Continental Learning
Laboratory 3.A SW

Laboratorul 6:

Partea I

- Partea I
  - Prezentarea protocolului CAN
  - Comparatie intre protocoalele studiate

- Partea a II-a:
  - Interfete HAL CAN
  - Aplicație demonstrativa folosind CAN.

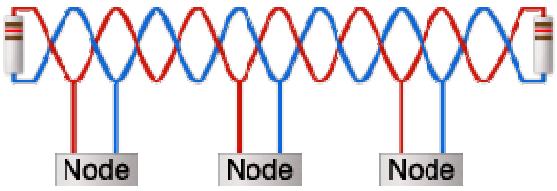
1. Prezentarea protocolului CAN (Controller Area Network)

1.1 Prezentare sumara

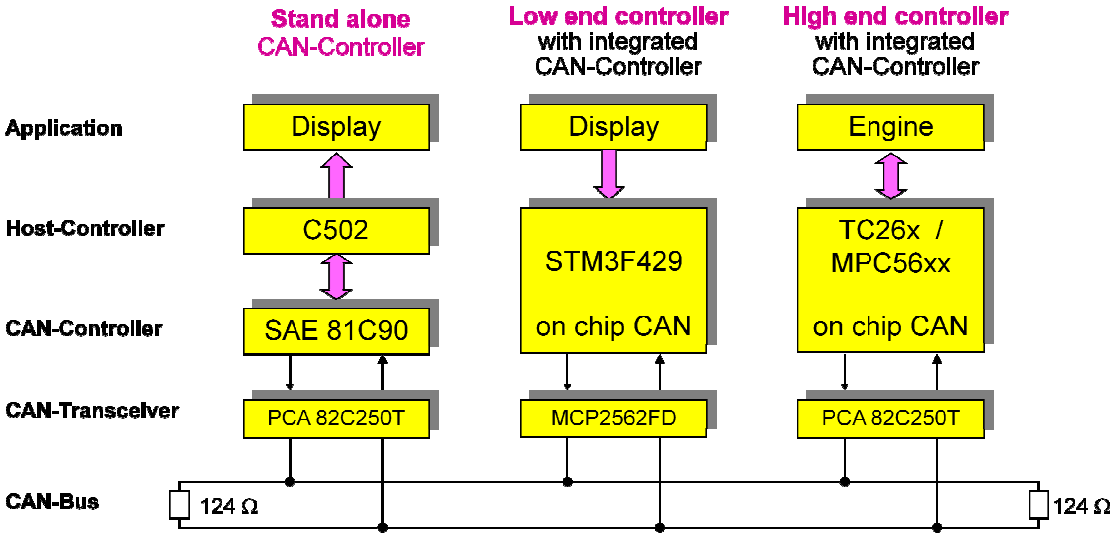
Comunicaţie asincronă
Transmisie prin 2 fire, cu tensiune diferenţială
Arbitrare la nivelul de transfer bazată pe prioritatea informaţiei (identificator)
Baud rate: configurabil până la 1Mbit/s, distanţă maximă 1000m
Variante CAN: - High Speed (<=1Mbit/40m)
- Low speed (<=125Kbit/20noduri/40m)

CSMA/CA

1.2 Bus & node description



www.can-cia.org



1.3 Generalitati

Biti pe CAN:

Dominanti – 0

Recesivi – 1

Nodurile nu au adrese in schimb
mesajele au numere de identificare (ID-uri).

Exista mesaje CAN standard (11 biti adresa) si mesaje CAN extinse (29 biti adresa)

Biti de umplutura (bit stuffing) – procesul de inserare de biti fara valoare informational pentru a evita pierderea sincronizarii intre noduri.

