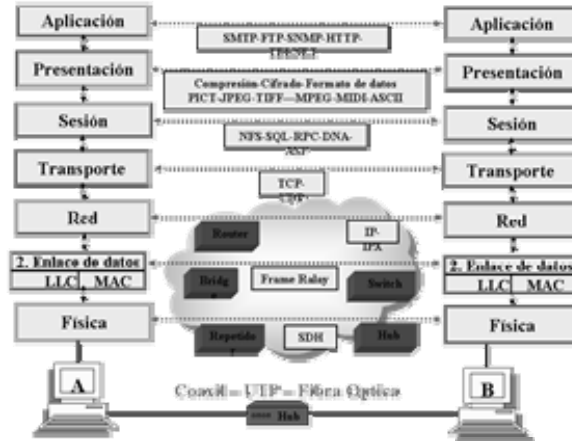


Modelo ISO OSI

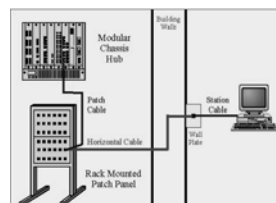
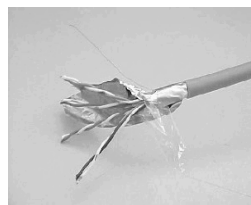
Bases del Modelo OSI



TDII - Conexión serie con el mundo.

1

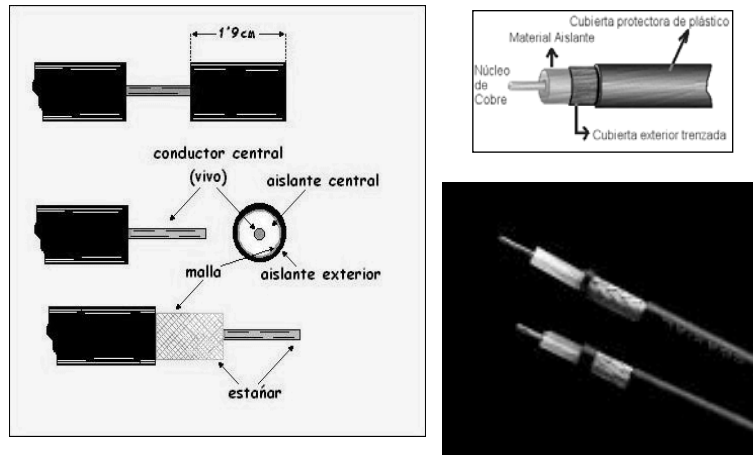
Vínculo Físico



TDII - Conexión serie con el mundo.

2

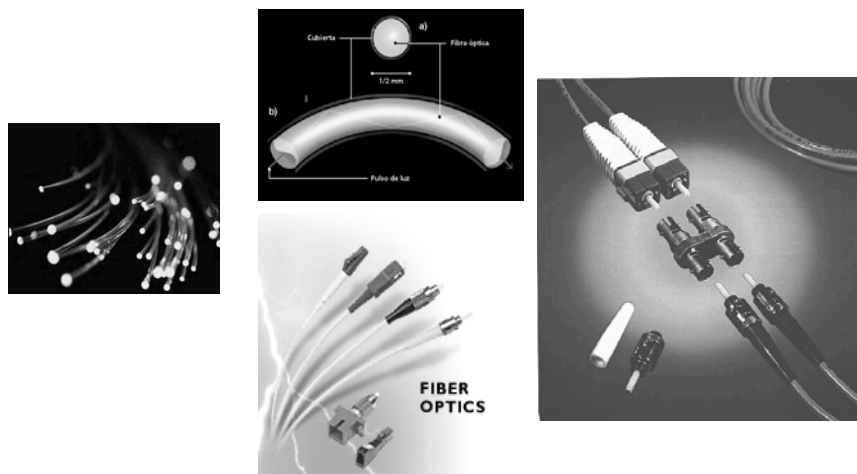
Vínculo Físico



TDII - Conexión serie con el mundo.

3

Vínculo Físico



TDII - Conexión serie con el mundo.

4

Clasificaciones

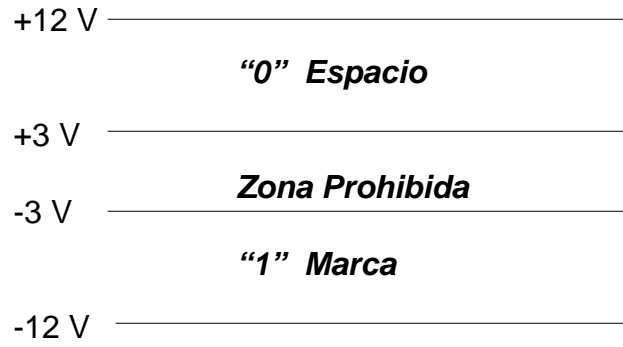
Comunicación Serie → •Asincrónica
•Sincrónica

Comunicación Serie → •Single ended
•Diferencial

Contenido

- Lazo de corriente de 20 mA
- RS232
- RS422
- RS423
- RS485
- I2C
- SPI
- CAN

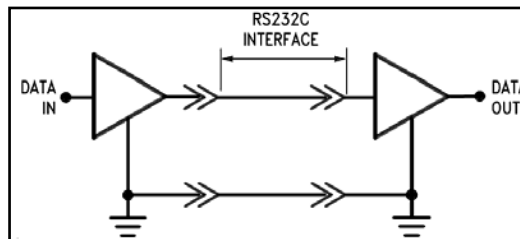
RS232



TDII - Conexión serie con el mundo.

7

RS232 - Drivers

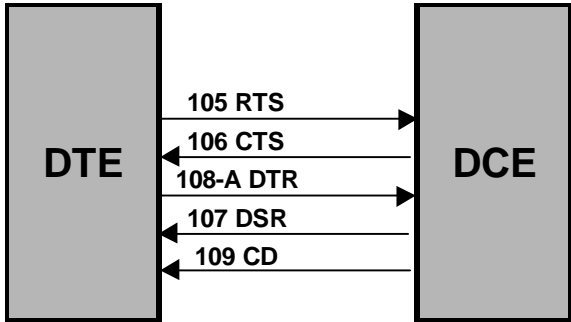


Pendiente de crecimiento $< 30 \text{ V}/\mu\text{s}$

TDII - Conexión serie con el mundo.

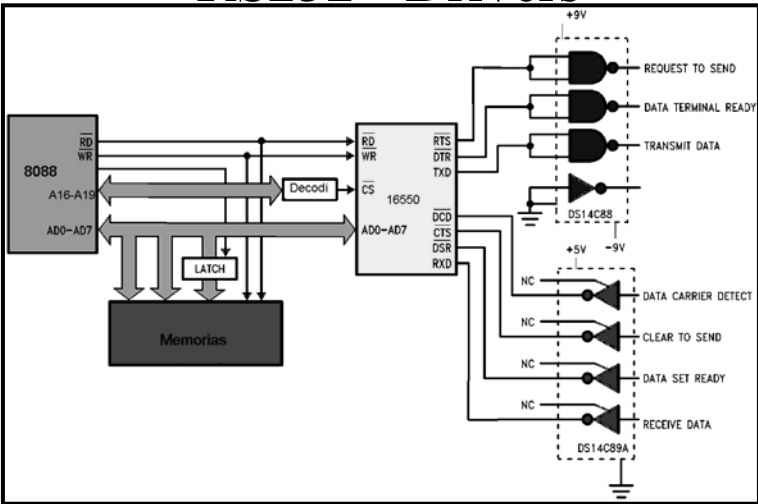
8

Protocolo RS232



TDII - Conexión serie con el mundo.

