SAMG – 8 bit AVR Microprocessors

- Peter Gheude September 2016

A brief look at the successful 8 bit Atmel Mega AVR Microcontrollers – specifically Mega328p.
Alf and Vergart's Risc, after the original Norwegian designers – Not confirmed

Why are 8 bit microcontrollers still so common?

- some of the larger manufacturers are;

Ti MSP430 - Microchip Technology PICs - Altera - Analog Devices - Cypress Semiconductor - Maxim Integrated - ELAN Microelectronics Corp. - Energy Micro - EPSON Semiconductor - Freescale Semiconductor - Fujitsu - Holtek - Hyperstone - Infineon - Intel - Lattice Semiconductor - National Semiconductor - NXP Semiconductors - Panasonic - Parallax - Rabbit Semiconductor - Renesas (Hitachi, Mitsubishi Electric and NEC Electronics) - Rockwell - Silicon Laboratories - Silicon Motion - Sony - Spansion - STMicroelectronics - Texas Instruments - Toshiba - Ubicom - Xemics - Xilinx – XMOS - Zilog - Could be future presentations from a SAMG member?

Jargon and Terms related to Microcontrollers which can be covered at a later date.

Debugging - debugWIRE - Joint Test Action Group (JTAG) - In-circuit debugging (ICD) - In-circuit emulator (ICE) - In-target probe (ITP) – Integrated Development Environment (IDE)

Programming - In-circuit serial programming (ICSP) - In-system programming (ISP) - Program and Debug Interface (PDI) - High-voltage serial programming (HVSP) - High voltage parallel programming (HVPP)

Bootloaders - programme to initialise the Microcontroller and initiate user programmes.

Why the ATMega328p is so successful ?

My Answer – thank the Italians for the Arduino for students and hobbyists, cheap, powerful, lots of support groups, unrestricted compilers, IDEs, libraries, support groups, many training/development kits including STK200, Dragon, Arduino,
– A boot loader program is programmed into specific address of the ATMega328 memory which allows you to program it without external hardware.

8-bit MCUs are commonly used in Microwave ovens, refrigerators, freezers, washing machines, dryers, air-conditioners, Televisions, dishwashers, irrigation systems and numerous other devices.

Market share of Microcontrollers (2014 Source: Gartner, Inc.)

- 8 bit 39.7% - 32 bit 38.5% - 16 bit 21.8%

Top 8-Bit Manufacturers, By Revenue in 2014 - $6.2 billion in 8-bit MCUs

- Microchip Technology $970 M
- Renesas Electronics $878 M
- NXP Semiconductors $832 M
- Atmel $634 M
- STmicroelectronics $620 M

Numerous package size and pinouts – Not all I/O ports are present on the lower pin count packages. to make it easier for us the ATmega328p-PU was chosen – PU means PDIL Flash Memory write resilience - re-flash guaranteed minimum 10,000 cycles.
Dangerous Prototypes Test using Flash Destroyer Tool
- Tested Microchip 24AA01-I/P 128byte I2C EEPROM lasted 11,494,06X Writes over 13 days.
- Microcontroller writes in excess of 1,000 times

Programming AVR Microcontrollers

- Narrowing the focus at this time as the ATMega328p is used in the Component/Transistor Tester.

Arduino IDE, Atmel Studio, Geany(GTK+ toolkit), Eclipse, Code::Blocks and other integrated development environment suites are necessary to test and burn programs into Atmel microcontroller. They usually incorporate a debugger, source code editor and compiler and associated build tools.

AVRDude is an "open source command line application" utilised by Ardino IDE and many other IDEs.
AVRDUDE - AVR Downloader/UploaDEr
Supports Intel Hex, Motorola S-Record, and raw binary files – AVR Chip Definitions in AVRDude.conf
AVRDude requires a serial or usb programmer device such as USBAsp, nano or other programmer.
AVRDudess GUI interface for AVRDude.
ExtremeBurner – Avinash Gupta from Extreme Electronics – displays flash, EEProm and Fuse

What is an Arduino?

