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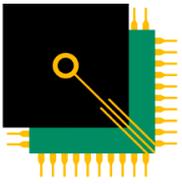
# Controller Area Network with Flexible Data for LPC5461x

presented by

**Andy Ayre**  
**Embedded Systems Academy, Inc.**

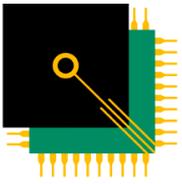
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# Webinar Contents

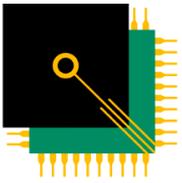
- LPC family introduction**
- Introduction to ESA**
- Differences between CAN and CAN-FD**
- CAN-FD Protocol Overview**
- CAN-FD on the LPC5461x**
- CAN Controller Block Diagram**
- CAN-FD Applications**
- CAN-FD Support**
- CANopen Stack Availability**
- Software API**
- API Demonstration**



# Why Developers Select LPC Microcontrollers

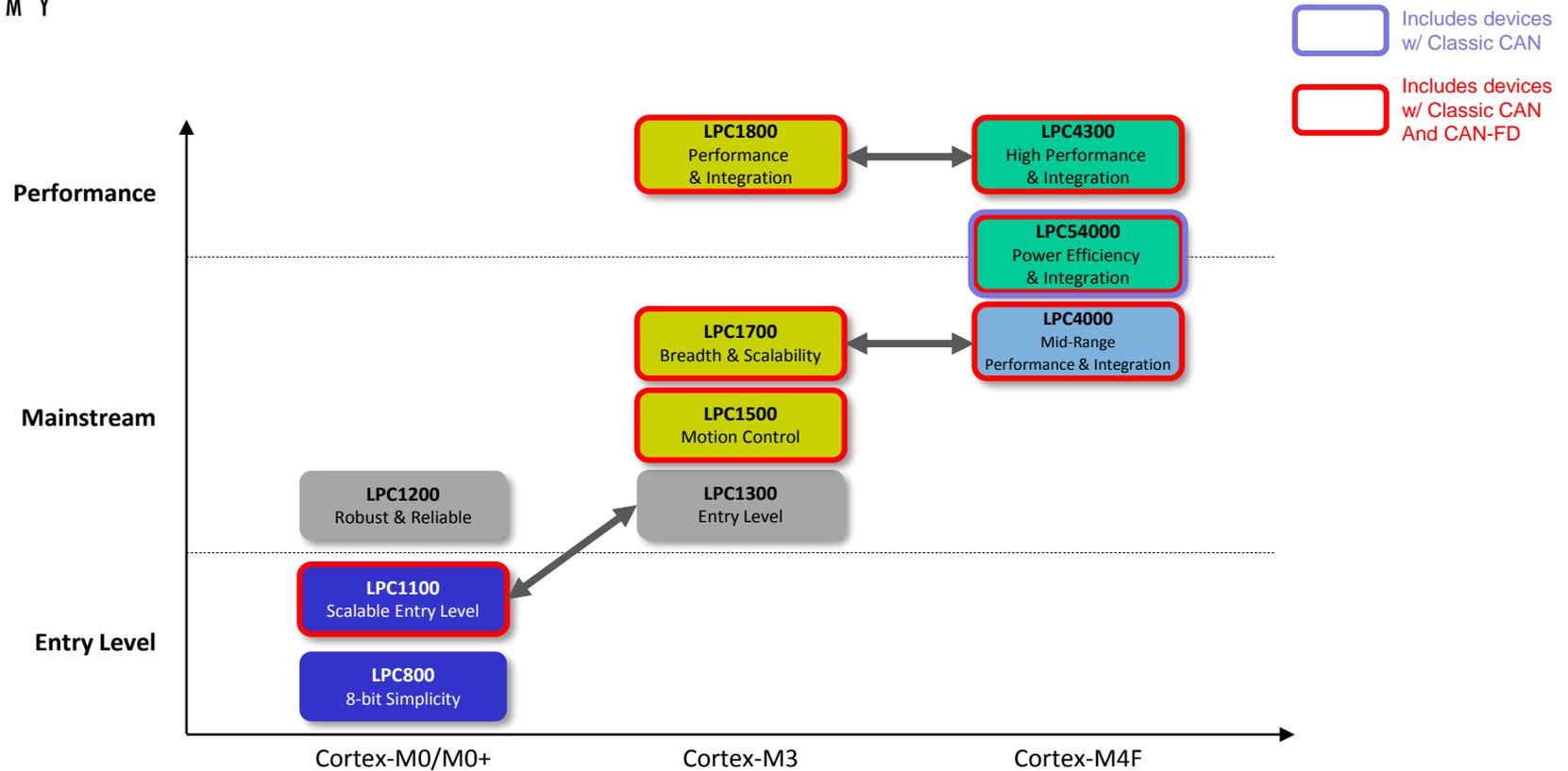


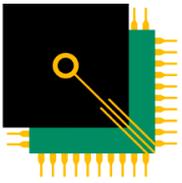
Investing in Innovative & Differentiated Technologies  
to Maintain our Global Leadership in the Broad Market



# LPC Microcontroller Portfolio

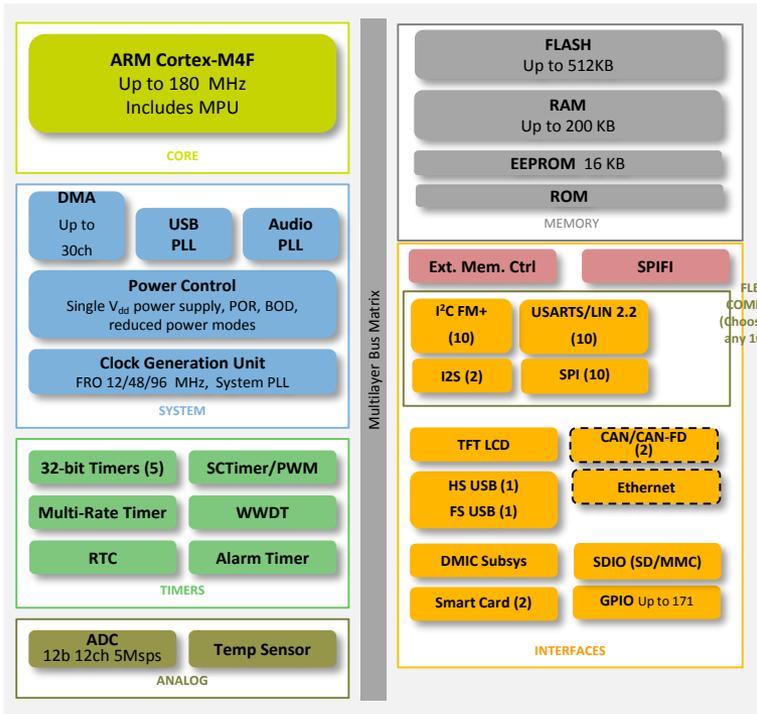
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# LPC546xx Block Diagram

