AVR® ATICE10

User Guide

ATMEL®

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Section 1

Introduction

Figure 1-1. ATICE10

Congratulations on your purchase of the ATICE10 AVR® In-Circuit Emulator (ICE). ICE10™ is a high-end emulator designed to provide a complete, and easy to use, development and debug environment for the AVR Flash microcontrollers from Atmel Corporation.

1.1 About this Manual

This user guide serves as a reference manual for the Atmel AVR ICE10 in-circuit emulator. The AVR ICE10 User Guide is an easy introduction on how to use the ICE10, and a detailed reference for advanced users. Throughout the manual, many references to the AVR microcontrollers are made in short form, i.e. AT90S2313 is referred to as S2313 and so on.

1.2 General Description

The Atmel AVR ICE10 is a real-time in-circuit emulator for a wide range of AVR devices. The ICE10 is controlled by AVR Studio®, version 3.5 or later.

1.3 ICE10 Features

- Devices Supported: ATtiny11, ATtiny12, ATtiny15, ATtiny22, ATtiny28 AT90S1200, AT90S2313, AT90S/LS2323, AT90S/LS2343, AT90S/LS2333, AT90S/LS4433, AT90S4414, AT90S8515, AT90S/LS4434, AT90S/LS8535
- Emulates all On-Chip Functions, both Digital and Analog
- Trace Buffer (32K x 96-bit)

- Unlimited Number of Breakpoints
- Full Visibility of and Access to Register File, SP, PC and Memories
- Access to all I/O Registers
- Logic Analyzer Interface Output
- Supports Assembler and C Source Level Debugging
- 5 Trigger Outputs
- 5 Trigger Inputs
- Internal and External Clock Options
- External Data Memory Emulation
- 2.7 - 6.0V Operating Voltage
- Software Upgradable for Future AVR Devices

1.4 ICE10 Contents

The ATICE10 Contains the Following Items:

- ICE10 In-Circuit Emulator Unit
- Pod Card ATtiny15POD with Cables
- Pod Card AT90ADCPOD with Cables
- RS-232 Cable
- Universal Voltage Power Supply (100 - 240V, 50 - 60 Hz)
- American Power Cable
- European Power Cable
- Atmel CD-ROM Containing Software
- ATICE10 User Guide
- Warning Note

1.5 System Requirements

For the ICE10 to operate correctly and trouble free, the following software and hardware requirements should be met.

1.5.1 Hardware Requirements

Pentium-class personal computer with:

- 32 MB RAM
- 20 MB free hard disk space
- CD-ROM or Internet access (for software and databooks)
- VGA monitor
- 19200 bps RS-232 port (COM port)

1.5.2 Software Requirements

The following operating systems are currently supported by AVR Studio:

- Windows® 95
- Windows 98 (SE) (ME)
- Windows NT® 3.51
- Windows NT 4.0
- Windows 2000

1.5.3 Operating Conditions

- Operation Temperature: 0^oC - 70^oC
- Operating Humidity: 10 - 90% RH (non-condensing)

1.5.4 Host Interface

- RS-232C @ 19200 bps, N81
- 9-pin female connector

Section 2

Preparing the ICE10 System for Use

For successful operation, the ICE10 must be connected and configured correctly. This section explains how to connect the system, and how to determine which Pod to use to successfully emulate a specific AVR part.

2.1 General Hardware Description

Figure 2-1 shows a simplified block diagram of the ICE10 connected to a target board. Once the emulator is connected and configured correctly, it will behave like the emulated device, and allows easy prototyping and debugging of applications in real-time.

Figure 2-1. ICE10 Connected to Target Board

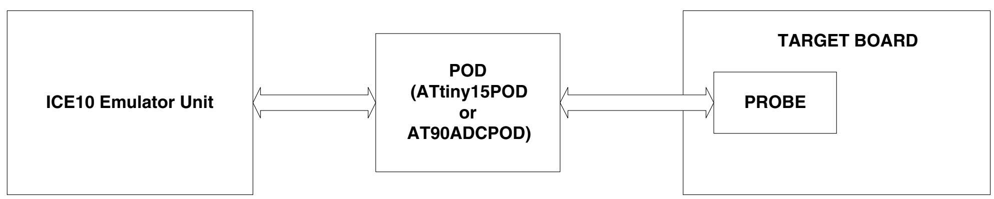


Figure 2-2. ICE10 Emulator Unit

The ICE10 emulator unit (Figure 2-2) contains the necessary logic to emulate all digital functions of the emulated AVR. It also contain hardware needed to communicate with

AVR Studio. Configuration of this device is controlled and done directly from AVR Studio.

Figure 2-3. ATtiny15POD

Figure 2-3 shows the ATtiny15POD which should be used when emulating the ATtiny15 device. The Pod provides a buffer protecting the emulator unit. In addition, the ATtiny15POD contains a 4-channel 10-bit A/D converter with one differential input with optional gain stage. This Pod is configured from AVR Studio, no manual jumper settings are required.

Figure 2-4. AT90ADCPOD

Figure 2-4 shows the AT90ADCPOD which should be used for a wide range of AVR devices. This Pod must be configured manually with jumpers for correctly operation. Configuration of the AT90ADCPOD is described in Section 4, and is also available as an interactive configuration walkthrough in the on-line AVR Studio help system.

There are different Probe cables supplied with the ICE10 emulator. Only one pod, and one probe cable should be used at any given time, and the pin count and shape of the probe should match the device being emulated.

