

## OVERVIEW

This application note demonstrates programming and simulation of the on-chip CAN interface of the Atmel WM T89C51CC01. The T89C51CC01 integrates a full CAN controller that can be programmed and tested using the Keil 8051 development tools.

This application note provides sample source code that can be compiled using the Keil C51 compiler. To test the program you may use the  $\mu$ Vision2 debugger/simulator that is part of the Keil DK51 or PK51 package. Even the Keil PK51 Evaluation Version that is available at [www.keil.com](http://www.keil.com) can be used, since the program of this sample CAN application fits into the limitations of the evaluation version. You may adapt the sample CAN application and re-use it for your own programs.

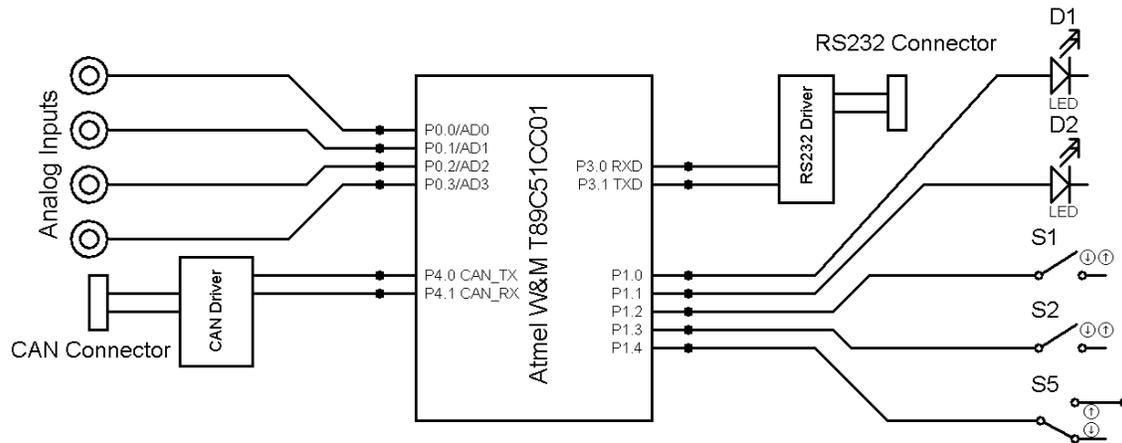
This application note gives you a detailed insight into the usage of the on-chip CAN controller. The sample CAN application uses several different methods to transmit and receive CAN objects:

- Simple send and receive routines that use status polling.
- Interrupt driven send and receive routines.
- Request remote frames and automatically reply to remote frames.

The CAN (Controller Area Network) is a serial bus originally developed for use in automobiles. It is finding additional applications in other areas such as factory automation. The physical layer is usually a differential twisted wire pair. This application note assumes some familiarity with CAN and its associated terminology. Introduction documents on CAN can be accessed through links on the Keil web site ([www.keil.com/can](http://www.keil.com/can)).

## HARDWARE

The sample CAN application can be executed on a single chip device that uses only a few external hardware components. This single chip hardware is shown in the schematic below.



The sample CAN application uses the hardware components as follows:

- The CAN connector is used to connect the board to a CAN bus.
- The push buttons S1 and S2 trigger the outgoing CAN messages.
- The two LEDs signal the status of one of the incoming CAN messages.
- The analog inputs provide input for the remote frames.
- The RS232 connector is used to output text messages.
- The switch S5 configures the CAN ID's so that two identical boards can be connected together.

