ISP Target System Header Selection for AVR & AT89S FLASH Microcontrollers

1.0 Overview

This application note details the possible connection methods between a Target System and Programmer when implementing in-system programming (ISP) of Atmel AVR and AT89S FLASH microcontrollers. The various ISP header types which can be designed onto a Target System are discussed, along with the relative advantages and disadvantages of each connection method.

2.0 Definitions

2.1 ISP

ISP stands for In-System Programming. This is the mechanism by which Atmel AVR and AT89S microcontrollers can be programmed in-situ, without physically removing them from the Target System. This type of programming can usually be performed at the Target System Vcc voltage, with no requirement for a higher Vpp voltage to be applied to the device during programming.

2.2 ISP Programmer

This is a programmer which is capable of producing the required logic and power signals to in-system program (ISP) the Target Microcontroller. Equinox manufacture a range of programmers which are designed to ISP Atmel AVR and AT89S microcontrollers in development, production and field environments.

2.3 Target Microcontroller

This is the Atmel AVR or AT89S microcontroller which is to be in-system programmed.

2.4 Target System

The Target System is the physical Printed Circuit Board (PCB) which contains the microcontroller to be in-system programmed.

2.5 ISP Header

In order to in-system program (ISP) the Target Microcontroller on the Target System, the programmer must interface to the correct pins of



Figure 1 - Target board + ISP connector + programmer

the target device. This is usually achieved by designing a suitable connector onto the 'Target System' which brings out all the signals required to implement ISP using an external ISP Programmer as shown in fig 1.

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Version 1.02

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3.0 Which ISP Header?

The choice of interconnection method between the Target System and the ISP Programmer depends on many factors including the chosen ISP programmer, Target System space requirements, extra ISP functionality required and the quantity/throughput of Target Systems to be programmed. There is also now a trend to allow field service personnel and even customers to remotely upgrade the product firmware in the field.

The factors influencing the selection of the ISP Header are detailed below:

3.1 ISP Programmer Choice

Most Equinox programmers feature the 'Equinox 10-way' ISP Header. It is possible to convert this header pinout to any other required header pinout by making a suitable conversion cable/PCB. The table below details the 'standard' connectors supported by the Equinox range of ISP programmers.

Programmer	Micro-ISP	Activ8r	FS2000A	PRO10x
Equinox 10-way IDC Header	YES	YES	YES (internally user selectable)	YES (user selectable using separate PCB)
Atmel 10-way IDC Header	NO Use 'ISP Cable Converter'	NO Use 'ISP Cable Converter'	YES (user selectable)	YES (user selectable using separate PCB)
Atmel 6-way IDC Header	NO Requires user to make custom lead			

3.2 Target System PCB Space Requirements

If the Target System is very small or densely populated with components, spare board area for an ISP Header may be hard to come by. In these instances it is often better to choose the 6-way IDC header or to go for a 'single-in-line' 6 way header as these connectors require the least space. **Figure 2** - ISP Header Selection Guide for Equinox Programmers



3.3 Signals required for the specific microcontroller being programmed

Most Atmel AVR and AT89S microcontrollers require only six connections to implement basic ISP programming as follows: Vcc, GND, MOSI, MISO, SCK and RESET. However, there are certain instances where more pins are required to implement extra functionality. The extra pins are SS(Slave Select), SCK2 (Serial Clock 2), PROG_LED and a second GROUND connection. The function of these pins is detailed in section 4.



Figure 3 - Typical Connections for ISP Programming.



3.4 Quantity / throughput of Target Systems to be programmed in Production

If the intended use of the Target system is for development only, the manual insertion of an ISP cable should not present much of a problem. However, in automated high throughput production environments any manual insertion operations need to be avoided as they slow down the production cycle. A so-called 'bed-of-nails' test fixture is often used which connects the relevant points on the Target System to the programmer when the PCB is inserted into the test fixture.



3.5 Method of reprogramming the Target System in the field

Many Target Systems are programmed once at the factory and then are never subsequently reprogrammed by the customer in the field. However, some manufacturers are now designing systems which can be reprogrammed once they have left the factory. In order to implement this functionality, the Target System must have the ISP Header in a place which can be easily located by the customer.



4.0 ISP Selection Guide

The relevant advantages and disadvantages of each header type are shown in fig. 5. It is also possible to implement a custom ISP connector by using an interface cable or PCB between the programmer and the header.