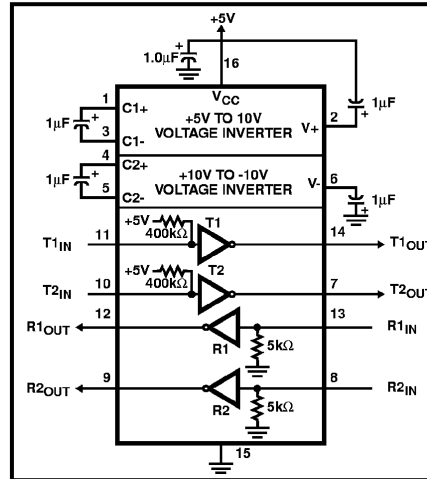
RS232 - Drivers



1488
y
1489

TDII - Conexión serie con el mundo.

RS232 - Drivers

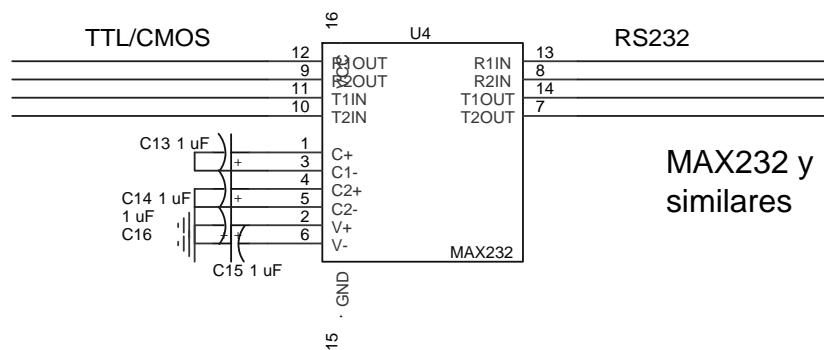


MAX232 y similares

TDII - Conexión serie con el mundo.

11

RS232 - Drivers

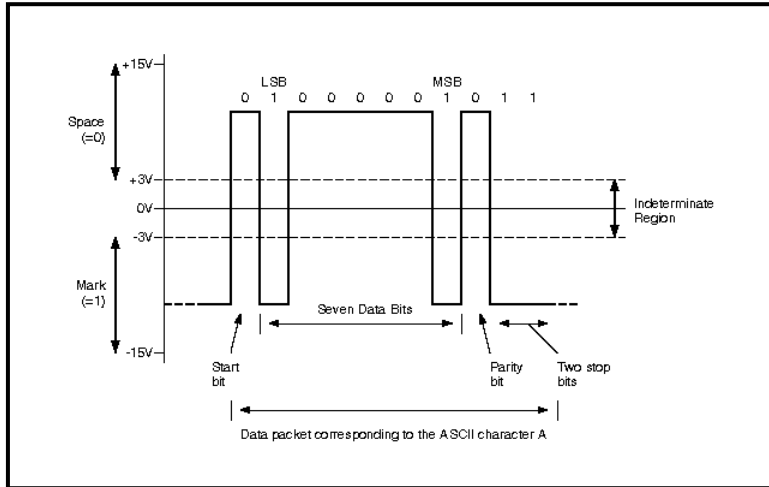


MAX232 y similares

TDII - Conexión serie con el mundo.

12

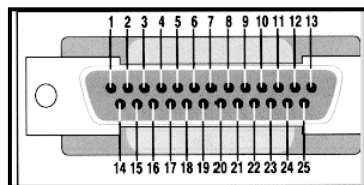
Señal en RS232



TDII - Conexión serie con el mundo.

13

Conector DB25

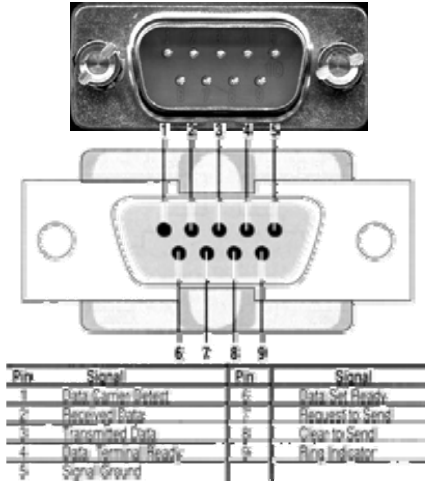


| Pin | Description | EIA CKT | From DCE | To DCE |
|-----|------------------------------------|------------|-------------|-------------|
| 1 | Frame Ground | AA | | |
| 2 | Transmitted Data | BA | | D (Data) |
| 3 | Received Data | BB | D | |
| 4 | Request to Send | CA | | G (Control) |
| 5 | Clear to Send | CB | C | |
| 6 | Data Set Ready | CC | C | |
| 7 | Signal Gnd Common Return | AB | | |
| 8 | Rcvd. Line Signal Detector | CF | C | |
| 11 | Undefined | | | |
| 12 | Secondary Rcvd. Line Sig. Detector | SCF | C | |
| 13 | Secondary Clear to Send | SCB | C | |
| 14 | Secondary Transmitted Data | SBA | | D |
| 15 | Transmitter Sig. Element Timing | DB | T (Timing) | |
| 16 | Secondary Received Data | SBB | D | |
| 17 | Receiver Sig. Element Timing | DD | T | |
| 18 | Undefined | | | |
| 19 | Secondary Request to Send | SCA | | C |
| 20 | Data Terminal Ready | CD | | C |
| 21 | Sig. Quality Detector | CG | | C |
| 22 | Ring Indicator | CE | C | |
| 23 | Data Sig. Rate Selector (DCE) | CI | C | |
| 23 | Data Sig. Rate Selector (DTE) | CH | | C |
| 24 | Transmitter Sig. Element Timing | DA | | T |
| 25 | Undefined | | | |

TDII - Conexión serie con el mundo.

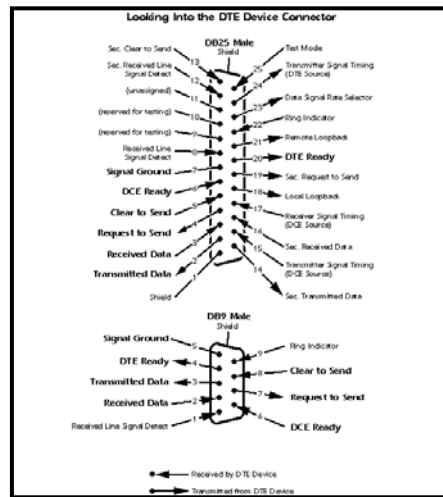
14

Conector DB9



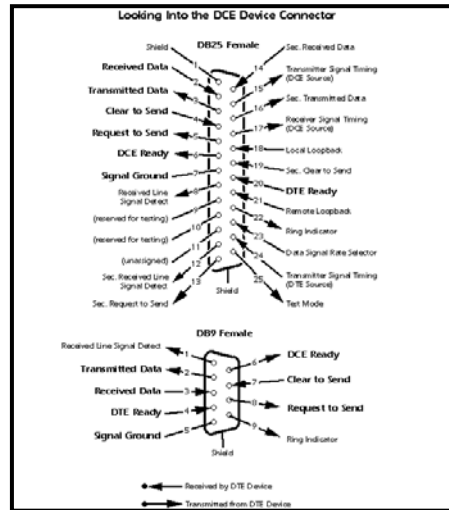
TDII - Conexión serie con el mundo.