Destuffed bit stream	01011111010	10100000101	01011111000010	10100000111101
Stuffed bit stream	01011111o010	10100000i101	01011111o0000i10	10100000i1111o01
"0", "o" = dominant (stuff) bit; "1", "i" = recessive (stuff) bit				

Sursa: ISO11898-4/2015

1.4 Structura mesajului CAN standard / extins

Structura mesajului CAN Standard

IFS/IDLE	InterFrame State(stare recesiva)
SOF	Start of Frame (1 bit dominant - 0)
ID	Standard CAN: 11 Biti / Extended CAN: 29 Biti
Control	RTR, identifier extension, biti rezervati, Data Length Code
Data	0 pana la 8 octeti date
CRC	CRC (15biti) + delimtator CRC(1bit recesiv - 1)
ACK	Confirmare(Acknowledge) + delimitator confirmare (1bit recesiv)
EOF	End of Frame (7 biti recesivi)
IFS	Inter Frame Space (3 biti recesivi)
IDLE	Bus Inactiv (stare recesiva)

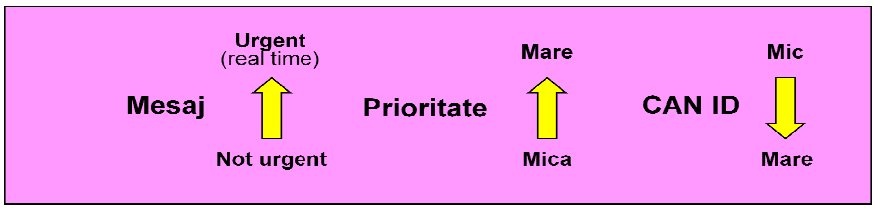
1.5 CAN ID, prioritati, arbitraj

Biti pe CAN:

Dominanti – 0

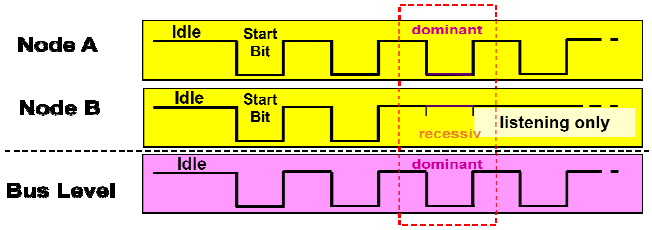
Recesivi – 1

Prioritatea unui mesaj este data ID dupa cum urmeaza:



Arbitraj CSMA/CA

Procesul de arbitrare: castiga nodul care trimite mesajul cu cel mai mic ID



Arbitraj:

Standard Can:12 biti (11 CAN ID + 1bit RTR)

Extended CAN: 32 bit (29 CAN ID +SRR + IDE + RTR)

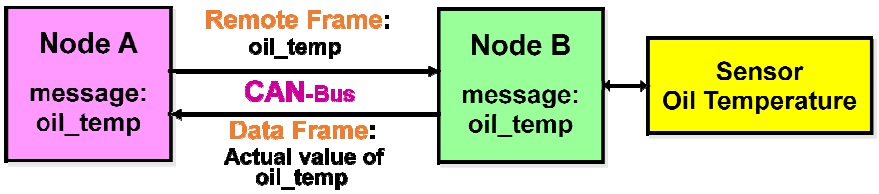
1.6 RTR - Tipuri de transmisii

Mesaje de date (DATA FRAME) — Se transmit pana la 8 octeti de date folosind mesaje standard sau extinse (Remote-Bit **RTR = 0**)

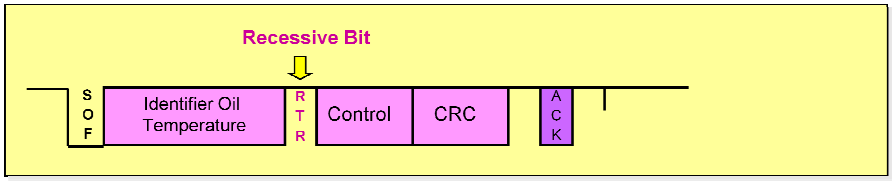
Mesaje de cerere date (REMOTE FRAME) — Nodul destinatarpoate cere date de la nodul sursa trimitand un mesaj de cerere (mesaj Standard sau Extended) (Remote-Bit **RTR = 1**)

Mesaj de eroare (ERROR FRAME) — Fiecare nod care detecteaza o eroare de transmisie trimite transmite un "Error Frame" (o secventa de 6 biti cu acelasi nivel))