There are many Italian Arduino Boards customized for different Microcontroller types.
Most contain an onboard USB to Serial converter to communicate and program the microcontroller.
An Arduino bootloader is preprogrammed into the flash memory allowing "sketches" (.ino) to be installed into separate program flash memory from the bootloader. The programming language is a simplified version of C++ customized for the Arduino IDE. I/O is organized to standard layout configuration? Many are the I/O libraries which are selected as required. (.ino define **setup()** and **loop()** functions and can be replaced with .CPP and .H as the sketch grows in complexity)

The Arduino IDE compiles the sketch using GNU C++ AVR toolchain

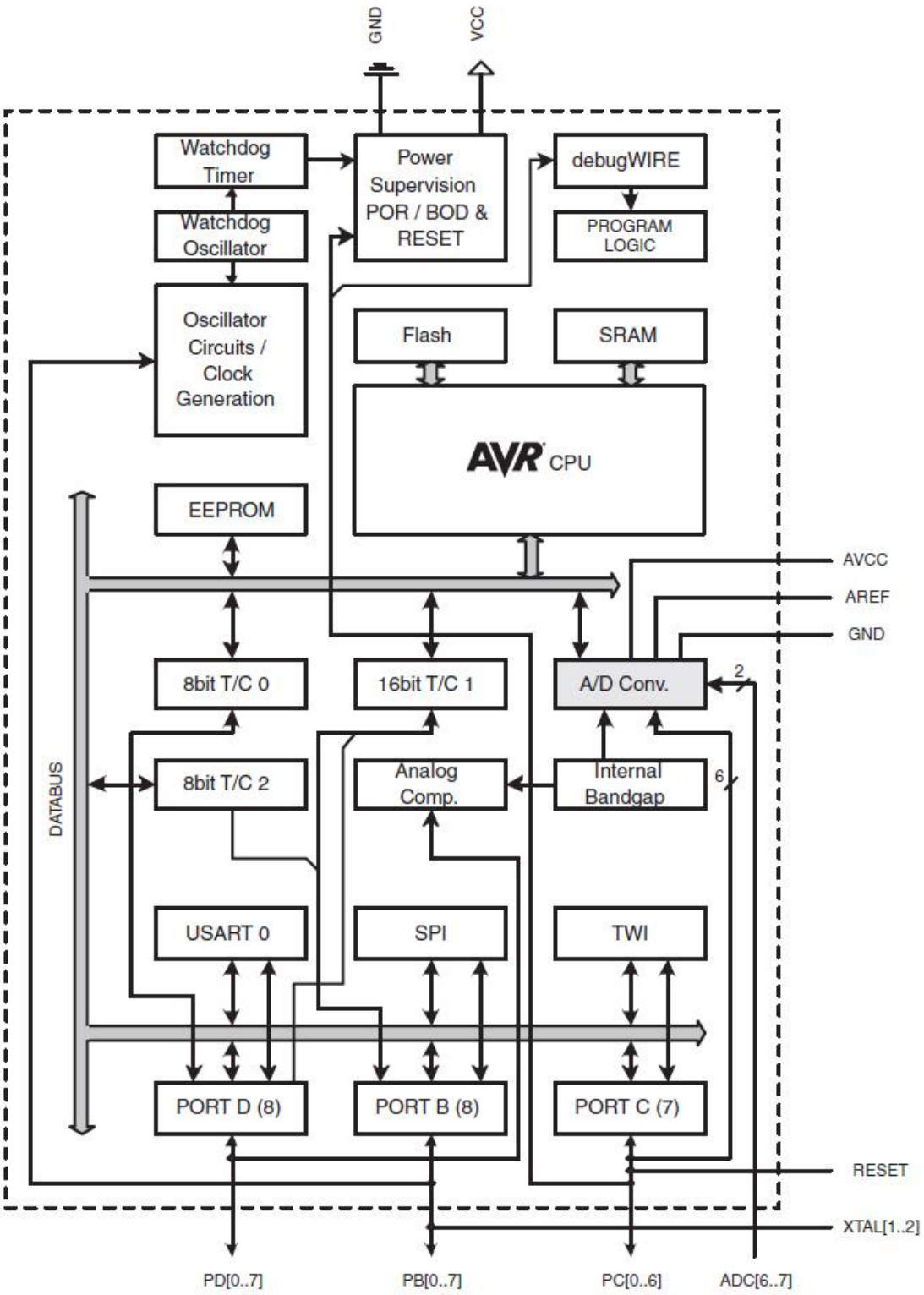
What is an Arduino Shield?

