AVR® ATICE10

User Guide

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Section 1

Introduction

1.1 General Description

The Atmel AVR® ATICE10 is a real-time in-circuit emulator for ATtiny devices. The ICE10 is controlled by AVR Studio, version 3.0 and later. The ICE10 currently supports the following device:

- ATtiny15

This document describes the configuration and setup of the ICE10 and configuration of AVR Studio to support emulation of this device. The ICE10 consists of the following components:

- ICE10 emulator unit
- Pod card ATtiny15POD
- Pod cable
- ATtiny15 probe with cable
- RS-232 cable
- Power supply unit
- Documentation

The ICE10 emulator unit is the main part of the AVR ICE10 system. The ICE unit is controlled by AVR Studio, which runs on a host PC. The AVR Studio automatically detects if there is an emulator present on one of the PC's serial ports. Note that if no ICE is detected, AVR Studio will show **Simulator** in the lower right corner of the main window. If the ICE10 is detected, **AVR Emulator** will be indicated and your connections are correct. The AVR Studio will issue a warning if a program previously run in emulator mode is started in simulator mode.

1.2 External Connections

The ICE unit is connected to an RS-232 port on the host PC with the supplied RS-232 cable. The connection on the back panel is shown in Figure 1-1. The **Parallel Port** and **AVR Prog.** connectors have no function on this ICE. Two reset buttons are placed on the back panel of the ICE unit. The **AVR RESET** button resets the application. The **ICE RESET** button resets both the ICE unit and the application.

Figure 1-1. ICE Unit Back Panel

The ICE unit front panel is shown in Figure 1-2. 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.

Figure 1-2. ICE Unit Front Panel

The emulator pod is connected to the **POD** connector on the ICE unit. The **LOGIC ANALYZER** and **AUX** connectors are described later. See “Connector Description” in Section 5.

1.3 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 $15V_{DC}$ 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.

1.4 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 button is labeled **ICE RESET** and 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.

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, 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.

1.5 Trace Buffer

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 User Guide." 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.

1.6 External Triggers

The ICE10 has five external trigger inputs and five trigger outputs, all located on the Aux connector next to the Pod connector.

- 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.

The details on how to enable and set up triggers and mask registers are presented in **AVR Studio Help**. 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.

1.7 Preparing the ICE10 System for Use

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 pod card to the ICE10 unit with the supplied pod cable.
- Connect the probe cable to the pod.
- Connect the enclosed power supply (9 - 15V_{DC}) 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. The target power should under no circumstance be present when the probe is connected and the emulator is switched off. Pay attention to connect it in the correct orientation. If it is not connected correctly, the ICE10 system may be damaged.
- Make sure that the AVR Studio pod settings are set according to the requirements.
- Turn on the power.
- Connect power to the target application.
- Start AVR Studio.

Section 2

Emulating ATtiny15

2.1 The ATtiny15POD

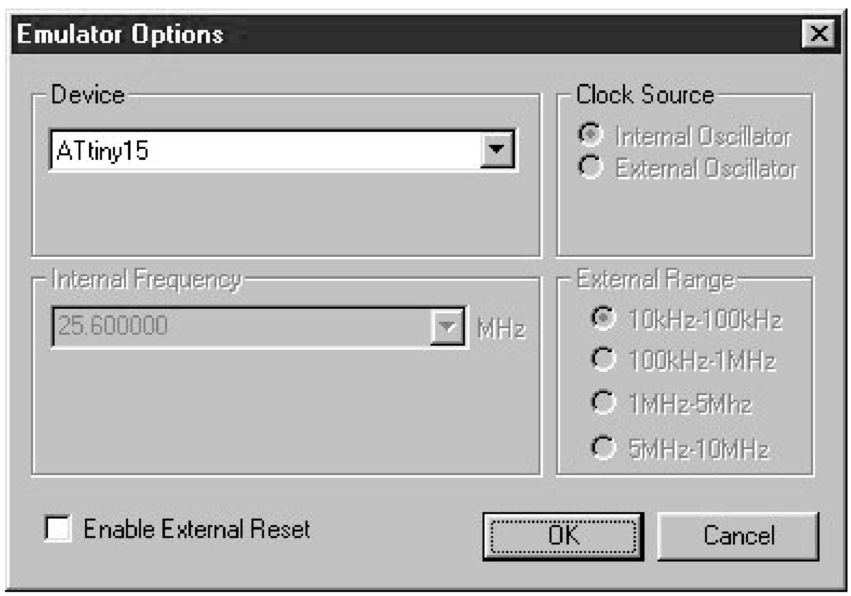
To emulate ATtiny15, the ATtiny15POD should be used. The ATtiny15POD is fully configurable from AVR Studio.

The ATtiny15POD has a reset button and this can be used to reset the application when it is running.

2.2 Configuration of the ATtiny15POD

The ATtiny15POD is configured directly from AVR Studio. When an object file is opened in AVR Studio for the first time, a dialog box with the ICE10 emulator options is displayed (Figure 2-1). The option can also be changed later from the **Options > Emulator Options** menu.

