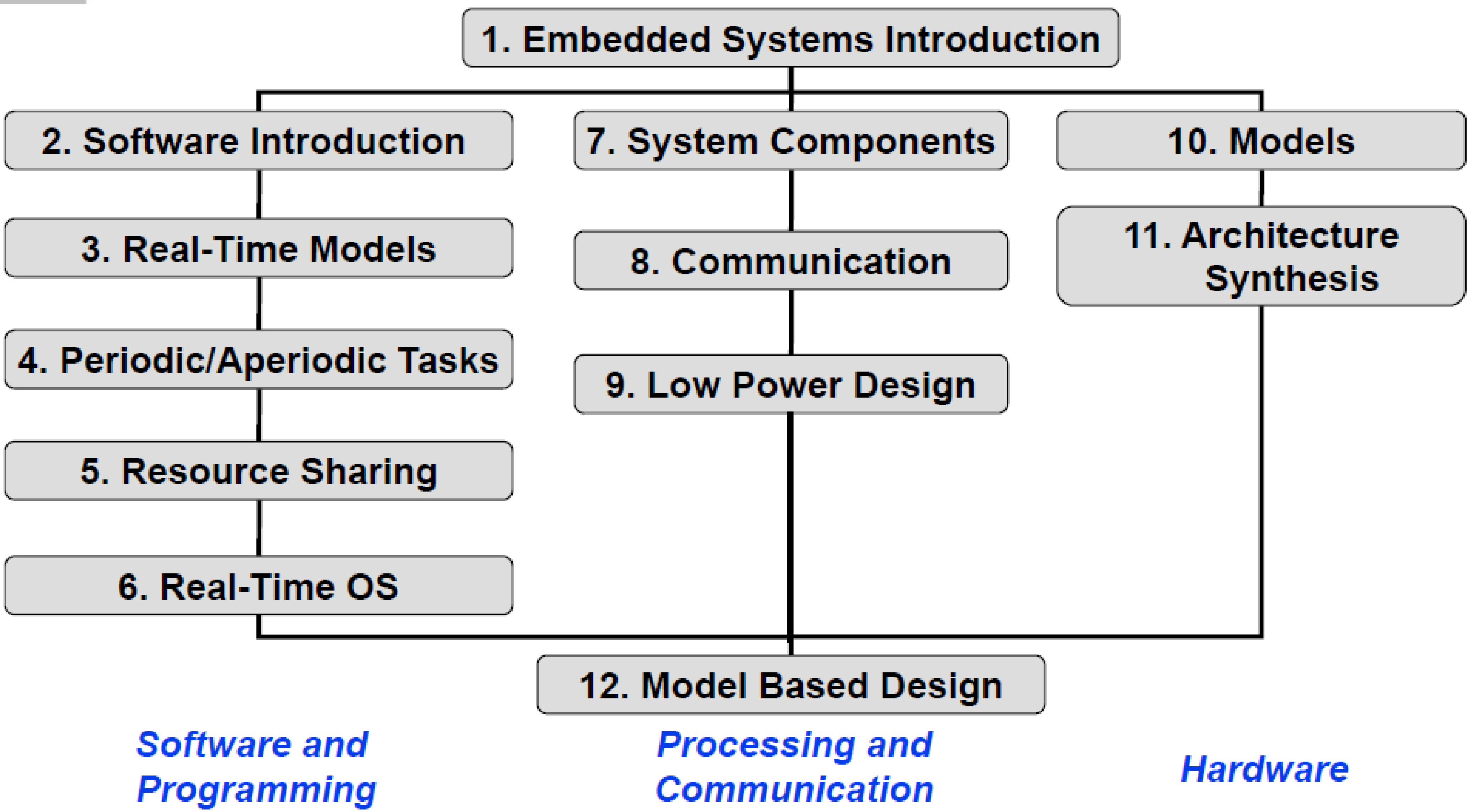
Tempo real

- Comportamento temporal previsível
  - Tempo de resposta conhecido no melhor caso e pior caso de operação
- *Soft real-time systems*
  - perda de prazo implica degradação do serviço prestado (gravação de CD)
- *Hard real-time systems*
  - perda de prazo pode causar grandes prejuízos econômicos ou ambientais (usina nuclear, caldeiras industriais)

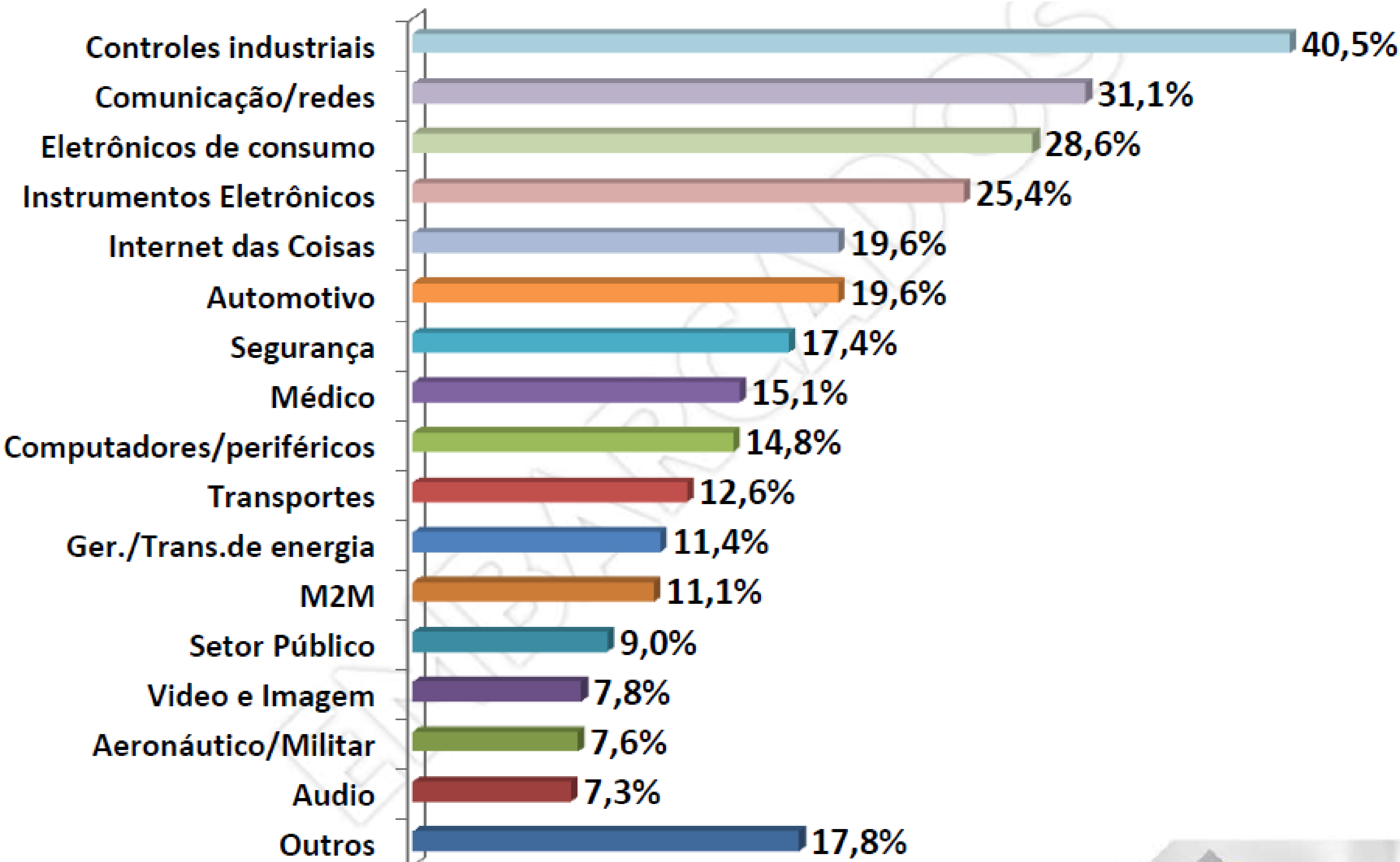
Atividades de Desenvolvimento



Temas Relacionados



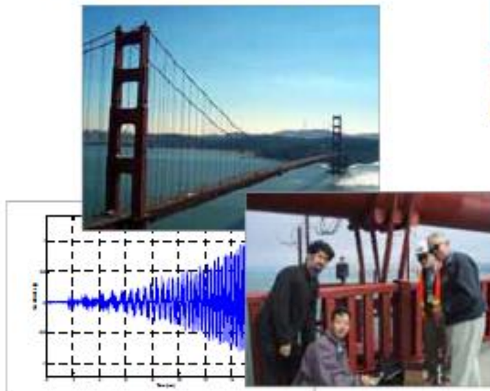
Tipos de Aplicações



Tipos de Aplicações

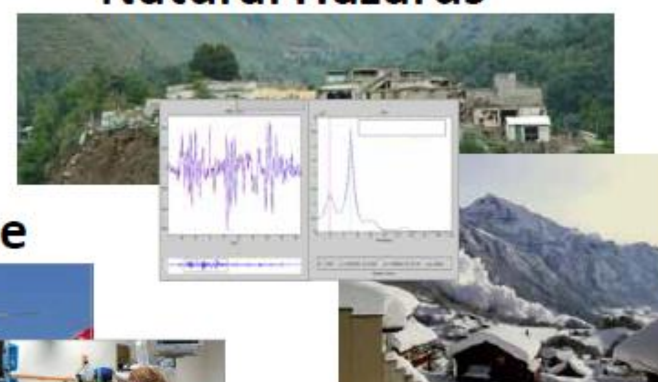
Logistics

Maintenance



Factory Automation

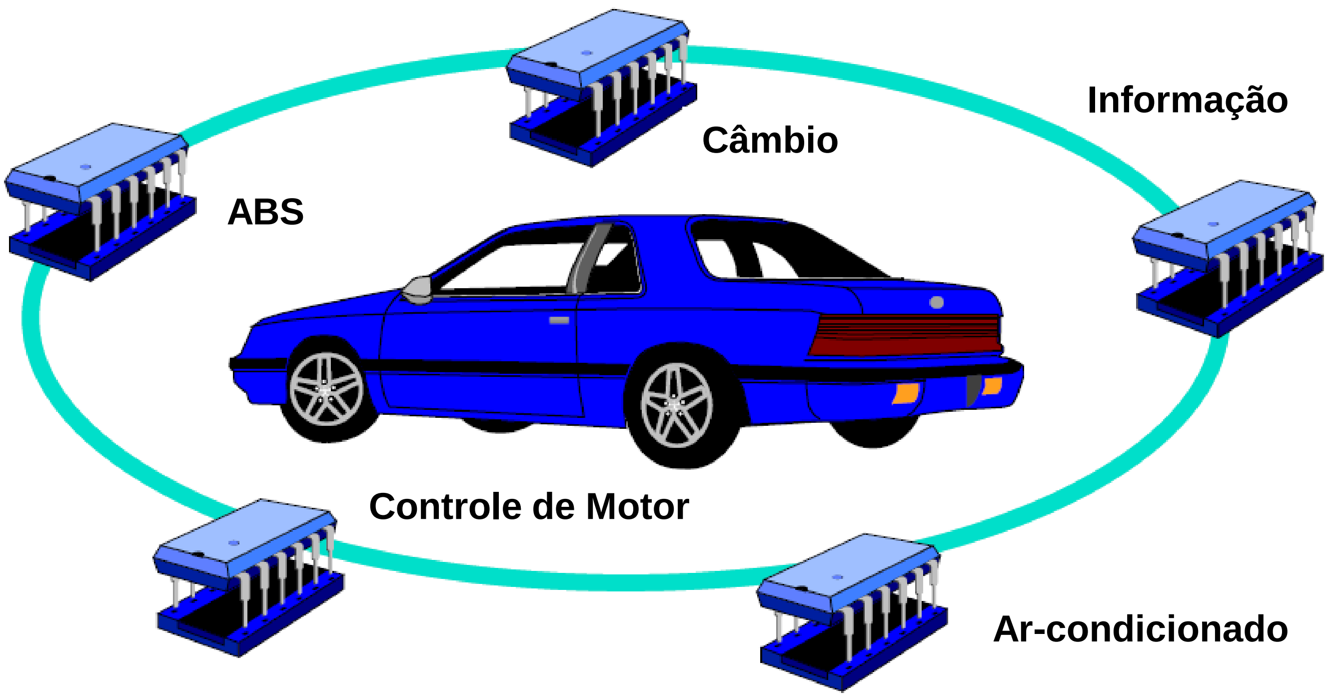
Natural Hazards



Building Automation

Health Care

Exemplo – Sistema Automobilístico



Exemplo – IoT

“A Internet das Coisas será Omnipresente!”

Características

- ***Seguros***
  - ***Confiabilidade***
    - *Probabilidade do Sistema funcionar corretamente, desde que seja garantido seu funcionamento em t=0*
  - ***Disponibilidade***
    - *Probabilidade do Sistema atender às requisições a todo instante*
  - ***Segurança***
    - *Não causa dano (Safety) OU Assegura que a comunicação seja realizada de forma autêntica e confidencial (Security)*

Características

- Devem ser ***eficientes:***
  - *Energia*
  - *Tamanho de código*
  - *Desempenho*
  - *Peso*
  - *Custo*

- ***Dedicado*** a alguma ***aplicação***

- ***Interface*** de usuário ***Dedicada***.

Características

- ***Tempo real:***
  - *Soft*
  - *Hard*

- ***Reativo***
  - *Sensores*
  - *Atuadores*

- ***Sistemas Híbridos***
  - *Analógicos*
  - *Digitais*

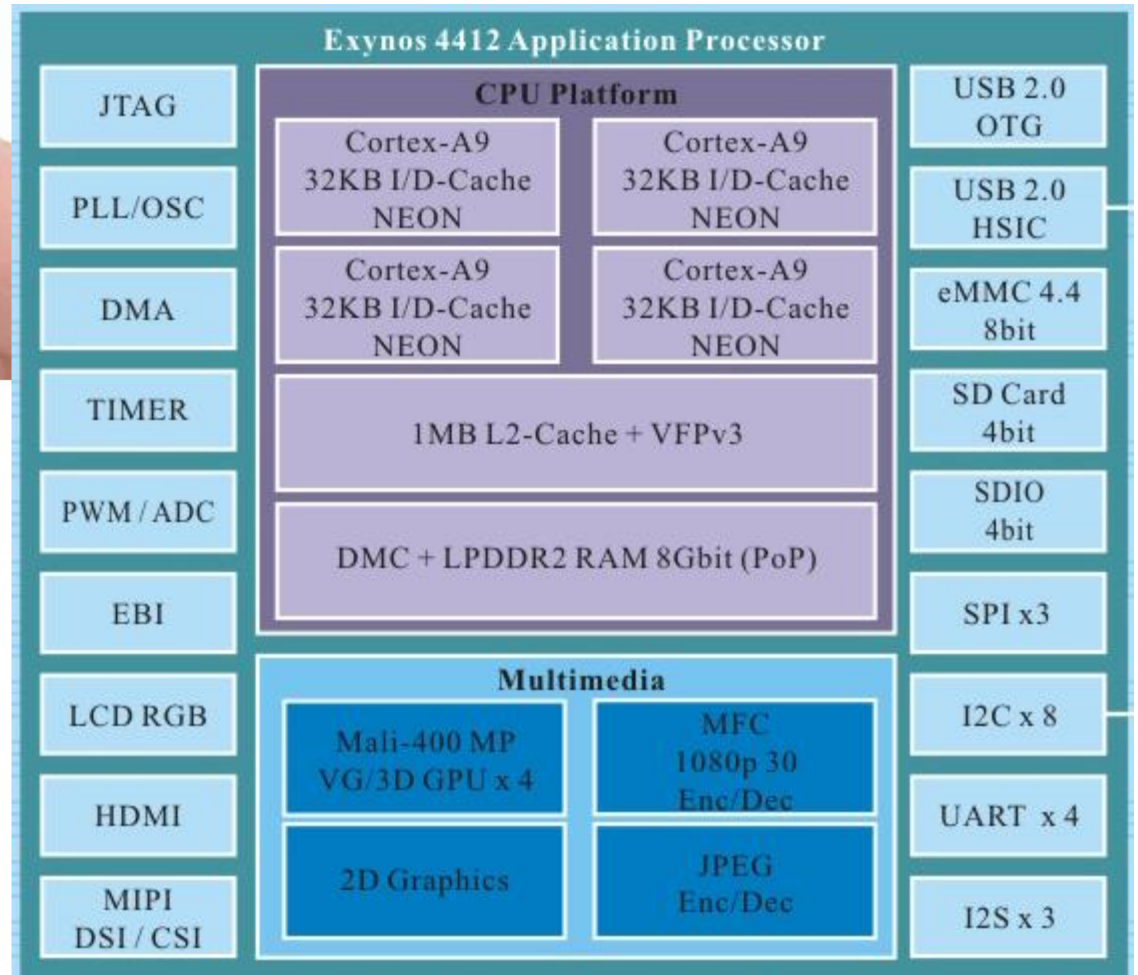
Tendências

- ***Tamanho de código aumentando***
  - *Código médio: 16-64KB em 1992, 64K-512KB em 1996, ??? MB em 2016.*
  - *Migração do assembly para Alto nível (C, C++, Java!!)*

- ***Reuso de HW e SW***
  - *processadores (micro-controladores, DSPs)*
  - *componentes de SW (drivers)*

- ***Complexidade e Integração crescentes***
  - *RF, DSP, interfaces de rede*
  - *Procesadores de 32 bits, Procesadores de E/S*

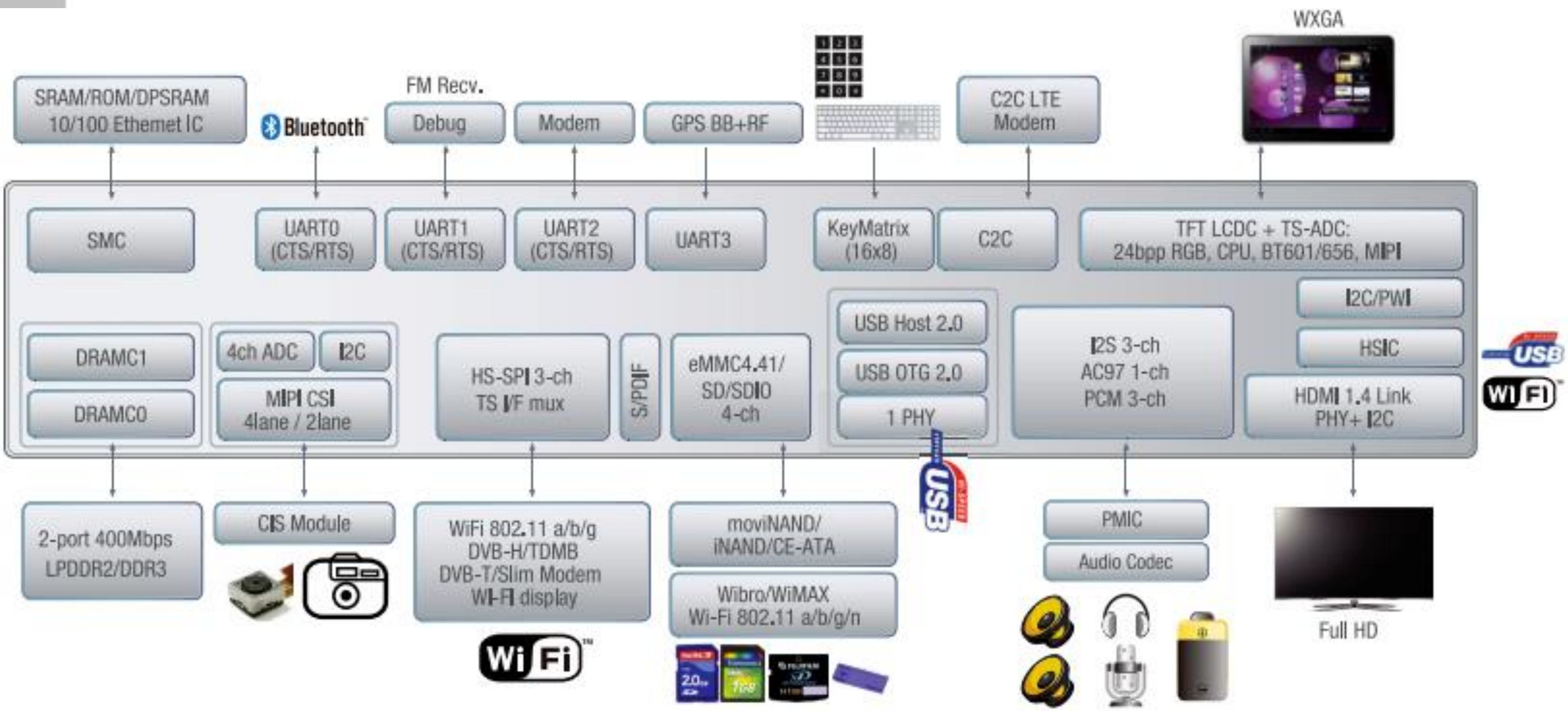
Multiprocessor systems-on-a-chip (MPSoCs)