An interface board laid out in a constantly evolving standard?
They are sometimes stackable and provide miscellaneous devices, sensors, displays, isolating buffering, drivers, prototyping area and standard connectors some are vary slightly?

Integrated Development Environment (IDE)

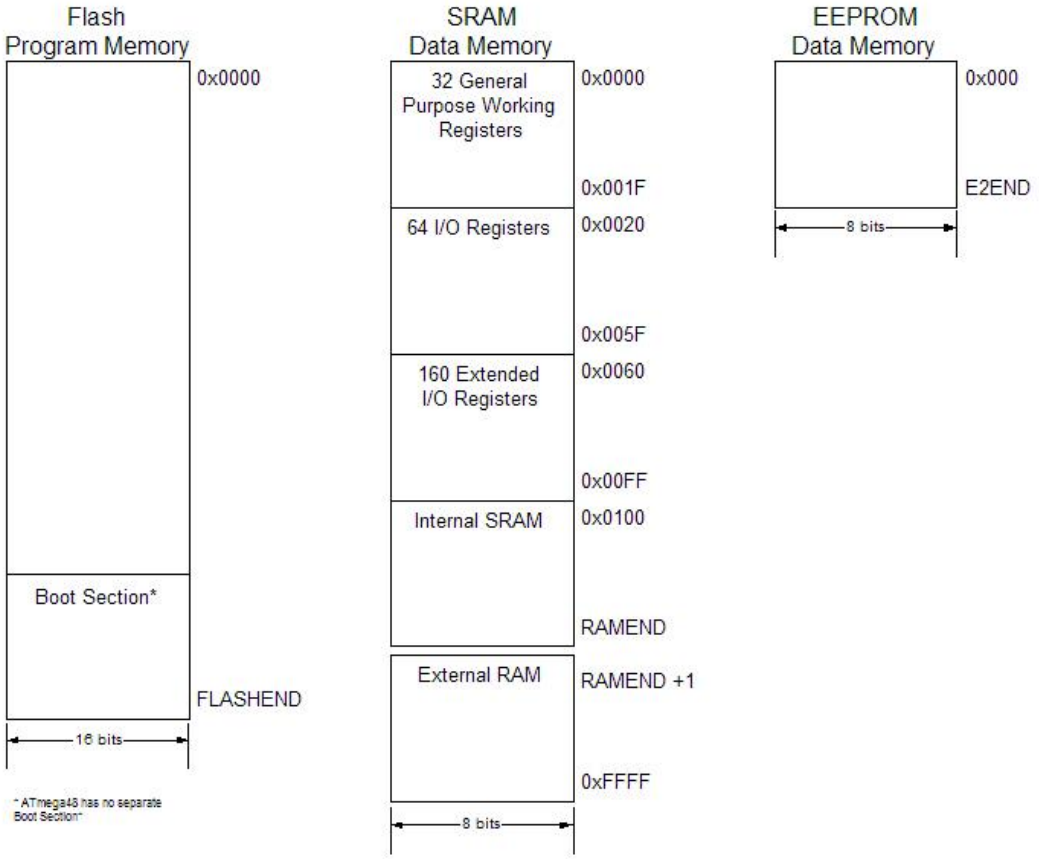
Arduino IDE Version - 4.18 with SP3 is best on older computers – Less overhead

WinAVR – open source suite includes the GNU GCC compiler for C and C++.