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## CPU

- 180MHz Cortex-M4F

## Memory

- Up to 512 KB Flash, Up to 200 KB RAM
- 16 KB EEPROM

## Interfaces for connectivity & sensors

- Stereo DMIC subsystem
- 1x HS USB (H/D) w/ on-chip HS PHY, XTAL-less FS USB (H/D)
- 10 SPI, 10 I2C, 10 UART, 2 I2S channels (max 10 channels total)
- Graphic LCD with resolutions up to 1024x768
- Ethernet with IEEE1722 timestamp
- 2 x CAN-FD controller
- Quad SPI flash interface
- External Memory interface (up to 32 bits)

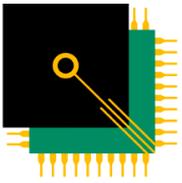
## Packages

- LQFP208 (28 x 28 mm), TFBGA180 (12 x 12 mm)
- LQFP100, TFBGA100

## Operating

- Operating voltage: 1.71 to 3.6V
- Temperature range: -40 to 105 °C

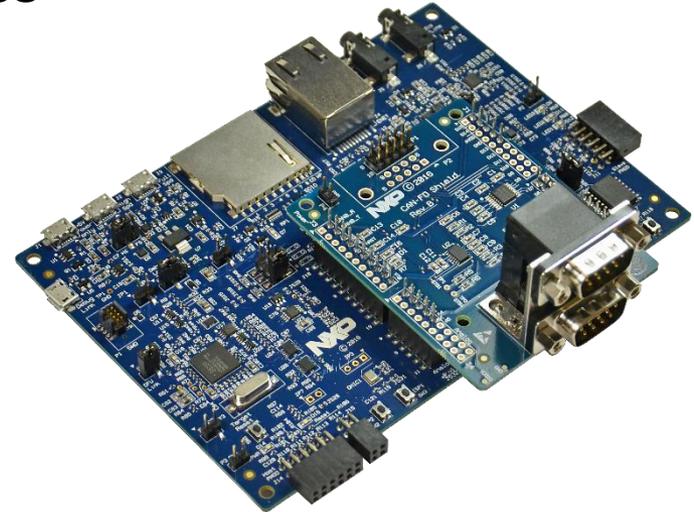


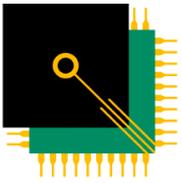


# LPCXpresso54618 CAN-FD Kit

## Development platform for LPC546xx Series

- LPC54618 MCU running at 180MHz
- 128Mb Micron SDRAM
- 128Mb Micron quad SPI flash
- Built-in CMSIS-DAP/J-link debug probe
- Ethernet, DMIC, SD card, USB HS/FS ports
- Stereo audio codec
- Arduino UNO R3 compatible expansion ports
- Shield board with TJA1059 dual transceiver
- Supported by MCUXpresso SDK for MCUXpresso IDE, Keil and IAR tools

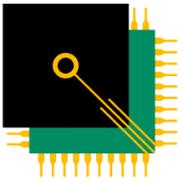




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# Embedded Systems Academy, Inc.

- Founded 1999**
- Consulting services**
- Training services**
- CANopen stacks, PC development/analysis tools, bootloaders**
- Participate in CANopen standardization**
- J1939**
- Flash Magic**



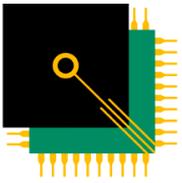
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# DIFFERENCES BETWEEN CAN AND CAN-FD

CAN-FD  
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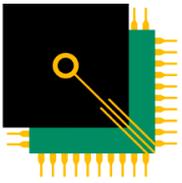
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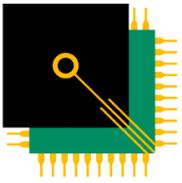
# Differences between CAN and CAN-FD

- Invented by Bosch in 2011**
- Finalized and ISO standardized 2015**
  - ISO 11898-1:2015
- Significantly higher bitrates for data**
  - Limited by transceivers in practice
- More data per frame**
  - Up to 64 bytes
- Up to six times higher throughput**
- Can mix FD and non-FD CAN controllers**
- Can mix FD and non-FD frames**
- Need FD-compliant transceivers above 1Mbps**



# Differences between CAN and CAN-FD

- Remote transmission requests not supported
- Bit to indicate transmitter error status
- Improved error checking
- Bus topology and wiring stays the same
  - Same networking costs



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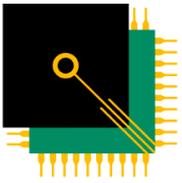
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# CAN-FD PROTOCOL OVERVIEW

CAN-FD  
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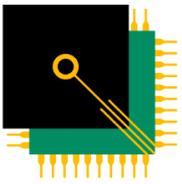