Exynos 4412 MPSOC

- Núcleo ARM Cortex-A9
- 32 nm
- 4 núcleos

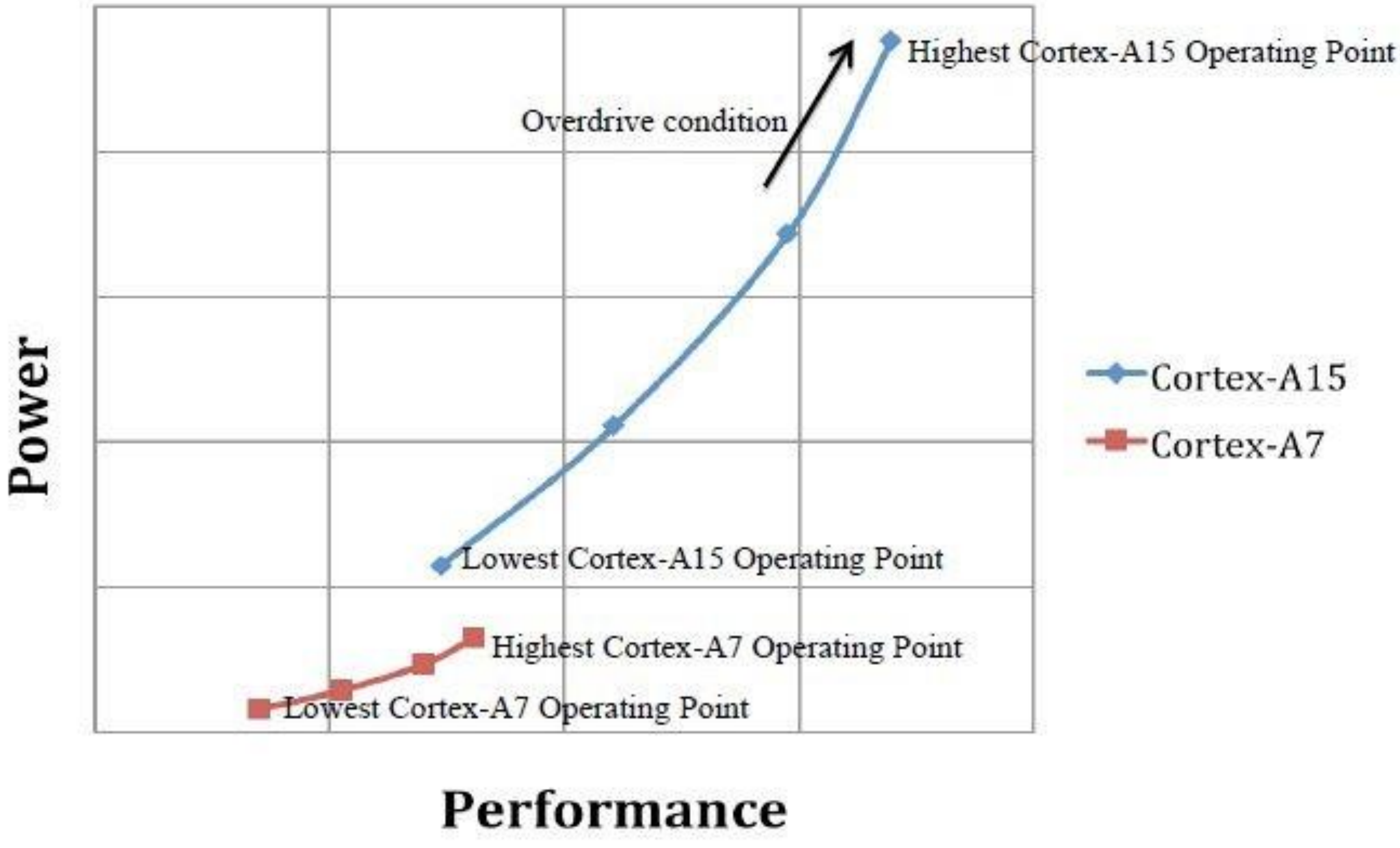
Multiprocessor systems-on-a-chip (MPSoCs)



Métricas

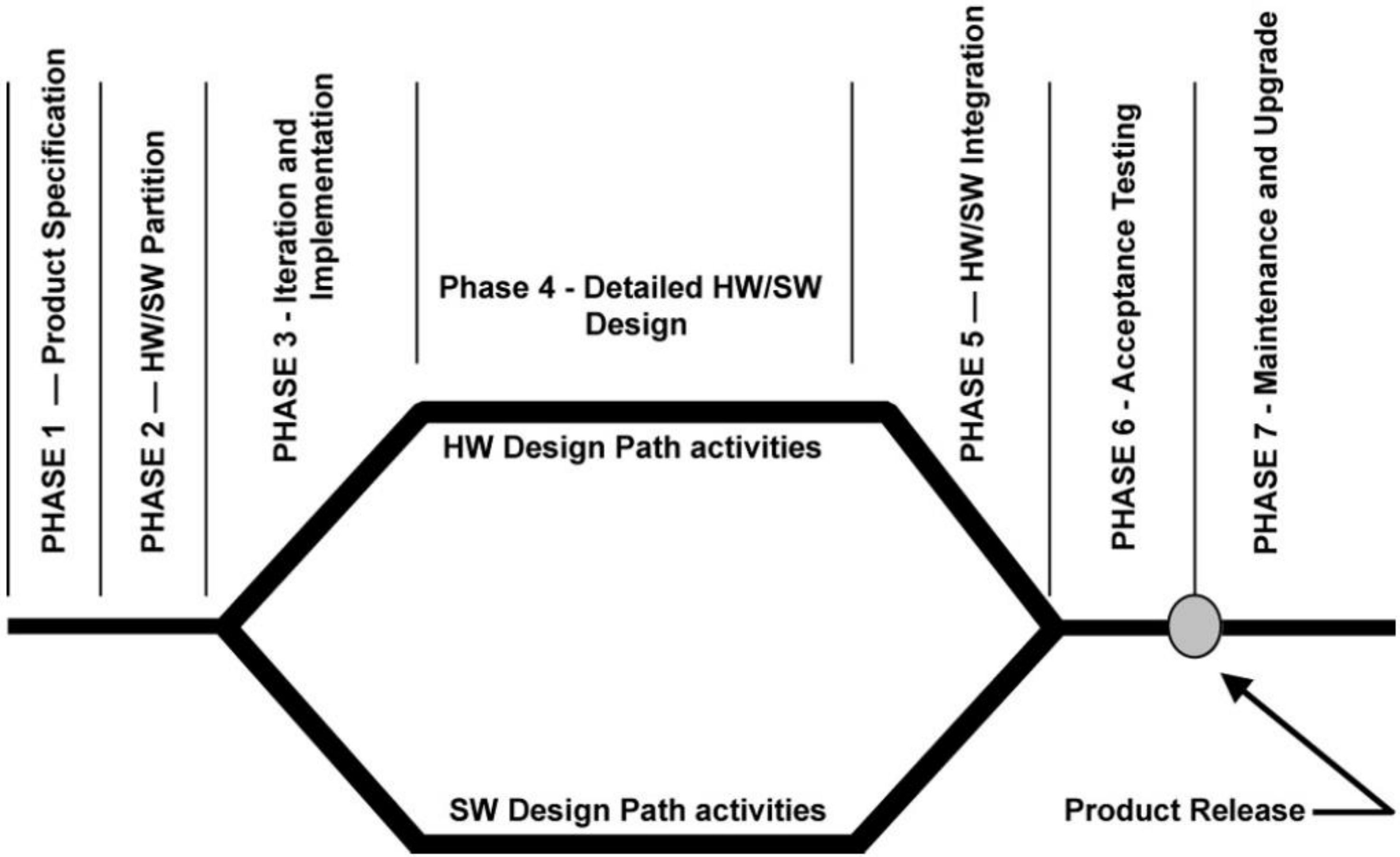
- Gerais:
  - *desempenho*: MIPS, leituras/seg, etc.
  - *energia*: Watts
  - *custo*: $
    - Custo de projeto, produção
  - *tamanho*: bytes, # componentes, espaço físico
  - Flexibilidade, *Time-to-prototype*, *time-to-market*
  - Manutenção, exatidão, segurança
- MIPS, Watts e Custo estão relacionados
  - Dependente da tecnologia
  - Mais MIPS com menos Watts
    - Busque as fontes de maior consumo no seu projeto
    - Use gerenciamento de energia e nível de tensão escalável