ATMega328p-PU - p is for picopower version and PU means PDIL (Parallel Dual in Line)

modified Harvard structure



Type / Device	Program (Flash)		Data (SRAM)		Data (EEPROM)		Interrupt Vector Size
	FLASHEND	Words	RAMEND	Bytes	E2END	Bytes	
ATmega48	0x07FF	4K	0x02FF	512	0x0FF	256	1 word
ATmega88	0x0FFF	8K	0x04FF	1K	0x1FF	512	1 word
ATmega168	0x1FFF	16K	0x04FF	1K	0x1FF	512	2 words
ATmega328	0x3FFF	32K	0x08FF	2K	0x3FF	1024	2 words

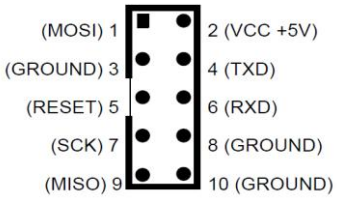
ATmega Microcontroller Electrical Characteristics

ATMega	Pakage	Progam Mem	RAM	EEProg	Pins	Timer	A/D	PWM	USART	Freq
ATMEGA48V-10PI	PDIP28	4k	512	256	23	2x8-bit,1x16-bit	6x10-bit	6	Yes	10
ATMEGA8A-PU	PDIP28	8k	1024	512	23	2x8-bit,1x16-bit	6x10-bit	3	Yes	16
ATMEGA8L-8PU	PDIP28	8k	1024	512	23	2x8-bit,1x16-bit	6x10-bit	3	Yes	8
ATMEGA88-20PU	PDIP28	8k	1024	512	23	2x8-bit,1x16-bit	6x10-bit	6	Yes	20
ATMEGA88PA-PU	PDIP28	8k	1024	512	23	2x8-bit,1x16-bit	6x10-bit	6	Yes	20
ATMEGA88V-10PU	PDIP28	8k	1024	512	23	2x8-bit,1x16-bit	6x10-bit	6	Yes	10
ATMEGA168-20PU	PDIP28	16k	1024	512	23	2x8-bit,1x16-bit	6x10-bit	6	Yes	20
ATMEGA168V-10PU	PDIP28	16k	1024	512	23	2x8-bit,1x16-bit	6x10-bit	6	Yes	10
ATMEGA328-PU	PDIP28	32k	2048	1024	23	2x8-bit,1x16-bit	6x10-bit	6	Yes	20