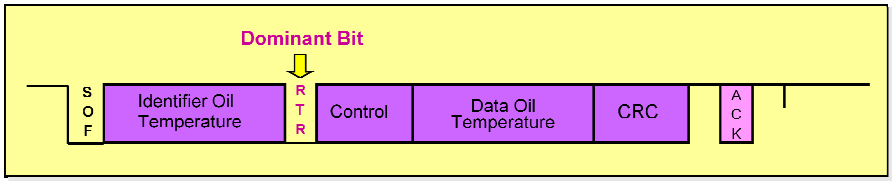
Exemplu:



Node A transmits Remote Frame (request data)



Node B transmits requested Data Frame

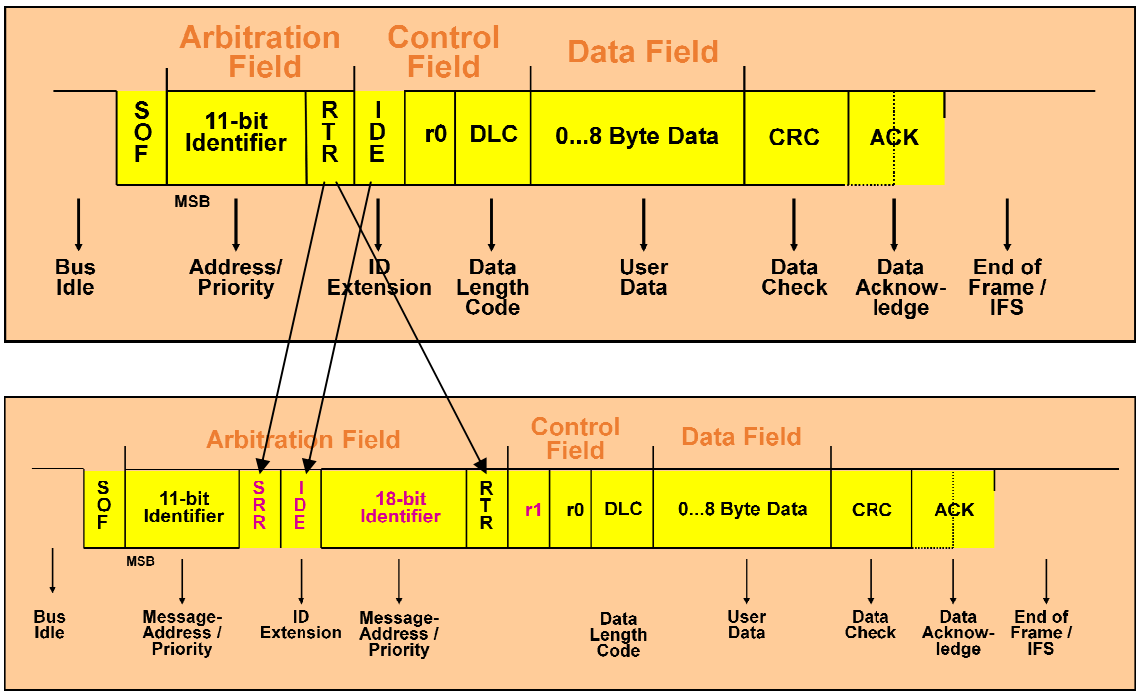


1.7 Bitii de control

IDE	Identifier Extension :	IDE = 0 mesaj standard(11 Bit ID)
		IDE = 1 mesaj extins(29 Bit ID)
r0	bit rezervat (pentru utilizare ulterioara)	
DLC3 ... DLC0	Lungime date (Data Length Code)	

DLC	No. of Data Bytes
0	0
1	1
...	...
8	8
9 ... 15	8 *

1.8 IDE - Structura mesajului CAN standard vs CAN extins



1.8 Campul de date

0 octeti date

1 octet date rata transmisie date joasa

.

.

.