When using the ATtiny15POD only, the 8-pin DIP Probe can be used. When Using the AT90ADCPOD, use the appropriate Probe for the device being emulated.

2.2 Connecting ICE10 to PC

The ICE10 connects to any PC through a standard RS-232 port (COM port). Connect the RS-232 Cable between the ICE10 and any free COM port on the PC. AVR Studio will automatically search through all available COM ports and detect the emulator.

Note: If there are other devices taking control over the COM ports, these have to be shut down before starting AVR Studio. AVR Studio cannot force control over a COM port if other resources have control of the port (e.g., Modem, IrDA, PDA, etc.)

2.3 Connecting ICE10 to Target Board

Depending on which AVR microcontroller should be emulated, either the ATtiny15POD or the AT90ADCPOD should be connected to the Pod connector on the ICE10. Table 2-1 shows which Pod to use.

Table 2-1. Pod Selection

POD	Supported AVR Microcontrollers
ATtiny15POD	ATtiny15
AT90ADCPOD	ATtiny11, ATtiny12, ATtiny22, ATtiny28 AT90S1200, AT90S2313, AT90S/LS2323, AT90S/LS2343, AT90S/LS2333, AT90S/LS4433, AT90S4414, AT90S8515, AT90S/LS4434, AT90S/LS8535

In short, the ATtiny15POD should be used for ATtiny15 only. The AT90ADCPOD is used for all other listed devices.

2.4 Jumper Settings

The configuration system on the ATtiny15POD and AT90ADCPOD is different. The AT90ADCPOD uses jumpers that need to be placed manually on the Pod. The ATtiny15POD uses a jumperless system where all configuration is done directly from AVR Studio. For in-depth information about AT90ADCPOD jumper settings see Section 4.

2.5 Connecting Power

The ICE10 system has an internal power regulator that delivers 15W at 5V. The ICE10 itself uses about 10W. The power supply delivered with the ICE10 is dimensioned to meet the requirements of the emulator. If another power supply is used, it should supply a voltage between 9 and 15 VDC and a minimum of 20W. The battery eliminator connector on the ICE10 system is a standard type with 2.1 mm center tap. Ground should be connected to the center tap.

Note: The target application power must not be present when the emulator is turned off, as this may cause damage to the pod.

2.6 Summary

Complete the following procedure in order to start using the ICE10. Before connecting the probe cable to the user application:

- Connect the RS-232 cable between the ICE10 unit and the PC serial port.
- Connect the correct pod card to the ICE10 unit with the supplied pod cable.
- Connect the correct probe cable to the pod.
- Make sure that the pod settings (jumpers) on AT90ADCPOD are set according to the requirements.
- Connect the enclosed power supply (9 - 15 VDC) to the ICE10 unit.
- Turn on the power and check that the red LED marked POWER is lit.
- After a short time (<10 s), the green LED marked READY will be lit and the ICE10 system will be ready.

- Turn off the power.
- Plug the probe into the application/adapter. **Note:** The target power should under no circumstance be present when the probe is connected and the emulator is switched off. Pay attention to connect with the correct orientation. If it is not connected correctly, the ICE10 system may be damaged.
- Turn on the power on ICE10.
- Connect power to the target application.
- Start AVR Studio.

Section 3

Using the ICE10

This section will cover main features and considerations when using the ICE10 and AVR Studio to emulate AVR devices. AVR Studio is a professional front-end for both high-level and assembly level debugging. If no In-Circuit Emulator is connected AVR Studio will start up as a stand-alone simulator. AVR Studio is described in the on-line help system in AVR Studio, and should be studied carefully in order to take full advantage of all available options and features.

3.1 Installing AVR Studio

To install AVR Studio insert the supplied Atmel CD-ROM in the computer and navigate to "Products -> AVR 8-bit RISC -> Software". Right click with the mouse on the "astudio3.exe" file and select "save link as". Select an empty directory and save the file. Execute the "astudio3.exe" file. This is a self-extracting file that will extract all required files to the current directory. Execute the "Setup.exe" file. This will guide you through the setup process.

Note: AVR Studio version 3.5 or later is required for ICE10 support.

3.2 Emulating with ICE10

It is assumed that the reader has general knowledge of how to use the AVR Studio software. This section will focus on features and considerations applicable to the ATICE10 emulator.

3.2.1 Initial Setup

Before emulating with the ICE10, the emulator, pod and probe must be connected and configured correctly. This is described in Section 2.2 to Section 2.6 and Section 4.

3.2.2 Starting AVR Studio

When the system is correctly connected and powered up, AVR Studio should be launched. AVR Studio will look for any supported tool connected to the COM ports. Note that AVR Studio searches through the COM ports in a sequential manner. If other Atmel tools are connected to the COM ports, make sure that these are switched off, or disconnected, as AVR Studio will look for any supported tool, and connect to the first tool it finds.

Note: Make sure no other applications have control of the COM port that the ICE10 is connected to.

3.3 ICE10 Emulator Options

When the emulator is started with a new project the "Emulator Options" dialog will appear. This dialog determines how the emulator behaves.

Note: The emulator options dialog box (Options → Emulator Options) will not be available before a project has been loaded and the emulator has been detected by AVR Studio.

3.3.1 Device

Depending on which device is selected, unavailable options will be grayed out. A grayed out option indicates that this option is not applicable for the selected device. The ATtiny15POD is completely configured by this emulator options dialog. The AT90ADCPOD requires additional jumper settings to complete the configuration as described in Section 4.