Resumen DTE



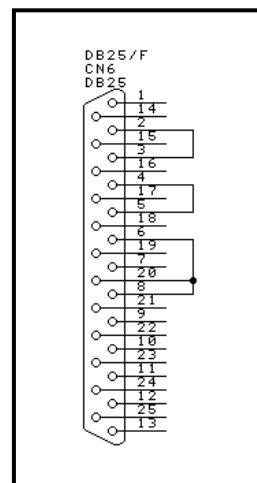
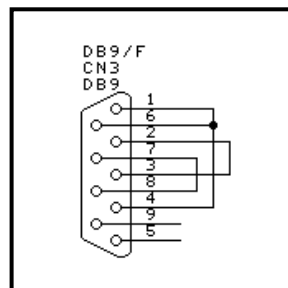
TDII - Conexión serie con el mundo.

Resumen DCE



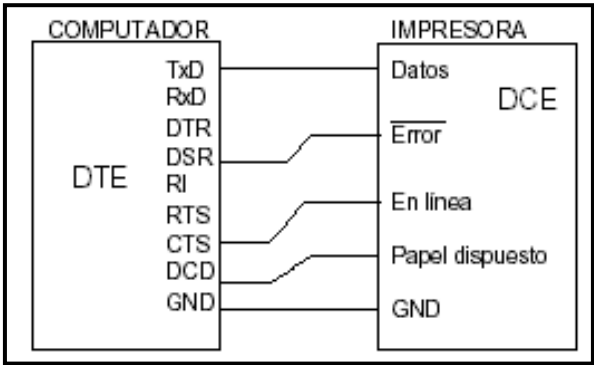
TDII - Conexión serie con el mundo.

Conector de prueba (Loopback)



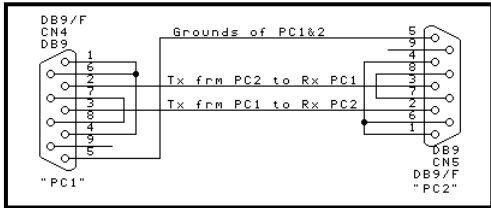
TDII - Conexión serie con el mundo.

Control de flujo

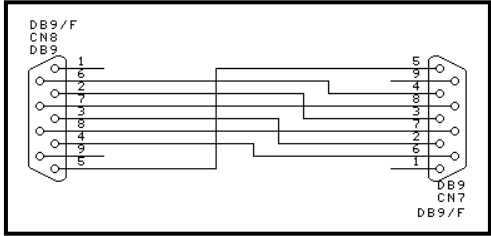


TDII - Conexión serie con el mundo.

Conexión de 2 PCs



Sin Handshake



Con Handshake

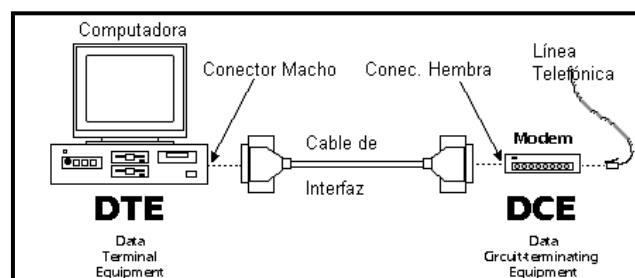
TDII - Conexión serie con el mundo.

Glosario

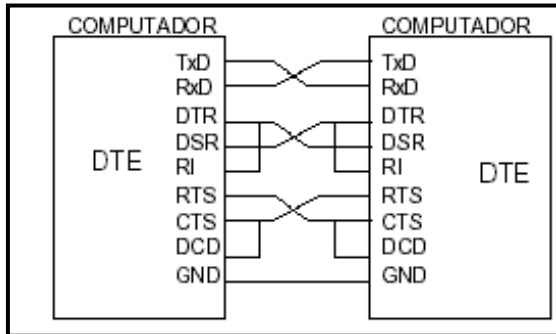
- DCE = Data Communications Equipment P.ej. modem
- DTE = Data Terminal Equipment P.ej. Computadora, impresora
- RTS = Request To Send [DTE --> DCE] (Control)
- CTS = Clear To Send [DCE --> DTE] (Control)
- DCD = Data Carrier Detected (Tono del modem) [DCE --> DTE]
- DSR = Data Set Ready [DCE --> DTE] (Modem listo)
- DTR = Data Terminal Ready [DTE --> DCE]

Teniendo solamente un multímetro, ¿Cómo puedo saber si un equipo es DCE ó DTE?

Glosario

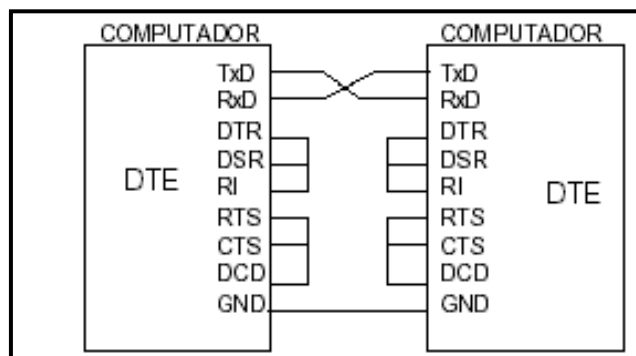


Null Modem

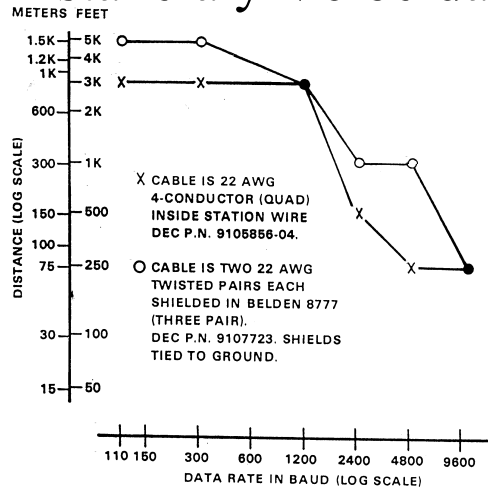


Nullmodem de 9 a 9
Nullmodem de 9 a 25
Nullmodem de 25 a 25

Protocolo de 3 hilos



Distancia y Velocidad



TDII - Conexión serie con el mundo.

25

Distancia y Velocidad

| Velocidad | Distancia |
|------------------|-----------|
| Bit por Segundos | Metros |
| 2400 | 60 |
| 4800 | 30 |
| 9600 | 15 |
| 19200 | 7,6 |

TDII - Conexión serie con el mundo.