MIPS vs. Watts



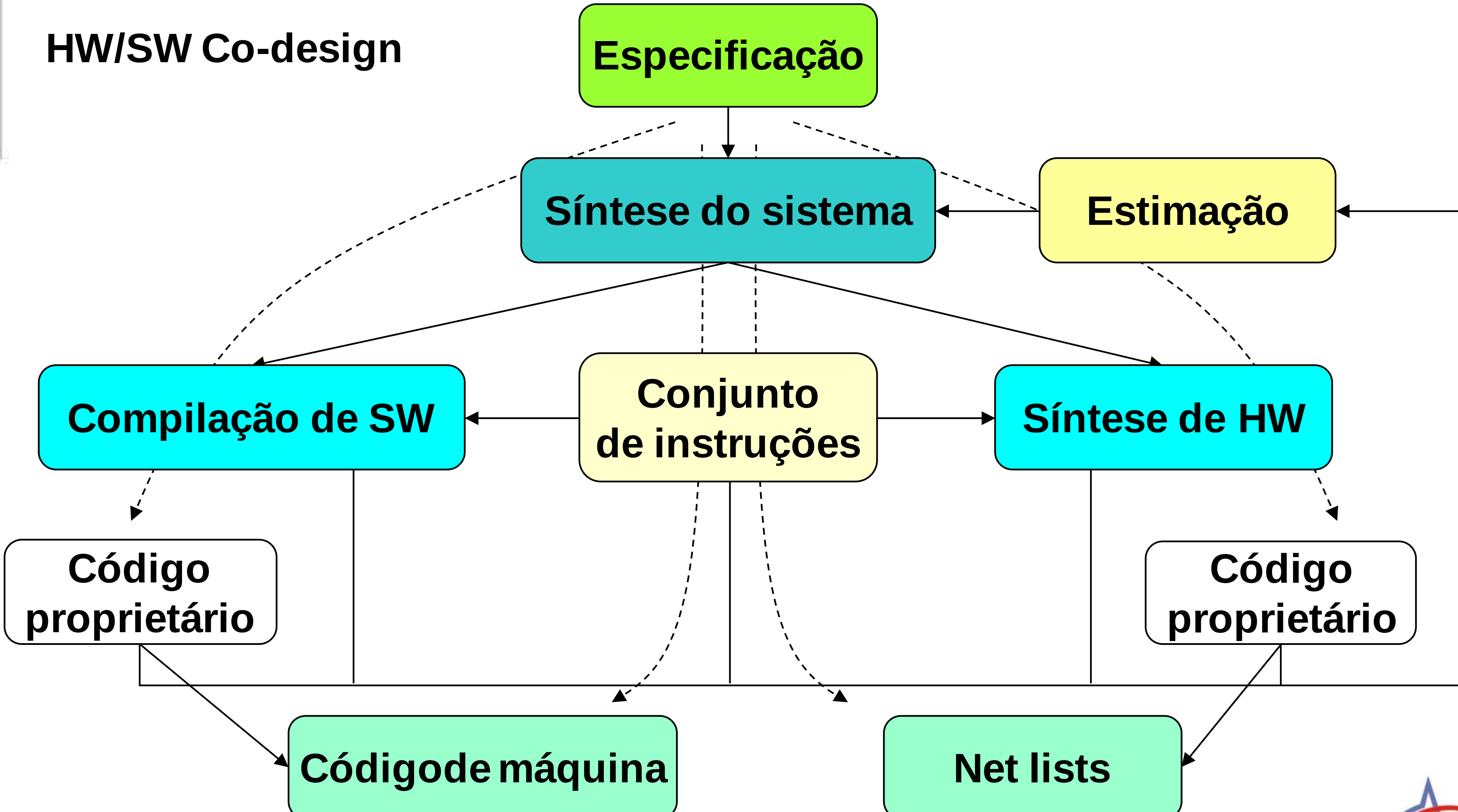
Projeto de Sistemas Embarcados - HW

Ciclo de Projeto

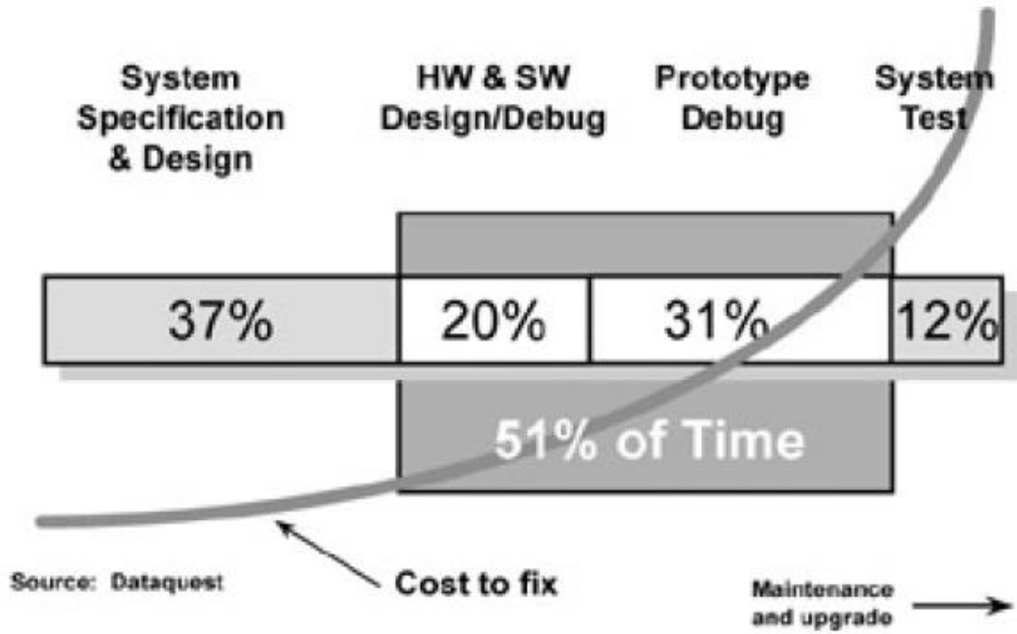


HW-SW Co-design

HW/SW Co-design



Fases do projeto
Testes x Custos



Questões Práticas - HW

Ferramentas

Equipamentos eletrônicos de laboratório

- Multímetro
- Osciloscópio
- Gerador de sinais
- Ferramentas manuais

Ferramentas

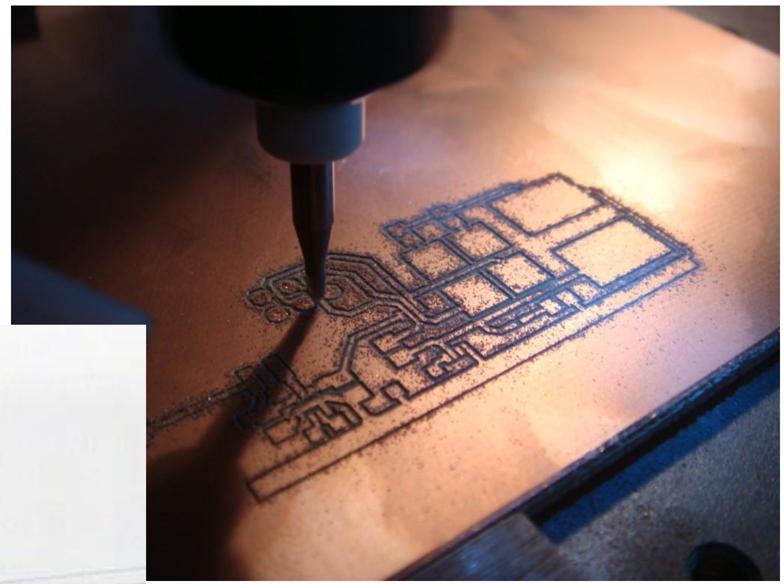
Prototipação

- Construção de PCIs
- Soldagem
- Ferramentas manuais

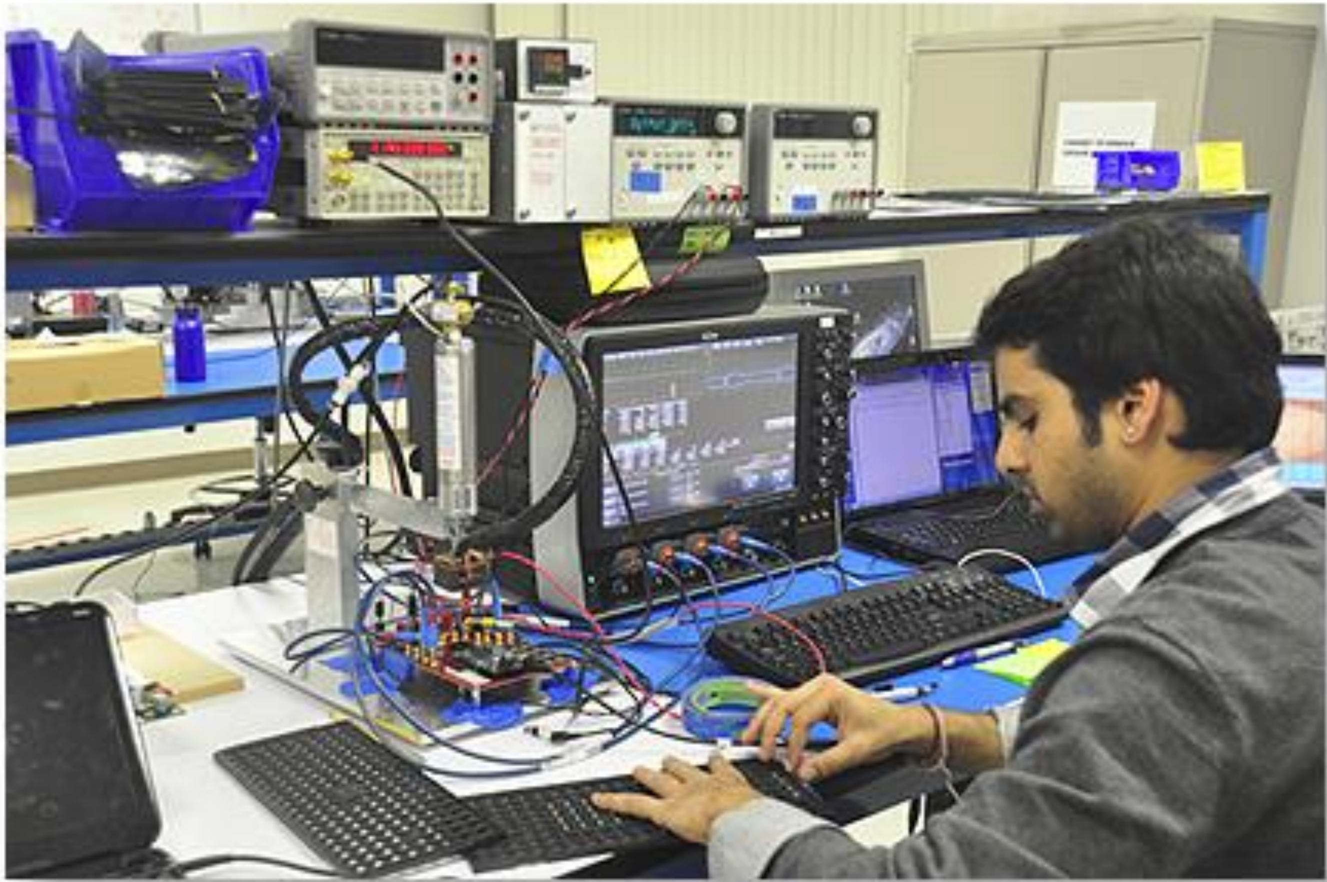
Ferramentas

Prototipação

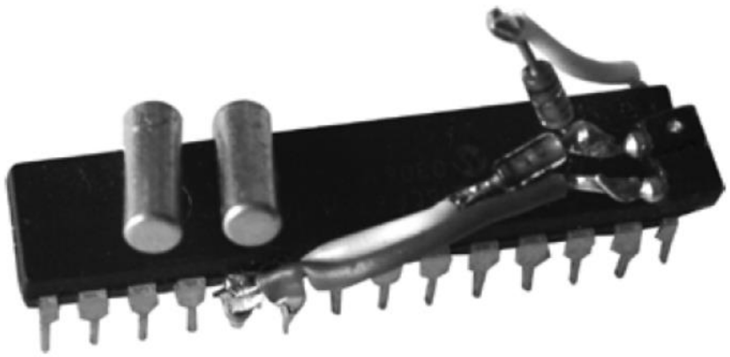
- Prototipadora



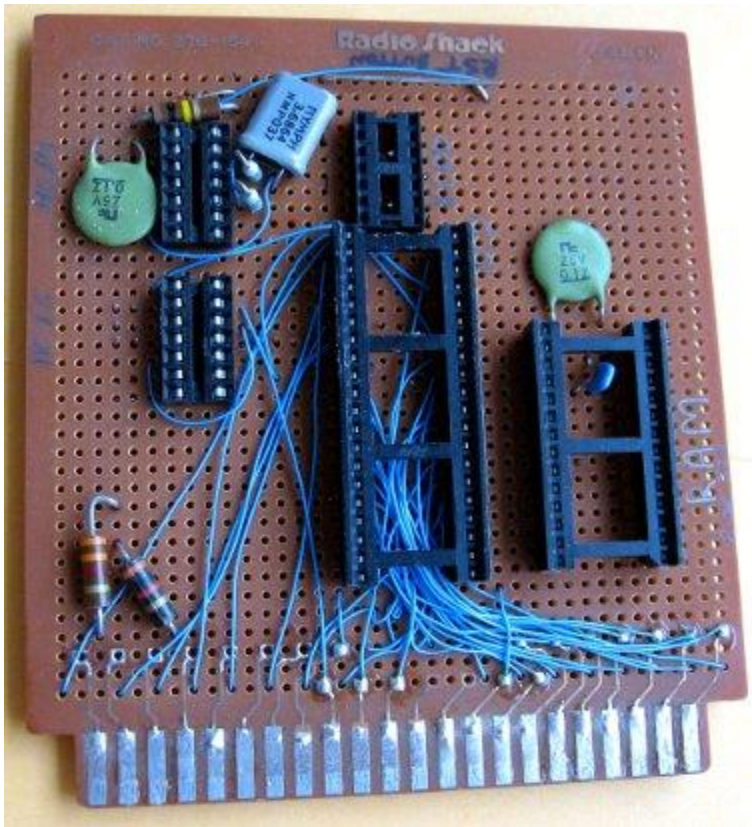
Ferramentas

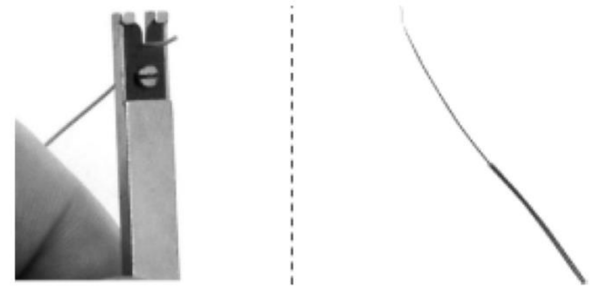


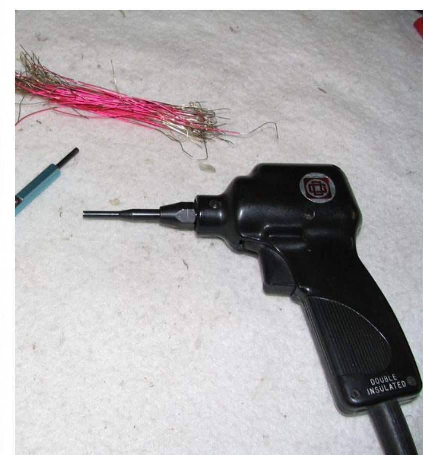
Montagem rápida



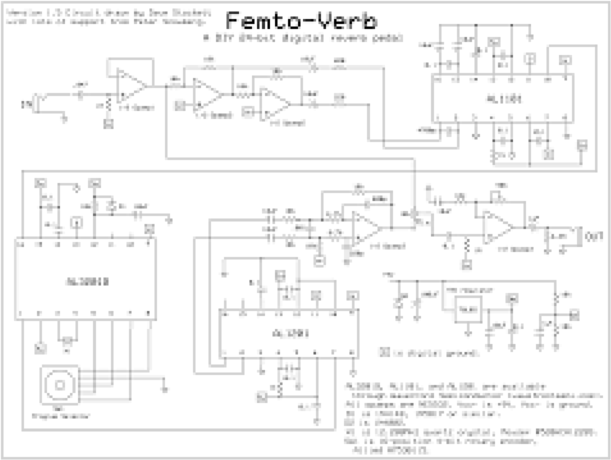
Wire Wrap

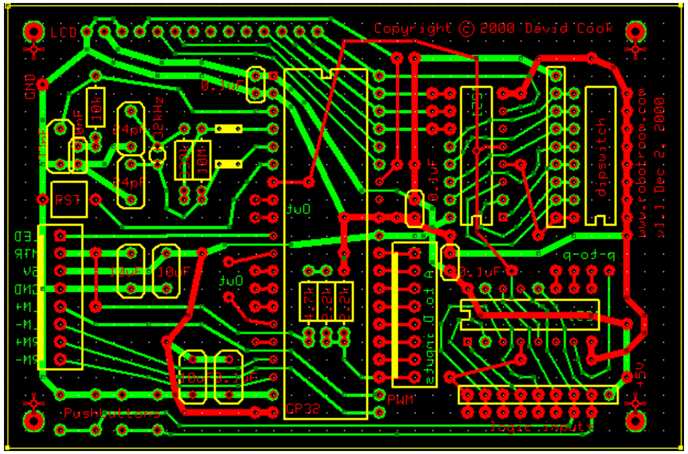


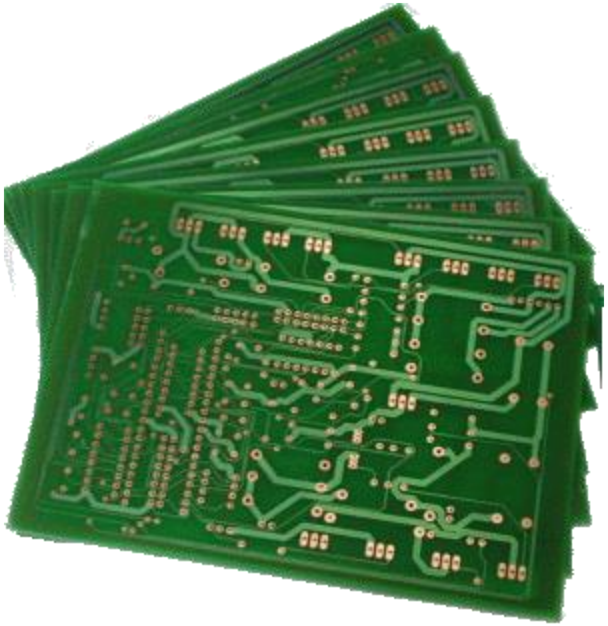




PCI – Placa de Circuito Impresso







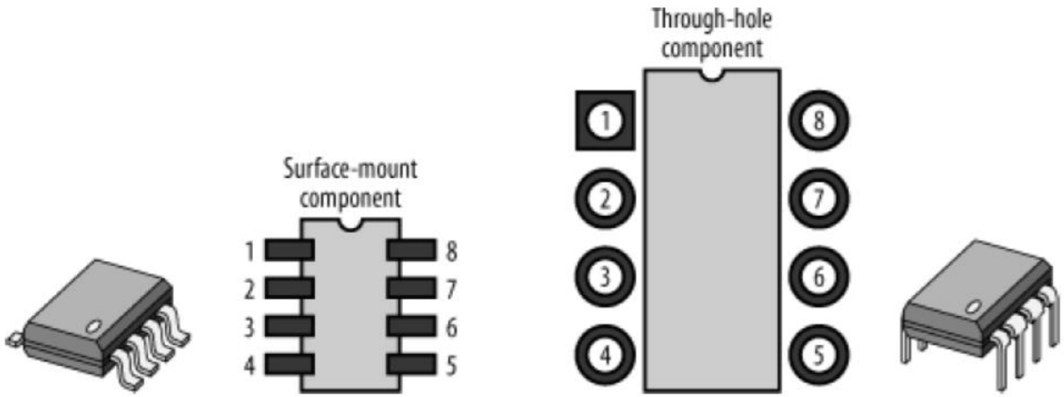
PCI – Placa de Circuito Impresso

Largura da trilha *versus* Corrente

Mils	mm	Amps
8	0.2	0.5
12	0.3	0.75
20	0.5	1.25
50	1.25	2.5
100	2.5	4
200	5	7
325	8.12	10

*Mils – milésimo de polegada

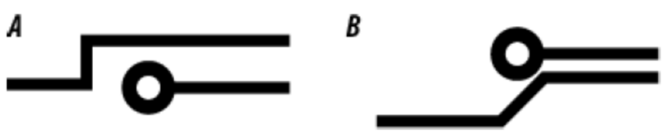
PCI – SMD x PTH



SMD **PTH**

PCI – Roteamento

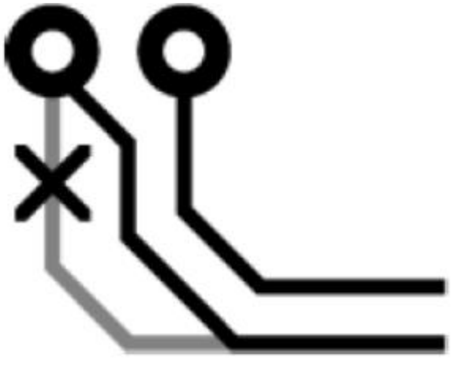
Roteamento de trilhas ao redor de ilha (*pad*)