# CAN-FD Protocol Overview

## □ Familiar frame format

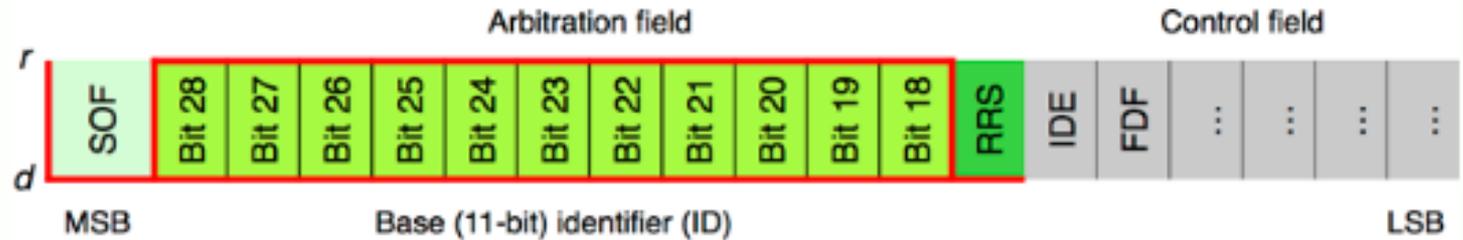
SOF	Arbitration field	Control field	Data field (payload)	CRC field	ACK field	EOF	IMF
1 bit	12 or 32* bit	8 or 9* bit	0 to 64* byte	28 or 33 bit**	2 bit	7 bit	3 bit

MSB LSB



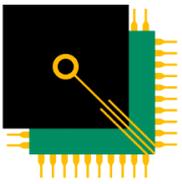
# CAN-FD Protocol Overview

## Arbitration field 11-bit identifier



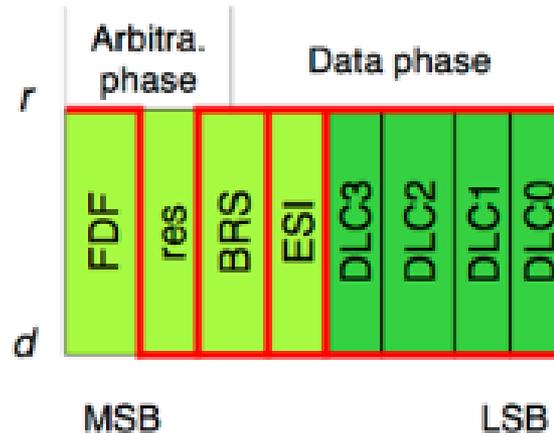
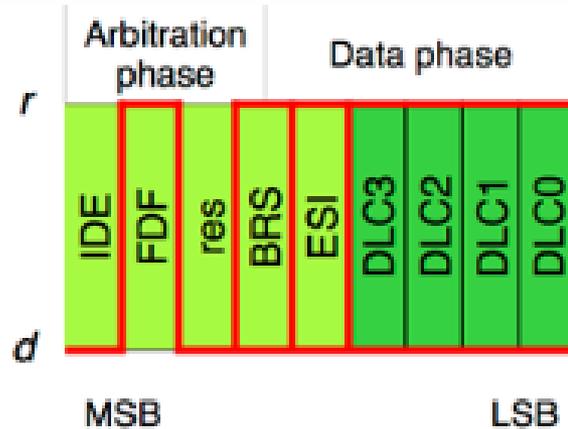
## Arbitration field 29-bit identifier



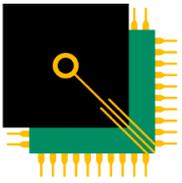


# CAN-FD Protocol Overview

## □ CAN-FD Control field

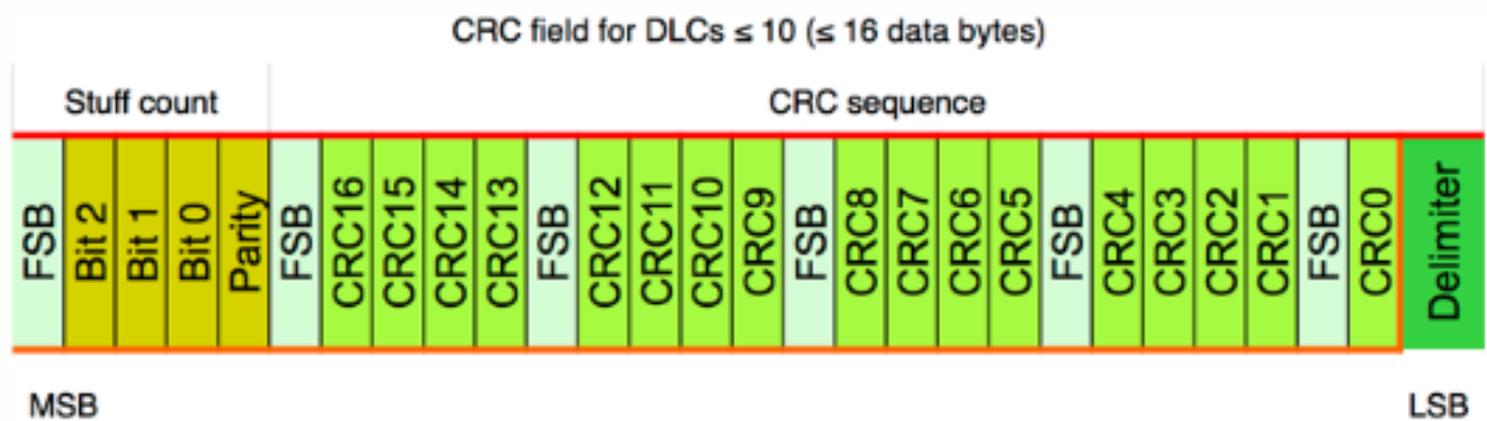


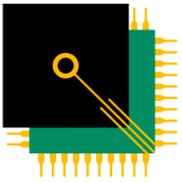
No. of data bytes	Data length code (DLC)			
	DLC3	DLC2	DLC1	DLC0
0 to 8	As in Classical CAN			
12	r	d	d	r
16	r	d	r	d
20	r	d	r	r
24	r	r	d	d
32	r	r	d	r
48	r	r	r	d
64	r	r	r	r