26

RS423

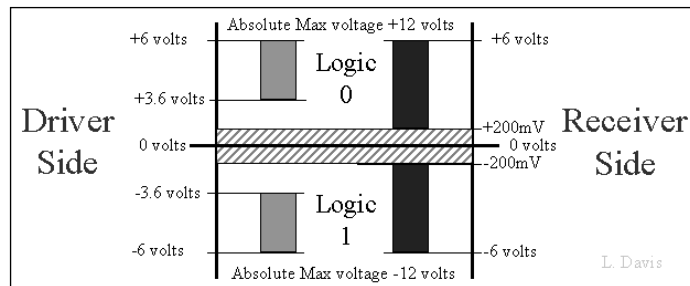
| DB25 | | Unbalanced | | DB37 | |
|------|--------------------------------|------------|----|------|--|
| 1 | Shield (A) | 1 | 1 | | |
| 2 | Transmit Data (A) | 4 | 4 | | |
| 14 | Transmit Data (B) | 22 | 22 | | |
| 3 | Receive Data (A) | 6 | 6 | | |
| 16 | Receive Data (B) | 24 | 24 | | |
| 4 | Request to Send (A) | 7 | 7 | | |
| 19 | Request to Send (B) | 25 | 25 | | |
| 5 | Clear to Send (A) | 9 | 9 | | |
| 13 | Clear to Send (B) | 27 | 27 | | |
| 6 | Dataset Ready (A) | 11 | 11 | | |
| 22 | Dataset Ready (B) | 29 | 29 | | |
| 7 | Signal Ground | 19 | 19 | | |
| 8 | Receive Line Signal Detect (A) | 13 | 13 | | |
| 10 | Receive Line Signal Detect (B) | 31 | 31 | | |
| 17 | Receive Timing (A) | 8 | 8 | | |
| 9 | Receive Timing (B) | 26 | 26 | | |
| 24 | External Timing (A) | 17 | 17 | | |
| 11 | External Timing (B) | 35 | 35 | | |
| 15 | Transmit Timing (A) | 5 | 5 | | |
| 12 | Transmit Timing (B) | 23 | 23 | | |
| 18 | Local Loopback | 10 | 10 | | |
| 20 | Data Terminal Ready (A) | 12 | 12 | | |
| 23 | Data Terminal Ready (B) | 30 | 30 | | |
| 21 | Remote Loopback | 14 | 14 | | |
| 25 | Test Mode Indicate | 18 | 18 | | |

TDII - Conexión serie con el mundo.

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RS423

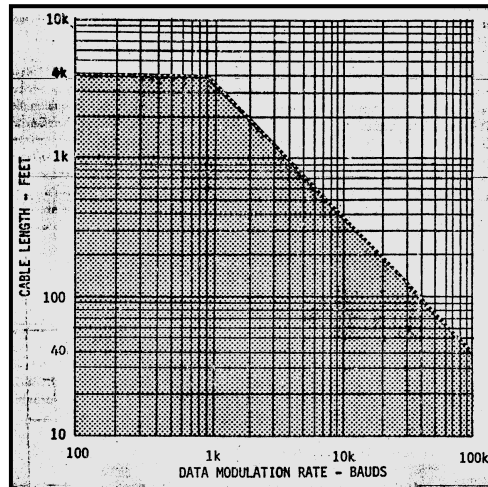
| | | |
|----------------|----------|----------|
| Tensión | -4 to -6 | +4 to +6 |
| Estado Binario | 1 | 0 |
| Señal | Marking | Spacing |
| Función | Off | On |



TDII - Conexión serie con el mundo.

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Velocidad vs Distancia



TDII - Conexión serie con el mundo.

29

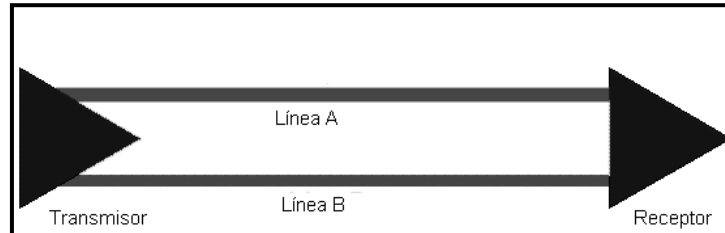
Comparación RS232 y RS423

| ESPECIFICACIONES | | RS232 | RS423 |
|--|------------|---------------------|----------------------|
| Modo de Operación | | SINGLE -ENDED | SINGLE -ENDED |
| Número Total de Transmisores y receptores en una línea | | 1 DRIVER 1 RECVR | 1 DRIVER 10 RECVR |
| Longitud máxima del cable | | 15 m. | 1200 m. |
| Máxima velocidad de comunicación | | 20kb/s | 100kb/s |
| Niveles máximos de tensión (abierto) | | +/-25V | +/-6V |
| Variación de la Salida (Carga mínima) | Cargado | +/-5V to +/-15V | +/-3.6V |
| Variación de salida (Descargado) | Descargado | +/-25V | +/-6V |
| Impedancia de salida de los drivers (Ohms) | | 3k to 7k | >=450 |
| Máx. Corriente de Driver (Alta Z) | Power On | N/A | N/A |
| Máx. Corriente de Driver (Alta Z) | Power Off | +/-6mA @ +/-2v | +/-100uA |
| Slew Rate (Max.) | | 30V/uS | Ajustable |
| Rango de Tensión de Entrada | | +/-15V | +/-12V |
| Sensibilidad de la entrada | | +/-3V | +/-200mV |
| Resistencia de entrada del receptor (Ohms) | | 3k to 7k | 4k min. |

TDII - Conexión serie con el mundo.

30

RS422



Comunicaciones Punto a Punto

$$V_A - V_B < -0.2v = 0$$

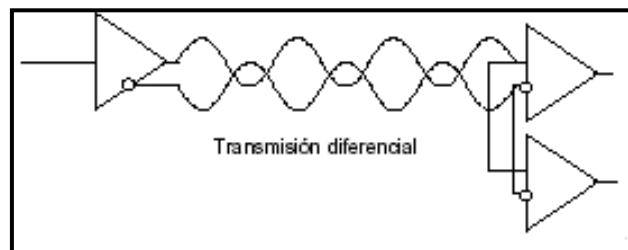
$$V_A - V_B > +0.2v = 1$$

Resistores de Terminación de 50, 75 ó 100 Ω

TDII - Conexión serie con el mundo.

31

RS422



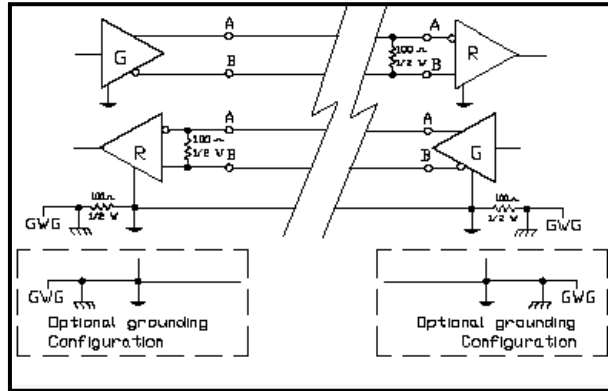
1200 metros hasta 2.5 MB/s

Punto a Punto

TDII - Conexión serie con el mundo.

32

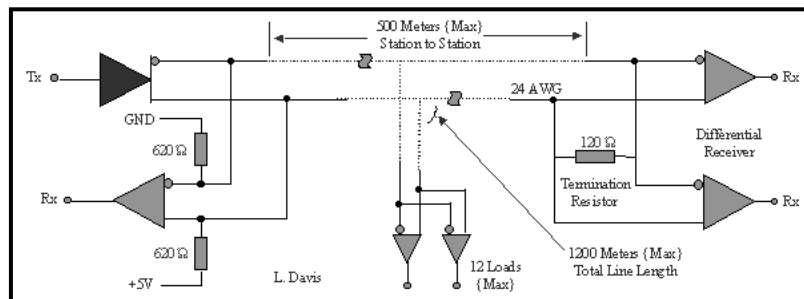
RS422



TDII - Conexión serie con el mundo.

33

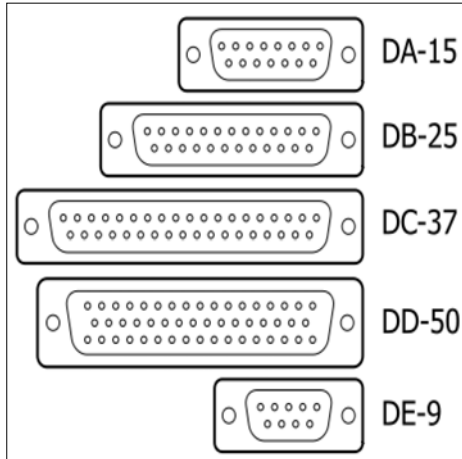
RS422



TDII - Conexión serie con el mundo.