PCI – Roteamento

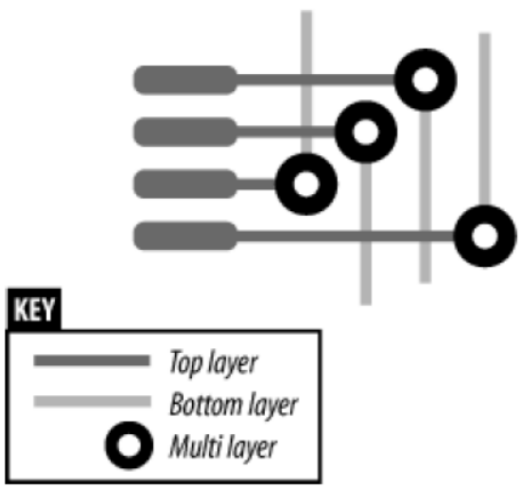
Roteamento de trilhas paralelas

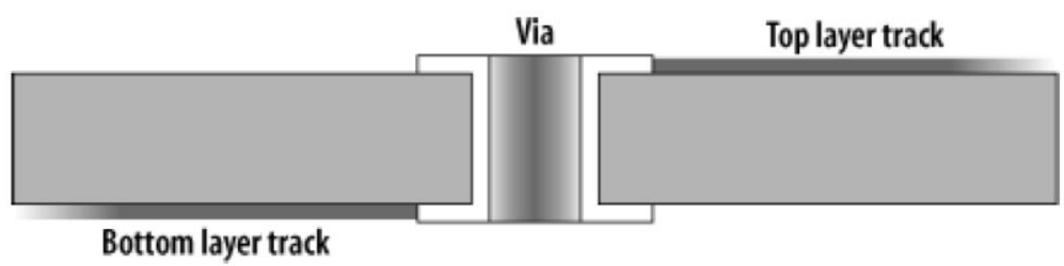
- Evita diferença de percurso



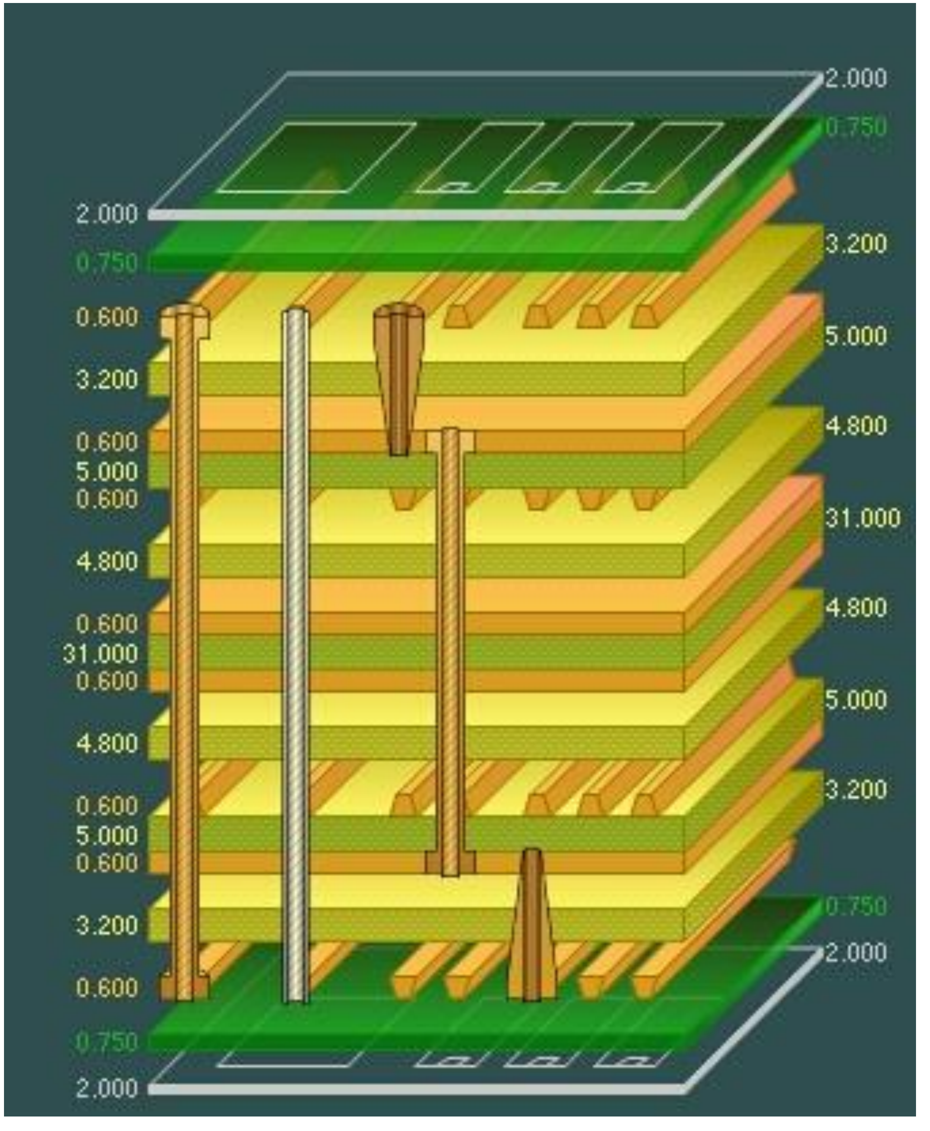
PCI – Multicamada

Uso de Vias



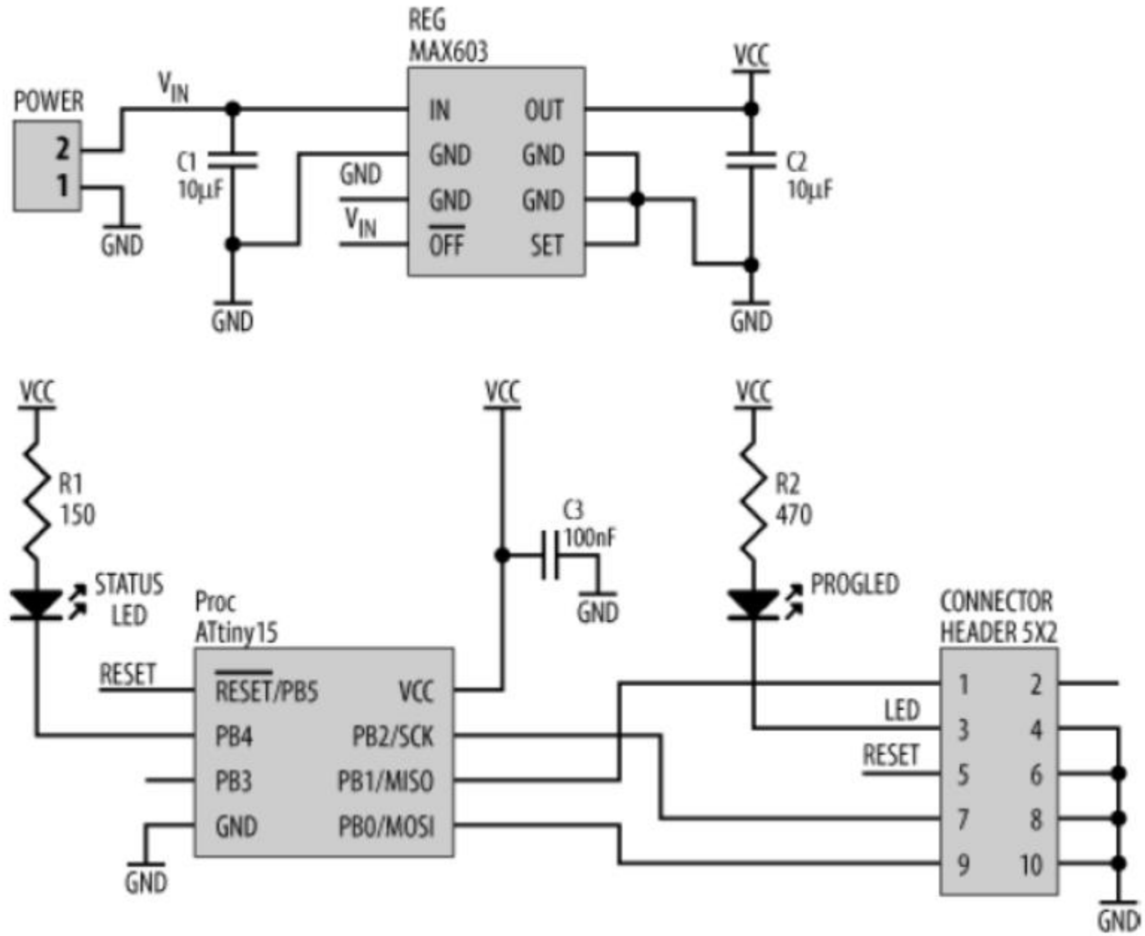


PCI – Multicamada



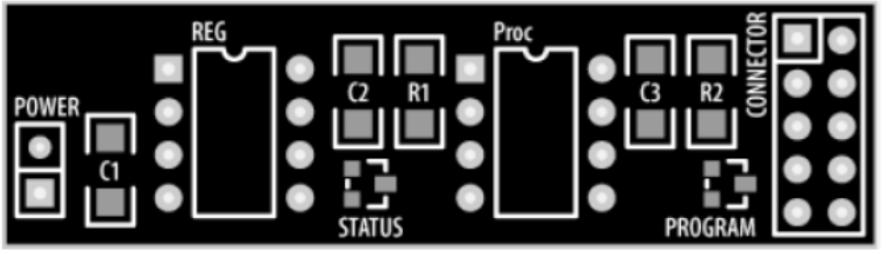
PCI – Exemplo

Esquemático

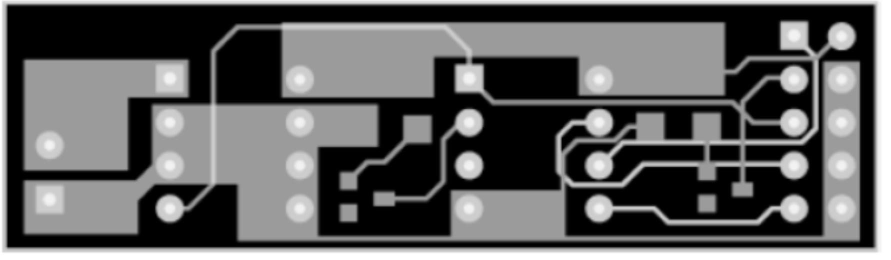


PCI – Exemplo

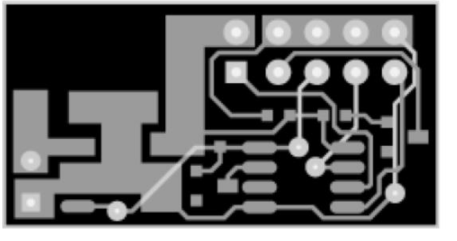
Componentes



PCI PTH

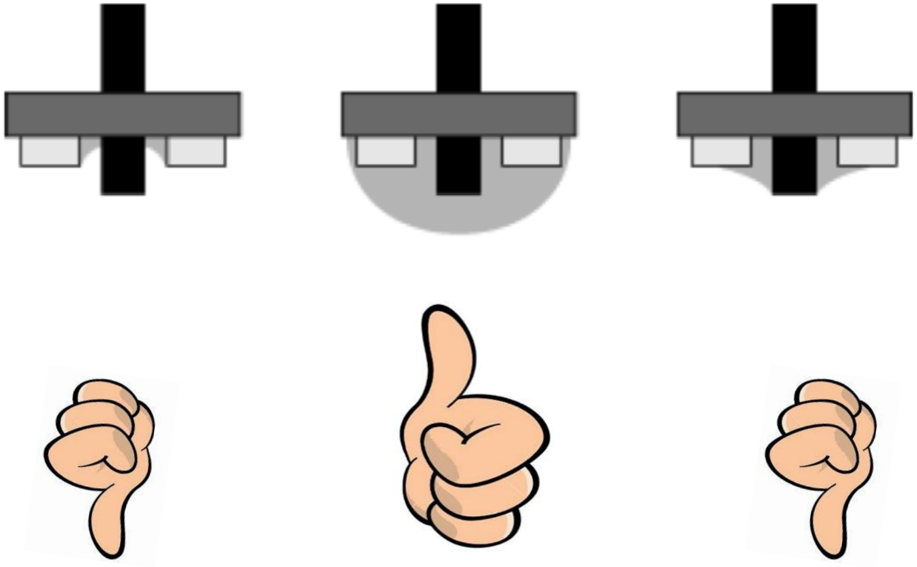


PCI SMD



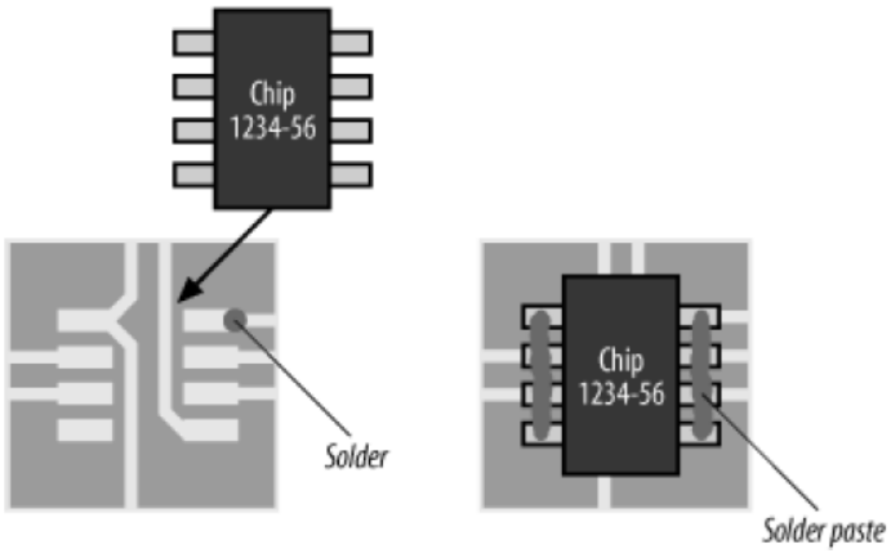
Soldagem

PTH – Pin Through Hole

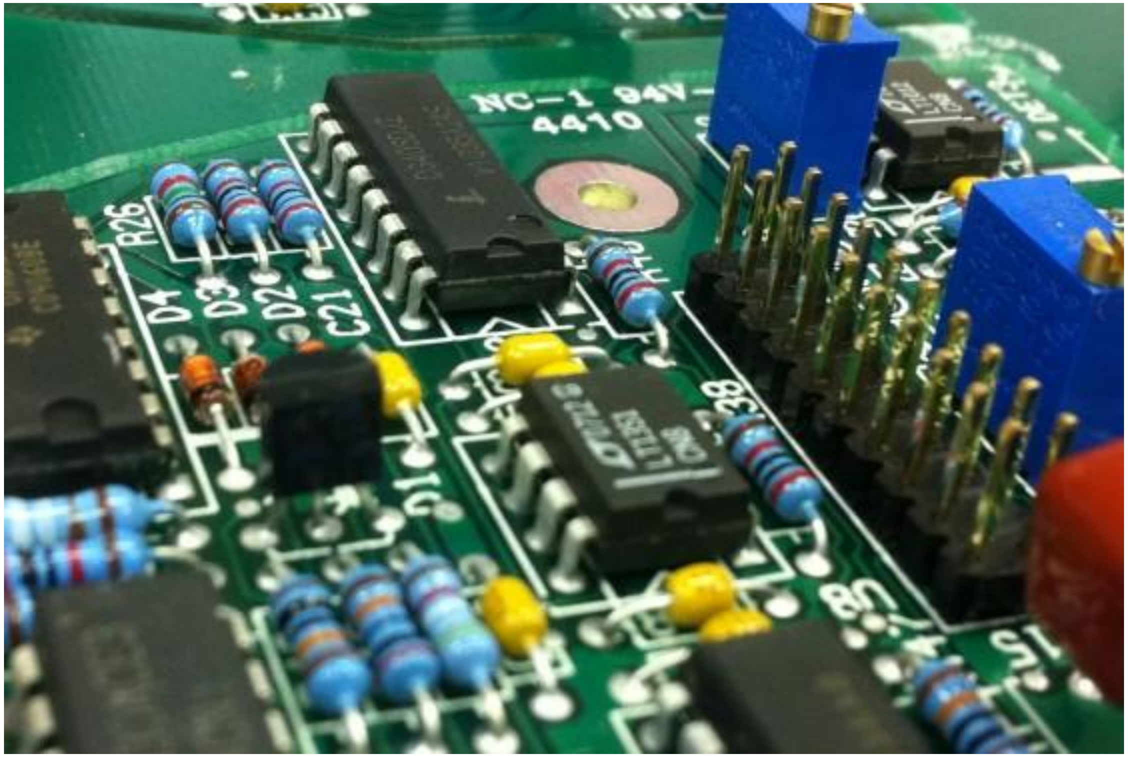


Soldagem

SMD – Surface Mount Device
SMT – Surface Mount Technology



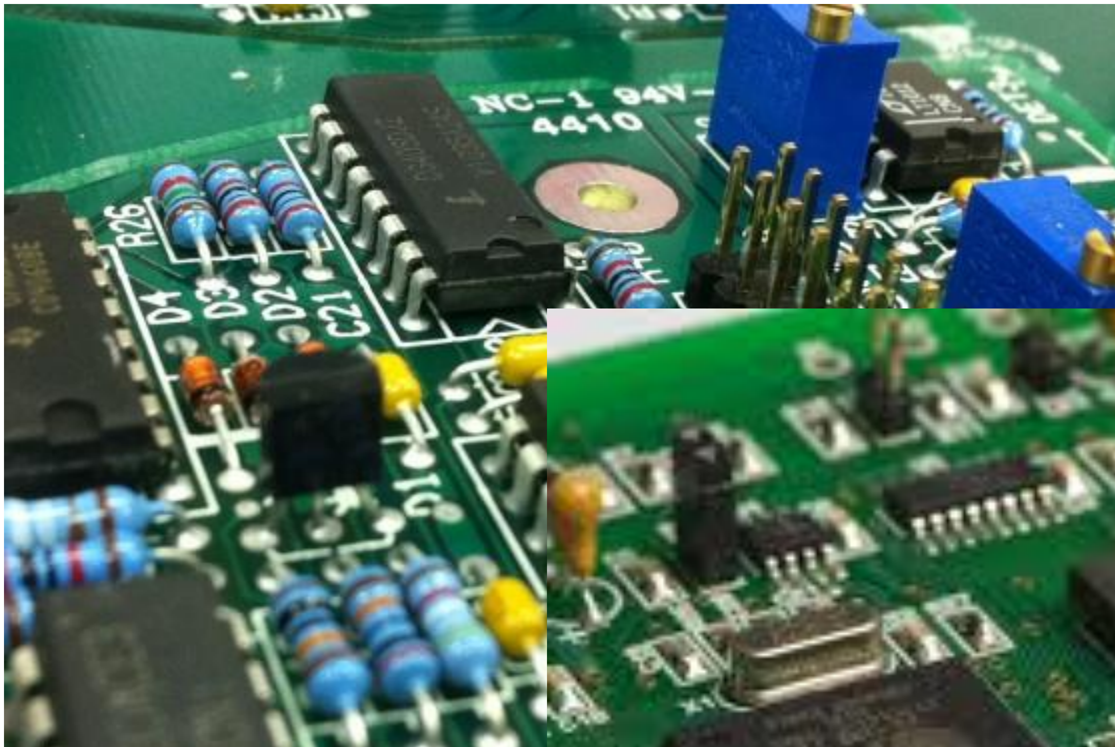
Soldagem



PTH

Soldagem

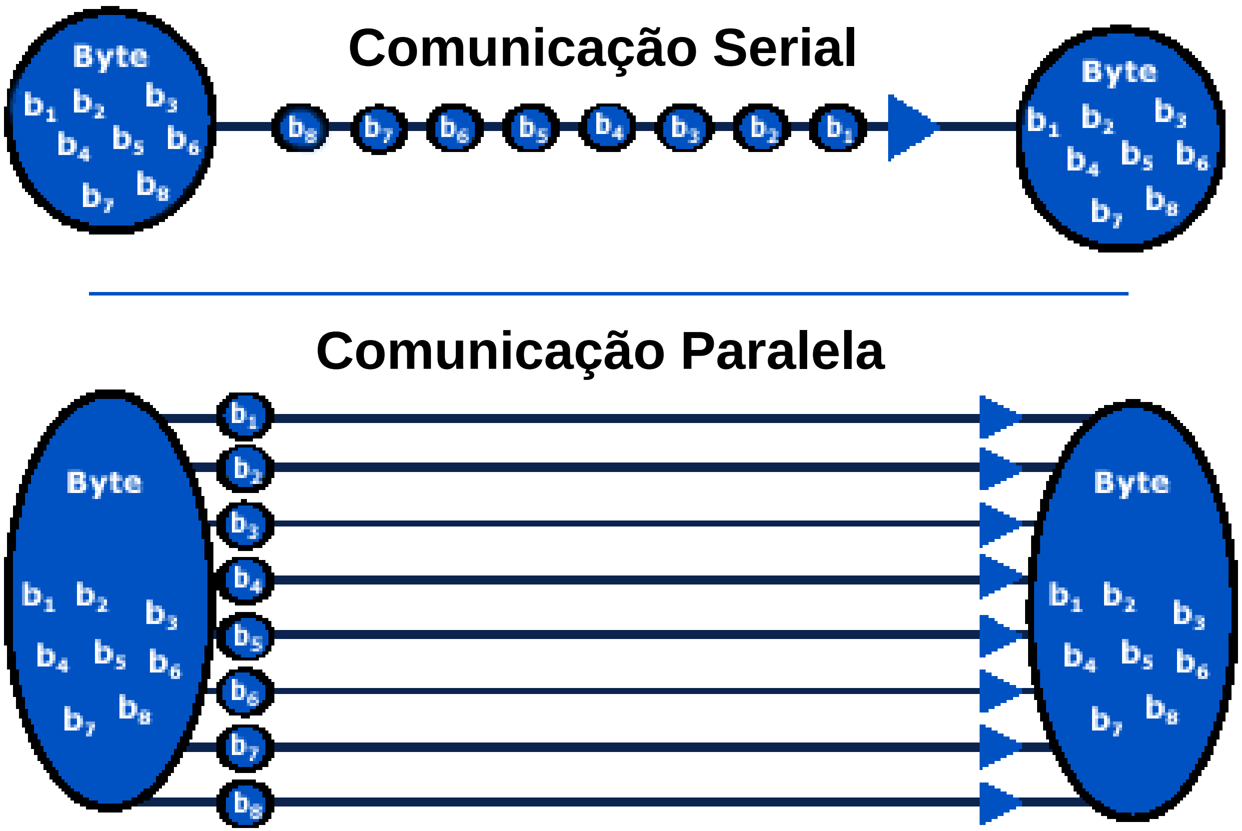
PTH



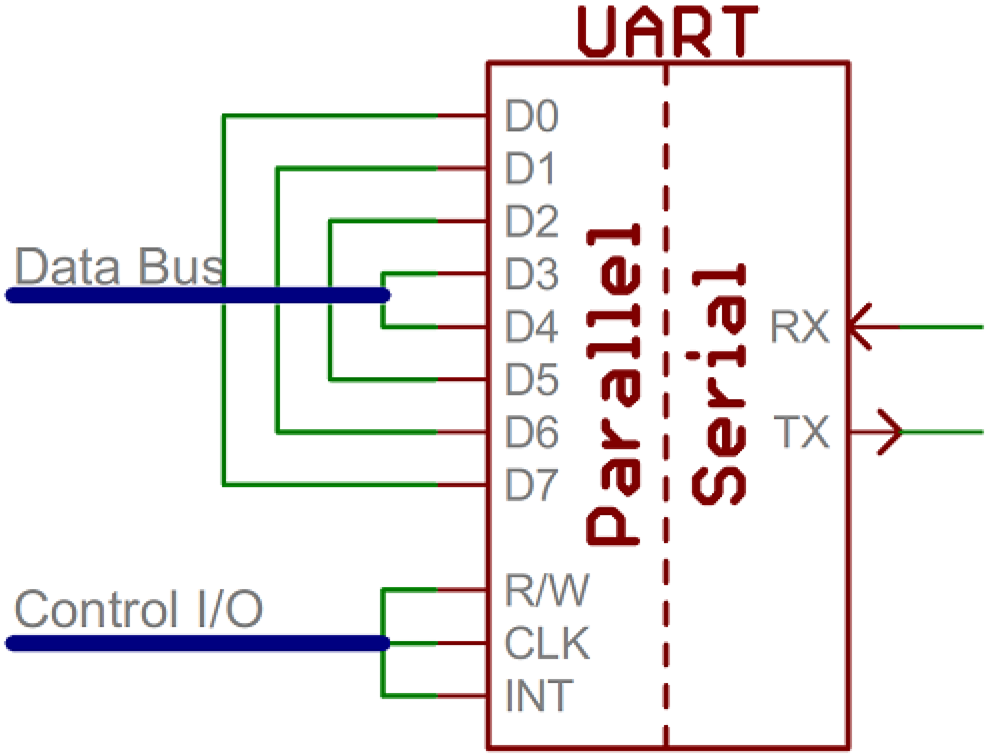
SMD

Interfaces

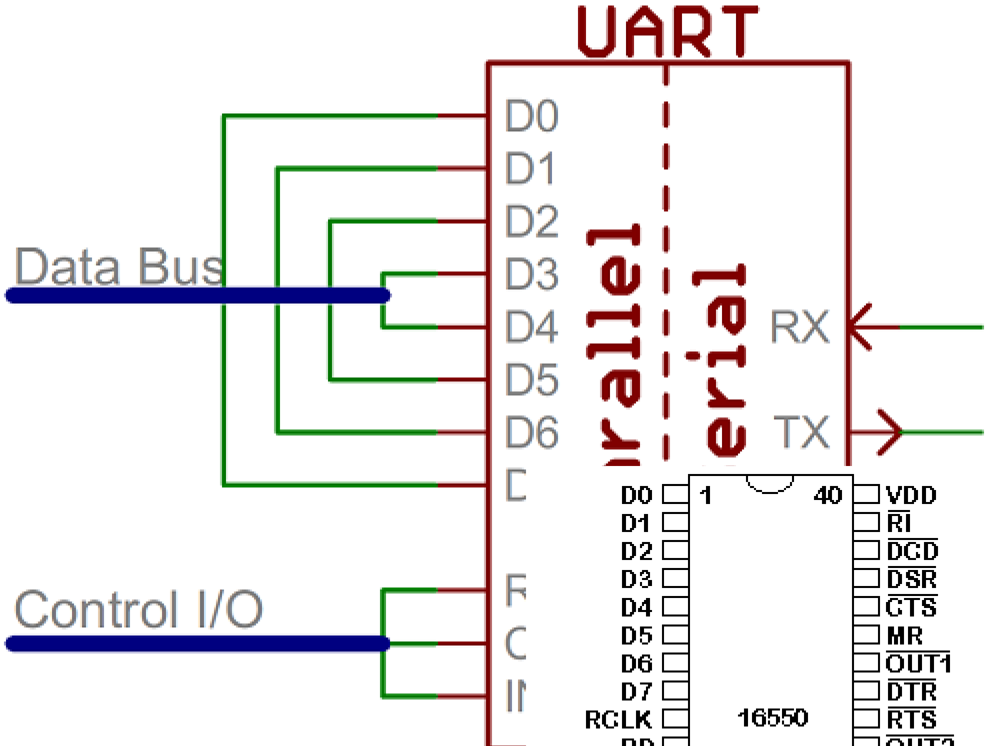
Comunicação

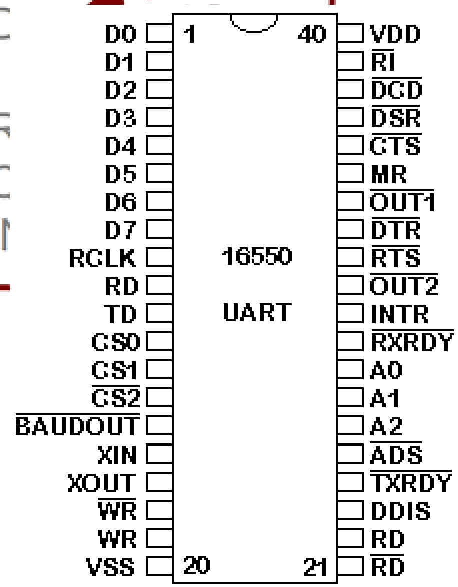


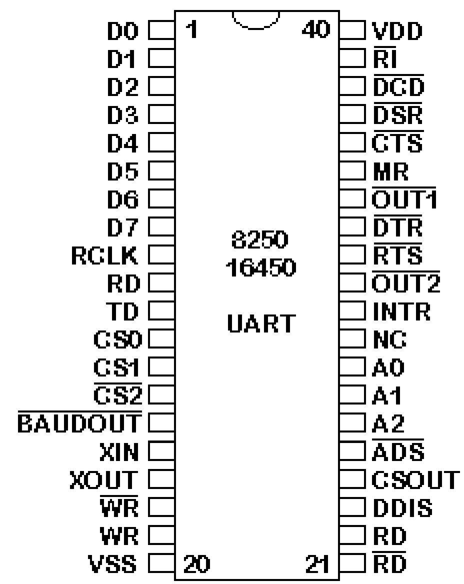
UART - Universal asynchronous Rx/Tx



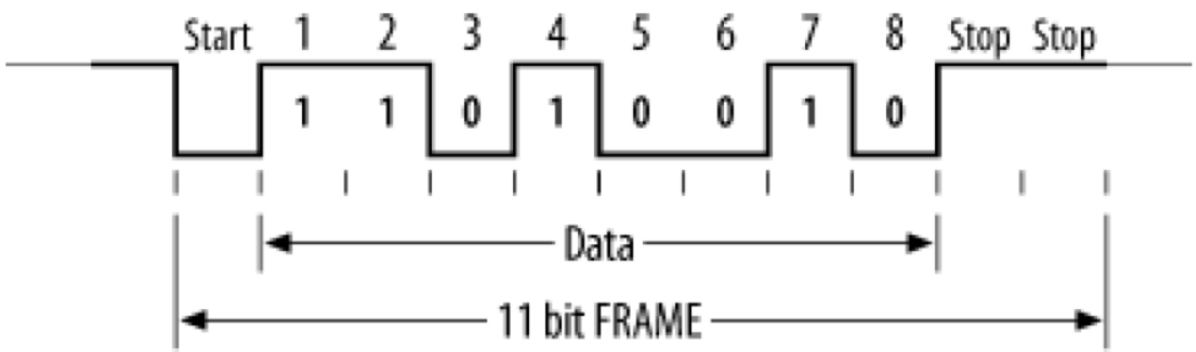
UART - Universal asynchronous Rx/Tx



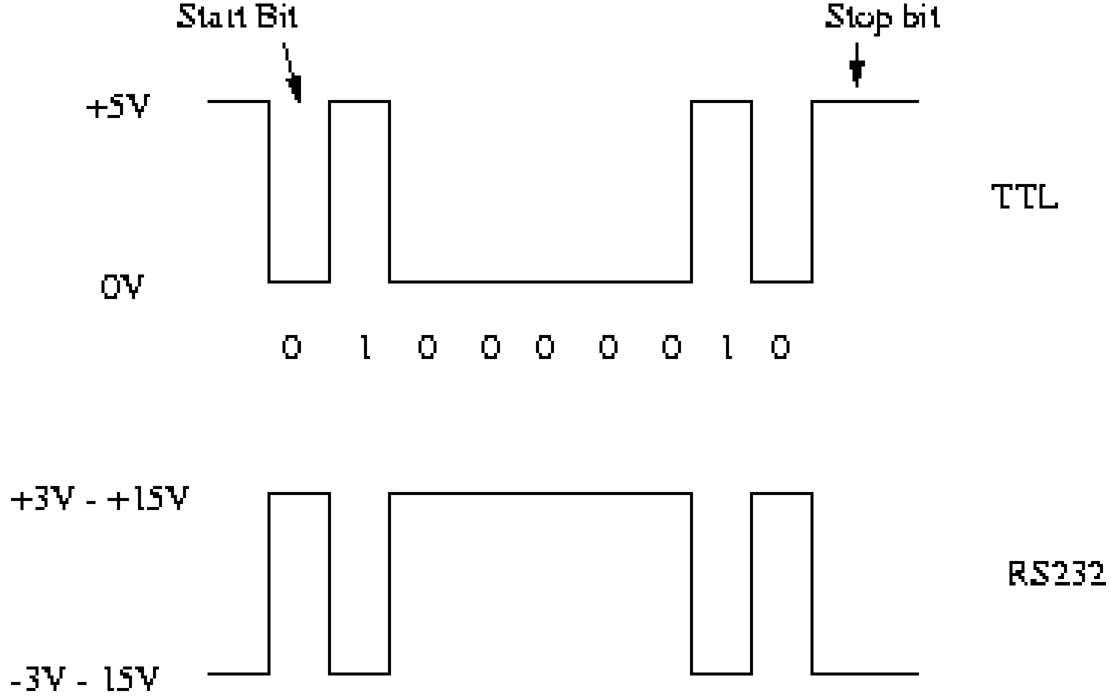




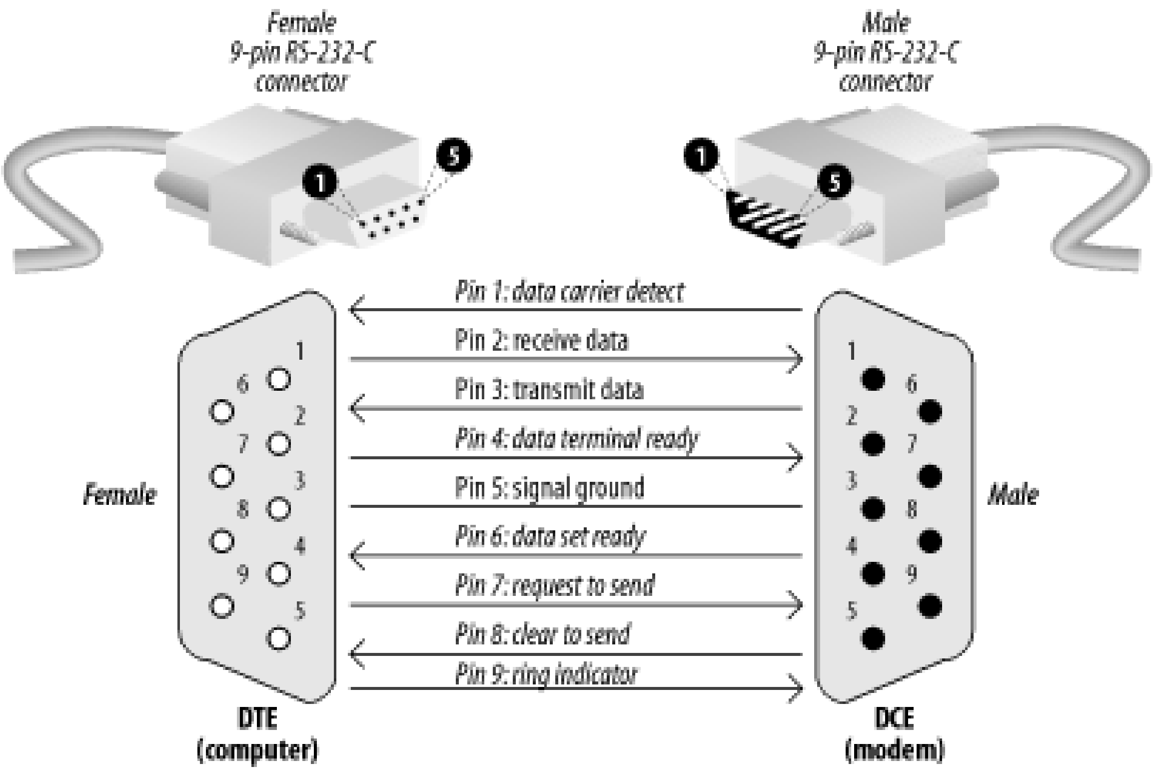
UART - Universal asynchronous Rx/Tx



UART – RS 232

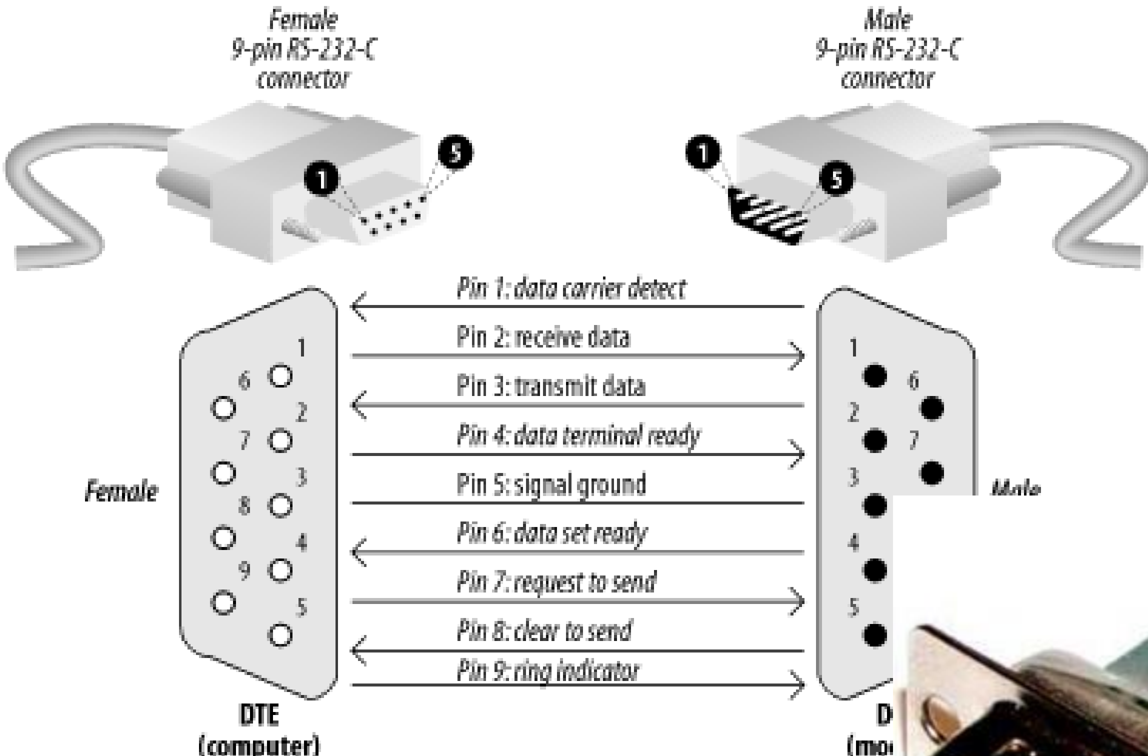


UART – RS 232



Female
9-pin RS-232-C
connector
Male
9-pin RS-232-C
connector
Pin 1: data carrier detect
Pin 2: receive data
Pin 3: transmit data
Pin 4: data terminal ready
Pin 5: signal ground
Pin 6: data set ready
Pin 7: request to send
Pin 8: clear to send
Pin 9: ring indicator
Female
Male
DTE
(computer)
DCE
(modem)