ISP Connection type	Advantages	Disadvantages	
Equinox 10-way IDC Header	 Extra serial clock signal available on SCK2 for clocking AVR devices Target LED control pin available (Micro-ISP only) Second GROUND pin may be used by the target system to sense presence of the programmer. IDC plug and socket are polarised to prevent incorrect insertion of the ISP cable Used on all Equinox target systems and in all Equinox application notes 	 Larger PCB footprint than 6-way header. Not compatible with the Atmel STK100, 200, 300 systems. 	
Atmel 10-way IDC Header	 Widely used on the Atmel STK100, 200 and 300 systems IDC plug and socket are polarised to prevent incorrect insertion of the ISP cable 	 Larger PCB footprint than 6-way header. No extra lines for SCK2 or LED control. 	
Atmel 6-way IDC Header	 Small physical PCB footprint Ideal for volume production where board space is a premium. 	 No extra lines available for SCK2 or LED control. 6-way non-reversible connector may be hard to source. 	
6-way SIL Header	 Simple to add to existing PCB design Easier alignment of bed-of-nails test pins 	1 No polarisation of ISP header/plug available	
Bed-of-nails	 No PCB area taken up by a dedicated connector Ideal for automated test handlers 	 ISP connector is not available if the product is to be reprogrammed in the field. ISP cable lengths are often longer. Board may require special design to bring out ISP connections. 	



4.1 ISP Header - Signal Definitions

The ISP Header is used to connect signal and power lines from the target microcontroller to the ISP Programmer. The definitions of each of the signals is shown in fig. 6 below. The six 'required' connections which must be made to implement ISP are listed at the top of the table. The optional signals are detailed in the next section.

Header Pin Label	Туре	Programmer pin description	Connect	Target Microcontroller	Target Note 1 ATmega103	
PROG_VCC	Р	Programmer Vcc connection	Y	Target Vcc	Target Vcc	
PROG_MOSI	0	Programmer MOSI signal (SPI Data Out)	Y	MOSI	PD1/RXD	
PROG_MISO	I	Programmer MISO signal (SPI Data In)	Y	MISO	PD0/TXD	IIRED
PROG_RESET	0	Programmer RESET Control Line	Y	RESET	RESET	REQU
PROG_GND	Р	Programmer Ground connection	Y	Target Ground	Target Ground	
PROG_SCK1	OG_SCK1 O Programmer Serial Clock 1 Signal		Y	SCK	SCK	
PROG_SS	0	Programmer Slave Select	N	N/C	N/C	
PROG_SCK2	0	Programmer Serial Clock 2 signal ^{Note 2}	Х	External Oscillator input pin	N/C	TIONAL
PROG_LED	0	Programmer LED control Line	Х	LED	LED	OP

KEY:				
Y	This connection must be made			
Х	Optional			
N/C	No Connect			
I	Input			
0	Output			
Р	Passive			

Note 1:

The ATmega 103(L) microcontroller requires that PROG_MOSI is connected RXD and PROG_MISO is connected to TXD. This is different from the AT90S and AT89S devices.

Note 2:

Required on some ATtiny and ATmega devices

Figure 6 - ISP Header Signal Definitions



4.2 Optional ISP Signals

The following signal lines are not absolutely necessary to implement ISP but should be taken into consideration at the PCB design stage. These signal lines may not be present on all Equinox programmers.

4.2.1 SCK2 - Oscillator pin

There are a few instances when the target microcontroller may require a clock source to be supplied from the programmer during programming as detailed in fig 7.



This requirement can arise for the following reasons:

i Slow programming with 'Internal RC Oscillator'

If the target device normally runs from an 'Internal RC Oscillator' with a nominal frequency of 1MHz, the maximum SPI frequency is limited to approximately 200 kHz. This results in the overall programming time being increased. Many Equinox programmers are capable of swapping the 'Oscillator Selection' to an 'External Clock Source' for programming and then swapping it back to 'Internal RC Oscillator' when programming is complete. This can result in a much faster programming cycle. Please consult the relevant Atmel data sheet for the following devices which feature 'Internal RC Oscillators': ATmega163(L), ATmega161(L), ATtiny12(L), ATtiny15(L).

ii Incorrect oscillator source has been selected

If the CKSEL fuse bits are incorrectly set on certain AVR devices, it is possible for the device to stop operating as it has no clock source. The SCK2 signal may be used to temporarily clock the device to set it back to the correct oscillator source. Please consult the relevant Atmel data sheet for the following devices which may exhibit this problem: ATmega163(L), ATmega161(L), ATtiny12(L), ATtiny15(L), AT90(L)S2333, AT90(L)S4333.