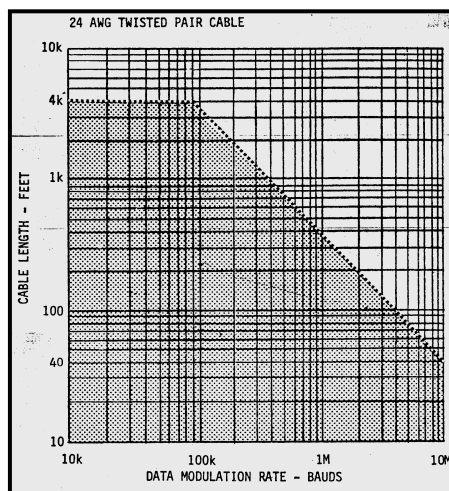
34

Conectores



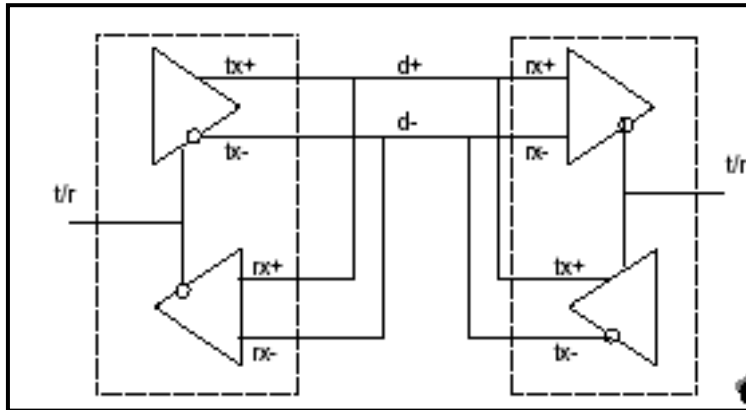
TDII - Conexión serie con el mundo.

RS422



TDII - Conexión serie con el mundo.

RS485

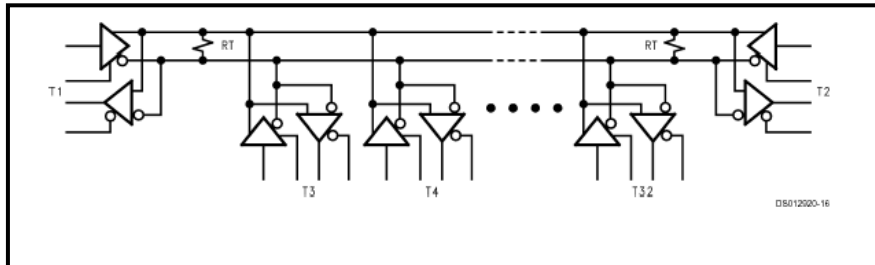


Hasta 32 cargas de 12 kohm o 256 de alta Z

TDII - Conexión serie con el mundo.

37

RS485



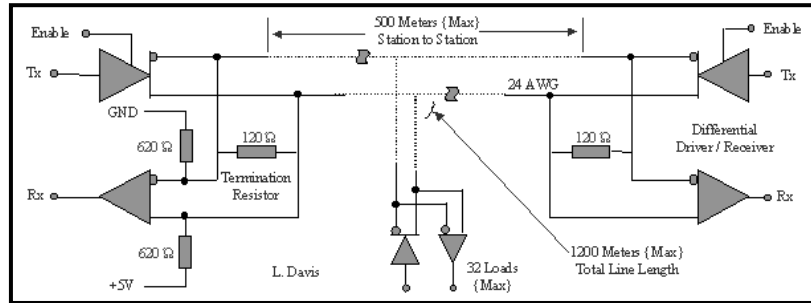
1200 metros hasta 2.5 MB/s

Multipunto

TDII - Conexión serie con el mundo.

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RS485

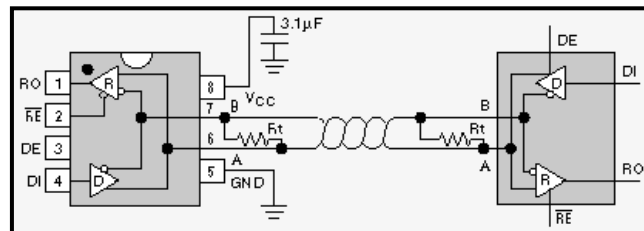
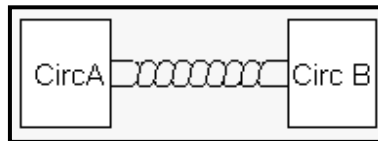


$V_i > 200 \text{ mV}$
 $V_o > 1,5 \text{ V}$

TDII - Conexión serie con el mundo.

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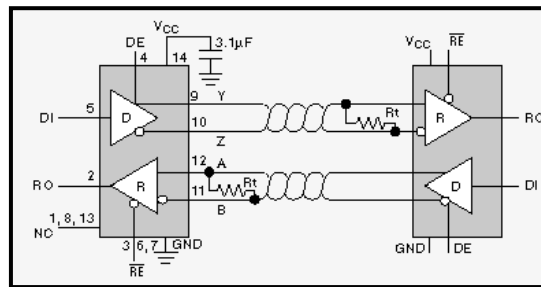
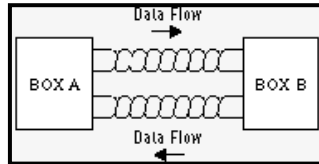
Half Duplex



TDII - Conexión serie con el mundo.

40

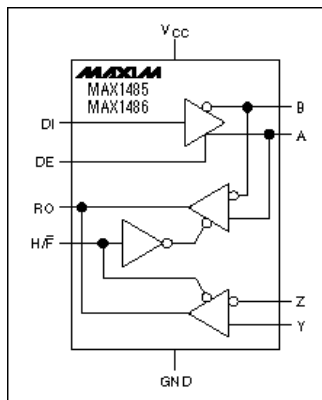
Full Duplex



TDII - Conexión serie con el mundo.

41

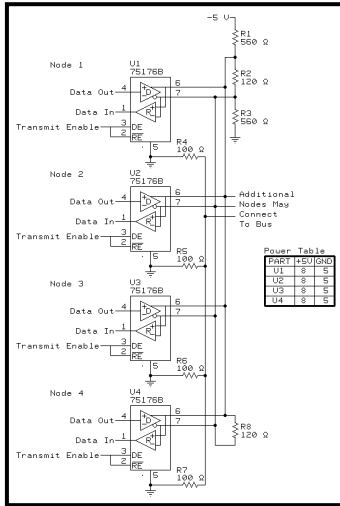
Sentido controlable



TDII - Conexión serie con el mundo.

42

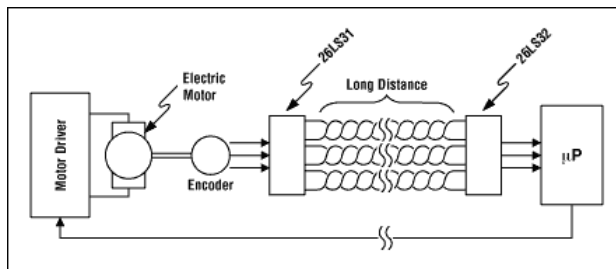
Conexión



TDII - Conexión serie con el mundo.