3.3.2 Clock Source

When using the AT90ADCPOD three clock source options are available. The AT90ADCPOD can use one out of three available clock sources; the programmable internal clock in the ICE10, a crystal or an external oscillator in the user application. The ATtiny15POD only uses the internal clock option.

3.3.3 Internal Frequency

The internal clock can be adjusted between 400 kHz and 20 MHz. Any frequency within this range can be selected, and will be produced with an accuracy better than 200 PPM for most frequencies. In addition jumpers needs to be configured on the AT90ADCPOD as described in Section 4.

3.3.4 External Range

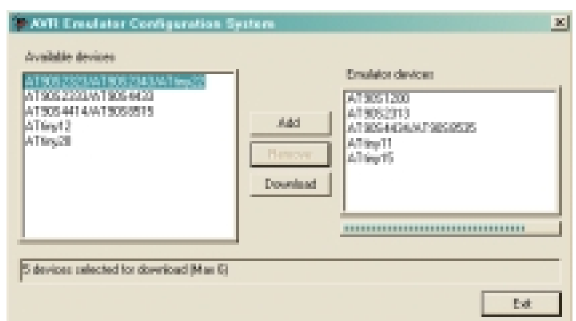
When external clock source in the user application is used, this must be in the range between 32.768 kHz and 10 MHz. To use an external clock source, select External Oscillator in the menu. When using external crystal, it is important to select the proper range in the External Range menu to make the clock system work properly.

Note: Make sure the jumper settings on the AT90ADCPOD are set according to the options selected in the Emulator Options menu.

3.4 Emulator Configuration System

The ICE10 has room to store 6 different devices in the Emulator unit Flash memory. Using the AVR Emulator Configuration system found in AVR Studio (Tools -> ICEPRO/AVRICE/ICE10 Configuration system), it is possible to select which device that should be downloaded to the emulator. Only devices downloaded to the emulator can be emulated. Figure 3-1 shows the AVR Configuration System dialog box where devices can be added or removed from the ICE unit.

Figure 3-1. AVR Configuration System Dialog



The left side column shows which devices are supported by the emulator, but not currently loaded. To be able to emulate one of these devices, the appropriate device should be marked, and the “Add” button should be pressed.

Note: If 6 devices are already stored in the emulator, remove the appropriate number of devices before trying to add more.

Once all wanted devices are listed in the right column press “Download” to start the actual update of the ICE10. This might take a few minutes, and the green LED will flash during the update. A dialog box will appear at the end of the update giving a confirmation that the update was successful.

Note: The update will not take effect util the next time the emulator is turned on.

3.5 Using Breakpoint

ICE10 supports an unlimited number of breakpoints. Breakpoints can be placed directly in the source code. When running the code, execution will be halted **before** executing the code line with the breakpoint. ICE10 does not support advanced or complex breakpoints. For in-depth description of breakpoints and how to use them, see the on-line help system in AVR Studio.

3.6 Using Traces

The ICE10 has a 32K x 96-bit trace buffer that stores information about program execution for every clock cycle. When the emulator is stopped, this trace buffer can be examined to extract information about the history of the emulated program. The details on which data are stored and how to retrieve them are described in the "AVR Studio On-line Help." When the trace buffer is full, it will wrap around and start overwriting the oldest entries.

The trace buffer can be turned on or off at any program line. This makes it possible to skip tracing delay loops and other subroutines which would otherwise fill the trace memory with unnecessary data. The trace buffer is inactive by default. To trace an entire program, a **Trace on** marker should be placed on the first line of the program.

For in-depth description of Traces and how to understand the contents of the trace buffer, see the on-line help system in AVR Studio.

3.7 Using Triggers

The ICE10 has five external trigger inputs and five trigger outputs, all located on the Aux connector next to the Pod connector. The pinout is shown in Figure 3-2 and Table 3-1.

- The trigger inputs can act as break signals to the emulator and/or they can be logged in the trace buffer. Any inputs set up to break the emulator are activated when a rising edge is detected.
- The trigger outputs may be set as trigger points on any instruction in the code window in AVR Studio. If enabled on an instruction, the output(s) will remain high for one AVR clock cycle when the marked instruction is executed. This can be used to trigger a logic analyzer or an oscilloscope.

Figure 3-2. AUX Connector

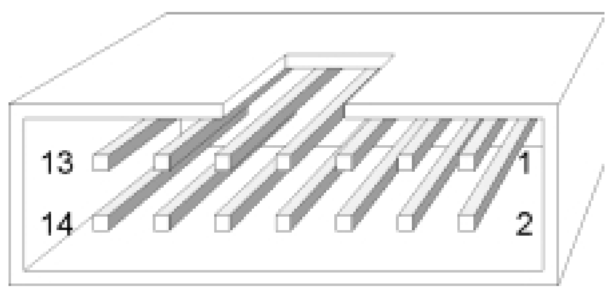


Table 3-1. Pinout for Aux Connector

Signal	Aux		Signal
GND	Pin 1	Pin 2	GND
Input 0	Pin 3	Pin 4	Output 0
Input 1	Pin 5	Pin 6	Output 1
Input 2	Pin 7	Pin 8	Output 2
Input 3	Pin 9	Pin 10	Output 3
Input 4	Pin 11	Pin 12	Output 4
GND	Pin 13	Pin 14	GND

There are three global mask registers that are used to control the behavior of the triggers:

- The Trigger Output Global Mask Register controls which of the output pins are allowed to be controlled by the trigger settings in the code. An output pin that is disabled will remain low even if a trigger point for that particular pin is set in the code.
- The Trigger Input Global Mask Register controls which of the input pins are allowed to break the emulator. If more than one line is enabled, the emulator will break on either one, but will not store any information about which input caused the event. Note that unconnected inputs are pulled high by internal pull-up resistors. Unused lines must not be enabled.
- The External Trace Mask Register controls which of the input pins will be stored in the trace memory. Input pins that are not enabled in this register will be stored as zero in the trace memory. To be traced, input signals must be valid and stable at the rising edge of the AVR clock and for 50 ns thereafter. It is also necessary that the trace buffer is enabled.