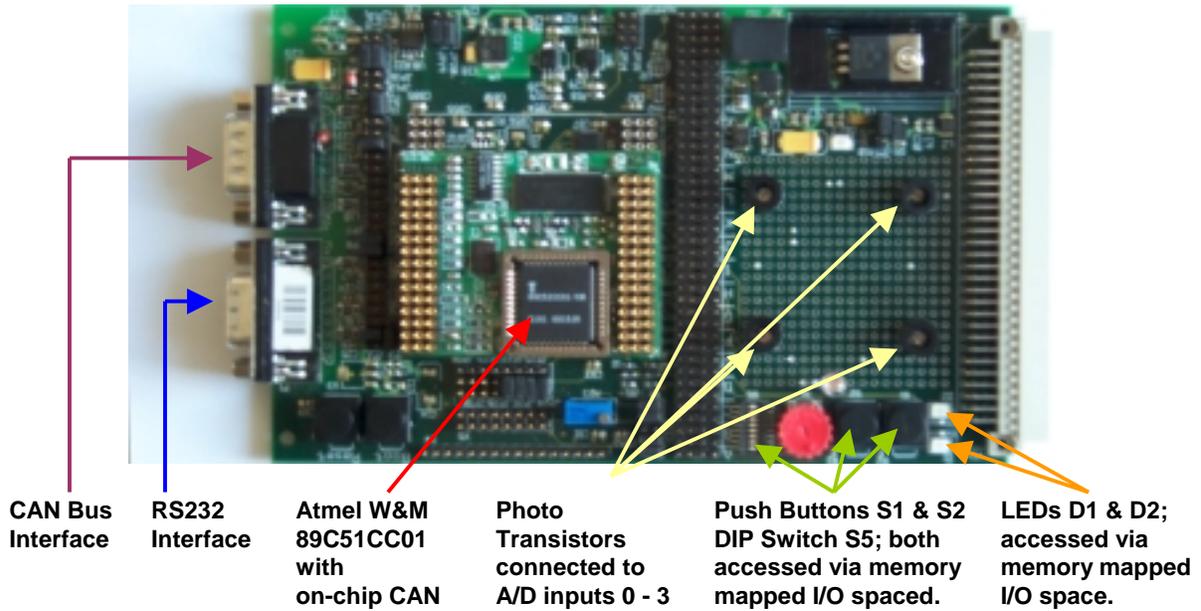
The functions are described in detail under “Re-use of the sample CAN application” on page 4.

If you do not want to create such a system, you may use the  $\mu$ Vision2 simulator to test the sample CAN application without real hardware.

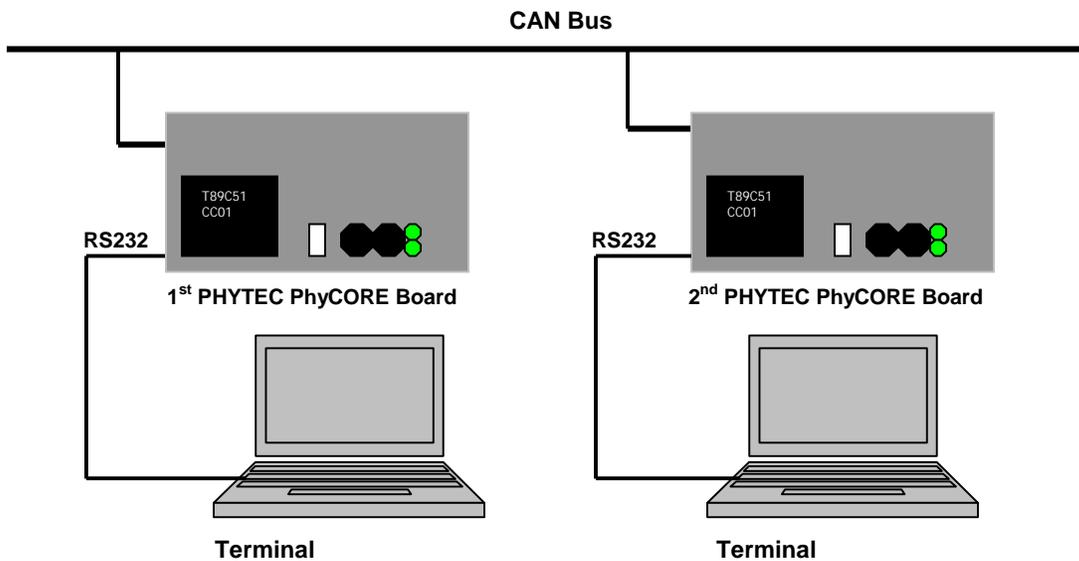
Another alternative is to use pre-build boards, like the PHYTEC PhyCORE T89C51CC01. This standard hardware provides all components needed for running the sample CAN application. Compared to single chip hardware shown before, you need a few software modifications since LEDs and switches are connected to memory mapped I/O ports rather than direct 8051 Port I/O lines.

The sample CAN application that we are supplying, is configured for the PHYTEC PhyCORE T89C51CC01.

The picture below shows the PHYTEC PhyCORE T89C51CC01 board. To provide input for the A/D converter we have connected four photo transistors to the A/D inputs.