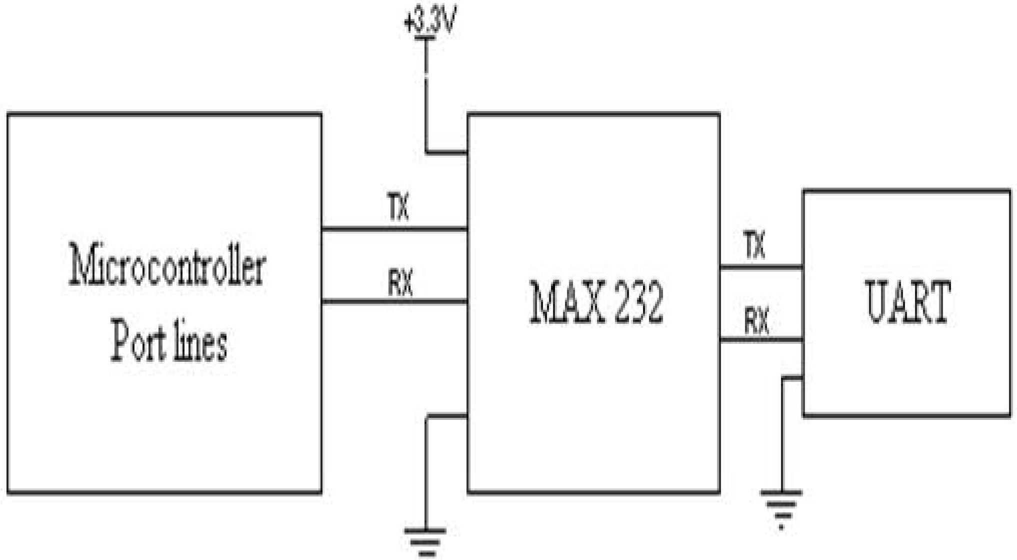
UART – RS 232


Female
9-pin RS-232-C
connector
Male
9-pin RS-232-C
connector
1
5
Pin 1: data carrier detect
Pin 2: receive data
Pin 3: transmit data
Pin 4: data terminal ready
Pin 5: signal ground
Pin 6: data set ready
Pin 7: request to send
Pin 8: clear to send
Pin 9: ring indicator
Female
1
2
3
4
5
6
7
8
9
DTE
(computer)

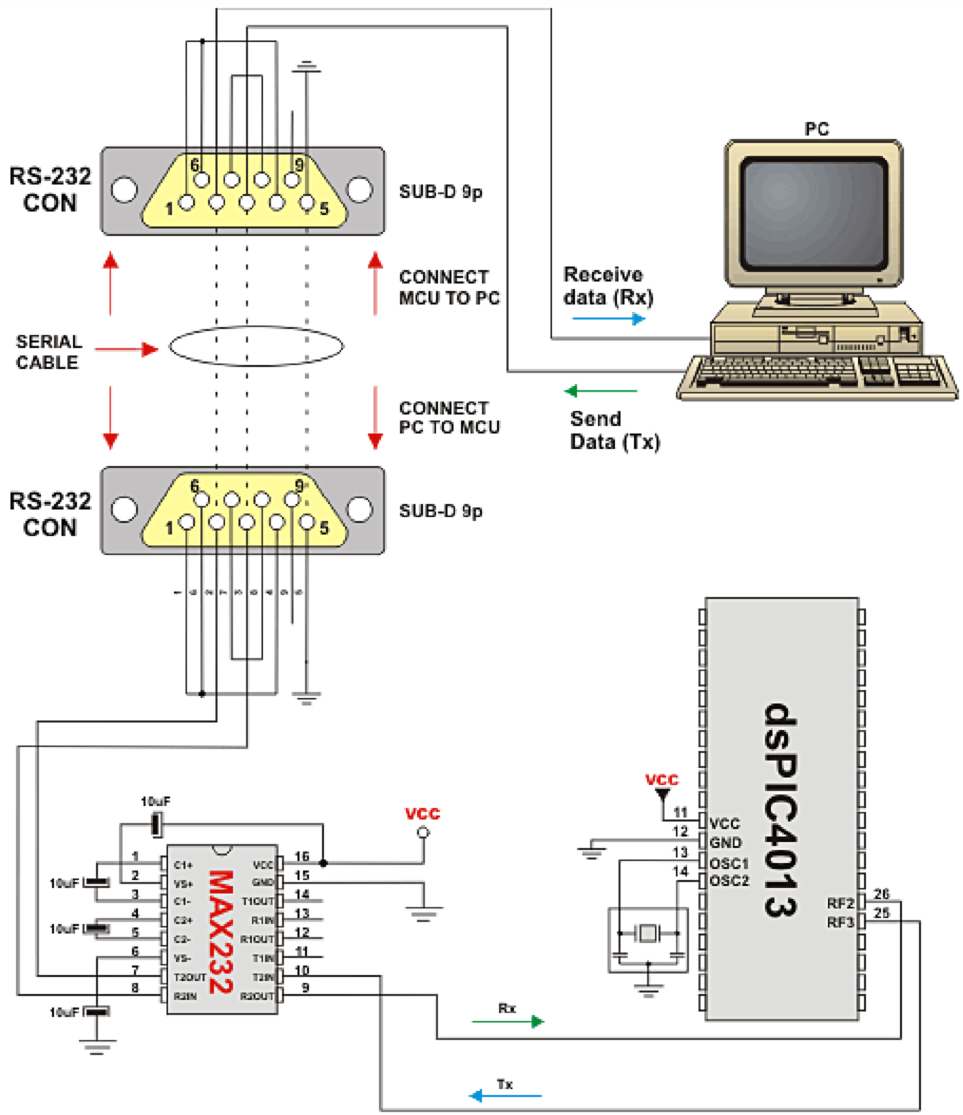
RS 232 – Shake Hands

Signal	Function	25-pin	9-pin	Direction
Tx	Transmitted Data	2	3	From DTE to DCE
Rx	Received Data	3	2	To DTE from DCE
RTS	Request To Send	4	7	From DTE to DCE
CTS	Clear To Send	5	8	To DTE from DCE
DTR	Data Terminal Ready	20	4	From DTE to DCE
DSR	Data Set Ready	6	6	To DTE from DCE
DCD	Data Carrier Detect	8	1	To DTE from DCE
RI	Ring Indicator	22	9	To DTE from DCE
FG	Frame Ground (chassis)	1	-	Common
SG	Signal Ground	7	5	Common

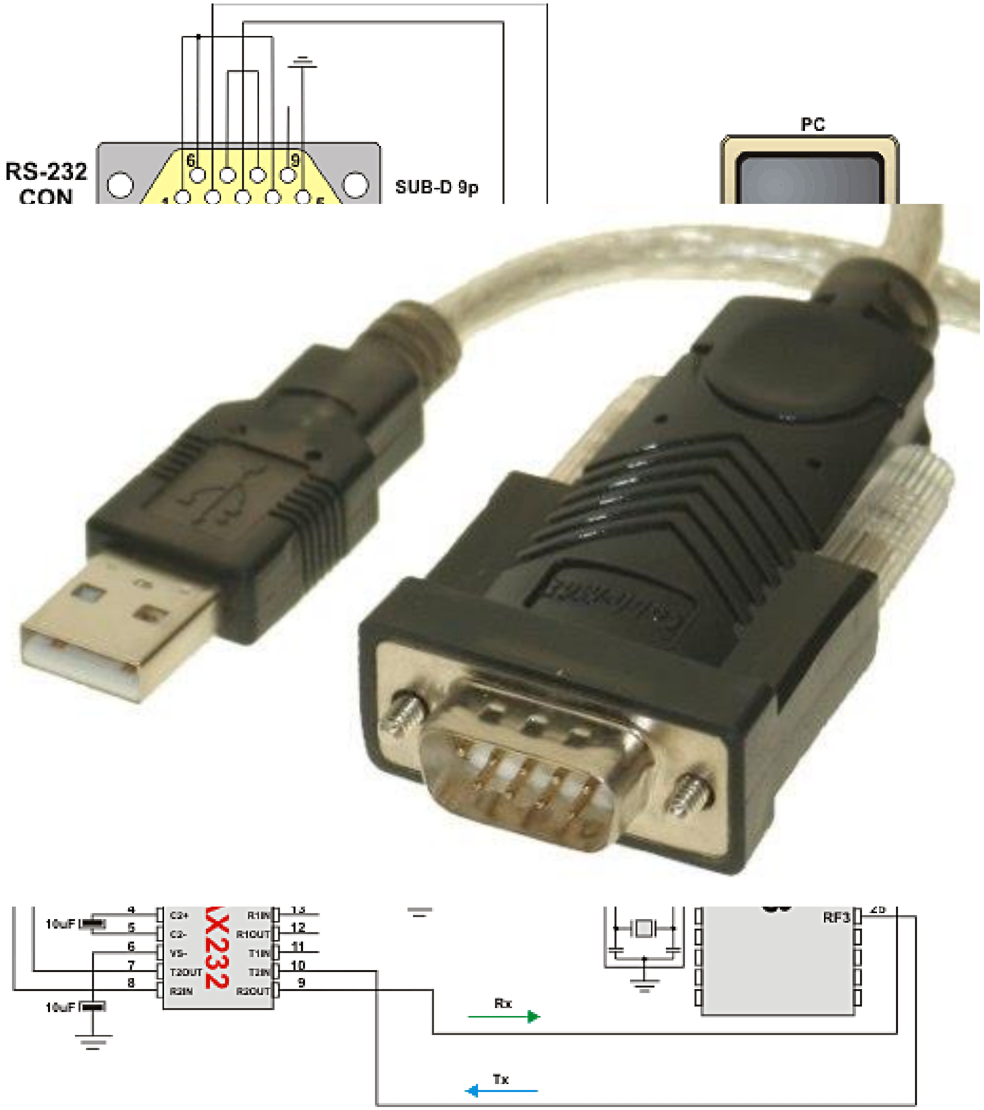
Interface RS 232



Interface RS 232

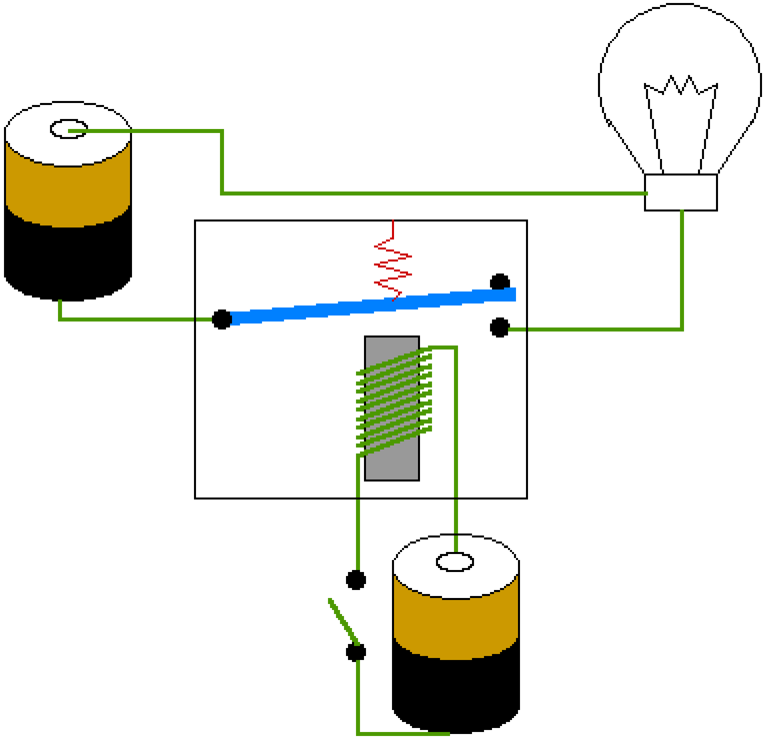


Conversor USB-Serial



Chave eletromecânica

Relé

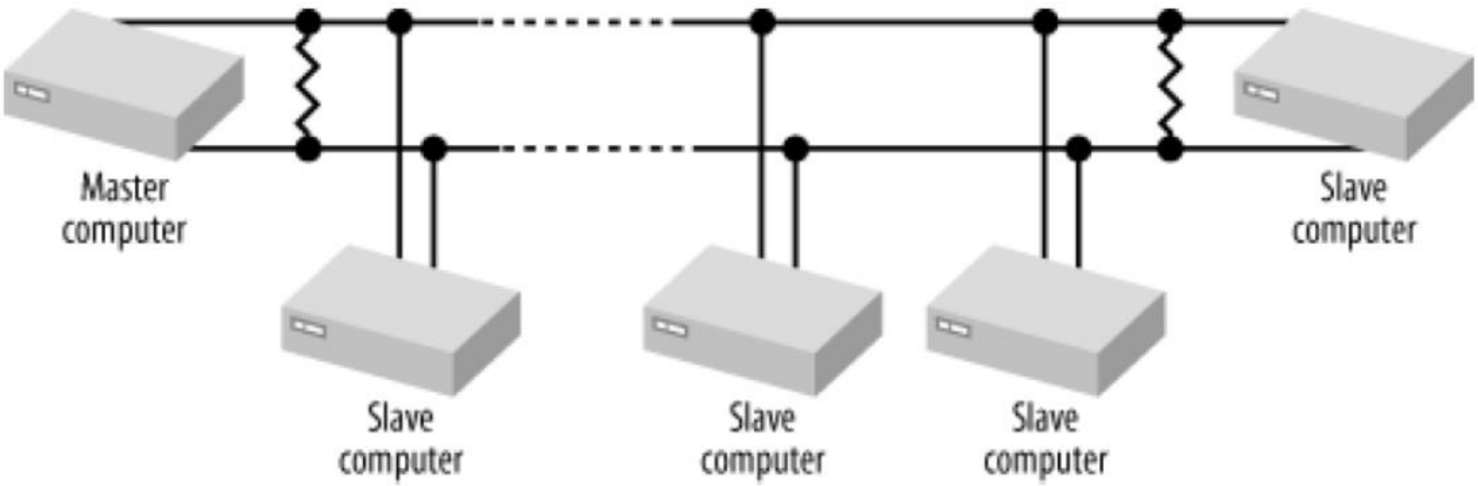


Comunicação Serial

Outras possibilidades:

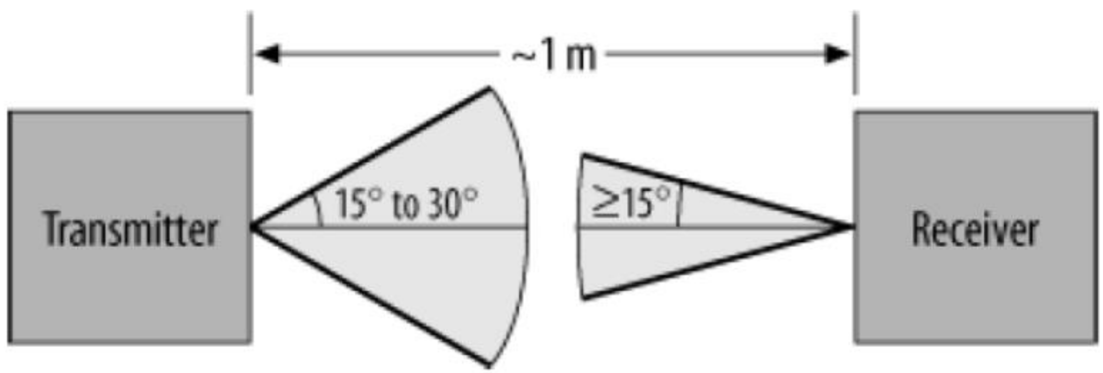
- **RS 422**
- **RS 485**
- **IrDA**
- **I^2C**
- **USB**