Figure 2-1. Emulator Options Dialog



2.2.1 Device

Select the device from the list. The device list includes all devices currently supported in the emulator.

2.2.2 Enable External Reset

If PortB5 of ATtiny15 should be used as reset pin, this selection should be checked. If not checked, PINB5 functions as an input or an open-drain output. In the actual device, this is controlled by the RSTDISBL fuse.

2.3 Connecting to the System

The pod card is connected to the Pod connector of ICE10 using the pod cable (the wide cable). The 8-lead probe cable should be connected between the ATtiny15POD and the target application.

The application should provide its own power supply.

Note: It is important that the probe is correctly connected to the user application. If not, the pod may be damaged.

WARNING: Turn off power to the target application before the emulator is turned off.

Section 3

Special Considerations

There are a few important differences between emulation of ATtiny15 in ICE10 and running code in the actual device.

3.1 Stack

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

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

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

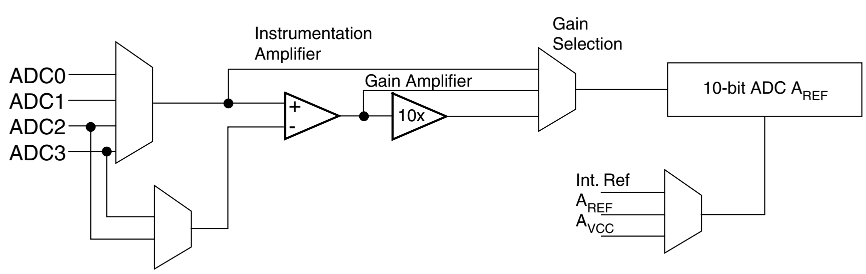
3.2 Assembling

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.

3.3 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 3-1. 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 3-1.

Figure 3-1. 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. See Figure 3-1.

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 3-1. 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 10x	8		550	mV
	Differential 200x	8		27.5	mV
A_{REF}		1.2		5.5	V
V_{INT}		2.440	2.495	2.550	V
V_{BG}		1.20	1.25	1.29	V
V_{REF}	Normal operation	1M			ohm
	Target V_{CC} present, emulator turned off	470			ohm

3.4 Noise Canceler Mode

The ADC noise canceler mode featured in ATtiny15 is implemented as idle mode in ICE10, not power-down mode as in the actual device.

3.5 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 speed or another I/O location is written.

Section 4

Troubleshooting Guide

Table 4-1. Troubleshooting

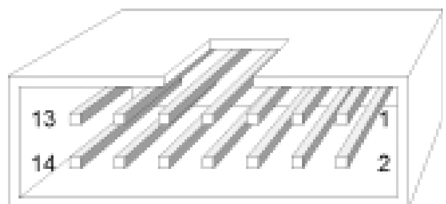
Problem	Solution
The red LED is not lit when the power is turned on	- Check that the power cord is properly inserted in the wall - Check that the power plug is properly inserted in the ICE - Check that you are using a power supply with negative center on the DC output
When a file is opened in AVR Studio, 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 5

Connector Description

5.0.1 Logic Analyzer 1

Figure 5-1. Logic Analyzer 1 Connector



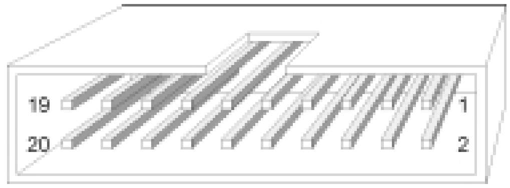
The connector marked **LOGIC ANALYZER 1** on the back panel of the AVR ICE unit has the following pinout with signals from the instruction address bus.

Table 1. 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

5.0.2 Logic Analyzer 2

Figure 5-2. Logic Analyzer 2 Connector



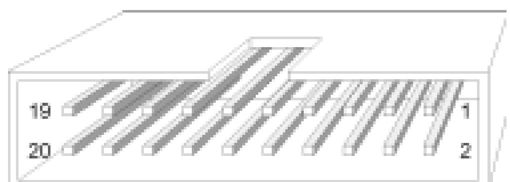
The connector marked **LOGIC ANALYZER 2** on the back panel of the AVR ICE unit has the following pinout with signals from the instruction data bus.

Table 5-1. 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

5.0.3 Aux Connector

Figure 5-3. Aux Connector



The connector marked **AUX** on the back panel of the AVR ICE unit is used for external triggers and has the following pinout.

Table 5-2. 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

Section 6

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 in

Weight . . . . 400 g/0.88 lbs

Power Voltage Requirements . . . . 9 - $15V_{DC}$

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/two 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 - 5.5V_{DC})

Maximum Sink Current . . . . 24 mA

Maximum Source Current . . . . 10 mA

Permanent Pull-up . . . . .1.0 MΩ

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