The trigger input and the external trace are two independent functions acting on the same input pins. Note that the trigger logic is asynchronous and edge driven, whereas the trace logic is clocked on the AVR clock. The emulator may therefore break on a glitch signal that is too narrow to be traced.

The details on how to enable and set up triggers and mask registers are presented in "AVR Studio On-line Help".

3.8 Logic Analyzer

ICE10 has two connectors on the front marked Logic Analyzer 1 and 2. These connectors provide signals from the instruction address and data bus. This allows users to use an external Logic Analyzer to monitor the activity on these busses.

Figure 3-3. Logic Analyzer 1 and 2 Connectors

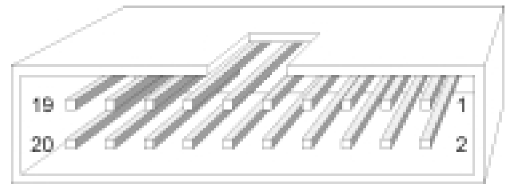


Table 3-2. Pinout for Logic Analyzer 1

Signal	Logic Analyzer 1		Signal
AVRCLK	Pin 1	Pin 2	Low
Low	Pin 3	Pin 4	A15
A14	Pin 5	Pin 6	A13
A12	Pin 7	Pin 8	A11
A10	Pin 9	Pin 10	A9
A8	Pin 11	Pin 12	A7
A6	Pin 13	Pin 14	A5
A4	Pin 15	Pin 16	A3
A2	Pin 17	Pin 18	A1
A0	Pin 19	Pin 20	GND

Table 3-3. Pinout for Logic Analyzer 2

Signal	Logic Analyzer 2		Signal
AVRCLK	Pin 1	Pin 2	Low
Low	Pin 3	Pin 4	D15
D14	Pin 5	Pin 6	D13
D12	Pin 7	Pin 8	D11
D10	Pin 9	Pin 10	D9
D8	Pin 11	Pin 12	D7
D6	Pin 13	Pin 14	D5
D4	Pin 15	Pin 16	D3
D2	Pin 17	Pin 18	D1
D0	Pin 19	Pin 20	GND

Section 4

AT90ADCPOD Configuration

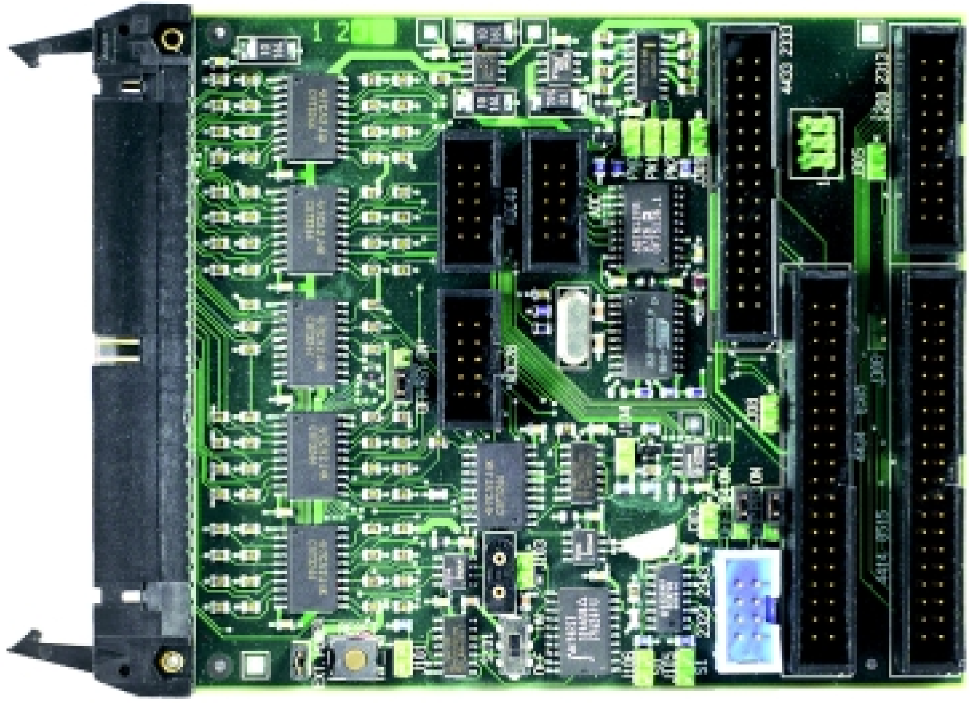
4.1 Introduction

This section describes how to set up and use the emulator pod card AT90ADCPOD. The setup procedure is also available as a walk trough guide in “AVR Studio On-line Help”.