# CAN-FD Protocol Overview

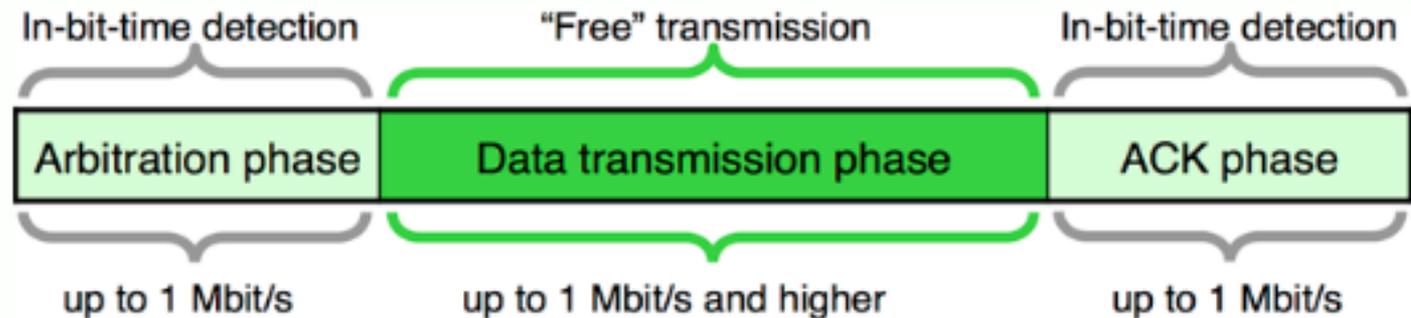
## ❑ CAN-FD Checksum field

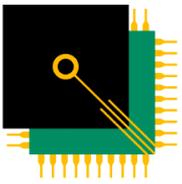




# CAN-FD Protocol Overview

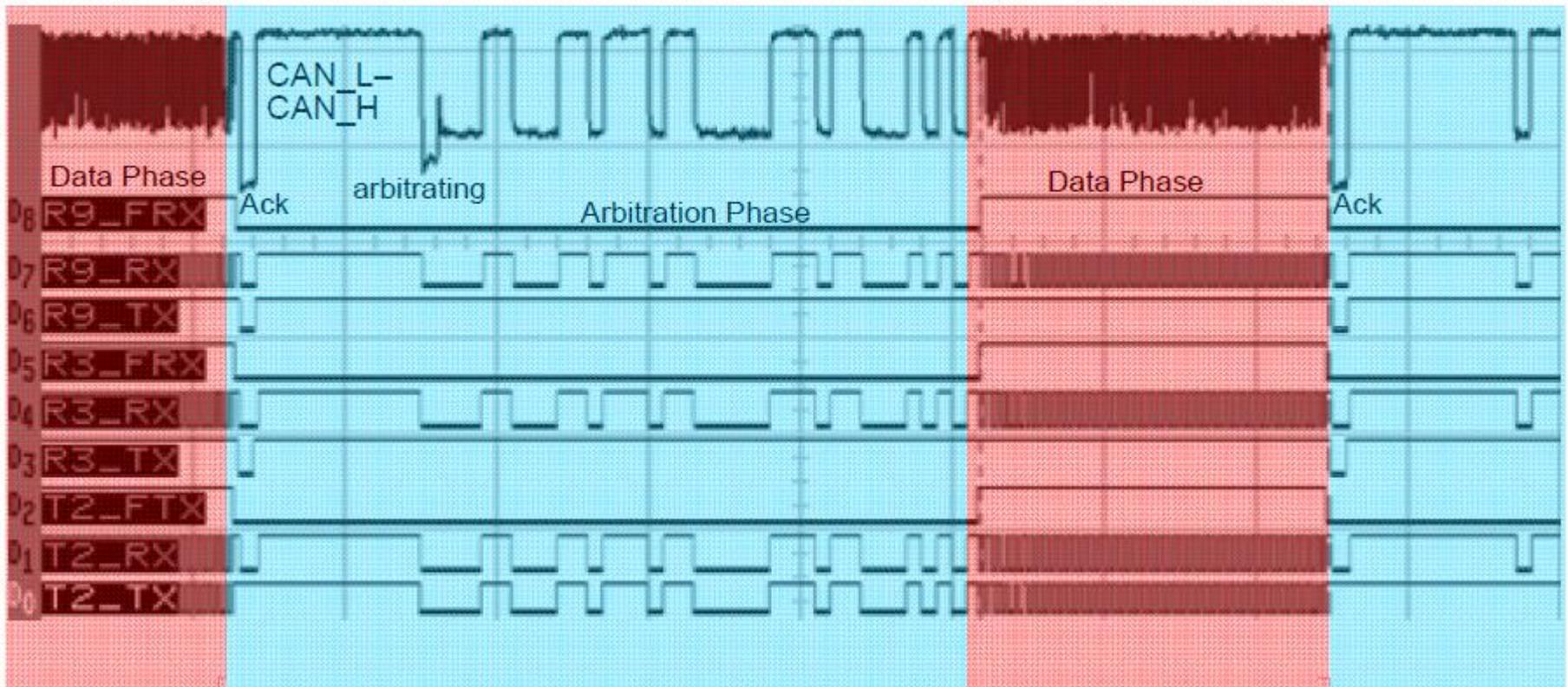
- ❑ “Classical” and “FD” frame formats
- ❑ FDF - Uses previously reserved bit to select FD
- ❑ BRS - bit used to change data bitrate

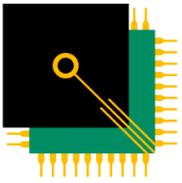




# CAN-FD Protocol Overview

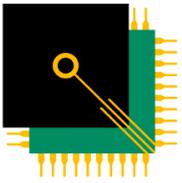
## Scope waveform





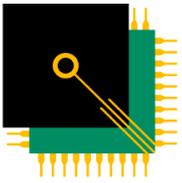
# CAN-FD Protocol Overview

	11-bit ID	29-bit ID	FDF	BRS
Non-FD 11-bit	✓			
Non-FD 29-bit		✓		
FD 11-bit	✓		✓	
FD 11-bit, fast data	✓		✓	✓
FD 29-bit		✓	✓	
FD 29-bit, fast data		✓	✓	✓



# CAN-FD Protocol Overview

- Independent sample points**
- ESI - bit to indicate error status of transmitter**
- Frame includes encoding of number of stuff bits**



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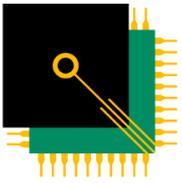
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# CAN-FD ON THE LPC5461X