43

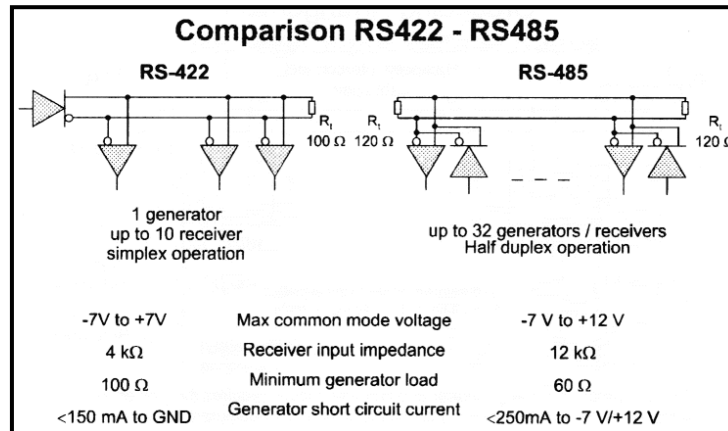
Aplicación



TDII - Conexión serie con el mundo.

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RS422 y RS485



TDII - Conexión serie con el mundo.

45

Comparación RS422 y RS423

| ESPECIFICACIONES | | RS423 | RS422 |
|--|------------|----------------------|----------------------|
| Modo de Operación | | SINGLE - ENDED | DIFERENCIAL |
| Número Total de Transmisores y receptores en una línea | | 1 DRIVER 10 RECVR | 1 DRIVER 10 RECVR |
| Longitud máxima del cable | | 1200 m. | 1200 m. |
| Máxima velocidad de comunicación | | 100kb/s | 10Mb/s |
| Niveles máximos de tensión (abierto) | | +/-6V | -0.25V to +6V |
| Variación de la Salida (Carga mínima) | Cargado | +/-3.6V | +/-2.0V |
| | Descargado | +/-6V | +/-6V |
| Impedancia de salida de los drivers (Ohms) | | >450 | 100 |
| Máx. Corriente de Driver (Alta Z) | Power On | N/A | N/A |
| Máx. Corriente de Driver (Alta Z) | Power Off | +/-100uA | +/-100uA |
| Slew Rate (Max.) | | Ajustable | N/A |
| Rango de Tensión de Entrada | | +/-12V | -10V to +10V |
| Sensibilidad de la entrada | | +/-200mV | +/-200mV |
| Resistencia de entrada del receptor (Ohms) | | 4k min. | 4k min. |

TDII - Conexión serie con el mundo.

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Comparación final

| SPECIFICATIONS | RS232 | RS423 | RS422 | RS485 |
|--|-----------------------------|----------------------|----------------------|-----------------------|
| Mode of Operation | SINGLE-ENDED | SINGLE-ENDED | DIFFERENTIAL | DIFFERENTIAL |
| Total Number of Drivers and Receivers on One Line (One driver active at a time for RS485 networks) | 1 DRIVER 1 RECVR | 1 DRIVER 10 RECVR | 1 DRIVER 10 RECVR | 32 DRIVER 32 RECVR |
| Maximum Cable Length | 50 FT. | 4000 FT. | 4000 FT. | 4000 FT. |
| Maximum Data Rate (40ft. - 4000ft. for RS422/RS485) | 20Kb/s | 100Kb/s | 10Mb/s-100Kb/s | 10Mb/s-100Kb/s |
| Maximum Driver Output Voltage | +/-25V | +/-6V | -0.25V to +6V | -7V to +12V |
| Driver Output Signal Level (Loaded Min.) | +/-5V to +/-15V | +/-3.6V | +/-2.0V | +/-1.5V |
| Driver Output Signal Level (Unloaded Max.) | +/-25V | +/-6V | +/-6V | +/-6V |
| Driver Load Impedance (Ohms) | 3k to 7k | >=450 | 100 | 54 |
| Max. Driver Current in High Z State | Power On N/A | N/A | N/A | +/-100uA |
| Max. Driver Current in High Z State | Power Off +/-6mA @ +/-2v | +/-100uA | +/-100uA | +/-100uA |
| Slew Rate (Max.) | 30V/uS | Adjustable | N/A | N/A |
| Receiver Input Voltage Range | +/-15V | +/-12V | -10V to +10V | -7V to +12V |

TDII - Conexión serie con el mundo.

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I2C - Orígenes

- A principios de la década del 80, Philips creó una norma de 2 hilos para interconectar componentes en un televisor.
- I2C = Inter Ics Bus
- Adoptado por Xicor, ST Microelectronics, Infineon Technologies, Intel, Texas Instruments, Maxim, Atmel, Analog Devices

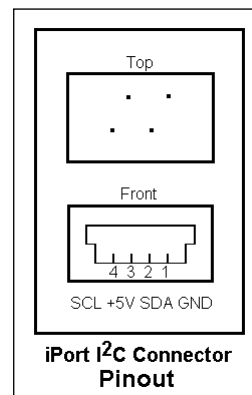
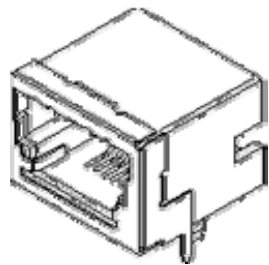
TDII - Conexión serie con el mundo.

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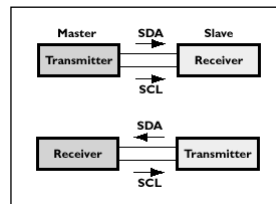
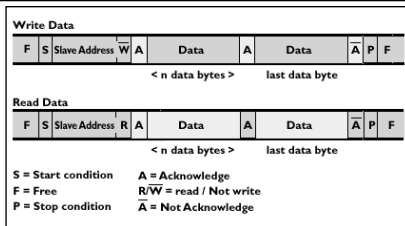
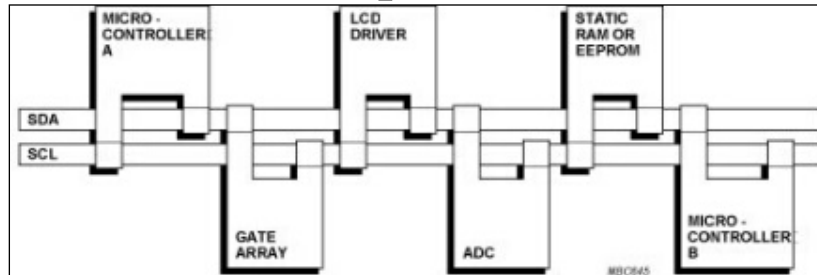
I2C

- Hasta 400Kb/s (3,4 Mb/s)
- Pequeñas distancias
- EEPROMS
- Relojes de Tiempo Real
- Trasductores de Temperatura

Conectores



Componentes



TDII - Conexión serie con el mundo.