The AT90ADCPOD supports the following AVR devices:

- AT90S1200
- AT90S2313
- AT90S2323
- AT90S2333
- AT90S2343
- AT90S4414
- AT90S4433
- AT90S4434
- AT90S8515
- AT90S8535
- ATtiny11
- ATtiny12
- ATtiny22
- ATtiny28

Figure 4-1. Component Placement of AT90ADCPOD



The AT90ADCPOD contains the following functions:

- Analog comparator
- Clock circuits for handling of the timer oscillator and XTAL signals from the target application
- Analog to digital converter
- Bus switches for converting the voltage on the I/O signals

11 jumpers and one switch must be set on AT90ADCPOD to configure it for desired operation.

4.2 Configuring the AT90ADCPOD

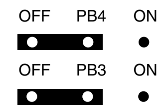
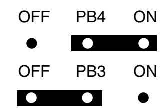
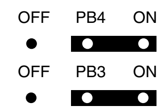
AT90ADCPOD is connected to the ICE10 unit using the pod cable (the wide cable) and to the user application using the 8-pin, 20-pin, 28-pin, or 40-pin probe.

Note: It is important that the probe cable is correctly connected to the user application. Only one probe cable should be connected. The colored wire of the probe cable indicates pin 1 of the AVR device.

Use the appropriate probe cable and connect the application to the connector labeled with the correct part number. Please note that the ICE10 may be damaged if the probe cable is connected to the wrong connector.

The 8-pin AVR devices have multiple options for using port pins PB3, PB4 and PB5. Please refer to data sheets for detailed information. To select how PB3 and PB4 should be used, the jumpers labeled PB3 and PB4 must be set correctly. Table 4-1 shows the settings for these jumpers.

Table 4-1. Jumper Settings when Selecting between ATtiny11, ATtiny12, ATtiny22, AT90S2323 and AT90S2343

Device	PB3/J310	PB4/J311	Jumper Setting
AT90S2323, ATtiny11 or ATtiny12 with External Crystal	OFF	OFF	
AT90S2343, ATtiny11, ATtiny12 or ATtiny22 with External Clock	OFF	ON	
AT90S2343, ATtiny11, Attiny12 or ATtiny22 with Internal Clock	ON	ON	

Note: The jumper setting does not affect operation for other devices.

ATtiny11 and ATtiny12 also have the possibility to disconnect the external $\overline{\text{RESET}}$ pin and use it as a general I/O pin (PB5). This is done by setting the jumper marked $\overline{\text{RST}}$ in position OFF. Jumper $\overline{\text{RST}}$ must always be set in position ON for all other devices.

To use AT90S2333, AT90S4433, AT90S4434, or AT90S8535, the 10-lead cable on the pod must be mounted. Table 4-2 shows how to connect this cable.

Table 4-2. Connections of 10-lead Cable

Device	10llead Cable
AT90S2333 and AT90S4433	Connect ADC and ADC28
AT90S4434 and AT90S8535	Connect ADC and ADC40

Note: Connection of the 10-lead cable does not affect operation for other devices.

4.3 The ICE10 Power System

The ICE10 system has an internal power regulator that can deliver 15W at 5V. The ICE10 itself uses about 10W, so if the user application is powered from the ICE10 system, it cannot use more than 5W (i.e. 1A/5V). If this value is exceeded, the ICE10 system may be damaged or not work properly.

The power supply delivered with your ICE10 is dimensioned to meet the requirements of the emulator. If another power supply is used, it should supply a voltage between 9 and 15 VDC, minimum 20W. The battery eliminator connector on the ICE10 system is a standard type with 2.1 mm center tap. Center tap is negative.

4.3.1 The Target Applications Power Requirements

If the target application should be powered from the ICE10, the jumper named "EXT.POWER" must be mounted and the jumpers labeled "PW2", "PW1" and "PW0" removed.

If the target application has its own power supply, the jumper named "EXT.POWER" must be removed. The ADCPOD must also be set to convert voltages to the required voltage level. Use Table 4-3 to find the settings on the jumpers named "PW2", "PW1" and "PW0".

Table 4-3. Settings of PW2, PW1 and PW0

Targe V_{CC}	PW2	PW1	PW0
2.7 - 2.9V	(ON)	(ON)	(ON)
3.0 - 3.3V	(ON)	(ON)	(OFF)
3.4 - 3.7V	(ON)	(OFF)	(ON)
3.8 - 4.1V	(ON)	(OFF)	(OFF)
4.2 - 4.5V	(OFF)	(ON)	(ON)
4.6 - 4.8V	(OFF)	(ON)	(OFF)
4.9 - 5.1V	(OFF)	(OFF)	(ON)
5.2 - 5.5V	(OFF)	(OFF)	(OFF)

4.4 The ICE10 Clock System

The AVR ICE10 system can use one of three available clock sources:

- Internal programmable clock in the ICE10
- Crystal from the user application
- External oscillator from the user application

The internal clock can be adjusted between 400 kHz and 20 MHz. Any frequency within this range can be selected, and will be produced with an accuracy better than 200 PPM for most frequencies.

If an external clock source from the user application is used this can be in the range of 32.768 kHz to 10 MHz. To use an external clock source, select External Oscillator in the Emulator Options menu in AVR Studio. It is important to tune the oscillator driver by choosing the corresponding range in the Clock Range menu to make the clock system work properly with an external crystal.

On the pod card, the XTAL pins are connected to the ICE10 by using the 2-wire cable. Connect the cable from J103 to the 2-pin header nearest the used probe connector. Table 4-4 shows where to connect the 2-wire for various devices.