To run the sample CAN application you may use two identical hardware boards that are connected via CAN Bus. For text output, each hardware board might be connected to a PC with terminal emulation or a real terminal. The complete hardware is shown below:



## USING THE SOFTWARE

The push buttons S1 and S2 trigger outgoing CAN messages. Any status change of these buttons is transmitted via CAN object 1 to the opposite CAN board. In addition, the push buttons are used to generate additional messages that are listed in the table below:

Button	Description
Press S1	The application will send a long text string over channel 3 in interrupt mode.
Press S2	The application sends a remote frame request over channel 5.

Channel 1 sends the status of the switches S1 & S2 in polling mode.

The two LEDs signal the status of the push buttons S1 and S2 of the opposite CAN board.

The A/D input values AIN0-AIN3 are captured and stored to the automatic reply message object for the remote frame mode. If button S2 on the opposite controller is pressed, this data is requested.

The RS232 connector is used to output text messages. Text messages are the text strings, that are send when pressing S1 or S2. The switch S2 displays the A/D values.

The switch S5 configures the CAN ID's so that two identical boards can be connected together. If the DIP switch is set to a logical 1, the CAN initialization routine in **CAN\_DRV.C** inverts the lowest bit of all CAN message object ID's.

## SOURCE FILES

The following table gives you an overview of the files that are included in this application note:

Filename	Description
<b>CAN_CC01.UV2</b> <b>CAN_CC01.OPT</b>	µVision2 project file that allows you to build and test the sample CAN application.
<b>MAIN.C</b>	Includes the main routine and calls the CAN interface routines.
<b>CAN_DRV.C</b>	Includes the CAN interface routines and configures the message objects including the CAN ID's for the user application.
<b>CAN_DRV.H</b>	Extern definitions for the CAN interface routines.
<b>DEBUGGER.INI</b>	Debug-Script that defines functions for I/O Simulation.

You can build the project within µVision2 with the following commands:

- Open the project file **CAN\_CC01.UV2** with **Project – Open Project**.

- Translate and link the project with **Project – Build Target**. This generates object files, listing files, and the executable program in absolute and Intel HEX format.

```

// ***** CAN Baudrate Calculation *****
// Tactl = (1+BRP)/(XTAL) // f
// Tactl = 2*(1+BRP)/(XTAL) // f
// Tbit = (1 + (PRS+1) + (PHS1+1) +
//
// Examples:

```

```

Build target 'Target 1'
compiling main.c...
compiling Can_drv.c...
linking...
creating hex file from "CAN_CC01"...
"CAN_CC01" - 0 Error(s), 0 Warning(s).

```

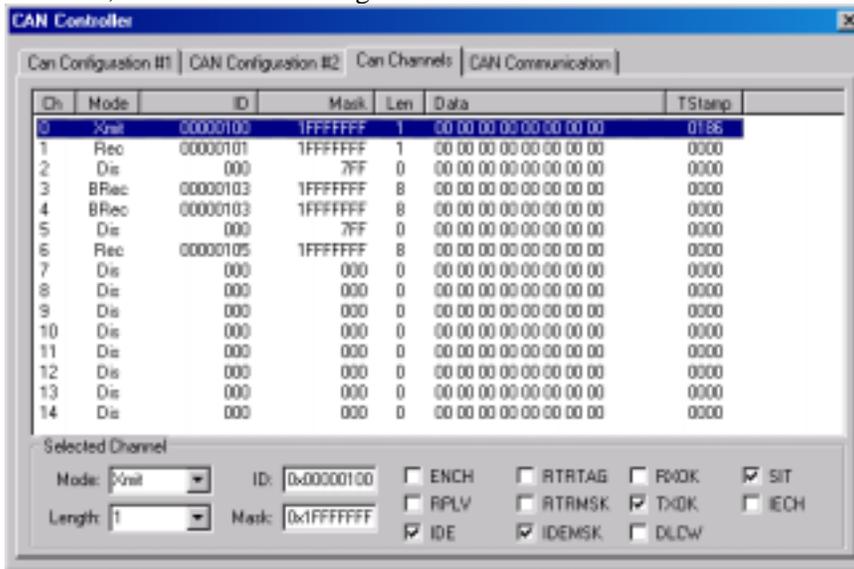
## PROGRAMMING OF THE ON-CHIP FLASH ROM

The executable HEX file can be programmed into the on-chip flash memory of the T89C51CC01 with the FLIP flash tool. The FLIP flash tool is available along with documentation from the Atmel W&M website ([www.atmel-wm.com](http://www.atmel-wm.com)). The setup of the T89C51CC01 for flash programming is described in the T89C51CC01 data sheet. The flash programming on the Phytec board is enabled with Jumper JP2 in position 2+4.

## SIMULATION WITH THE $\mu$ VISION2 DEBUGGER

 Start the  $\mu$ Vision2 simulator with **Debug – Start/Stop Debug Session**.

- $\mu$ Vision2 simulates the behavior of all on-chip peripherals. In case of the Atmel W&M T89C51CC01, also the CAN controller is fully simulated. You can review the status by using the **Peripherals** menu items.
- **Peripherals – CAN** opens the CAN dialog, that shows the CAN configuration, the CAN channels, and the CAN messages that are transmitted via the CAN network.



 The project in this application note includes a **Debugger.INI** file. This file defines  $\mu$ Vision2 debug functions that provide simulation for CAN message I/O. The **Debugger.INI** file is specified under **Options for Target – Debug – Initialization File** and therefore automatically loaded at startup of the  $\mu$ Vision2 simulator. This file defines also Toolbox buttons that allow quick access to the debug functions. The Toolbox opens with **View – Toolbox** and provides the following buttons:

Toolbox Button	Description
<b>Press S1</b>	Simulates a pressed button S1 of the PHYTEC board
<b>Press S2</b>	Simulates a pressed button S2 of the PHYTEC board
<b>Press Both</b>	Simulates two pressed buttons S1 and S2 of the PHYTEC board.
<b>Send Switches = ON</b>	Simulate an incoming "Switches on" status message, which is send with CAN ID 101h;
<b>Send Switches = OFF</b>	Simulate an incoming "Switches off" status message, which is send with CAN ID 101h;
<b>Send Remote Frame</b>	Generates the reply frame for the remote frame, requested by ID 104h
<b>Send 40-Byte String</b>	Send a 5*8 Bytes long string, which is received by buffered channel 3/4 in interrupt mod.

Each toolbox button invokes a debug function that is defined in the **Debugger.INI** file. Details of the CAN simulation with  $\mu$ Vision2 can be found in the Application Note 147, CAN Simulation in  $\mu$ Vision2.

 When you execute the program with **Debug – Go** you can review the CAN traffic in the CAN communication dialog page. By using the Toolbox buttons described above you can generate CAN messages.

- You may use all features of the  $\mu$ Vision2 debugger. You may single-step through the code or set breakpoints. You can use the memory windows, the performance analyzer, the code coverage feature, or just view some variables.

The content of the file **DEBUGGER.INI** is listed below. The functions of this file are available during debugging. This **.INI** file is automatically loaded at start of a debug session since it is specified under **Options for Target – Debug**.

```

/* =====DEBUGGER.INI=====
 * Contains debug functions for the sample CAN project (App_Nt 165).
 *
 * - PressSwitch enables simulation of buttons on memory mapped I/O
 * - CANMessage prints message information of send messages
 * - SendInfo sends 8Byte messages on a arbitrary ID
 * - SimTraffic simulates sending of messages in a short interval
 *
 * =====
 */

/*
 * Simulate a 0.1 Second Click on Switch I/O Port (for S1 & S2)
 */
SIGNAL void PressSwitch (unsigned char v) {
    unsigned char cx;

    cx = _rbyte (X:0xFFA0); // get current value on I/O Port
    _wbyte (X:0xFFA0, cx | v); // set I/O Port value for switch v
    swatch (0.1); // press switch for 0.1 seconds
    cx = _rbyte (X:0xFFA0); // get current value on I/O Port
    _wbyte (X:0xFFA0, cx & (~v)); // reset I/O Port value switch v
}

/*
 * Define Buttons for the toolbox with presets for PressSwitch
 */
define button "Press S1", "PressSwitch (1)"
define button "Press S2", "PressSwitch (2)"
define button "Press Both", "PressSwitch (3)"

/*
 * Print the last message sent by the controller
 */
FUNC void CANmessage (void) {
    switch (CAN0OUT) {
        case 1: printf("\nSend Message (11-bit ID=%04X)", CAN0ID); break;
        case 2: printf("\nSend Message (29-bit ID=%08X)", CAN0ID); break;
        case 3: printf("\nRequest Message (11-bit ID=%04X)", CAN0ID); return;
        case 4: printf("\nRequest Message (29-bit ID=%08X)", CAN0ID); return;
    }
    printf("\nMessage Length %d, Data: ", CAN0L);
    printf("%02X %02X %02X %02X ", CAN0B0, CAN0B1, CAN0B2, CAN0B3);
    printf("%02X %02X %02X %02X\n", CAN0B4, CAN0B5, CAN0B6, CAN0B7);
}

```

```

/*
 * Set Breakpoint on CAN Output VTREG
 */
BS WRITE CAN0OUT, 1, "CANmessage()"

/*
 * Send Information on any ID
 */
FUNC void SendInfo (unsigned long id,      // message ID
                   unsigned char len,    // message length
                   unsigned char val) { // 1. value byte

    CAN0ID = id;      // Set VTREG that keeps next ID
    CAN0L  = len;     // Set VTREG with message length
    CAN0B0 = val;     // Set the data registers
    CAN0B1 = val+1;
    CAN0B2 = val+2;
    CAN0B3 = val+3;
    CAN0B4 = val+4;
    CAN0B5 = val+5;
    CAN0B6 = val+6;
    CAN0B7 = val+7;
    CAN0IN = 2;      // Send message to simulated controller
}

/*
 * Send 5 messages in short intervals on ID 103h
 */
SIGNAL void SimTraffic (void) {
    int i;
    for (i=0; i<=5; i++) {
        SendInfo(0x103,8,'0'+(i*8)); // Send CAN message on ID 103h
        swatch(0.00025);             // wait 0.00025sec before next message is send
    }
}

/*
 * Define Buttons for the toolbox for easy access to SendInfo and SimTraffic
 */
define button "Send Switches = ON", "SendInfo(0x101,1,0x30)"
define button "Send Switches = OFF", "SendInfo(0x101,1,0x00)"
define button "Send Remote Frame", "SendInfo(0x104,8,0x00)"
define button "Simulate Reception Traffic", "SimTraffic()"

```

## RE-USE OF THE SAMPLE CAN APPLICATION

The files **candrv.h** and **candrv.c** of this application note can be re-used in your own CAN projects. The can driver provides the following functions:

Functions	Description
<b>CanInit</b>	Initialization of the CAN Controller.
<b>CanSend</b>	Sends a message over a channel. The message length must not exceed channel definition
<b>CanRead</b>	Reads a message received by a channel. The message length is specified in the channel definition.
<b>CanSendIsr</b>	Interrupt driven Send Routine.
<b>CanReadIsr</b>	Interrupt driven Receive Routine.
<b>CanInterrupt</b>	The interrupt service routine for the CAN Controller.

The file **candrv.c** needs to be adapted for your application as described below:

- The section CAN ID definitions specifies the CAN message objects.
- The table **id\_typ** needs entries for all CAN message objects.
- Under CAN baud rate calculation you can configure the baud rate of the CAN bus.
- In the function **CanInit** all CAN message objects need to be initialized.
- Adapt the interrupt driven CAN I/O routines to the requirements of your application.
- To add or remove interrupt driven CAN message objects, adapt the function **CanInterrupt**.

The include file **can\_drv.h** enables you to access the functions of the file **candrv.c** in own source files.

## CONCLUSION

This sample CAN application shows that the implementation of a CAN interface is straightforward. The application note also shows most features of that T89C51CC01 CAN controller. You may adapt this sample CAN application for your own software projects. You may also convert this application software for other on-chip CAN controllers.

The Keil 8051 development tools allow you fast and reliable development of complete applications. With the  $\mu$ Vision2 simulator you can debug the application without real hardware.  $\mu$ Vision2 simulates the behavior of all on-chip peripherals, including complex peripherals like the CAN controller and the A/D converter. In fact, this sample CAN application was completely tested with the simulator before we checked it in real hardware.

This application note uses the  $\mu$ Vision2 debug functions to simulate external hardware components as well as CAN communication. Specific information on CAN simulation can be found in **Application Note 147 “CAN Simulation in  $\mu$ Vision2”**.

It is even possible to extend the build-in peripherals of  $\mu$ Vision2 with custom define peripherals. This is described in the **Application Note 154 “Implementing  $\mu$ Vision2 DLLs for Simulating User Defined Hardware”**.

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