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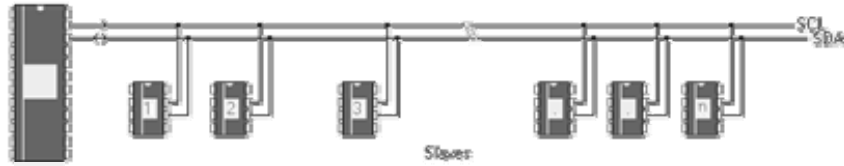
I2C

- Dos líneas activas y tierra
- SDA es Serial DATA line, y SCL es Serial CLOCK line.
- Cada dispositivo puede ser transmisor y/o receptor (LCD → receptor, memoria → Transmisora y receptora).
- Dirección única

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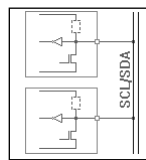
52

I2C

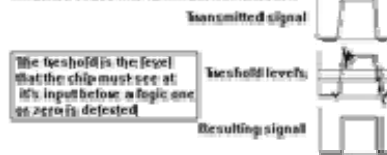


Start →
 Dirección →
 Ack ←
 Datos
 Stop →

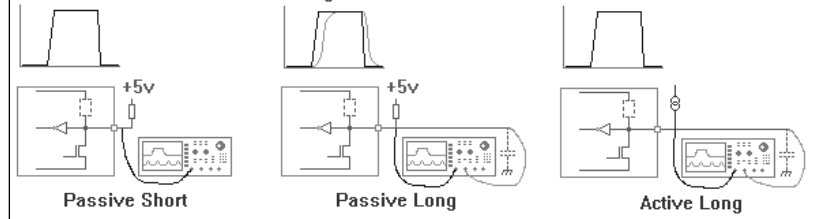
I2C - Hardware



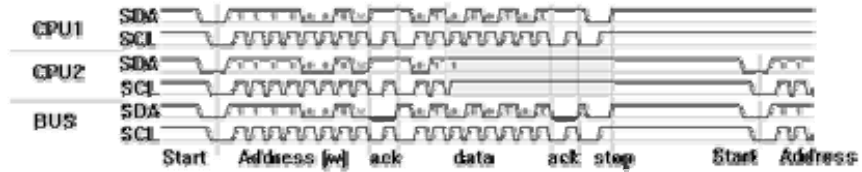
Influence of bad line termination: Reflection



Influence of line length and bus termination on waveforms



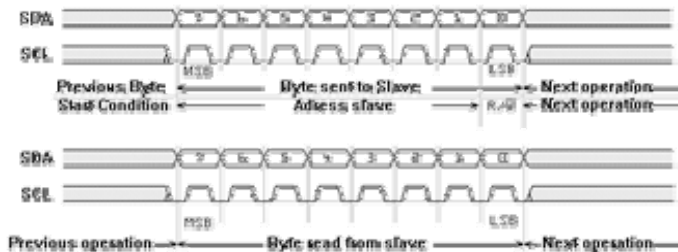
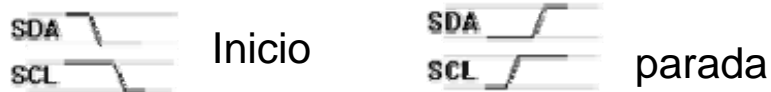
I2C - Arbitración



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Inicio y parada



Aún en el modo de 10 bits de direccionamiento, el bit 0 indica el modo de acceso ('1' = read / '0' = write).

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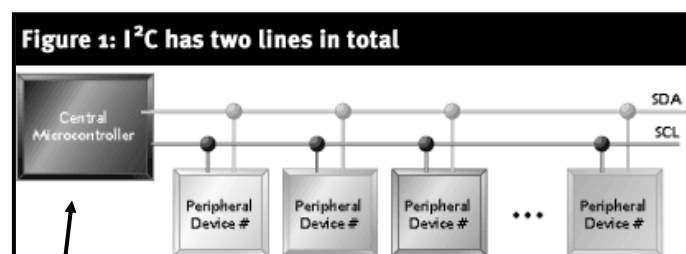
Direcciones Reservadas

| Address | R/W | Designation |
|----------|-----|--|
| 0000-000 | 0 | General Call address (see note 1) |
| 0000-000 | 1 | START byte (see note 2) |
| 0000-001 | x | reserved for the (now obsolete) C-Bus format |
| 0000-010 | x | Reserved for a different bus format |
| 0000-011 | x | Reserved for future purposes |
| 0000-1xx | x | Reserved for future purposes |
| 1111-1xx | x | Reserved for future purposes |
| 1111-0xx | x | 10-bit slave addressing mode |

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I²C - Conexión



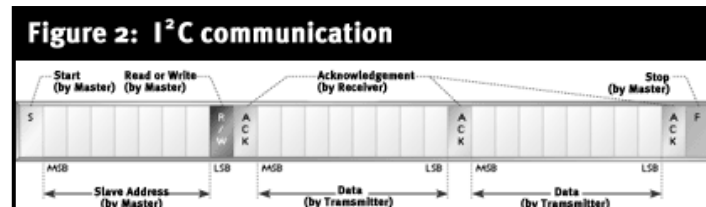
Maestro

Esclavos

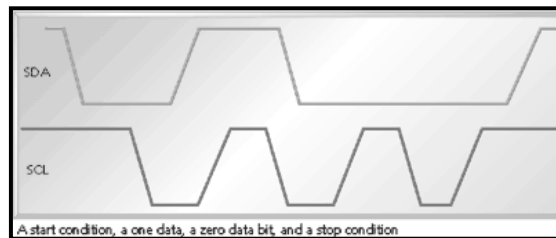
TDII - Conexión serie con el mundo.

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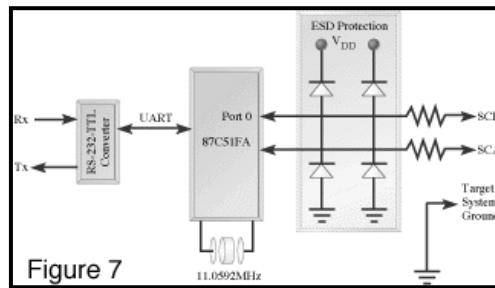
I2C Comunicación



I2C - Señales



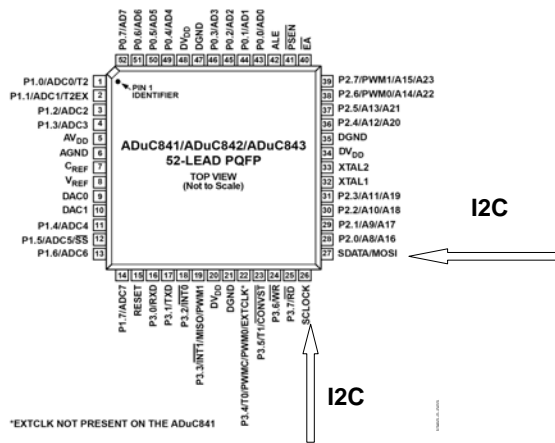
I2C - Implementación



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ADUC842 PIN OUT-EJ nro 1



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Micro con un Reg para I2C en SFR

| | | | | | | | | | | | | | | | | |
|------------------|------------------|-------------------|--------------------|---------------|----------------|----------------|---------------|------|---------------------------------|----------------------------------|----------------------------------|----------------------------------|---------------------------------|--------------------|----------|--------------------|
| ISPI FFH 0 | WCOL FEH 0 | SPE FDH 0 | SPIM FCH 0 | CPOL FBH 0 | CPHA FAH 1 | SPR1 F9H 0 | SPR0 FBH 0 | BITS | SPICON ¹ FBH 04H | DAC0L F9H 00H | DAC0H FAH 00H | DAC1L FBH 00H | DAC1H FCH 00H | DACCON FDH 04H | RESERVED | RESERVED |
| F7H 0 | F6H 0 | F5H 0 | F4H 0 | F3H 0 | F2H 0 | F1H 0 | F0H 0 | BITS | B ¹ F0H 00H | ADCOFSL ³ F1H 00H | ADCOFSH ³ F2H 20H | ADCGAINL ³ F3H 00H | ADCGANH ³ F4H 00H | ADCCON3 F5H 00H | RESERVED | SPIDAT F7H 00H |
| I2CIND0 EFH 0 | I2CGMDE EEH 0 | I2C10MCO EDH 0 | I2C10MMDI ECH 0 | I2CM EBH 0 | I2CRS EAH 0 | I2CTX E9H 0 | I2CI EBH 0 | BITS | I2CCON1 EBH 00H | RESERVED | RESERVED | RESERVED | RESERVED | RESERVED | RESERVED | ADCCON4 EFH 40H |
| E7H 0 | E6H 0 | E5H 0 | E4H 0 | E3H 0 | E2H 0 | E1H 0 | E0H 0 | BITS | ACC ¹ E0H 00H | RESERVED | RESERVED | RESERVED | RESERVED | RESERVED | RESERVED | RESERVED |
| ADCI DFH 0 | DMA DEH 0 | CCONV DDH 0 | SCONV DCH 0 | CS3 DBH 0 | CS2 DAH 0 | CS1 D9H 0 | CS0 DBH 0 | BITS | ADCCON2 ¹ DBH 00H | ADCDATAL ³ D9H 00H | ADCDATAH ³ DAH 00H | RESERVED | RESERVED | RESERVED | RESERVED | PSMCON DFH DEH |