Table 4-4. Connections of 2-wire Cable

Device	2-wire Cable
S1200 and S2313	Connect J103 and J305
S4414 and S8515	Connect J103 and J306
ATtiny11, ATtiny12, ATtiny22, S2323, and S2343	Connect J103 and J307
S4434 and S8535	Connect J103 and J308
ATtiny28, S4433, and S2333	Connect J103 and J309

Pin 1 on each connector is labeled with *.

Connector J101 must be left open if the clock source from the user application is a crystal, If the clock source from the user application is an oscillator, a jumper must be mounted on connector J101. Table 4-5 shows the settings for J101. The switch S101 must be in position OFF in both cases.

Table 4-5. Settings for J101

Clock source	Jumper Setting
Crystal	(OFF)
Oscillator	(ON)

Long leads from your external crystal to the oscillator circuit on the pod may cause problems. It is possible to mount a crystal in the socket near J103. Do not use the 2-lead cable if you choose this option. If the crystal frequency is above 1 MHz and this is selected in the Clock Range menu in Emulator Options in AVR Studio, S101 should be in position ON. S101 should be in position OFF under all other circumstances.

Please note that a crystal cannot be used when emulating AT90S2343 or ATtiny22.

4.4.1 The Timer Oscillator

This section only applies to emulation of S4434 and S8535.

A 32.768 kHz crystal is mounted on the pod for use with the Timer oscillator. It is impossible to emulate the Timer oscillator with a crystal in the target application due to the long leads from the target application to the oscillator circuit. If an external oscillator output is used as the clock source of the Timer oscillator, mount jumper J104, otherwise leave it open.

4.5 The Analog Comparator

The jumpers labeled S0 and S1, must be set correctly to make the analog comparator work properly. Table 4-6 shows how to set these jumpers.

Table 4-6. Jumper Settings to Enable Analog Comparator

Device	S1/J105	S0/J106
ATtiny11, ATtiny12, ATtiny28, S1200, and S2313	(ON)	(ON)
S2333 and S4433	(ON)	(OFF)
S4414, S4434, S8515, and S8535	(OFF)	(ON)

Note: The jumper settings does not affect devices without Analog Comparator.

4.5.1 Connectors not Described in this User Guide

The 6-pin header connector is used for production testing.

4.6 Jumper Settings Reference Table

All jumpers on the pod card are described earlier in previous sections. Table 4-7 is meant as a short reference for experienced users.

Table 4-7. Jumper Settings Reference

Reference Number	Other Name	Description	Default Setting
J101		Jumper mounted if an external clock source (not a crystal) from the target is used to clock the ICE10	(OFF)
J102	EXT.POWER	Jumper mounted if the target application is powered from the ICE10 (V_{CC} = 5V)	(ON)
J103		Connect 2-wire cable if external crystal or clock source is used to clock the ICE10	Not connected
J305 - J309		Connect 2-wire cable to correct probe if external crystal or clock source is used to clock the ICE10.	Not connected
J104		Jumper mounted if an external clock source is used for the Timer Oscillator.	(OFF)
J105	S1	Analog comparator setting – See Table 4-5	(ON)
J106	S0	Analog comparator setting – See Table 4-5	(OFF)
J109	RST	Function select for RESET pin. OFF position if external reset is disabled. Only valid for tinyAVR devices.	(ON)
S101		In position ON if a crystal is mounted in the crystal socket and the frequency is above 1,0000 MHz.	(OFF)
J200	PW0	Power conversion setting – See Figure 4-3	(OFF)
J201	PW1	Power conversion setting – See Figure 4-3	(OFF)
J202	PW2	Power conversion setting – See Figure 4-3	(OFF)
J310	PB3	Clock options selection for 8-pin devices – See Table 4-1	OFF PB3 ON
J311	PB4	Clock options selection for 8-pin devices – See Table 4-1	OFF PB4 ON
J401	ADC	A/D converter connection. Connect 10-lead cable here if the A/D converter is used.	Not connected
J402	ADC28	A/D converter connection. Connect other end of 10-lead cable here if AT90S2333 or AT90S4433 is emulated.	Not connected
J403	ADC40	A/D converter connection. Connect other end of 10-lead cable here if AT90S4434 or AT90S8535 is emulated.	Not connected

Some settings are valid only when certain devices are emulated:

- J101, J103 and J305 - J309 are overridden if Internal Oscillator is selected in AVR Studio.
- J401, J402 and J403 are ignored for devices without ADC.
- S1 and S0 (J105 and J106) are ignored for devices without Analog Comparator.
- PB3 and PB4 (J310 and J311) are ignored for 20-, 28- and 40-pin devices.

Section 5

Hardware Description

5.1 Front Panel

Figure 5-1. ICE Unit Front Panel

5.1.1 Status LEDs

The ICE unit front panel is shown in Figure 5-1. Two LEDs on the front panel indicate the status of the emulator. After power-up, the red LED will be lit, indicating that the power supply is OK and the green LED is turned on after a few seconds when initialization and self-test are finished indicating that the emulator is ready for use.

5.1.2 Logic Analyzer Connectors

The Logic Analyzer connectors are outputs for external Logic Analyzer. Pinout and description on how to use these connectors can be found in Section 3.8.

5.1.3 AUX Connector

The AUX connector in an I/O-port for Trigger signals. Pinout and description on how to use this connector can be found in Section 3.7.

5.1.4 POD Connector

Both ATtiny15POD and the AT90ADCPOD should be connected to this connector. Table 2-1 on page 3 shows which pod to use.