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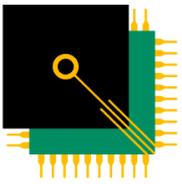
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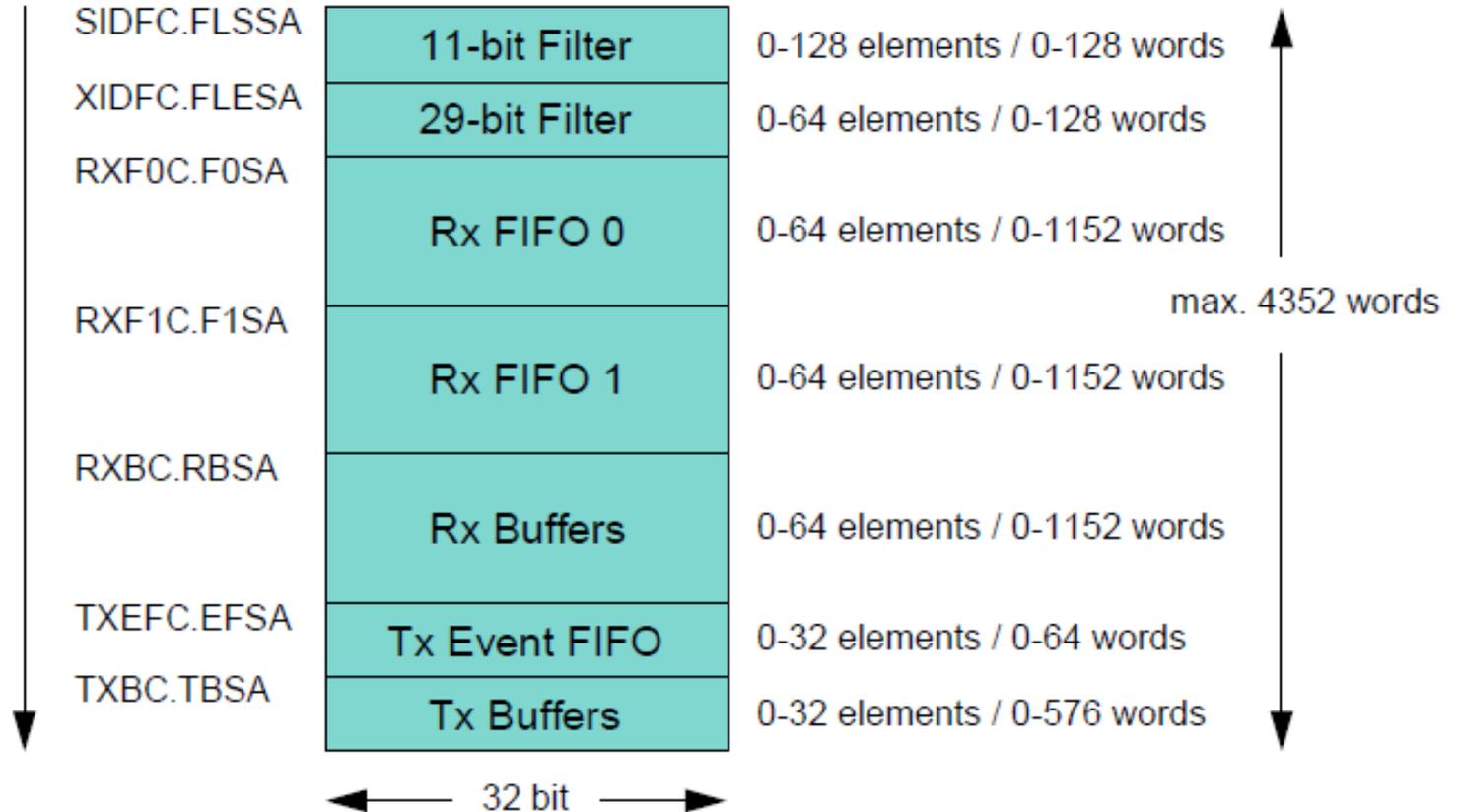
# CAN-FD on the LPC5461x

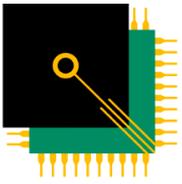
- ❑ **Two CAN controllers**
- ❑ **Conforms to ISO11898-1**
  - Supports CAN-FD ISO mode
  - Supports all CAN-FD functionality
- ❑ **Global FD and bit rate switching enable**
- ❑ **Flexible RAM configuration**
- ❑ **RAM sharing between CAN controllers**
  - Ideal for bridging applications



# CAN-FD on the LPC5461x

Start Address

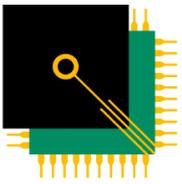




# CAN-FD on the LPC5461x

## Receive

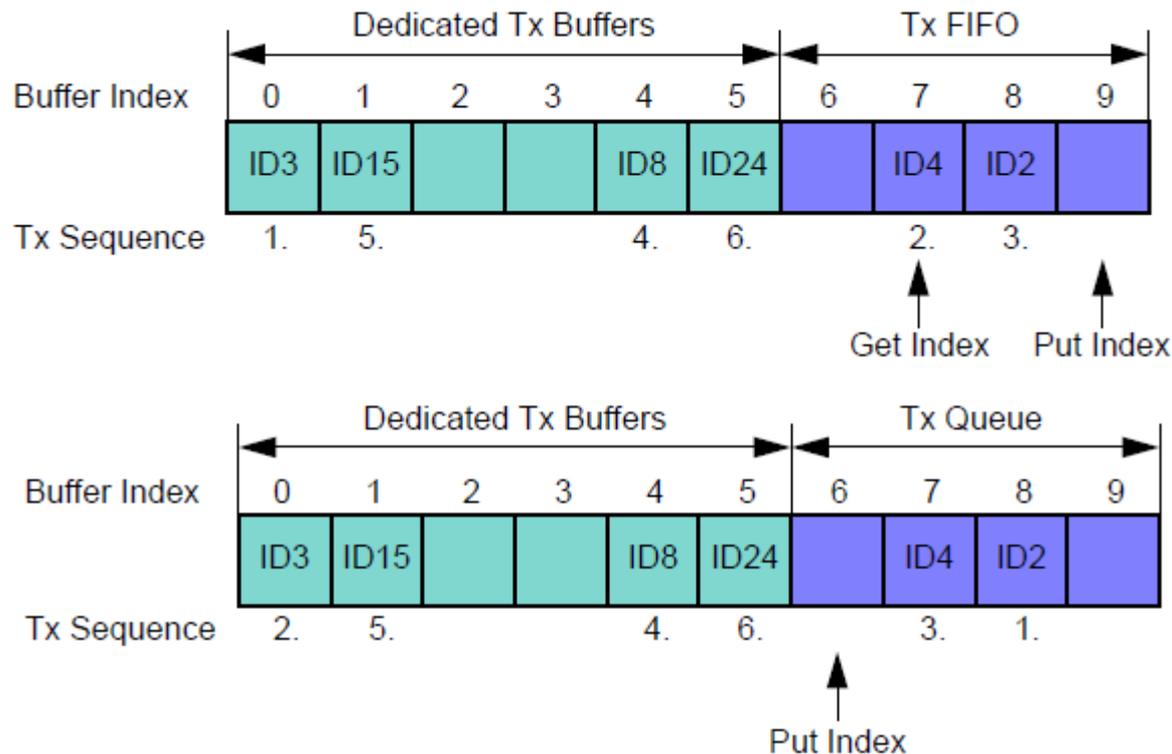
- Two receive FIFOs**
  - Circular or non-circular
  - Configurable fill-level interrupt
  - Configurable size
- 64 dedicated receive buffers**
- Flexible acceptance filtering**
- Global simplified acceptance filtering**
- Timestamping**
- High priority messages**