8 octeti date rata transmisie date ridicata

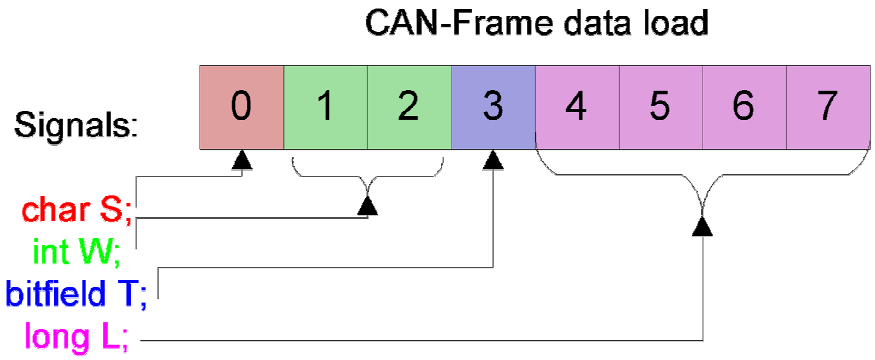
1.9 Mesaje, campuri de date, semnale

Un mesaj de CAN contine un camp de date de pana la 8 octeti

Mesajul poate contine numai un numar intreg de octeti

Campul de date contine **semnale**

Semnalele reprezinta datele si sunt corespondentele variabilelor din C



1.10 Campul CRC

Codul CRC suma de control (CRC-ul) pe 15 biti generate de transmitator si verificata de receptor

Delimitatorul CRC 1 bit recesiv

Polinomul generator $x^{15} + x^{14} + x^{10} + x^8 + x^7 + x^4 + x^3 + 1$

CRC Error Receptorul detecteaza o eroare de CRC daca codul calculat la receptie nu este egal cu cel continut de mesaj in campul CRC

1.11 Campul de confirmare (Acknowledge)

Campul **ACK**

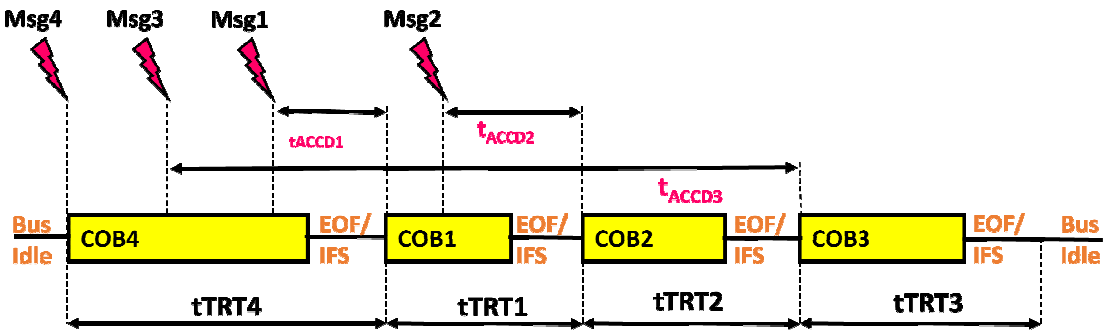
2 biti:	**Slotul ACK** si	**Delimitator ACK**
Transmitator:	recesiv	recesiv
Receptor:	dominant	

Confirmarea Fiecare receptor care primeste un mesaj valid va transmite 1 bit dominant pe durata slotului Ack.
Fiecare transmitator primeste informatia ca cel putin 1 nod a primit mesajul corect. Daca transmitatorul nu primeste nicio confirmare atunci transmite mesajul din nou.

1.12 Accesul la bus-ul de CAN

Example: **CAN Bus Access Time**

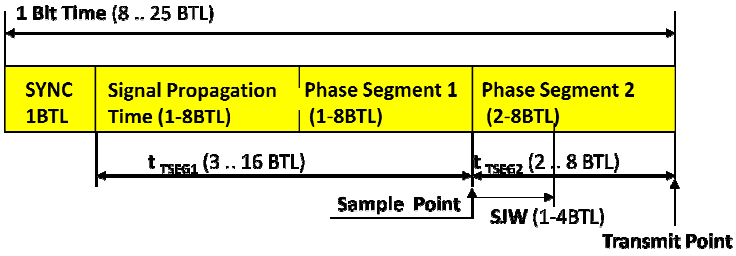
CAN message 1, Identifier 1 Priority High
CAN message 2, Identifier 2 ^
CAN message 3, Identifier 3 ^
CAN message, Identifier 4 Priority Low



1.13 Calculul si programarea bitului

A **bit time** can be divided in four parts:

Synchronization
Signal Propagation Time (including CAN controller process time)
Phase segment 1 (for resynchronization)
Phase segment 2 (time for sample and resynchronization)



1.14 Rezistori pe CAN

CAN Cable Termination Resistor

The CAN bus cable needs at the ends a termination resistor R_T to provide EMC chracteristics without corrupting the DC charcteristics:

For basic termination at a serial cable use for termination resistor R_T = 124 Ω with linear CAN bus lines.