Figure 7 - FS2000A providing SCK2 signal to clock target microcontroller



4.2.2 PROG_LED

Many Equinox programmers feature the PROG_LED pin which is capable of driving an LED on the Target System. The LED is automatically illuminated at the start of a programming operation and is switched off at the end of the operation. This output may also be used to signal other logic devices on the Target System that programming has commenced.



Figure 8- LED Circuit

4.2.3 Second GROUND connection

The Equinox ISP Header features two GROUND connections for enhanced EMC. It is possible to connect one of the GROUND pins to the Target System GROUND and then use the second GROUND pin to detect that an ISP Programmer is plugged into the ISP Header. This can be useful if there is other logic on the Target Board which needs to be automatically isolated during programming. See fig 9.



Figure 9- Detection of programmer presence using spare ground pin.



5.0 ISP Pin Assignments for Equinox Programmers

The table shown in fig. 10 details the ISP Header pin assignments for all Equinox ISP programmers. The Micro-ISP, Activ8r and FS2000A all feature the 'Equinox 10-way Header', but the FS2000A does not have the 'PROG_SS' or 'PROG_LED' lines. Please refer to the relevant appendix for further information on each programmer.

Programmer	Micro-ISP/Activ8r	FS20		
ISP Header Type Pin Number	Equinox 10-way Header	Equinox 10-way Header	Atmel 10-way Header	Atmel 6-way Header (All programmers)
Appendix	Appendix 1	Appendix 2	Appendix 3	Appendix 4
1	PROG_VCC	PROG_VCC	PROG_MOSI	PROG_MISO
2	PROG_SS	N/C	PROG_VCC	PROG_VCC
3	PROG_SCK2	PROG_SCK2	N/C	PROG_SCK1
4	PROG_MOSI	PROG_MOSI	PROG_GND	PROG_MOSI
5	PROG_LED	N/C	PROG_RESET	PROG_RESET
6	PROG_MISO	PROG_MISO	PROG_GND	PROG_GND
7	PROG_GND	PROG_GND	PROG_SCK1	-
8	PROG_SCK1	PROG_SCK1	PROG_GND	-
9	PROG_GND	PROG_GND	PROG_MISO	-
10	PROG_RESET	PROG_RESET	PROG_GND	-

Figure 10 - ISP Pin Assignments for Equinox Programmers



Appendix 1 - ISP Header Connections for Activ8r/Micro-ISP Programmers

Figure 1 indicates the position of Pin 1 for Red stripe both the ISP cable supplied and a 10-way Eauinox indicates Pin 1 ISP Cable Pin 1 IDC header situated on the target system. Top View Figure 2 indicates the pinout required for target system IDC header when using either a Micro-ISP or Activ8r programmer. Figure 2 Equinox ISP Cable 10-way Header Bottom View 1 on User Target System PROG_Vcc PROG SS 3 4 PROG_SCK2 PROG_MOSI 5 6 PROG_MISO PROG LED 7 8 PROG GND PROG_SCK1 Pin 1 9 10 PROG RESET PROG GND Figure 1 Target Microcontroller **ISP** Cable C User Target 0V Ø⊖ Target Vcc System Activ8r Programmer (-)Figure 3 Micro-ISP Target Programmer Microcontroller ISP Cable User Target 0V Ø⊖ Target Vcc System Figure 4



Pin 1

Red stripe

indicates

Equinox

Appendix 2 - ISP Header Connections for the FS2000A Programmer

Figure 1 indicates the position of Pin 1 for both the ISP cable supplied and a 10-way IDC header situated on the target system.

Figures 2 & 3 indicate the pinouts required for target system 10-way IDC header when using either an Equinox or Atmel 10-way Headers



Figure 4



Appendix 3 - ISP Header Connections for the ISP Cable Convertor



Figure 1 indicates the position of Pin 1 for both the ISP cable supplied and a 10-way IDC header situated the cable convertor.

The pinout for the Equinox 10-way header on the ISP cable convertor is shown in figure 3.

Figure 4 shows the pinout used for the Atmel 10-way header on the user target system. Using this header will require the use of the ISP Cable Convertor indicated in figure 4.









Appendix 4 - ISP Header Connections for the Atmel 6-way Header

Figure 1 shows the pinout used for the Atmel 6-way header on the user target system.

Using the Atmel 6-way header will require the use of a custom made 10-way to 6-way ISP cable (see figure 4). *Figure 1*