Rede RS 485



Master computer
Slave computer
Slave computer
Slave computer
Slave computer

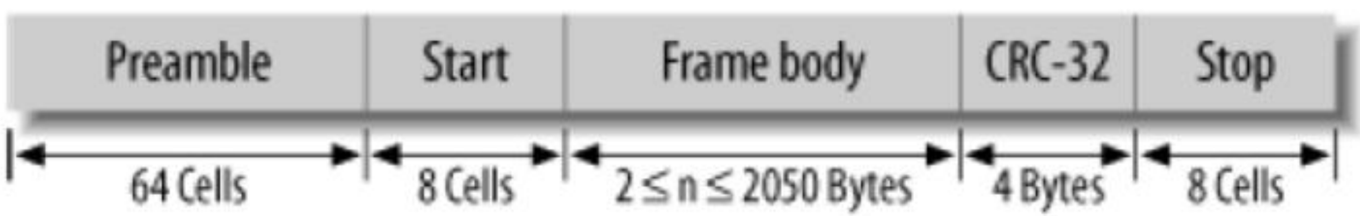
IrDA – Infrared Data Association



IrDA - PPM

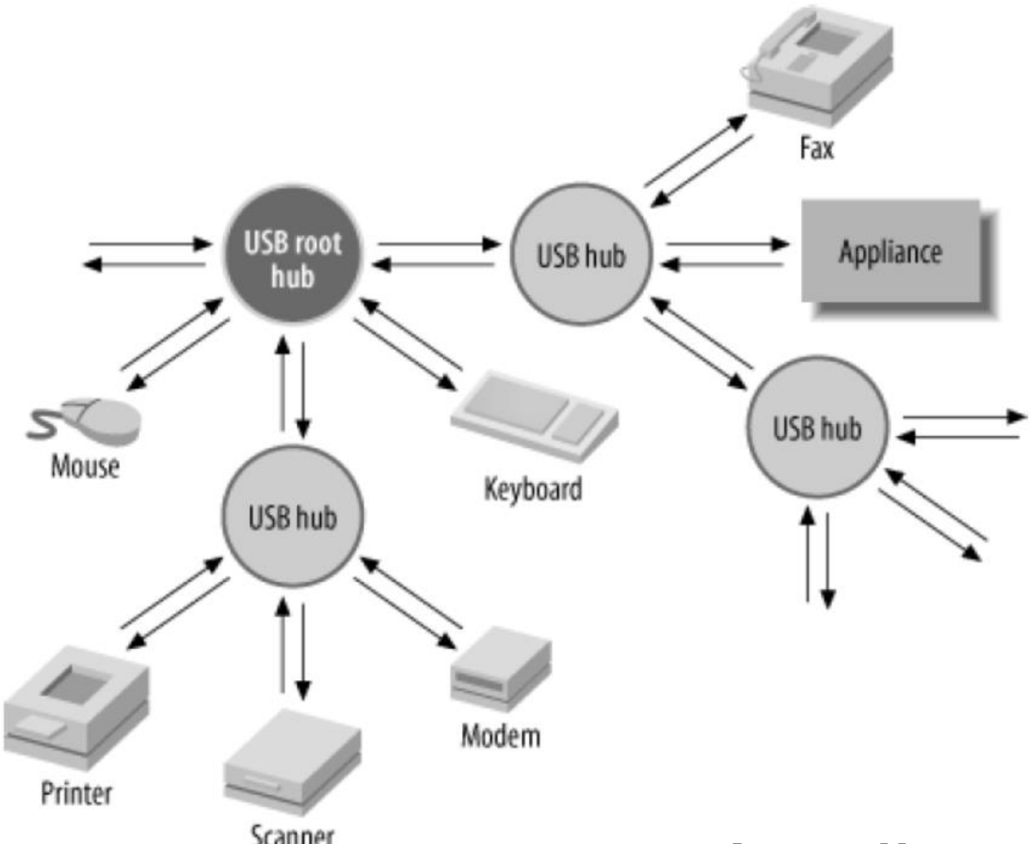
Pulse Position Modulation

Quadro – 4 Mbps



USB

Universal Serial Bus



http://www.usb.org/

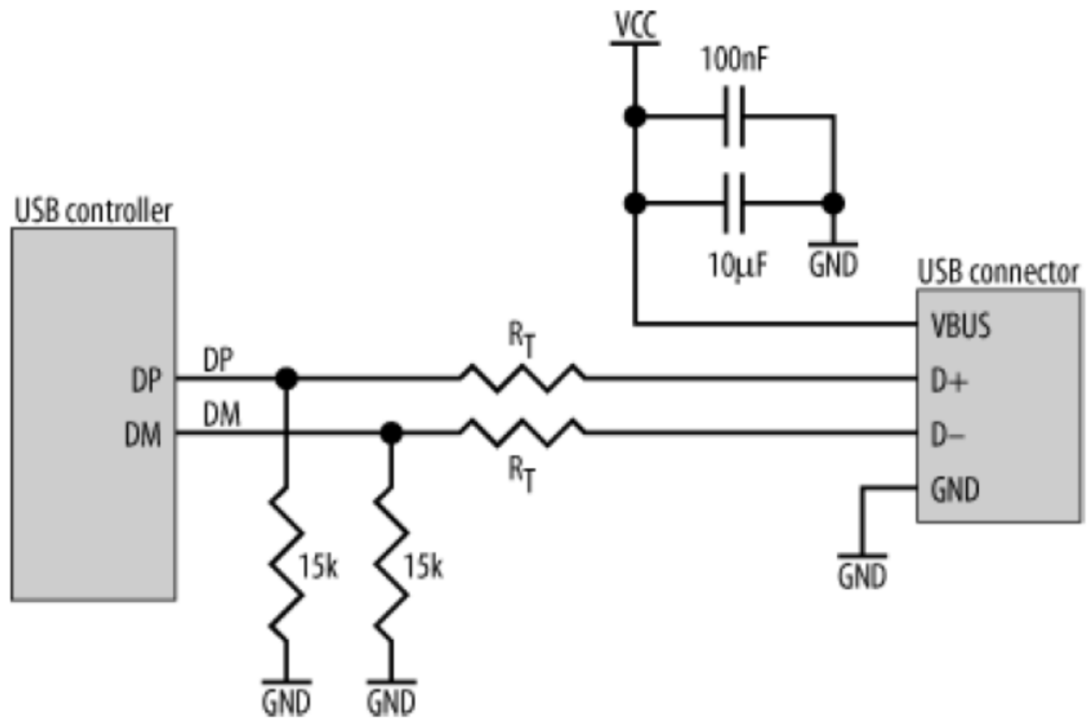
Universal Serial Bus

Versões

Nome	Lançamento	Velocidade
USB 0.8	1994	
USB 0.9	1995	
USB 1.0	1996	Low Speed (1.5 Mbit/s), Full Speed (12 Mbit/s)
USB 1.1	1998	
USB 2.0	2000	High Speed (480 Mbit/s)
USB 3.0	2008	SuperSpeed (5 Gbit/s)
USB 3.1	2013	SuperSpeed+ (10 Gbit/s) [20]

USB

Conexão

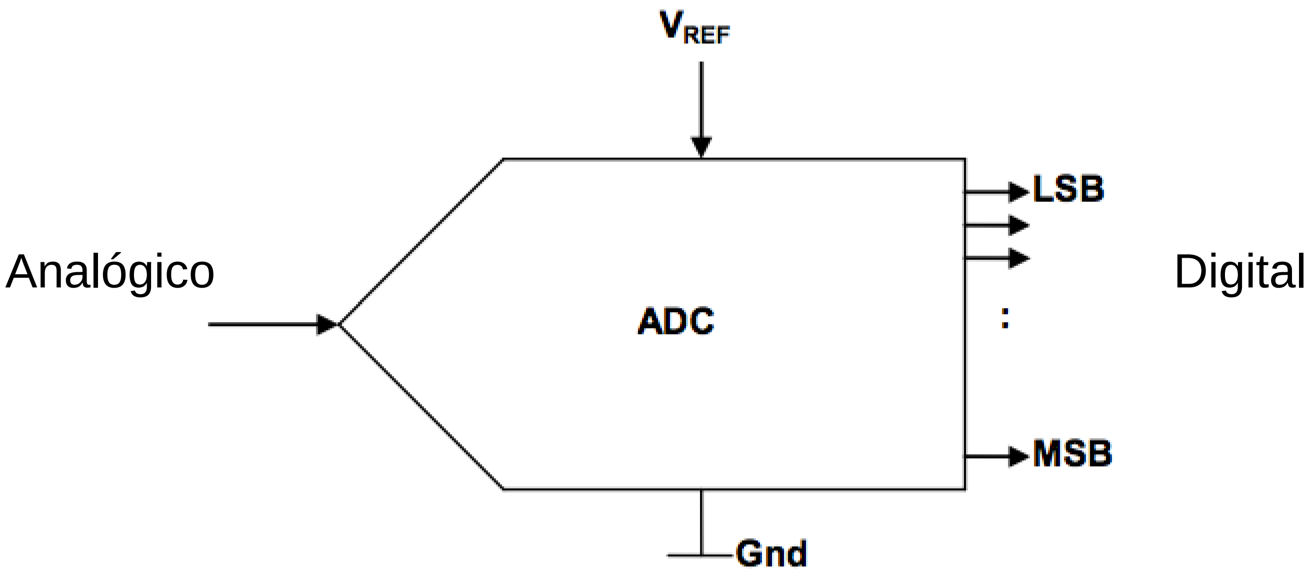


VCC
100nF
10µF
GND
USB controller
DP
DM
DP
DM
R_T
R_T
15k
15k
GND
GND
USB connector
VBUS
D+
D−
GND
GND

Interface Analógica

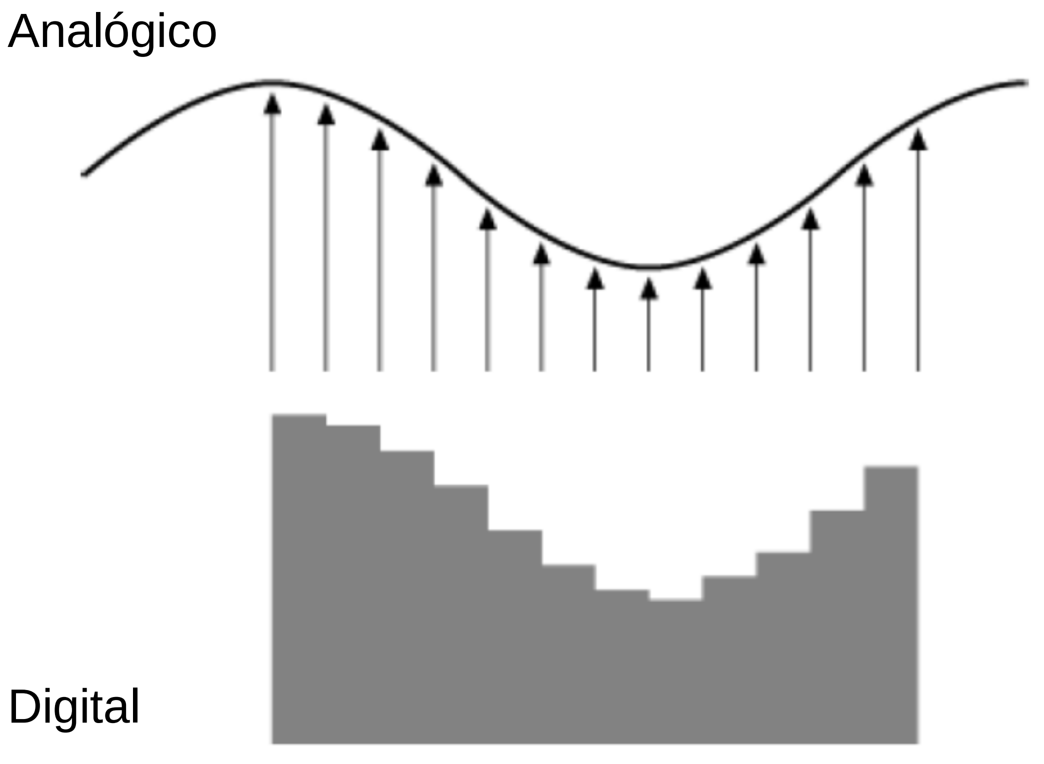
Interface Analógica

ADC – Analog to Digital Converter



Interface Analógica

ADC – Analog to Digital Converter



Tipos de ADC

- Flash ADC
- Rampa
- Aproximações sucessivas
- Delta-Sigma ADC
- Etc.

Tipos de ADC

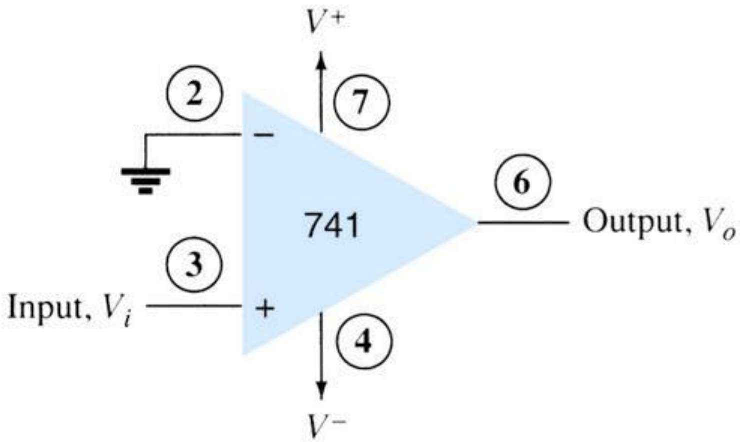
- Flash ADC
- Rampa
- Aproximações sucessivas
- Delta-Sigma ADC
- Etc.

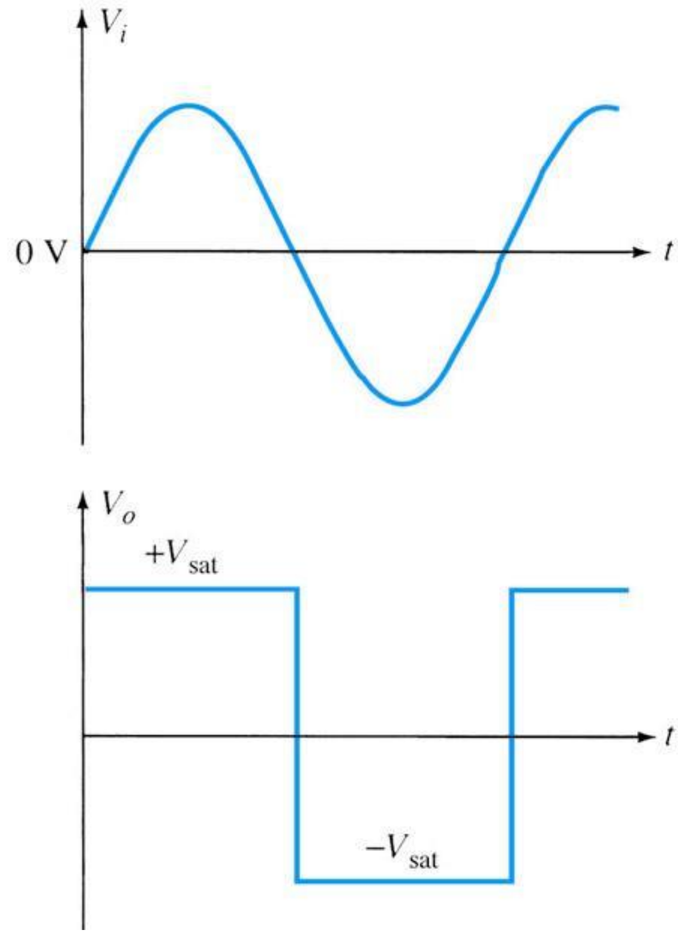
Parâmetros:

- Velocidade
- Precisão
    - SNR – relação sinal ruído

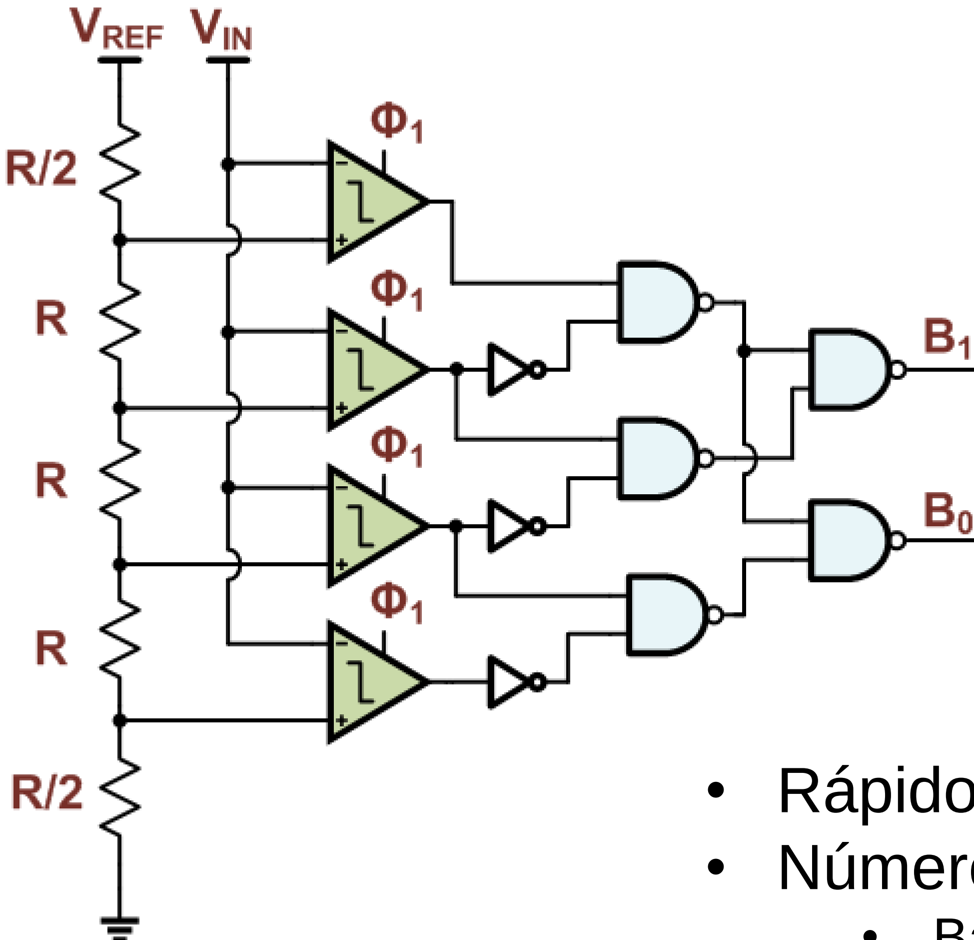
Ex.: *1-bit* ADC

Comparador



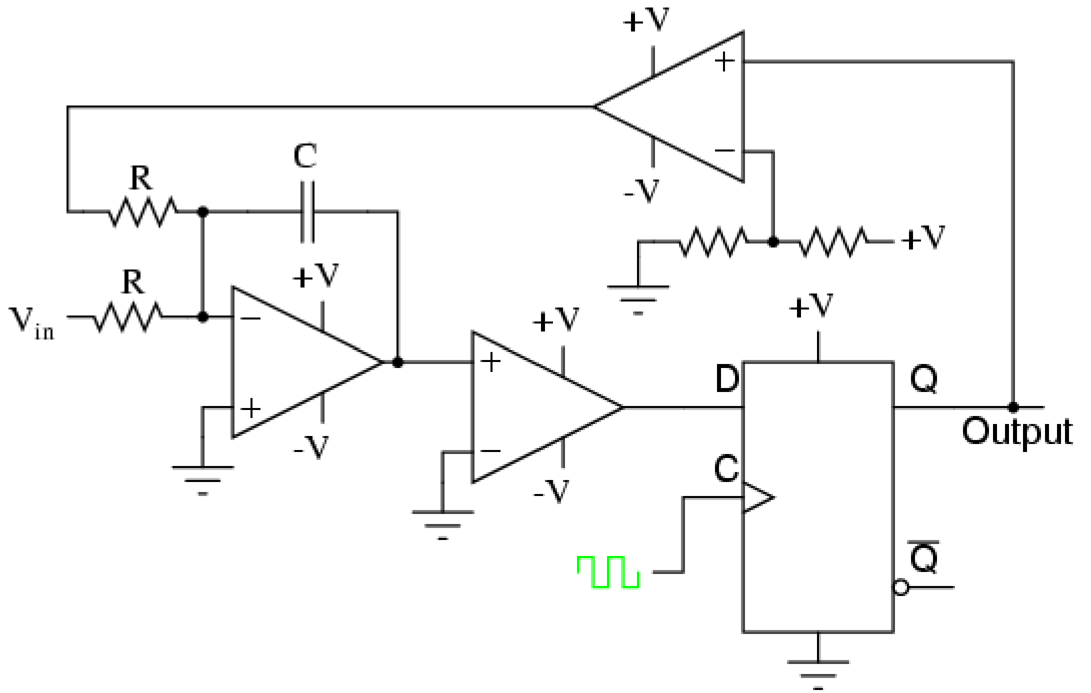


Ex.: *Flash* ADC



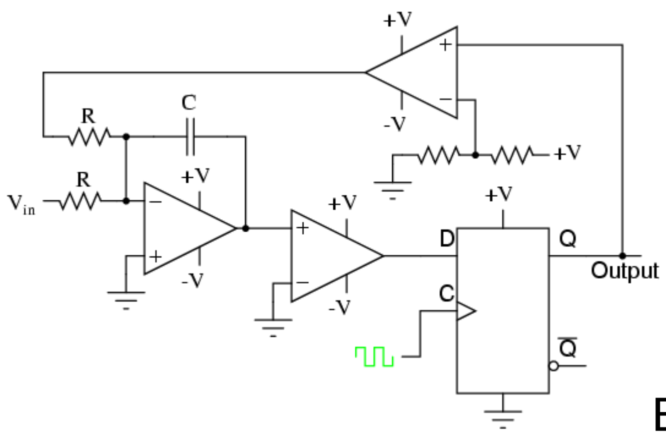
- Rápidos
- Número de bits limitado
  - Baixa precisão
  - Nr. de comparadores α $2^N - 1$