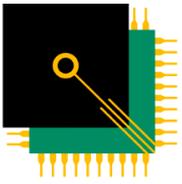


# CAN-FD on the LPC5461x

## Transmit

- ❑ **Transmit FIFO/queue**
  - Configurable size
- ❑ **Up to 32 Transmit buffers**

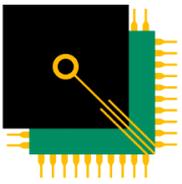




# CAN-FD on the LPC5461x Transmit

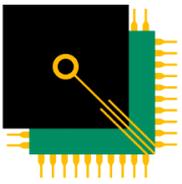
## ❑ Transmit events

- Stored in a FIFO
- Configurable FIFO size
- Timestamps



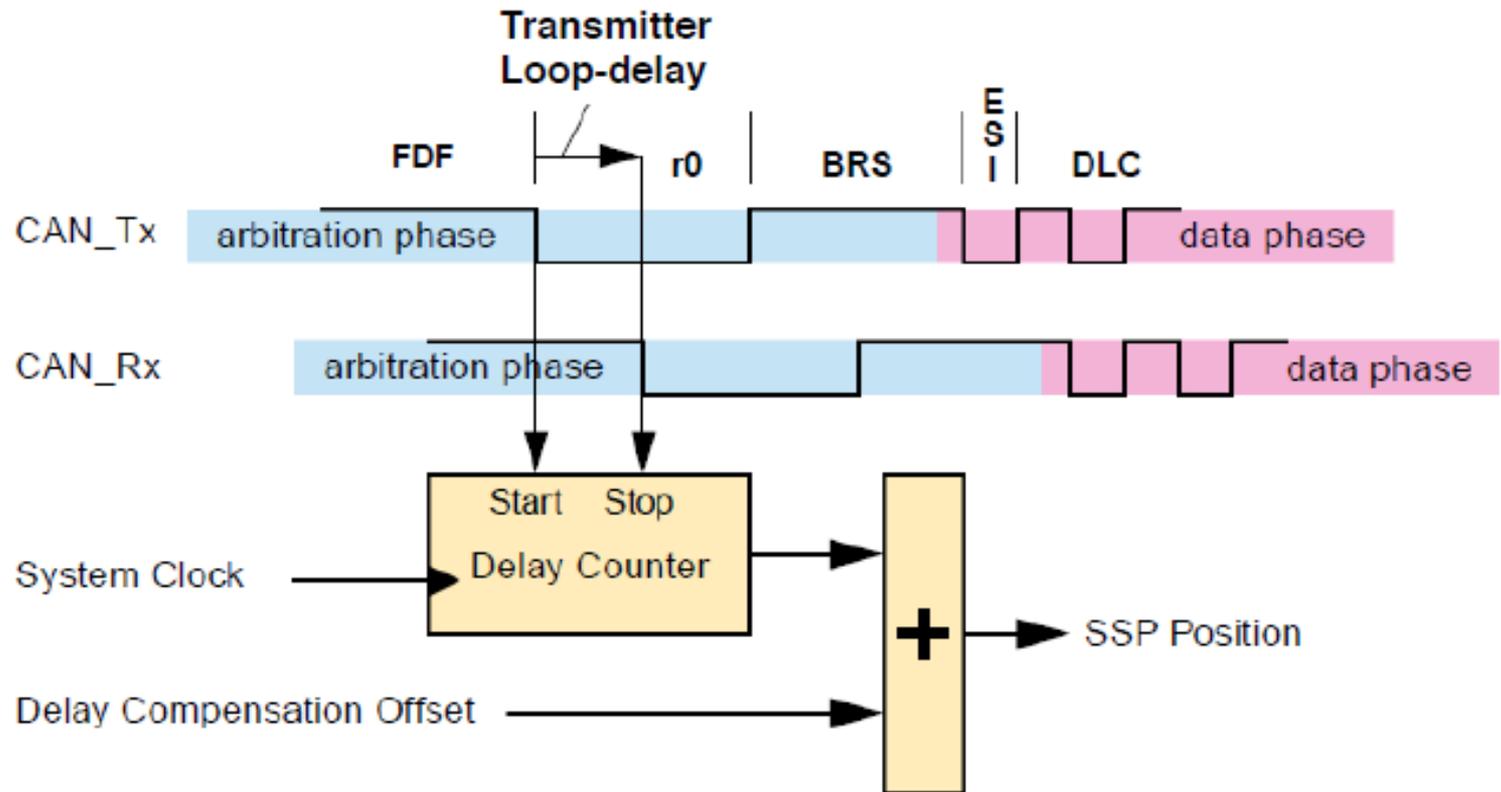
# CAN-FD on the LPC5461x

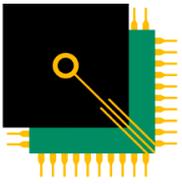
- Dual interrupts per CAN controller**
  - Configurable
- AUTOSAR support**
  - Can be used with other higher layer protocols, e.g. CANopen, J1939
- Test modes**
  - Loopback
  - Pin monitoring
  - Direct pin driving
- Restricted operation**
  - Autobauding
- Power down**