5.2 Back Panel

Figure 5-2. ICE Unit Back Panel

5.2.1 Serial Number

Every ICE10 unit has a unique serial number. If technical support is needed, this number should be provided with a detailed description of the problem. The serial allows technical support to track what firmware the specific ICE10 contains.

5.2.2 Serial Port RS232 C

The ICE unit is connected to an RS-232 port on the host PC with the supplied RS-232 cable. All serial communication is done at 19200 bps using no parity, 8 data bits and 1 stop bit (N81).

5.2.3 Parallel Port

The Parallel port is not in use on the ICE10.

5.2.4 AVR Prog. Connector

The AVR Prog. connector is not in use on the ICE10.

5.2.5 AVR Reset Button

This button resets the application. See Section 5.4 for details on different AVR reset options.

5.2.6 ICE Reset Button

The ICE Reset button is hidden in the back panel for safety reasons. If the emulator starts to behave unpredictably, use a thin tool to push this reset button. The green LED will be turned off for a while and will be switched on again when the system is ready. When the ICE10 reset button is pressed, the program memory is cleared, thus the project file must be closed in AVR Studio and then reopened.

5.2.7 ON-OFF Switch

On-Off switch for the Emulator. Do not turn off power on the emulator while there still is power on the target board. This might damage the pod.

5.2.8 12V DC Connector

The battery eliminator connector on the ICE10 system is a standard type with 2.1 mm center tap. Ground should be connected to the center tap.

5.3 Power System

The ICE10 system has an internal power regulator that delivers 15W at 5V. The ICE10 itself uses about 10W. The power supply delivered with the ICE10 is dimensioned to meet the requirements of the emulator. If another power supply is used, it should supply a voltage between 9 and 15VDC and a minimum of 20W. The battery eliminator connector on the ICE10 system is 1 standard type with 2.1 mm center tap. Ground should be connected to the center tap.

Note: The target application power must not be present when the emulator is turned off, as this may cause damage to the pod.

5.4 Reset System

The ICE10 has two independent reset systems. One is for the ICE10 itself and the other is for the emulated AVR device. The ICE10 reset button is placed on the back panel of the box. The AVR reset system can reset the emulated device both when the device is running and stopped. This reset can be activated from several sources:

- The push-button marked **AVR RESET** on the back panel of the AVR ICE unit (only when running)
- The push-button marked **RESET** on the pod (only when running)
- The reset button in AVR Studio. Note that the reset button in AVR Studio will stop the emulation process if it is running when the button is pushed.
- A reset signal from the user application (only when running)

Note: In order to enable external reset when emulating ATtiny15, the **Enable External Reset** option must be selected in the **AVR Studio Emulator Options** dialog.

Please note that only a reset from the user application will reset other components in the application connected to the AVR's reset pin.

Section 6

Special Considerations

There are a few important differences between emulating devices with the ICE10 and running code in the actual device. In this section some of the special considerations are listed. For more issues and considerations see the separate **avrtools.pdf** document on the supplied CD-ROM, or download the latest version from the Atmel web site (www.atmel.com).

6.1 Stack

There is no hardware stack in the ICE10. Therefore, a stack must be set up in the emulator's SRAM when emulating devices with hardware stack. The following two instructions will set up the stack.

```
ldi r16, $6F
out $3D, r16
```

Further writing to I/O locations $3D and $3E must be avoided.

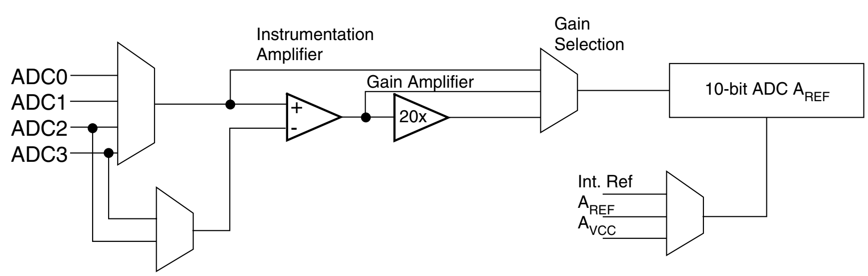
6.2 Assembling

Some instructions that are not available in tiny AVR devices will work in the ICE10. Use the assembler device directive when assembling to generate warnings when illegal instructions are used.

6.3 ADC

The ADC featured in ATtiny15 is implemented on the ATtiny15POD using an AD converter chip, several analog multiplexers, an operational amplifier to provide 20x gain and an instrumentation amplifier to provide differential mode inputs. See Figure 6-1. Due to this construction with discrete ICs on an open PCB, the ADC will be more susceptible to ambient noise and have electrical characteristics that differ from the actual chip. See Table 6-1.

Figure 6-1. ATtiny15POD



The internal voltage reference on the pod has a nominal voltage of 2.495V (minimum 2.440V, maximum 2.550V). This is within the specification of ATtiny15 (2.40V - 2.7V).

When measuring differential signals, the lowest possible signal is approximately 8 mV. For any signals below this value, the voltage output of the instrumentation amplifier will be 8 mV (maximum). When measuring single-ended signals, the instrumentation amplifier is bypassed and the signal may be in the range 0V to V_{REF}.

The differential amplifier and gain stages are supplied with 7V on the pod. To protect the ADC chip from any voltage levels exceeding 5.8V (for instance, when using 20x amplification and an input signal >0.29V), a clamping diode and a series resistor of 51Ω are coupled to the ADC input pin.

Note: The signal applied to the ADC inputs multiplied with the selected gain (1x or 20x) should never exceed $5.5V_{DC}$.