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Micro con un Reg para I2C en SFR

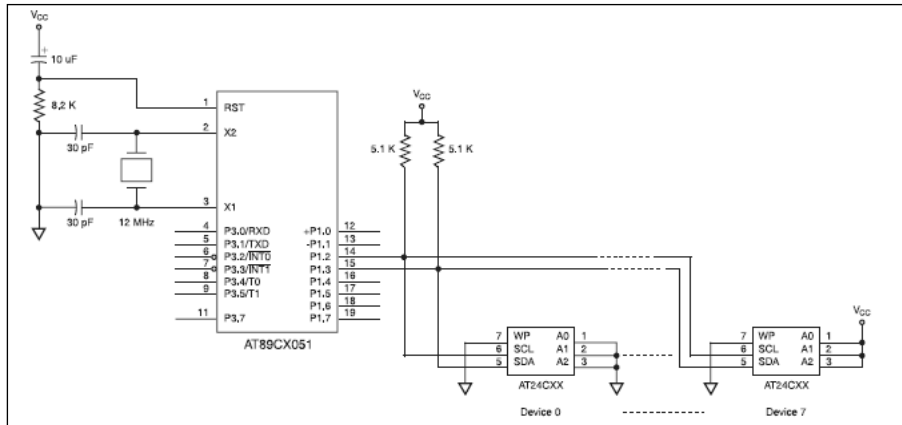
Table 19. I2CCON SFR Bit Designations, Master Mode

| Bit No. | Name | Description |
|---------|------|---|
| 7 | MDO | I ² C Software Master Data Output Bit (Master Mode Only). This data bit is used to implement a master I ² C transmitter interface in software. Data written to this bit is output on the SDATA pin if the data output enable (MDE) bit is set. |
| 6 | MDE | I ² C Software Master Data Output Enable Bit (Master Mode Only). Set by the user to enable the SDATA pin as an output (Tx). Cleared by the user to enable the SDATA pin as an input (Rx). |
| 5 | MCO | I ² C Software Master Clock Output Bit (Master Mode Only). This data bit is used to implement a master I ² C transmitter interface in software. Data written to this bit is output on the SCLOCK pin. |
| 4 | MDI | I ² C Software Master Data Input Bit (Master Mode Only). This data bit is used to implement a master I ² C receiver interface in software. Data on the SDATA pin is latched into this bit on SCLOCK if the data output enable (MDE) bit is 0. |
| 3 | I2CM | I ² C Master/Slave Mode Bit. Set by the user to enable I ² C software master mode. Cleared by the user to enable I ² C hardware slave mode. |
| 2 | --- | Reserved. |
| 1 | --- | Reserved. |
| 0 | --- | Reserved. |

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Conexión de dispositivos



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Memorias I2C

Table 1. Atmel's 2-Wire Serial EEPROM Family

| Device | Size (Bytes) | Page Size (Bytes) | Max Per Bus | Addresses Used |
|----------|--------------|-------------------|-------------|----------------|
| AT24C01 | 1K | 8 | 1 | None |
| AT24C01A | 1K | 8 | 8 | A0, A1, A2 |
| AT24C02 | 2K | 8 | 8 | A0, A1, A2 |
| AT24C04 | 4K | 16 | 4 | A1, A2 |
| AT24C08 | 8K | 16 | 2 | A2 |
| AT24C16 | 16K | 16 | 1 | None |
| AT24C164 | 16K | 16 | 8 | A0, A1, A2 |
| AT24C32 | 32K | 32 | 8 | A0, A1, A2 |
| AT24C64 | 64K | 32 | 8 | A0, A1, A2 |

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SPI

Full duplex y a velocidades mayores que I2C (1 Mb/s)

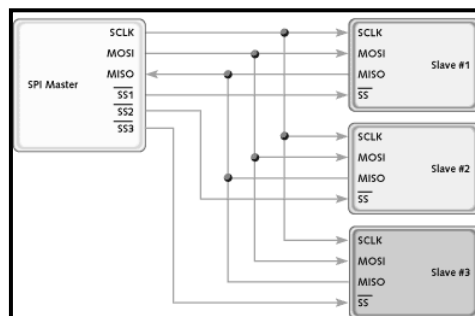
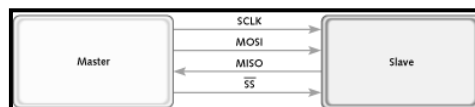
No se direcciona como I2C

Relación Amo - Esclavo

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SPI – Uno o más esclavos



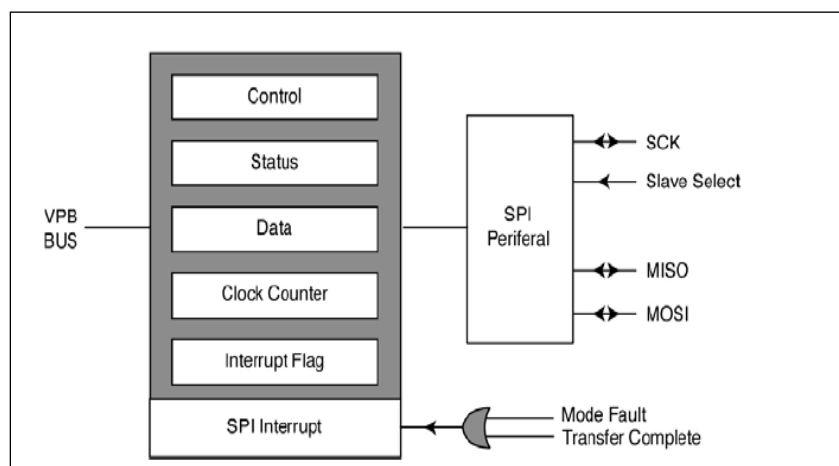
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Características SPI

- Puerto serie síncrono full duplex, sin gestión de bus.
- Velocidad de transmisión máxima: $1/8$ PCLK.
- Transferencias de 8 a 16 bits.
- Modo maestro o modo esclavo.

Características SPI



SPI

| Pin | Function | Function | Pin |
|-----|----------|----------|-----|
| 1 | MOSI | GND | 2 |
| 3 | MISO | GND | 4 |
| 5 | CLK | GND | 6 |
| 7 | CS0 | 5 Volt | 8 |
| 9 | CS1 | 5 Volt | 10 |
| 11 | CS2 | nc | 12 |
| 13 | CS3 | IRQ | 14 |

Abbreviations:

MOSI Master Out Slave In

MISO Master In Slave Out

CLK Clock for the shift registers

CS0-CS3 Chip Select

nc free for application-specific use

5 Volt supply voltage (5 Volt DC, stable)

IRQ Interrupt ReQuest