# CAN-FD on the LPC5461x

## ❑ Transmitter delay compensation





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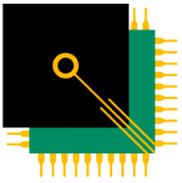
# CAN CONTROLLER BLOCK DIAGRAM

CAN-FD  
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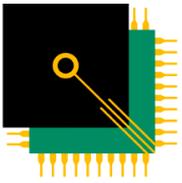
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# CAN-FD APPLICATIONS

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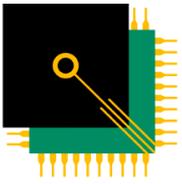
Slide 30





# CAN-FD Applications

- Automotive, Medical**
  - Improved error detection
- Firmware updates**
  - Faster data transfers, lower overhead
- Display data**
  - Better suitability for transferring periodic blocks of data
- Security**
- Data logging**



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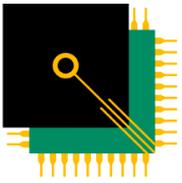
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# CAN-FD SUPPORT

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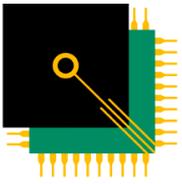
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# CAN-FD Support

- ❑ **Embedded Systems Academy, Inc.**
  - Provides full service support
  - CAN and CAN-FD
  - NXP forums
  - Consulting
- ❑ **CANopen Stack**
- ❑ **CANopen development tools**



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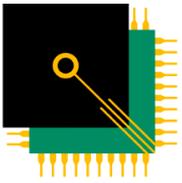
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# SOFTWARE API

CAN-FD  
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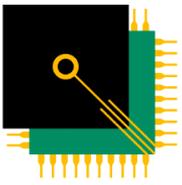
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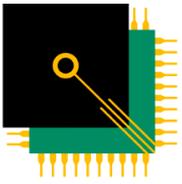
# Software API

- ❑ **Based on the FLEXCAN API for Kinetis K60**
- ❑ **Example**
  - Uses ISO CAN-FD, 64 bytes per frame
  - Uses 1Mbps nominal, 4Mbps data
  - Demonstrates transmit and receive
- ❑ **Setup**
  - NXP LPC5461x evaluation board
  - NXP CAN-FD shield
  - PC CAN-FD interface, e.g PEAK PCAN-USB FD
  - Regular 120 Ohm terminated cable



# Software API Configuration

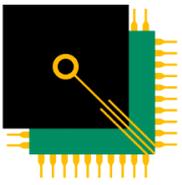
- ❑ **Board\_CAN0\_Init()**
  - Sets up pin multiplexing
- ❑ **CAN\_GetDefaultConfig()**
  - Gets a default configuration by filling in a structure
  - 125kbps nominal and data
  - 0x2001000 RAM base address
  - No RTRs
  - FD enabled
- ❑ **CAN\_Init()**
  - Uses a configuration structure to initialize CAN controller
- ❑ **CAN\_Enable()**
  - Enables CAN controller



# Software API Configuration

## ❑ `can_config_t`

- `nominalBaudRate`
- `dataBaudRate`
- `baseAddress`
- `timestampClock_Hz`
- `rejectStandardRTR / rejectExtendedRTR`
- `enableLoopBack`
- `enableNonISOMode`
- `disableFD`



# Software API

## Receive Configuration

### ❑ **CAN\_SetRxFifoConfig()**

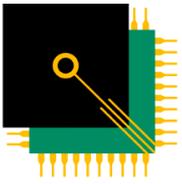
- Sets the size of a receive FIFO and enables the FIFO
- Supports both FIFOs

### ❑ **CAN\_SetRxGlobalMask()**

- Sets the global receive settings to accept all 11-bit or 29-bit messages into a FIFO

### ❑ **CAN\_SetRxIndividualMask()**

- Configures which 11-bit messages can be received into a FIFO or a message buffer
- Selection of destination is by using a macro
  - FLEXCAN\_RX\_FIFO0\_STD\_MASK
  - FLEXCAN\_RX\_FIFO1\_STD\_MASK
  - FLEXCAN\_RX\_MB\_STD

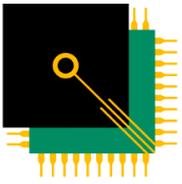


# Software API

## Receive Configuration

### ❑ **CAN\_SetRxExtIndividualMask()**

- Configures which 29-bit messages can be received into a FIFO or a message buffer
- Selection of destination is by using a macro
  - FLEXCAN\_RX\_FIFO0\_EXT\_MASK\_LOW / HIGH
  - FLEXCAN\_RX\_FIFO1\_EXT\_MASK\_LOW / HIGH
  - FLEXCAN\_RX\_MB\_EXT\_LOW / HIGH



# Software API

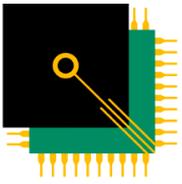
## Transmit configuration

### ❑ **CAN\_SetTxMbConfig()**

- Enables a transmit message buffer

### ❑ **CAN\_TransferCreateHandle()**

- Creates a “handle” for a specific CAN controller
- One handle per CAN controller
- Associates a CAN controller with a callback function

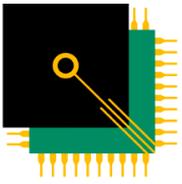


# Software API

## Transmit – Message Buffers

### ❑ **CAN\_TransferSendBlocking()**

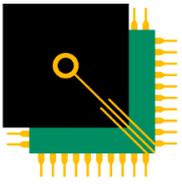
- Transmits a CAN message and waits for it to go out onto the bus
- Uses flexcan\_frame\_t
  - length
  - type
  - format
  - proto
  - bitratemode
  - id
  - dataWord / dataByte



# Software API

## Transmit – Message Buffers

- ❑ **CAN\_TransferSendNonBlocking()**
  - Transmits a message and returns immediately
  - Passed is a handle and the message
  - Callback function called on transmission
    - handle and status
- ❑ **CAN\_TransferAbortSend()**
  - Aborts send