Ex.: ∑-∆ ADC

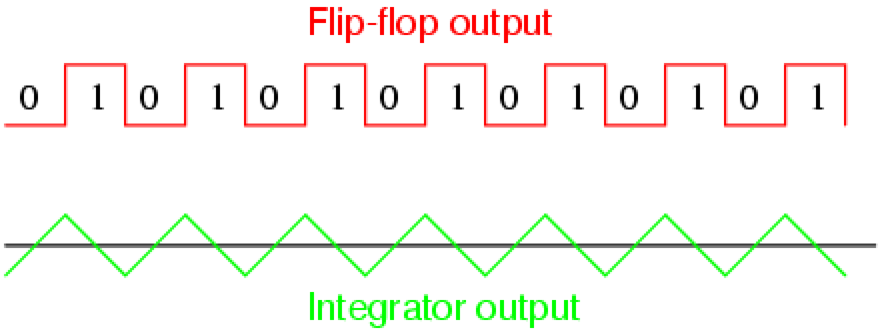


- Lentos
- Maior precisão

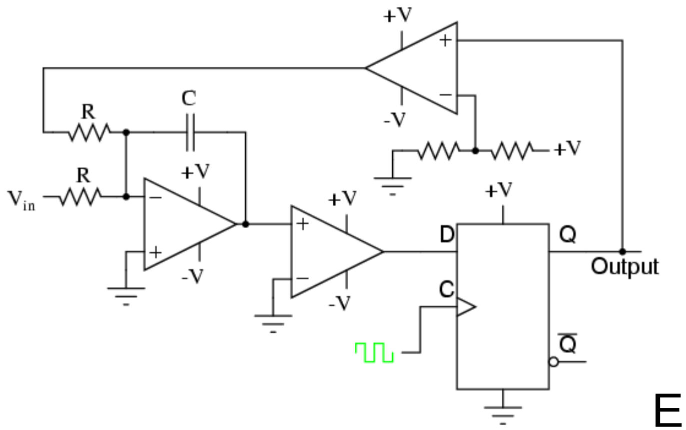
Ex.: ∑-∆ ADC



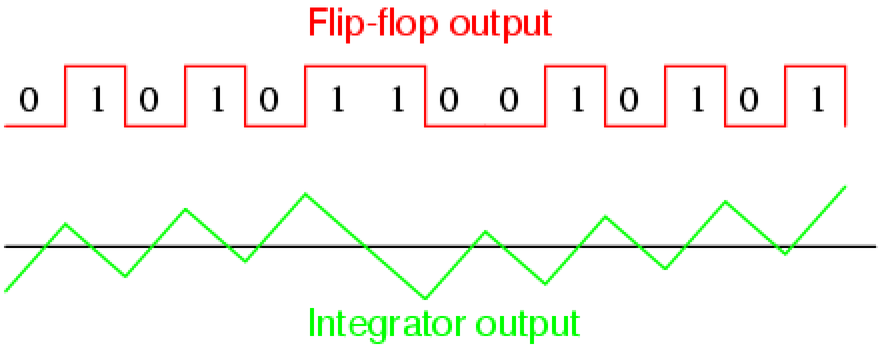
Entrada analógica *nula*



Ex.: ∑-∆ ADC

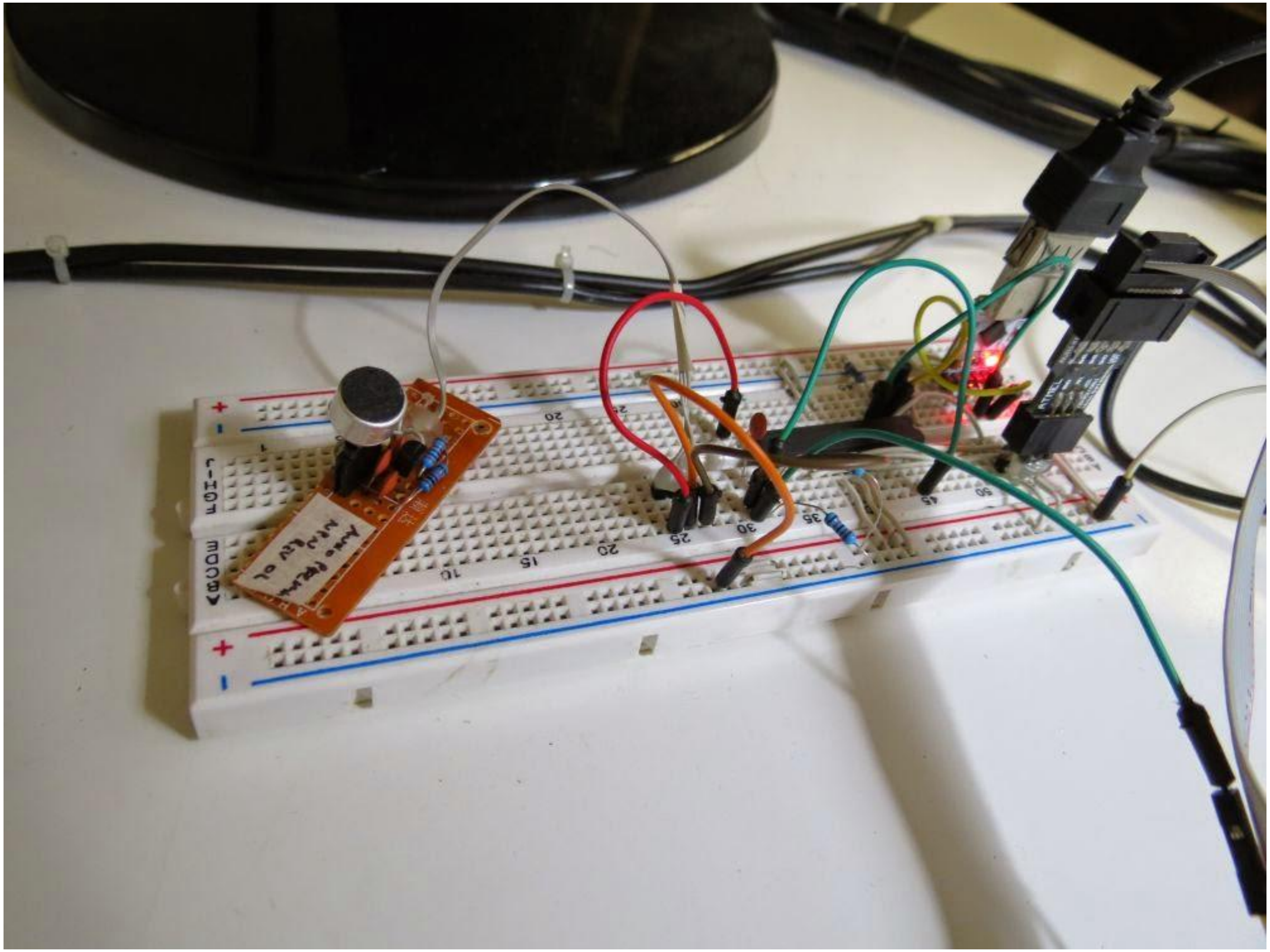


Entrada analógica *negativa*



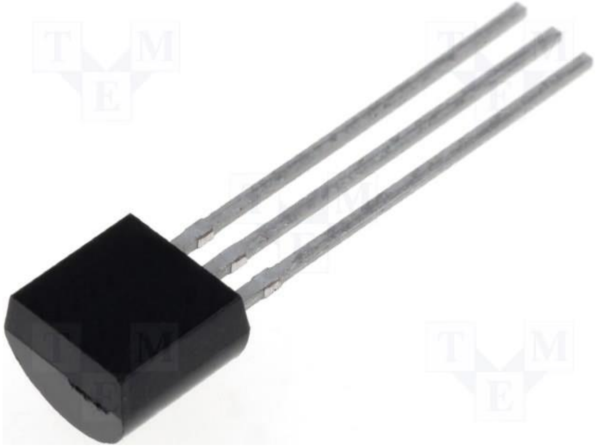
http://www.allaboutcircuits.com/textbook/digital/chpt-13/delta-sigma-adc/