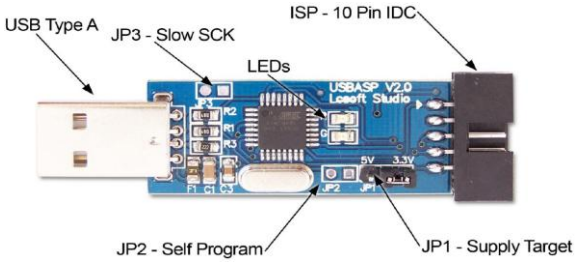
ATMEGA328P-PU	PDIP28	32k	2048	1024	23	2x8-bit,1x16-bit	6x10-bit	6	Yes	20
ATMEGA8515-16PU	PDIP40	8k	512	512	35	1x8-bit,1x16-bit	Comparator	3	Yes	16
ATMEGA8515L-8PU	PDIP40	8k	512	512	35	1x8-bit,1x16-bit	Comparator	3	Yes	8
ATMEGA8535-16PU	PDIP40	8k	512	512	32	2x8-bit,1x16-bit	8x10-bit	4	Yes	16
ATMEGA8535L-8PU	PDIP40	8k	512	512	32	2x8-bit,1x16-bit	8x10-bit	4	Yes	8
ATMEGA16-16PU	PDIP40	16k	1024	512	32	2x8-bit,1x16-bit	8x10-bit	4	Yes	16
ATMEGA16A-PU	PDIP40	16k	1024	512	32	2x8-bit,1x16-bit	8x10-bit	4	Yes	16
ATMEGA162-16PU	PDIP40	16k	1024	512	35	2x8-bit,2x16-bit	Comparator	6	Yes	16
ATMEGA32-16PU	PDIP40	32k	2048	1024	32	2x8-bit,1x16-bit	8x10-bit	4	Yes	16
ATMEGA32A-PU	PDIP40	32k	2048	1024	32	2x8-bit,1x16-bit	8x10-bit	4	Yes	16
ATMEGA32L-8PU	PDIP40	32k	2048	1024	32	2x8-bit,1x16-bit	8x10-bit	4	Yes	8
ATMEGA644-20PU	PDIP40	64k	4096	2048	32	2x8-bit,1x16-bit	8x10-bit	6	Yes	20
ATMEGA644P-20PU	PDIP40	64k	4096	2048	32	2x8-bit,1x16-bit	8x10-bit	6	Yes	20
ATMEGA644PA-PU	PDIP40	64k	4096	2048	32	2x8-bit,1x16-bit	8x10-bit	6	Yes	20
ATMEGA644V-10PU	PDIP40	64k	4096	2048	32	2x8-bit,1x16-bit	8x10-bit	6	Yes	10
ATMEGA1284P-PU	PDIP40	128k	16384	4096	32	2x8-bit,2x16-bit	8x10-bit	6	Yes	20
ATMEGA48-20AU	TQFP32	4k	512	256	23	2x8-bit,1x16-bit	8x10-bit	6	Yes	20
ATMEGA48V-10AU	TQFP32	4k	512	256	23	2x8-bit,1x16-bit	8x10-bit	6	Yes	10
ATMEGA8-16AU	TQFP32	8k	1024	512	23	2x8-bit,1x16-bit	8x10-bit	3	Yes	16
ATMEGA168-20AU	TQFP32	16k	1024	512	23	2x8-bit,1x16-bit	8x10-bit	6	Yes	20
ATMEGA168PA-AU	TQFP32	16k	1024	512	23	2x8-bit,1x16-bit	8x10-bit	6	Yes	20
ATMEGA168V-10AU	TQFP32	16k	1024	512	23	2x8-bit,1x16-bit	8x10-bit	6	Yes	10
ATMEGA328P-AU	TQFP32	32k	2048	1024	23	2x8-bit,1x16-bit	8x10-bit	6	Yes	20
ATMEGA162-16AU	TQFP44	16k	1024	512	35	2x8-bit,1x16-bit	Comparator	6	Yes	16
ATMEGA16L-8AU	TQFP44	16k	1024	512	32	2x8-bit,1x16-bit	8x10-bit	4	Yes	8
ATMEGA32L-8AI	TQFP44	32k	2048	1024	32	2x8-bit,1x16-bit	8x10-bit	4	Yes	8
ATMEGA64-16AU	TQFP64	64k	4k	2k	53	2x8-bit,2x16-bit	8x10-bit	6	2	16
ATMEGA64A-AU	TQFP64	64k	4k	2k	53	2x8-bit,2x16-bit	8x10-bit	6	2	16
ATMEGA64L-8AU	TQFP64	64k	4k	2k	53	2x8-bit,2x16-bit	8x10-bit	6	2	8
ATMEGA128-16AU	TQFP64	128k	4k	4k	53	2x8-bit,2x16-bit	8x10-bit	6	2	16
ATMEGA128A-AU	TQFP64	128k	4k	4k	53	2x8-bit,2x16-bit	8x10-bit	6	2	16
ATMEGA128L-8AU	TQFP64	128k	4k	4k	53	2x8-bit,2x16-bit	8x10-bit	6	2	8