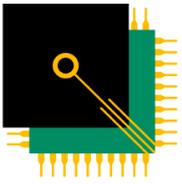


# Software API

## Transmit – FIFO/Queue

### ❑ **CAN\_WriteTxFIFO()**

- Puts a message into the FIFO/queue
- Returns immediately



# Software API

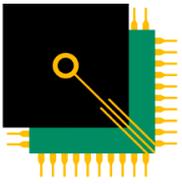
## Receive

### ❑ **CAN\_ReadRx\_FIFO()**

- Polls a FIFO
- Fills in structure if message waiting to be read

### ❑ **CAN\_ReadRxMb()**

- Polls a message buffer
- Fills in structure if message waiting to be read



# Software API

## Receive

### ❑ **CAN\_TransferCreateHandle()**

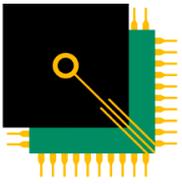
- Creates a “handle” for a specific CAN controller
- One handle per CAN controller
- Associates a CAN controller with a callback function

### ❑ **CAN\_TransferReceiveNonBlocking()**

- Returns immediately
- Passed is a handle and rx structure
  - Message structure
  - Message buffer number
- Callback function called on reception
  - handle and status

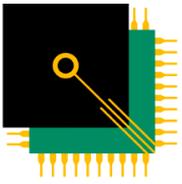
### ❑ **CAN\_TransferAbortReceive()**

- Aborts message buffer receive



# Software API Receive

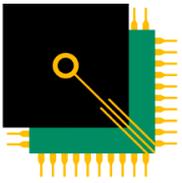
- ❑ **CAN\_TransferReceiveFifoNonBlocking()**
  - Non-blocking receive for FIFOs
- ❑ **CAN\_TransferAbortReceiveFifo()**
  - Aborts FIFO receive



# Software API

## Miscellaneous

- CAN\_DeInit()**
- CAN\_GetBusErrCount()**
- CAN\_GetStatusFlags()**



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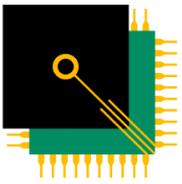
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# SOFTWARE API DEMONSTRATION

CAN  
May 2017

Slide 48





# Where to get started

- ❑ **LPC range of MCUs at [nxp.com/lpc](http://nxp.com/lpc)**
- ❑ **LPCXpresso54618 board at [nxp.com/demoboard/om13094](http://nxp.com/demoboard/om13094)**
- ❑ **CAN-FD driver add-ons under Downloads tab**
- ❑ **Free tools and software at [nxp.com/mcuxpresso](http://nxp.com/mcuxpresso)**

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## LPC546XX: Power-Efficient Microcontrollers (MCUs) With Advanced Peripherals Based on ARM® Cortex®-M4 Core

OVERVIEW DOCUMENTATION SOFTWARE & TOOLS BUY/PARAMETRICS PACKAGE/QUALITY TRAINING & SUPPORT

Jump To  
Overview  
Related Products

### Overview

The LPC546xx MCU family combines the power efficiency of the 180 MHz ARM® Cortex®-M4 core with multiple high-speed connectivity options, advanced timers and analog features. DSP capabilities enable LPC546xx MCU devices to support complex algorithms in data-intensive application. Providing flexibility with up to 512 KB Flash and external memory interfaces, this family provides the ability to adapt as requirements change. Flash options support large, flexible internal and external memory configurations. Compatibility within the LPC54000 series enables the LPC546xx MCU family to provide a seamless migration path for increasing processing power and adding the flexibility of additional advanced peripherals.

Data Sheets

Outline 3d SOT407-1



Related Products

Target Applications

## OM13094: LPCXpresso54618 CAN-FD kit

OVERVIEW GETTING STARTED DOCUMENTATION DOWNLOADS BUY/PARAMETRICS TRAINING & SUPPORT

### Jump To

Overview  
Features  
Community Discussion  
Supported Devices  
Kit Contains

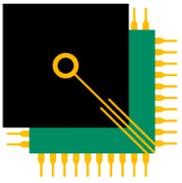
### Overview

The LPCXpresso54618 CAN-FD kit provides a flexible platform for developers wanting to evaluate and develop with CAN-FD on the LPC5461x family of devices. This kit is comprised of an LPCXpresso54618 board featuring an LPC54618 MCU with an on-board, CMSIS-DAP / SEGGER J-Link compatible debug probe, and a daughter card (also known as a shield board) with a dual CAN-FD transceiver and RS232C interface. The on-board probe is compatible with MCUXpresso IDE and other leading toolchains such as those from Keil and IAR. The board is also equipped with a standard 10-pin header enabling the use of 3rd party debug probes. In addition to standard LPCXpresso V3 features, this board includes a complete set of peripheral interfaces to enable developers to fully explore the capabilities of LPC5461x devices.

MCUXpresso configuration tools and extensive SDK drivers/examples for use are available for the board at <http://mcuxpresso.nxp.com>. Note that CAN-FD drivers are not included in SDK2.2 but are available as a separate download under the Downloads tab on this page.

OM13094 LPCXpresso54618 CAN-FD kit





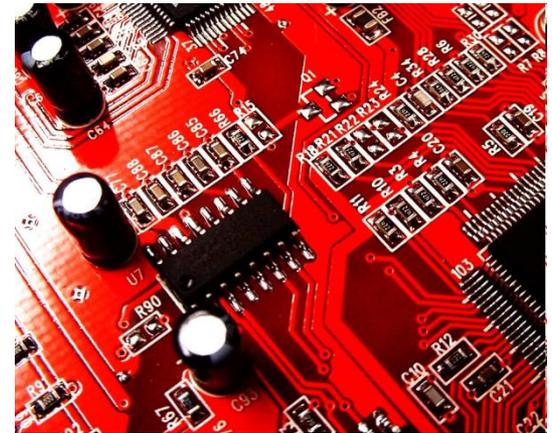
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# Embedded Systems Academy, Inc.

1250 Oakmead Parkway Ste. 210  
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aayre@esacademy.com



**THE  
END**