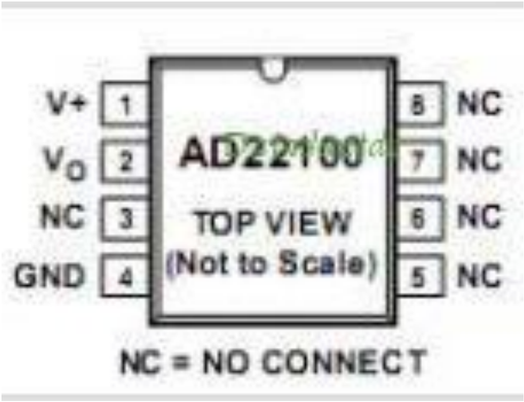
Conexão com ADC

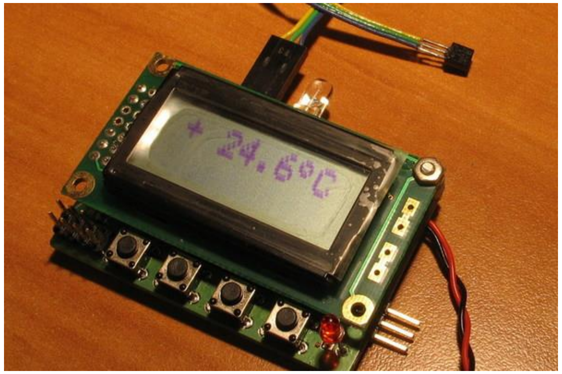


Ex.: Sensor de temperatura

AD 22100



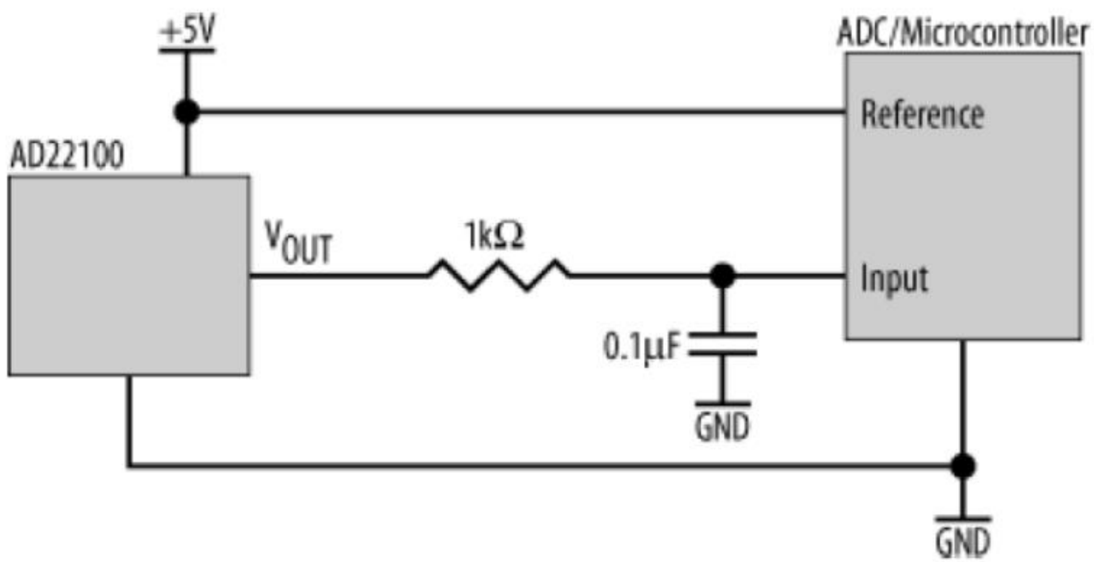




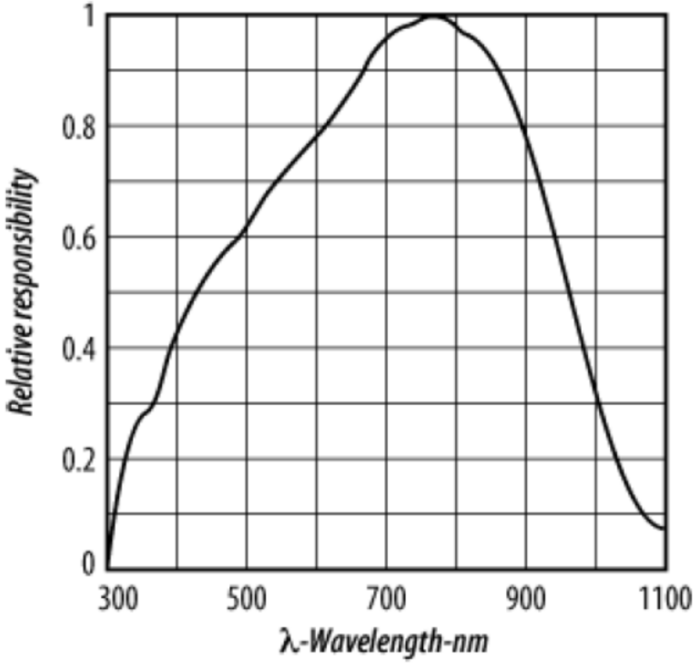
Ex.: Sensor de temperatura

$$V_{OUT} = (V_S / 5) \times [1.375 + (0.0225 \times T_A)]$$

$$T_A = (((V_{OUT} \times 5) / V_S) - 1.375) / 0.0225$$

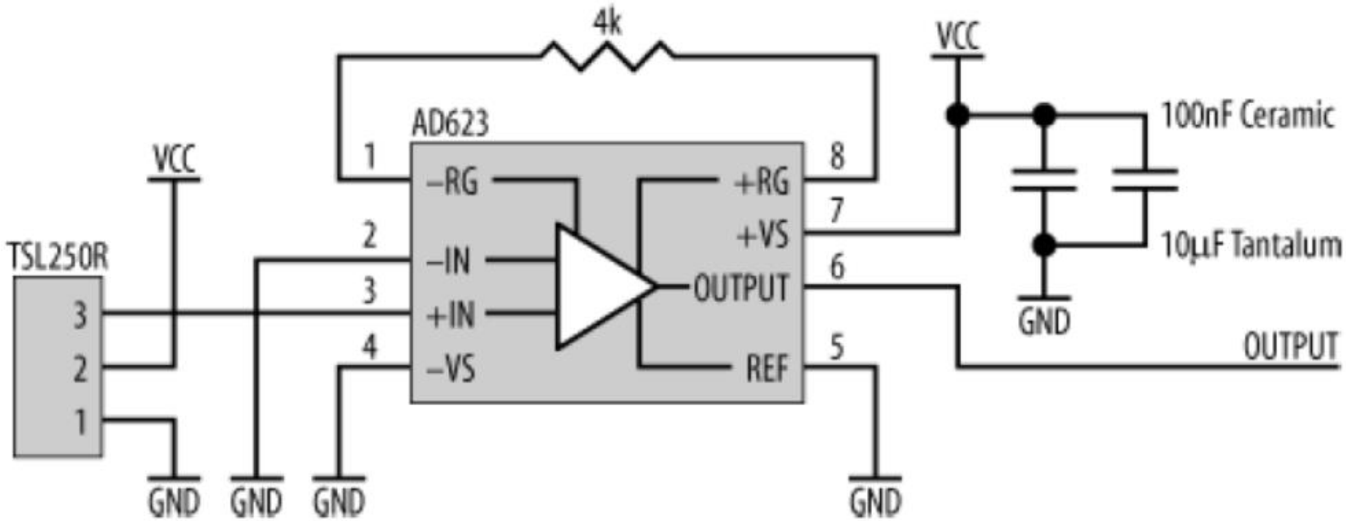


Ex.: Sensor óptico

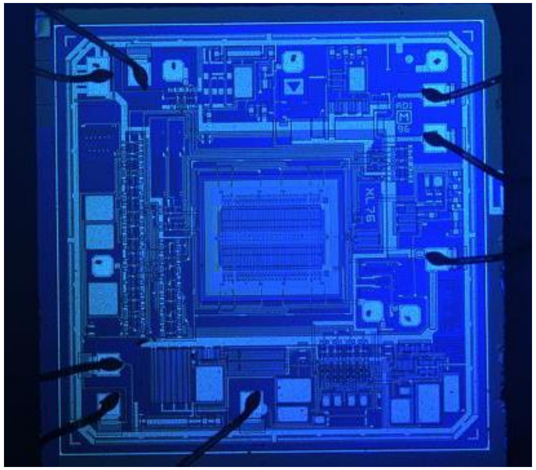


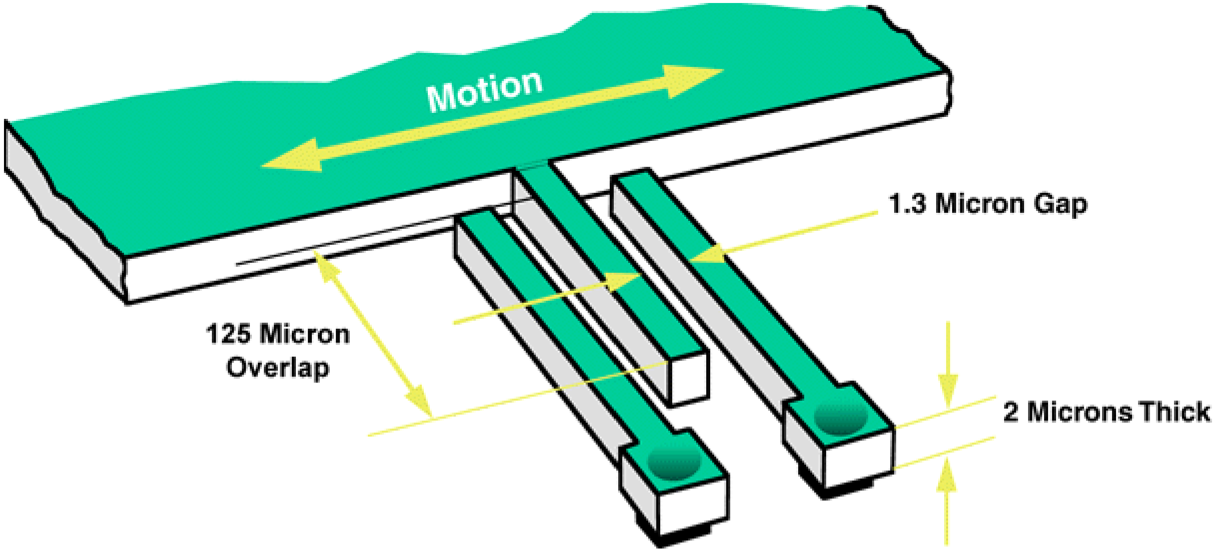
Ex.: Sensor óptico

Amplificação



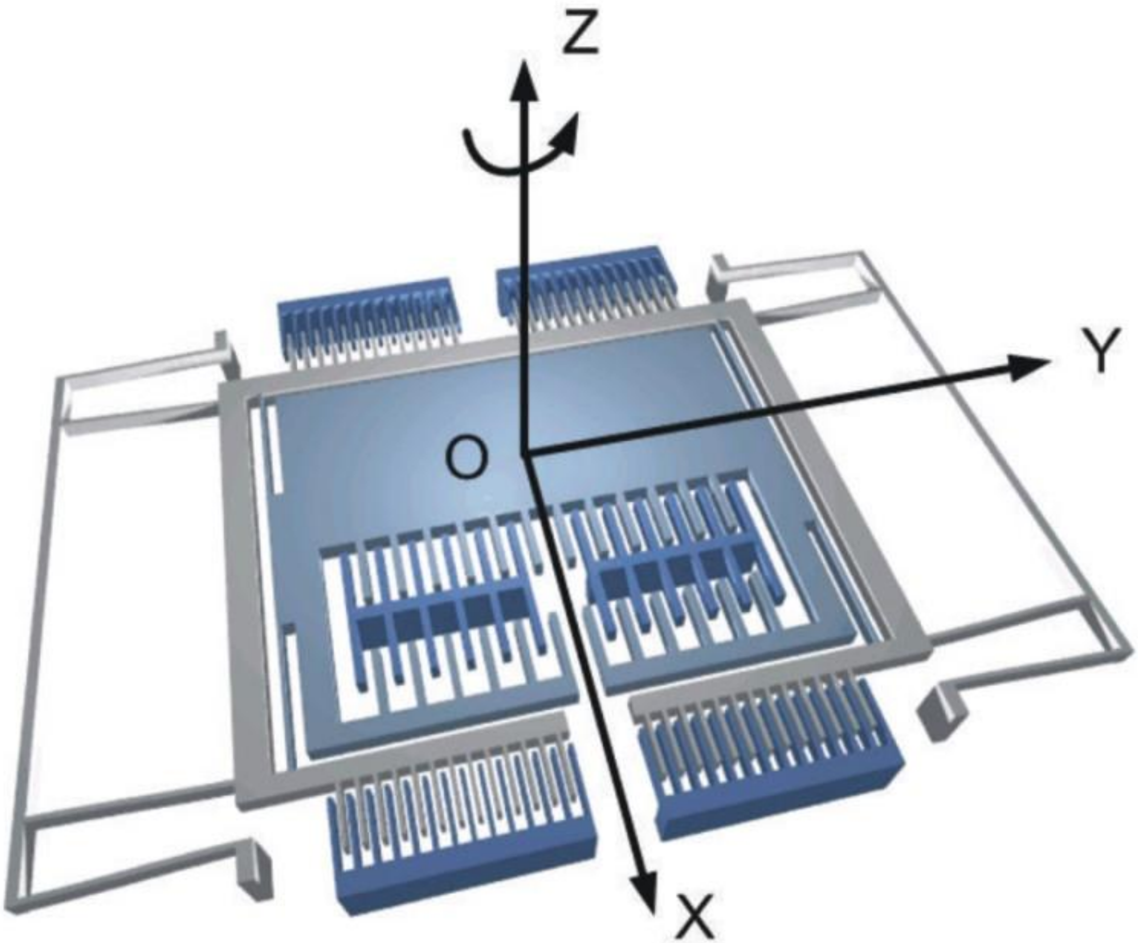
Ex.: Acelerômetro



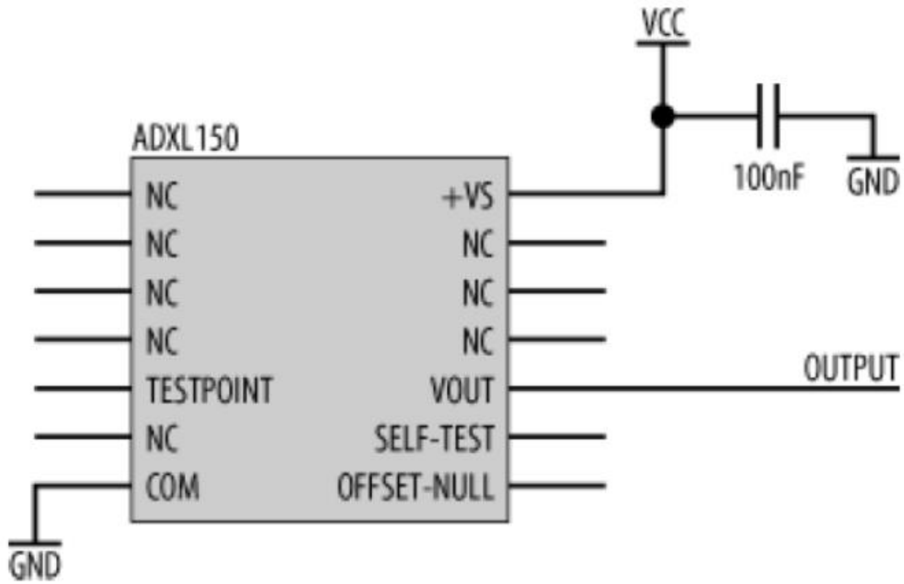


Ex.: Acelerômetro

3D



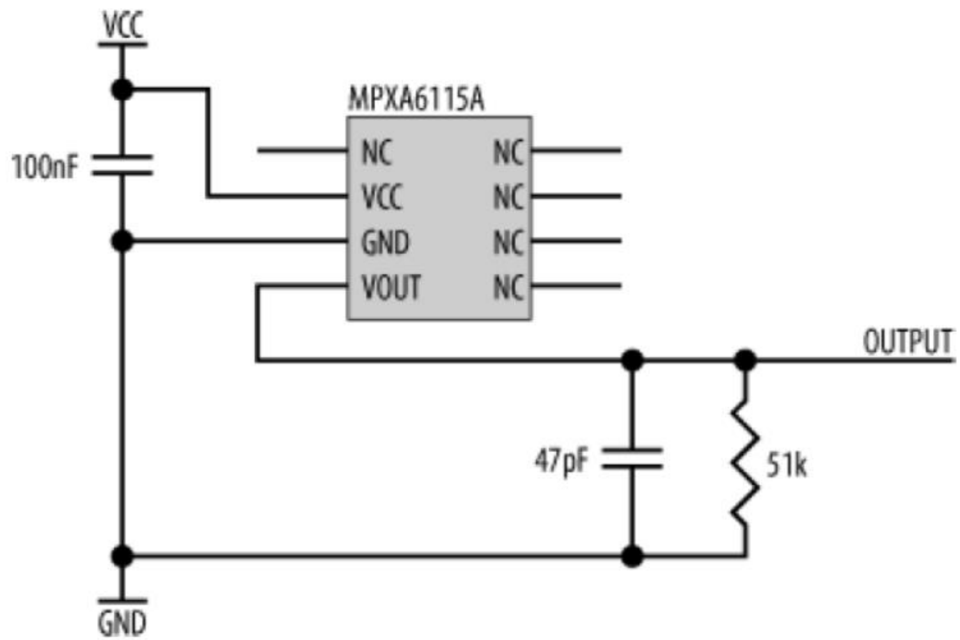
Ex.: Acelerômetro ADXL 150



$V_{OUT} = V_S/2 - (\text{sensitivity} * V_S/5 * \text{acceleration})$

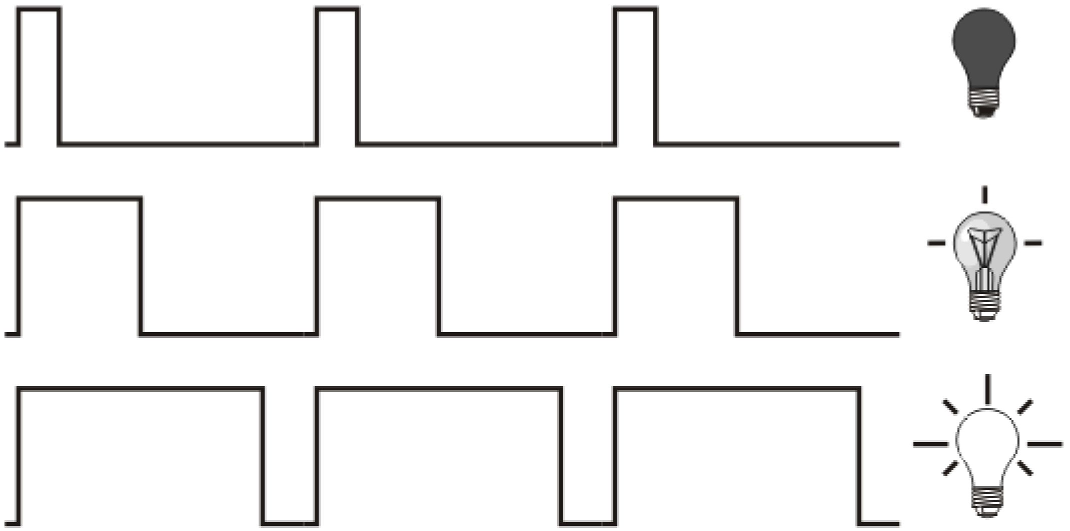
~38

Ex.: Sensor de pressão



Ex.: Sensor de pressão

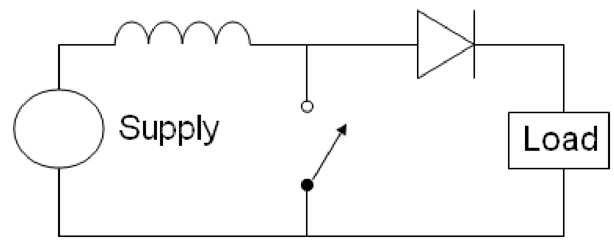
PWM



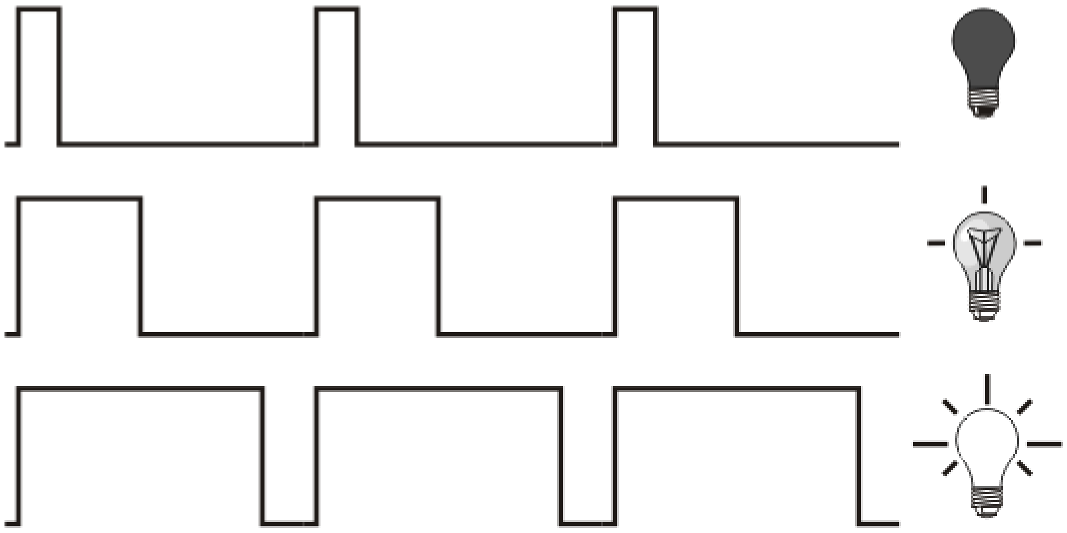
Pulse Width Modulation

Pulse Width Modulation (PWM) is a method of digitally encoding analog signal levels. High-resolution digital counters are used to generate a square wave of a given frequency, and the duty cycle of that square wave is modulated to encode the analog signal.

Typical applications for PWM are switching power supplies, motor control, servo positioning and lighting control.



Pulse Width Modulation



Série de Fourier

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} \left(a_n cos \frac{n\pi x}{L} + b_n sin \frac{n\pi x}{L} \right)$$

Nível DC

$$a_0 = \frac{1}{T} \int_{-T/2}^{T/2} x(t)\, dt$$

Pulse Width Modulation

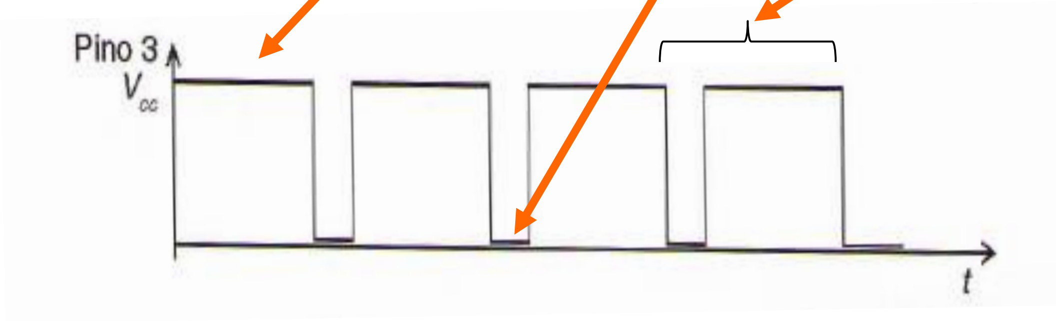
Duty Cycle

PWM - 555

$$T_{alto} = 0.693(R_1 + R_2)C$$

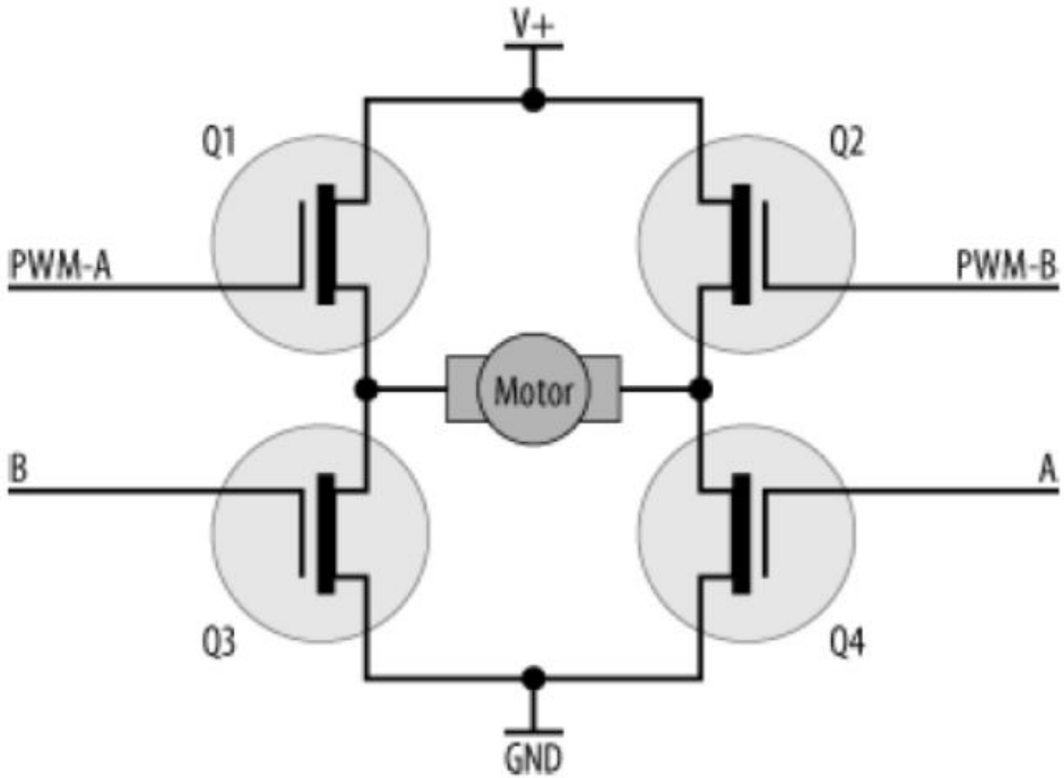
$$T_{baixo} = 0.693R_2C$$

$$T_{total} = 0.693(R_1 + 2R_2)C$$



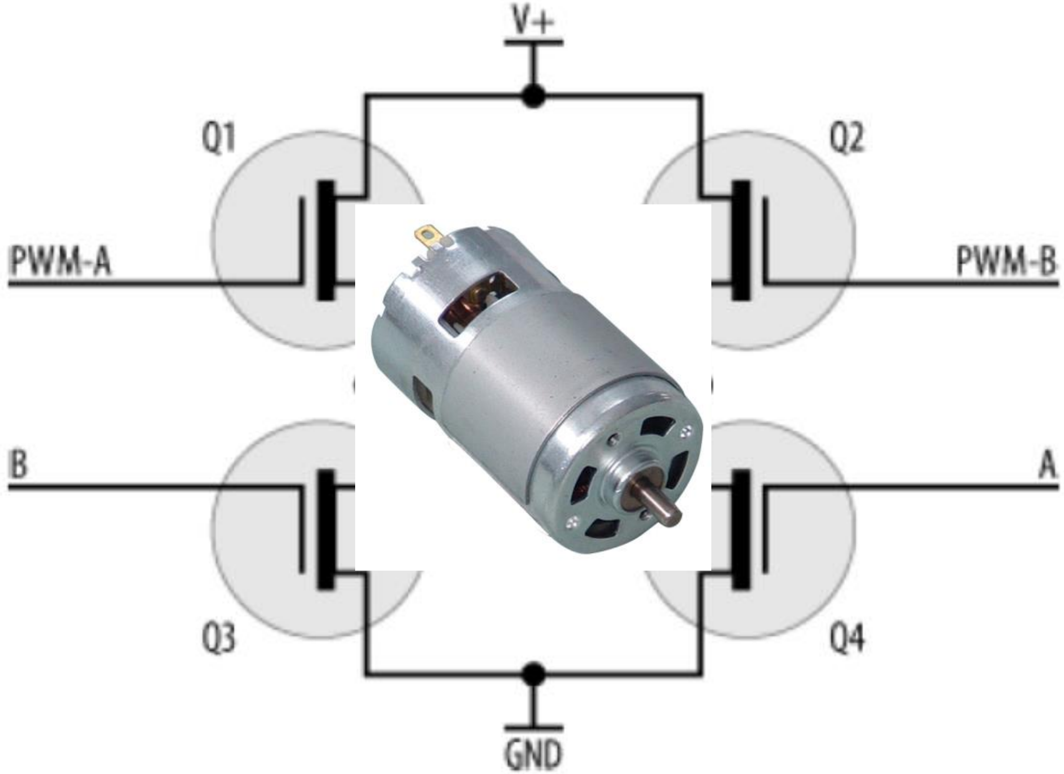
Ex.: Controle de Motor DC

Ponte H

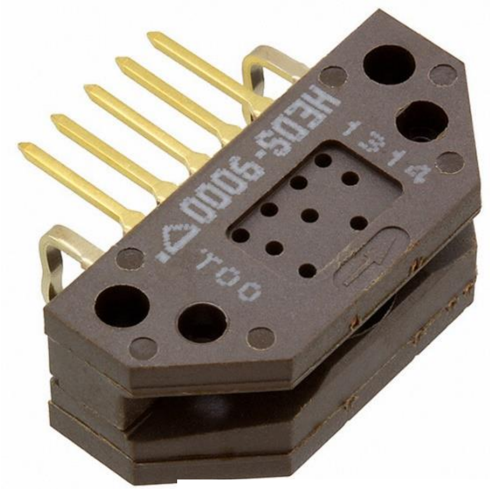


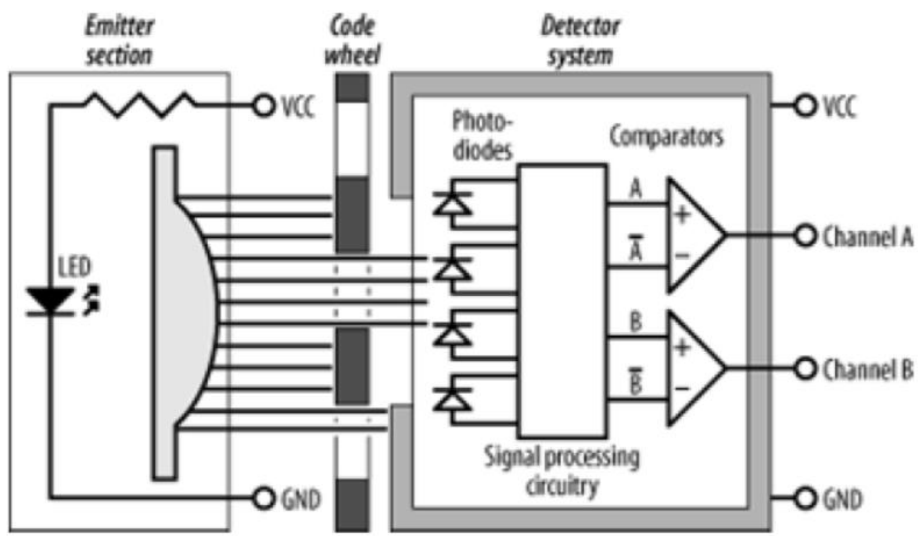
Ex.: Controle de Motor DC

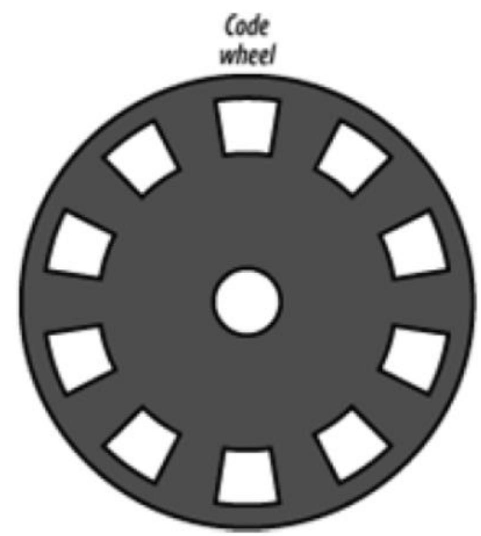
Ponte H



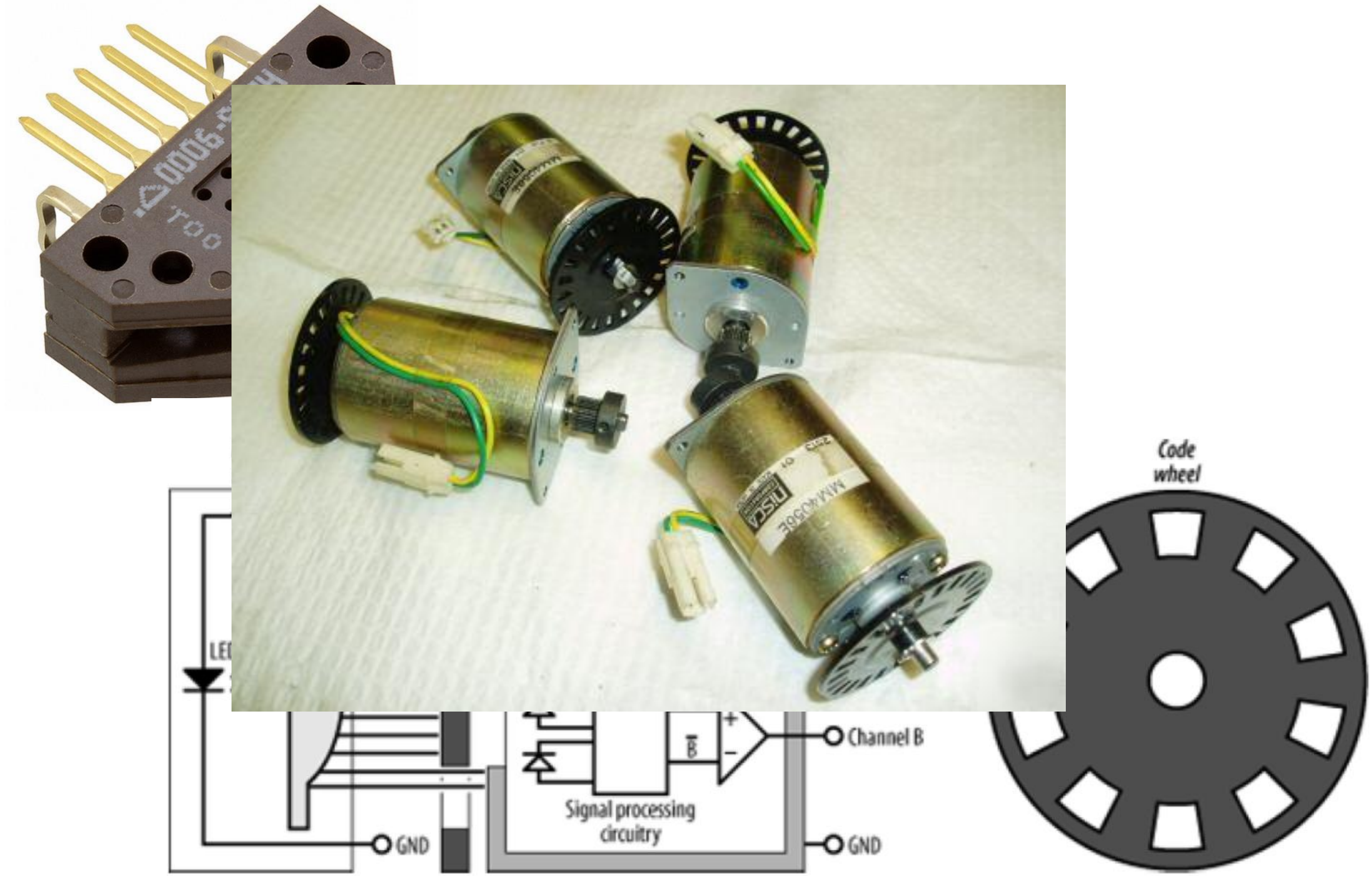
Motor – Leitura de velocidade



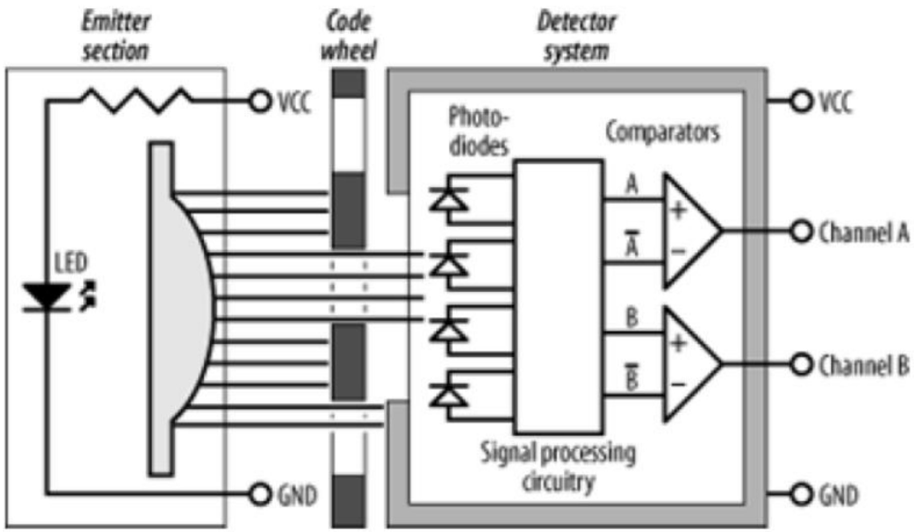


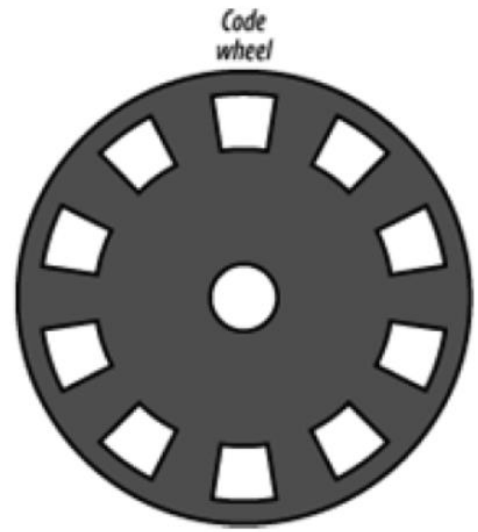


Motor – Leitura de velocidade



Motor – Leitura de velocidade





Sentido da rotação: