

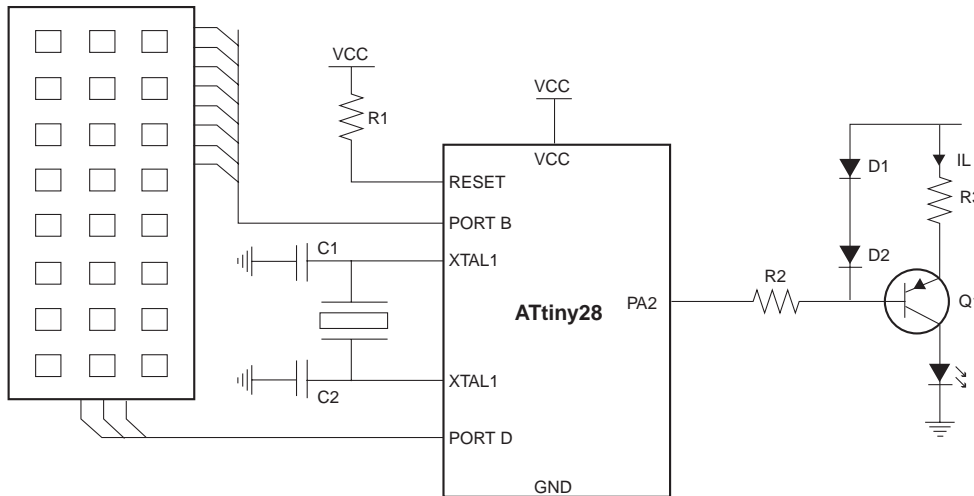


# AVR415: RC5 IR Remote Control Transmitter

## Features

- Utilizes ATtiny28 Special HW Modulator and High Current Drive Pin
- Size Efficient Code, Leaves Room for Large User Code
- Low Power Consumption through Intensive Use of Sleep Modes
- Cost Effective through Few External Components

Figure 1. RC5 Transmitter



## Introduction

Use of IR (infrared) light as a method for wireless communication has become popular for remote control applications. There are a number of different standards for such communication. In this application note the widely used RC5 coding scheme from Philips will be described, and a fully working remote control solution will be presented. This application will use the ATtiny28 AVR microcontroller for this purpose. This powerful unit contains a hardware modulator, a high current LED driver and interrupt options which makes it especially well suited for these kinds of applications.

Figure 2. RC5 Frame Format

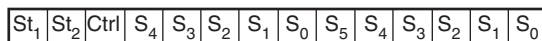


Figure 3. Bi-phase Coding



8-bit **AVR**<sup>®</sup>  
Microcontroller

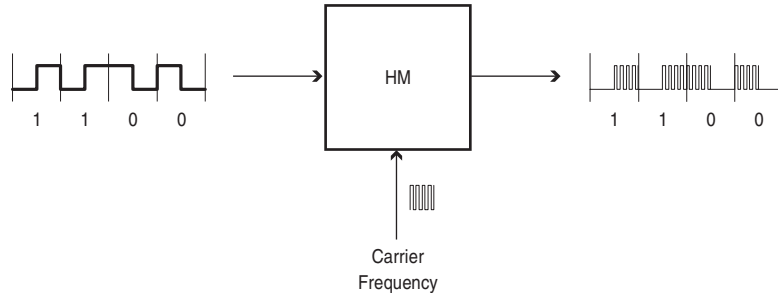
Application  
Note



**Figure 4.** Example of Transmission



**Figure 5.** Signal Before and After Modulation



## RC5 Coding Scheme

The RC5 code is a 14-bit word bi-phase coded signal (see Figure 2). The two first bits are start bits, always having the value “1”. The next bit is a control bit, which is toggled every time a button is pressed on the remote control transmitter. This gives an easy way of determining whether a button is pressed and held down, or pressed and released continuously. Five system bits hold the system address so that only the right system responds to the code. Usually, TV sets have the system address 0, VCRs the address 5 and so on. The command sequence is six bits long, allowing up to 64 different commands per address. The bits are transmitted in bi-phase code (also known as Manchester code) as shown in Figure 3. An example where the command 0x35 is sent to system 5 is shown in Figure 4. Note that Figure 3 and Figure 4 show the signal that enters the ATtiny28 hardware modulator. The actual signal emitted by the IR-LED will be modulated with a certain carrier frequency as shown in Figure 5.

## ATtiny28: The Ideal Solution for Intelligent Remote Control Systems

ATtiny28 is a low cost, high-performance 8-bit AVR RISC microcontroller with a number of features that makes it well suited for remote control applications. The built-in hardware modulator eases the task of generating the carrier frequency on which a data signal can be modulated. Frequency and duty-cycle are both easily changed by modifying the value residing in the Modulation Control Register MODCR. The high current driver on pin two of port A (PA2) is capable of driving a LED with a minimum of external components. This reduces size and system cost. In Power-down mode, the microcontroller can be configured to wake up on a low level from any pin on Port B. This provides an easy solution for waking up, scanning the keyboard, sending the command and returning to Power-down mode. This application implements an easy keyboard scanning routine using Port B and Port D.

## Implementation

Figure 1 shows the complete schematics for a remote control transmitter. The 455 kHz resonator gives the application a reliable and flexible clock base. The external LED driver circuit provides a constant current for the IR-LED. Resistor R3 determines the driver strength, and is in this application chosen to 7Ω giving a drive capability of approximately 100 mA. Higher resistor values will reduce current, and lowering the resistor value will increase driver strength. The diodes, D1 and D2, are present to ensure a close to constant driving current and to compensate for temperature variations in the transistor.

In this application note two different implementations will be presented; One low cost solution requiring only a minimum of external components, and one using an external resonator and circuitry for driving the LED. The supplied code will work for both designs.

## Low Cost Implementation

For cost sensitive applications with high tolerance on accuracy, a solution utilizing the internally calibrated RC Oscillator of the ATtiny28 could be used. The high current drive capabilities of PA2 can sink the LED directly giving a solution with only a few external components as shown in Figure 6.

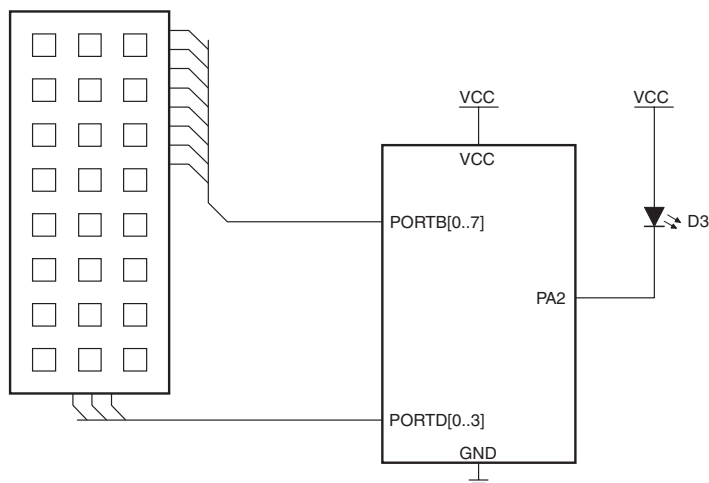
By using an external resonator and a driver circuit for the LED, a more flexible solution is achieved.

The main advantage is higher driver capabilities and higher frequency stability over voltage range. If however the receiver is self-synchronized, it will adapt to the changing frequency of the transmitter, and a solution using the internal RC Oscillator could be used with good results.

**Table 1.** Components

	Type	Comment
R1	3 kΩ	External pull-up resistor present to make the system less susceptible to external noise. Without this component, noise might Reset the microcontroller.
R2	3 kΩ	$R2 = \frac{V_{CCmin} - 1,4}{2I_L} \beta$
R3	7Ω	$R3 = 0.7/I_L$
C1	100 pF	Resonator dependant
C2	100 pF	Resonator dependant
D1	1N4148	Small signal diode
D2	1N4148	Small signal diode
D3		IR LED
Q1	BC807-40TD	$I_{MAX} = 0,5A, \beta = 250 - 600$
Xtal	455 kHz	Resonator

**Figure 6.** Lowcost RC5 Transmitter



## The Software

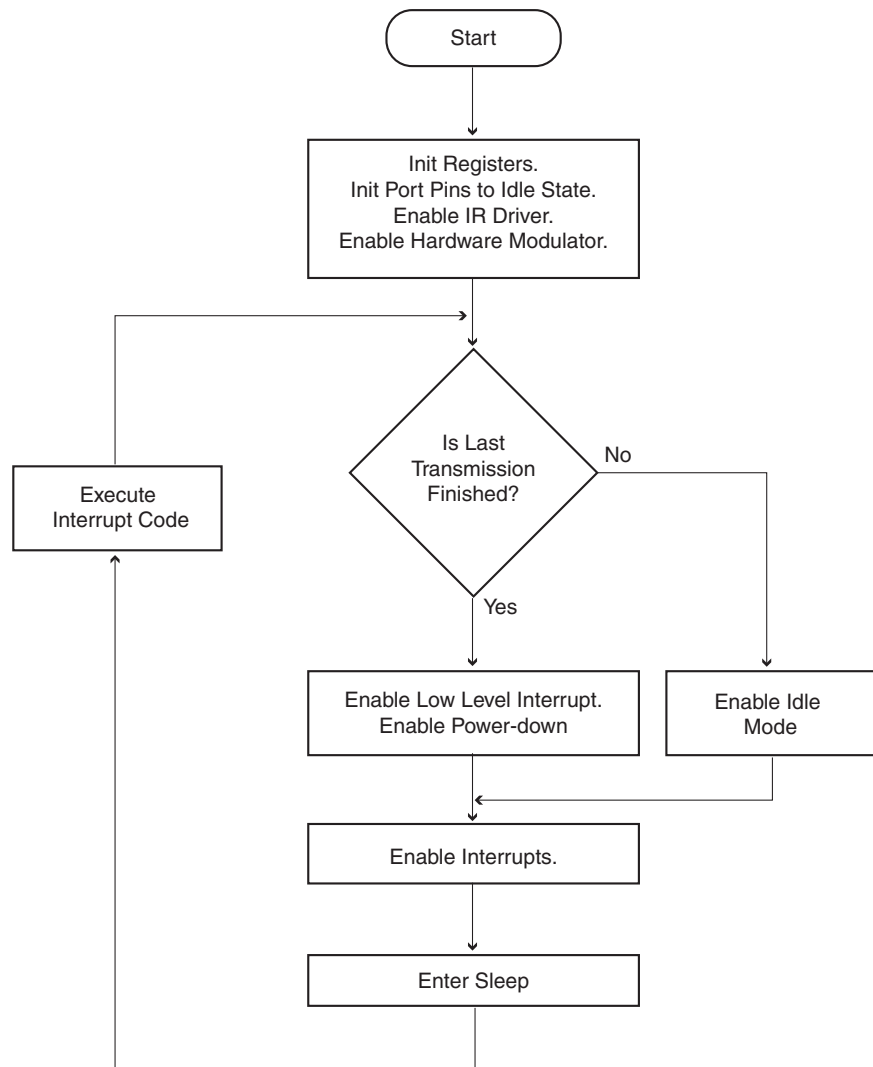
The assembly code found in the AVR415.ASM file contains the latest RC5 Transmitter software.

The main program flow is shown in the flowchart in Figure 7. The program execution can be divided into two routines. Both of them are interrupt driven, and use different Power-down modes to reduce power consumption. The program is designed to use only one level of hardware stack, leaving two levels for user code.

## Main

The main program loop is shown in Figure 7. First all registers are initiated; The hardware modulator is configured for correct frequency and duty-cycle. In this application 38 kHz is used as the carrier frequency. This differs from the RC5 standard, which specifies 36 kHz for the carrier wave. The RC5 signal will however be the same, and most standard RC5 Receivers should have no problem receiving and decoding the signal. Once the IO modules are initialized the purpose of the main loop is to decide what sleep mode to use after the next wake-up.

**Figure 7.** Main Loop Flowchart



The program execution can roughly be divided into two states: “Transmitting a RC5 code” and “Waiting for a key to be pressed”. While waiting for a key to be pressed, the ATtiny28 is put in Power-down mode. In this mode the current consumption for the device is at a minimum, and the wake-up time is slightly longer than for the Idle mode. Since the wake-up condition is caused by physically pressing a key, the longer wake-up time will not cause a noticeable delay in the system.

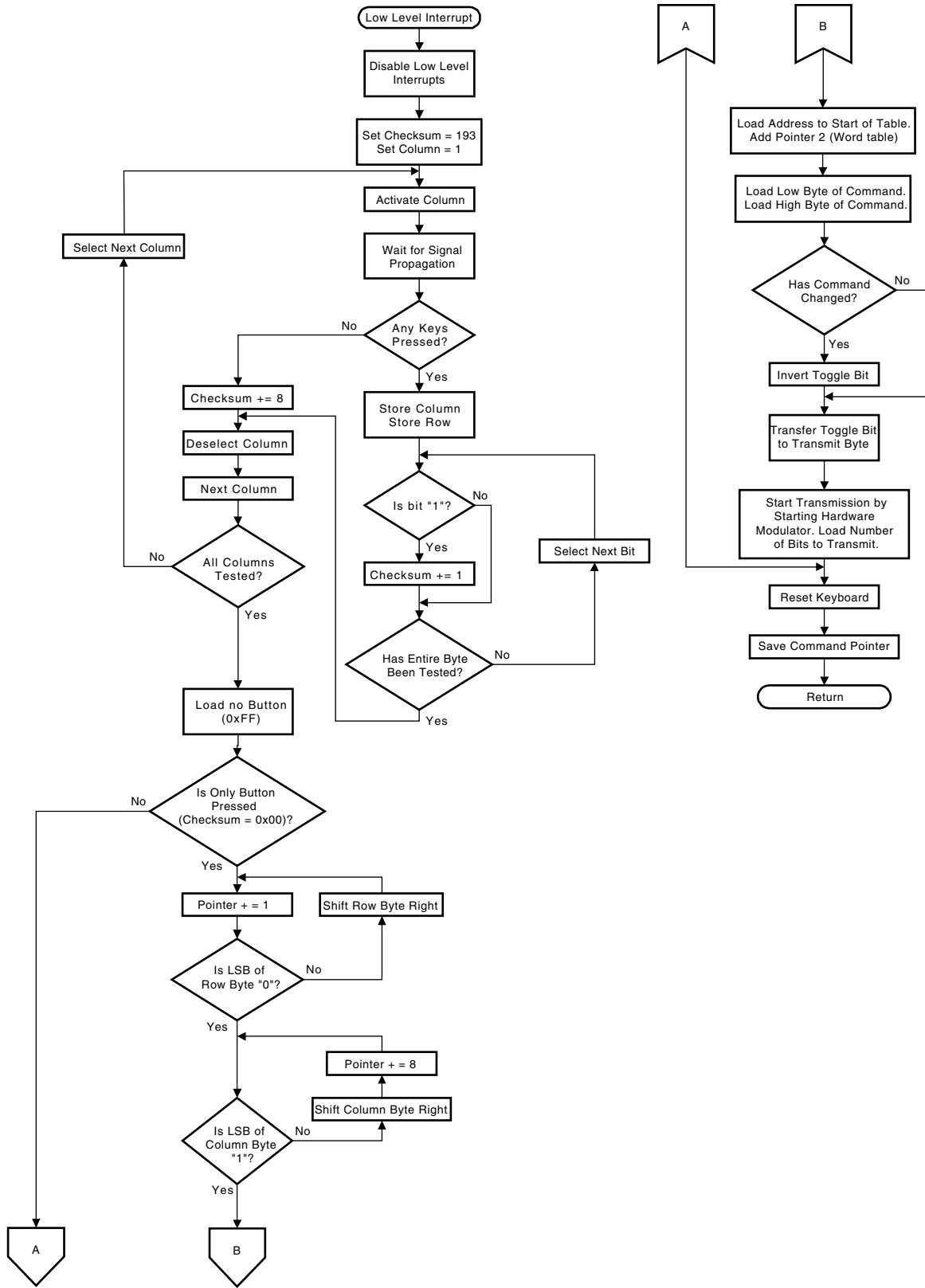
## Low Level Interrupt

When the ATtiny28 is in Power-down mode, a low level on any of the Port B pins will generate a Low Level interrupt, waking the device and executing the code illustrated by the flowchart in Figure 8. The main purpose of this routine is to scan through the keyboard, and determine if a valid key is pressed. If two or more buttons are pressed simultaneously the routine returns the value 0xFF indicating an error. The “checksum” ensures that 63 of 64 combinations of row and column lines are high – that only one unique combination, representing the key, is low.

If only one key is pressed, the column and row bit pattern is decoded into a pointer, which is used to perform a look-up in the Command table.

Further, the Low Level interrupt also controls the toggling of the control bit, indicating if a new “instance” of a command is present, or if the “same” command should be retransmitted. At the end of this routine, the hardware modulator is started preparing the transmission.

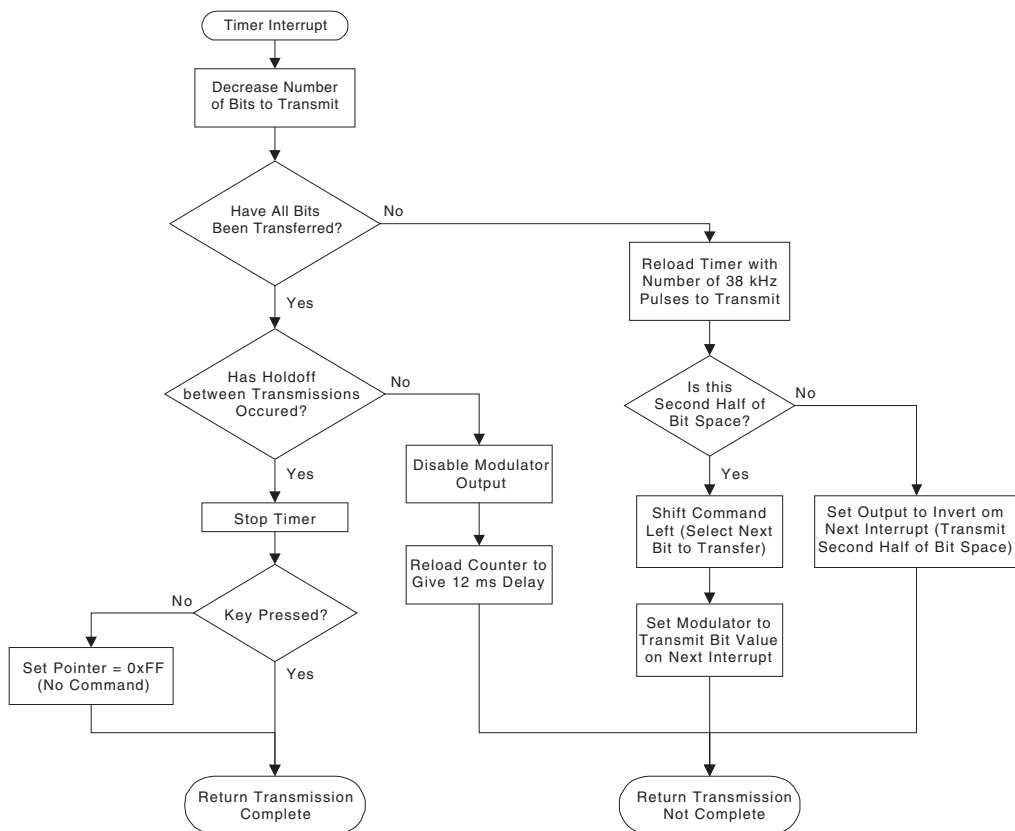
Figure 8. Low Level Interrupt Flowchart



## Timer Interrupt Routine

Figure 9 shows the flowchart for the Timer Overflow interrupt. The main task of the Timer Interrupt routine is to keep track of the bit pattern that will be modulated on the IR-LED, i.e., make sure that the transmitted signal is in accordance with the bi-phase coding scheme. Once a complete frame has been transmitted, the routines also generate a necessary delay before a new transmission is to be started.

**Figure 9.** Timer Overflow Interrupt Flowchart



## Summary

This application note describes how to make a simple RC5 Transmitter. Due to the flexible hardware of the ATtiny28, other IR coding schemes could easily be implemented. It is also possible to change the duty cycle of the transmitted signal, further decreasing the power consumption and thus extending battery life.

This application note acts as a foundation upon where the user can implement features giving a power efficient intelligent Remote Control Transmitter.



## Atmel Corporation

2325 Orchard Parkway  
San Jose, CA 95131  
Tel: 1(408) 441-0311  
Fax: 1(408) 487-2600

## Regional Headquarters

### Europe

Atmel Sarl  
Route des Arsenaux 41  
Case Postale 80  
CH-1705 Fribourg  
Switzerland  
Tel: (41) 26-426-5555  
Fax: (41) 26-426-5500

### Asia

Room 1219  
Chinachem Golden Plaza  
77 Mody Road Tsimshatsui  
East Kowloon  
Hong Kong  
Tel: (852) 2721-9778  
Fax: (852) 2722-1369

### Japan

9F, Tonetsu Shinkawa Bldg.  
1-24-8 Shinkawa  
Chuo-ku, Tokyo 104-0033  
Japan  
Tel: (81) 3-3523-3551  
Fax: (81) 3-3523-7581

## Atmel Operations

### Memory

2325 Orchard Parkway  
San Jose, CA 95131  
Tel: 1(408) 441-0311  
Fax: 1(408) 436-4314

### Microcontrollers

2325 Orchard Parkway  
San Jose, CA 95131  
Tel: 1(408) 441-0311  
Fax: 1(408) 436-4314

### La Chantrerie

BP 70602  
44306 Nantes Cedex 3, France  
Tel: (33) 2-40-18-18-18  
Fax: (33) 2-40-18-19-60

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13106 Rousset Cedex, France  
Tel: (33) 4-42-53-60-00  
Fax: (33) 4-42-53-60-01

1150 East Cheyenne Mtn. Blvd.  
Colorado Springs, CO 80906  
Tel: 1(719) 576-3300  
Fax: 1(719) 540-1759

Scottish Enterprise Technology Park  
Maxwell Building  
East Kilbride G75 0QR, Scotland  
Tel: (44) 1355-803-000  
Fax: (44) 1355-242-743

### RF/Automotive

Theresienstrasse 2  
Postfach 3535  
74025 Heilbronn, Germany  
Tel: (49) 71-31-67-0  
Fax: (49) 71-31-67-2340

1150 East Cheyenne Mtn. Blvd.  
Colorado Springs, CO 80906  
Tel: 1(719) 576-3300  
Fax: 1(719) 540-1759

### Biometrics/Imaging/Hi-Rel MPU/ High Speed Converters/RF Datacom

Avenue de Rochepleine  
BP 123  
38521 Saint-Egreve Cedex, France  
Tel: (33) 4-76-58-30-00  
Fax: (33) 4-76-58-34-80

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### e-mail

[literature@atmel.com](mailto:literature@atmel.com)

### Web Site

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