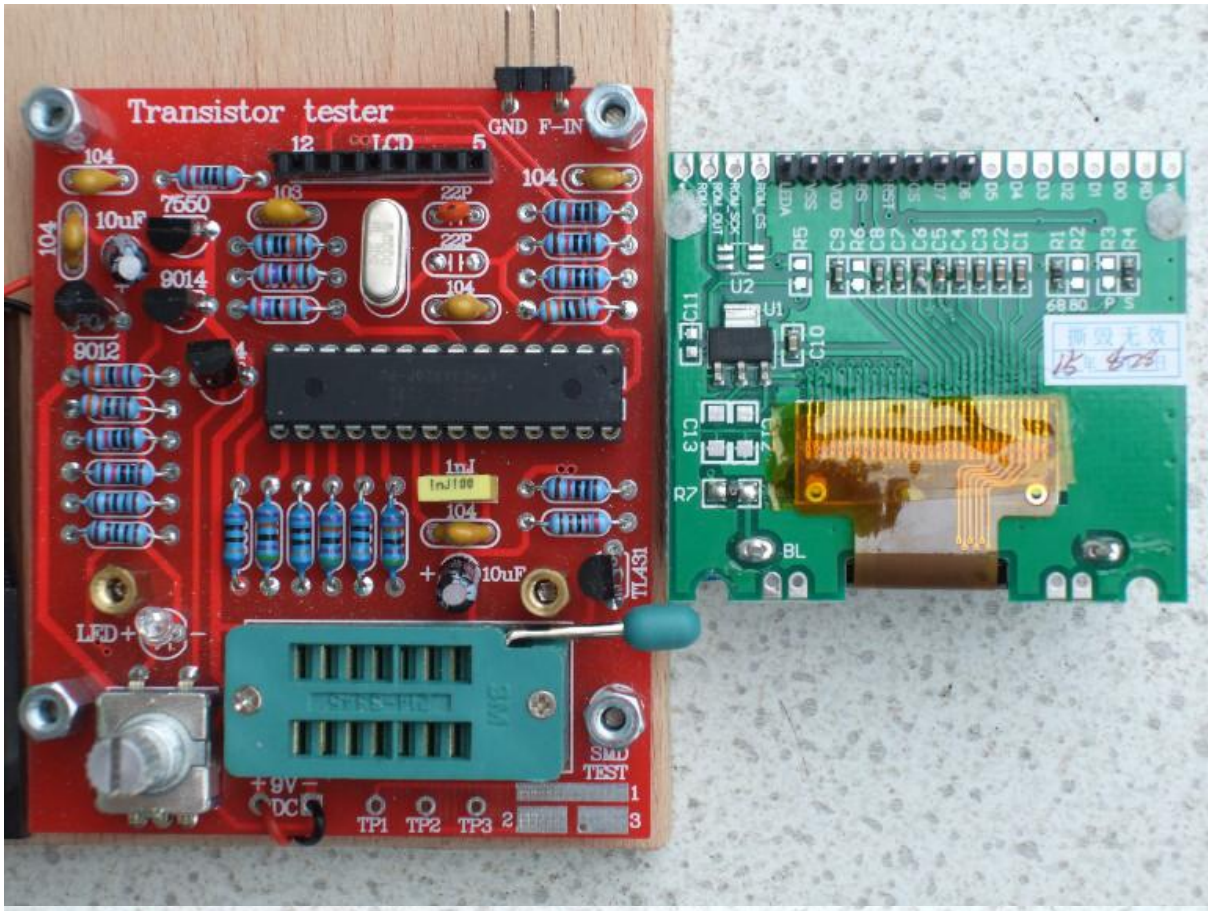
ICSP In Circuit Serial Programmer

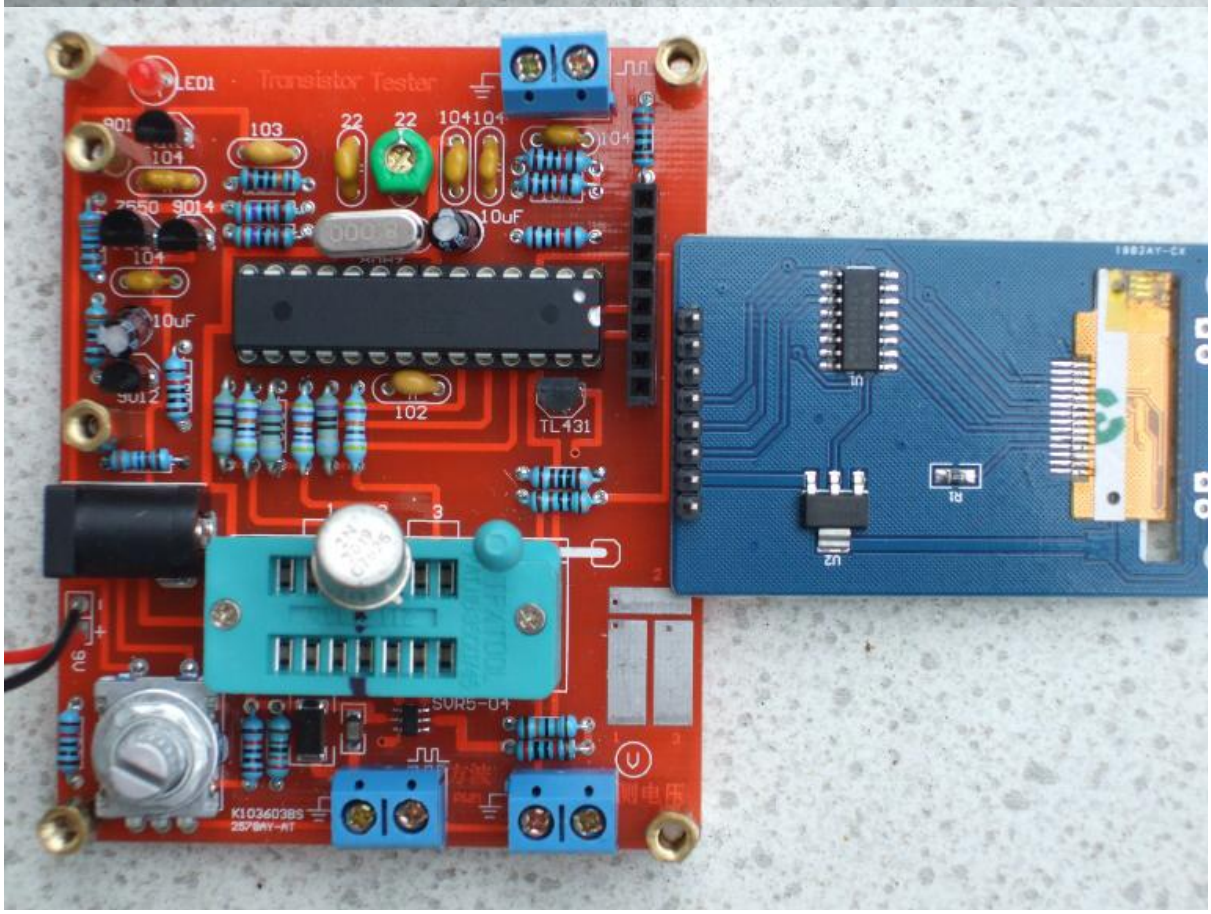
ATmega328p pin 7 (VCC)
ATmega328p pin 8 (GND)
ATmega328p pin 1 (RESET)
ATmega328p pin 17 (MOSI)
ATmega328p pin 18 (MISO)
ATmega328p pin 19 (SCK)



10 Pin ISP pinout




Transistor tester
GND F-IN
LCD
104
10uF
7550
9014
9012
103
22P
1nJ
TL431
LED+
SMD TEST
+9V-
DC
TP1 TP2 TP3
U1
U2
C11
C10
C13
R7
BL


LED1
Transistor Tester
103
22
22
10uF
102
TL431
9V
SOR5-04

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Programming with ISP (in system programmer), Serial, USB devices

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