The multiplexer selecting the reference voltage to the ADC has internal clamping diodes to V_{CC} on all inputs. If target V_{CC} is present and the emulator power is switched off, the clamping diodes will conduct current directly to GND. To limit this current, two 470Ω resistors are coupled in series with external reference signal.

Under no circumstances should the target power be present while the emulator is switched off.

IMPORTANT: In a critical application using ADC (for instance, a battery charger charging LiIon batteries), the emulator should not be used as a replacement for the actual device during testing due to inaccuracy and noise in the ADC.

Table 6-1. ADC Characteristics (Only Values Differing from the Actual Device are Displayed)

Parameter	Condition	Min	Typ	Max	Units
V_{IN}	Single-ended	0		5.5	V
	Differential 1x	0.008		5.5	V
	Differential 20x	8		275	mV
V_{REF}		1.2		5.5	V
V_{INT}		2.440	2.495	2.550	V
V_{BG}		1.20	1.25	1.29	V
R_{REF}	Normal operation	1M			ohm
	Target V_{CC} present, emulator turned off	470			ohm

6.4 Noise Canceler Mode

The ADC noise canceler mode featured is implemented as idle mode in ICE10, not power-down mode as in the actual device.

6.5 Timer/Counter1

Due to synchronization of the CPU and Timer/Counter1, data written into Timer/Counter1 is delayed by one CPU clock cycle. This applies to both the ATtiny15 device and ICE10 emulating ATtiny15. Due to this synchronization mechanism, values written to TCNT1 in AVR Studio's I/O view will not be updated before the program is single stepped or another I/O location is written.

6.6 Analog Comparator

The input voltage range of the analog comparator is 0 to 3.5 volts in ICE 10. Hence if both inputs are > 3.5 volts, the output of the comparator is undertermined.

Section 7

Troubleshooting Guide

Table 7-1. Troubleshooting

Problem	Solution
The red LED is not lit when the power is turned on	- Check that the power cord is properly inserted in the wall - Check that the power plug is properly inserted in the ICE - Check that you are using a power supply with negative center on the DC output
When a file is opened in AVR Studio, it starts in simulator mode	- Check that the serial cable is inserted in the PC and the ICE - Restart the PC with the ICE serial cable connected to the serial port to make sure no other devices (mouse, etc.) are using the serial port - Disconnect the pod from the emulator and restart the emulator
After performing an upgrade of the ICE from AVR Studio, the green LED is not lit when the power is turned on	- Wait 10 seconds - Restart the emulator - Perform the upgrade again
The application is not running in AVR Studio	- Make sure the target V_{CC} is connected or that the application is powered by the emulator - Make sure the target clock is connected or internal clock is selected in AVR Studio - Disconnect the pod and try again; if it is working now, the problem is in the application
AVR Studio shows the message “Error communicating with the emulator” when trying to download the code	- Check serial cable connections - Make sure the pod is correctly connected to the emulator and the target - Make sure the target power is present (LED lit on the pod) - Restart the emulator

Section 8

Technical Specifications

System Unit

Physical Dimensions . . . . (H x W x D) 32.4 x 277.1 x 218.6 mm/1.3" x 10.8" x 8.5"

Weight . . . . 400 g/0.88 lbs

Power Voltage Requirements . . . . 9 - 15 VDC

Power Consumption . . . . < 20W

ICE Power Consumption 10W

Max. Application Power Consumption 5W

Ambient Temperature . . . . 0 - +70°C (Operating)

. . . . -55 - +85°C (Non-operating)

Relative Humidity (Non-condensing) . . . . 10 - 90% (Operating)

. . . . 5 - 95% (Non-operating)

Shock . . . . 20 g, 11 ms half sine

Vibration . . . . 5 g

Connections

Power

Connector . . . . 5.5 mm OD/2.1 mm ID Center Negative

Host

Serial Connector (RS-232) . . . . 9-pin D-SUB Female

Serial Communications Speed . . . . 19200 bits/s

Pod

Connectors . . . . one 2 x 32 Male Header

External Trigger Inputs/Outputs

Connector . . . . 2 x 7 Male Header

Logic Analyzer Interface

Connectors . . . . two 2 x 10 Male Headers

Clock Specification

Internal Clock

Minimum Frequency . . . . 400 kHz

Maximum Frequency . . . . 20.0 MHz

External Crystal

Minimum Frequency . . . . .32.768 kHz

Maximum Frequency . . . . 10.0 MHz

Internal Watchdog RC Oscillator

Running Frequency . . . . 1.0 MHz ± 30%

Operation

Minimum Running Speed . . . . 32.768 kHz

Maximum Running Speed . . . . 12.0 MHz

Minimum Single-step Speed . . . . 32.768 kHz

Maximum Single-step Speed . . . . 10.0 MHz

Minimum Breakpoint Speed . . . . 32.768 kHz

Maximum Breakpoint Speed . . . . 10.0 MHz

Memory Specification

Program Memory . . . . 128K bytes

Event Memory . . . . 128K bytes

EEPROM Memory . . . . 64K bytes

SRAM Memory . . . . 64K bytes

Register File . . . . 32 bytes

I/O Area . . . . 64 bytes

Trace Buffer Memory . . . . 32K x 12 bytes

I/O Pins

Output Level . . . . TTL/CMOS (V_{CC}: 2.7 - 5.5 VDC)

Maximum Sink Current . . . . 24 mA

Maximum Source Current . . . . 10 mA

Permanent Pull-up . . . . 1.0 MΩ

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