2. Comparatie Protocoale

	SPI	I2C	CAN
Dezvoltator	Motorola	Philips	Bosch
Tip	Serial Sincron Full duplex	Serial Sincron Half duplex	Serial Asincron Half duplex
Semnale	SCLK MOSI MISO SS (CS)	SCL(serial clock) SDA(serial data)	CAN_H CAN_L
Viteza	100 MHz(Wiki)	400Khz	1Mhz@40m
Distanta	x10cm	x1m(Wiki)	1Km
Tip comunic.	Single Master -> Multi Slave	Multi Master -> Multi Slave	Multi Master
Arbitraj	N.A.	lowest address wins CSMA/CA	lowest Identifier wins CSMA/CA

Referinte:

1. **CAN Specifications Version2.0 Bosch 1991**

2. https://www.can-cia.org/can-knowledge/can/can-history/

3. **ISO 11898 series** specifies physical and data link layer (levels 1 and 2 of the ISO/OSI model) of serial communication technology called Controller Area Network that supports distributed real-time control and multiplexing for use within road vehicles.[10]

There are several CAN physical layer and other standards:

4. **ISO 11898-1:2015** specifies the data link layer (DLL) and physical signalling of the controller area network (CAN).[11] This document describes the general architecture of CAN in terms of hierarchical layers according to the ISO reference model for open systems interconnection (OSI) established in ISO/IEC 7498-1 and provides the characteristics for setting up an interchange of digital information between modules implementing the CAN DLL with detailed specification of the logical link control (LLC) sublayer and medium access control (MAC) sublayer.
5. **ISO 11898-2:2003** specifies the **high-speed** (transmission rates of up to 1 Mbit/s) **medium access unit** (MAU), and some **medium dependent interface** (MDI) features (according to ISO 8802-3), which comprise the physical layer of the controller area network. ISO 11898-2 uses a two-wire balanced signalling scheme. It is the most used physical layer in car powertrain applications and industrial control networks.
6. **ISO 11898-3:2006** specifies **low-speed**, fault-tolerant**, medium-dependent interface** for setting up an interchange of digital information between electronic control units of road vehicles equipped with the CAN at transmission rates above 40 kBit/s up to 125 kBit/s.
7. **ISO 11898-4:2004** specifies time-triggered communication in the CAN (TTCAN). It is applicable to setting up a time-triggered interchange of digital information between electronic control units (ECU) of road vehicles equipped with CAN, and specifies the frame synchronisation entity that coordinates the operation of both logical link and media access controls in accordance with ISO 11898-1, to provide the time-triggered communication schedule.
8. **ISO 11898-5:2007** specifies the CAN physical layer for transmission rates up to 1Mbit/s for use within road vehicles. It describes the medium access unit functions as well as some medium dependent interface features according to ISO 8802-2. This represents an extension of ISO 11898-2, dealing with new functionality for systems requiring low-power consumption features while there is no active bus communication.
9. **ISO 11898-6:2013** specifies the CAN physical layer for transmission rates up to 1Mbit/s for use within road vehicles. It describes the medium access unit functions as well as some medium dependent interface features according to ISO 8802-2. This represents an extension of ISO 11898-2 and ISO 11898-5, specifying a selective wake-up mechanism using configurable CAN frames.
10. **ISO 16845-1:2004** provides the methodology and abstract test suite necessary for checking the conformance of any CAN implementation of the CAN specified in ISO 11898-1.
11. **ISO 16845-2:2014** establishes test cases and test requirements to realize a test plan verifying if the CAN transceiver with implemented selective wake-up functions conform to the specified functionalities. The kind of testing defined in ISO 16845-2:2014 is named as conformance testing.