
Tools and Accessories

For many Arduino projects you don't need any tools, just some jumper wires, shield and sensor PCBs, and of course an Arduino. But after graduating to more advanced projects you will find that a selection of basic tools and accessories becomes essential. A set of hand tools, a soldering iron, and a few other items are usually sufficient for all but the most complex projects. If I may be so bold, I would recommend my book *Practical Electronics: Components and Techniques* (O'Reilly) as a reference for things like screw and bolt sizes, electronic components, and PCB fabrication.

In this chapter I will describe the basic tools you might want to consider having on hand for your own projects. Everything presented here can easily fit into a medium-sized toolbox when it's not needed.

Hand Tools

A good selection of hand tools is essential. With patience and some effort you can accomplish just about any task with good hand tools. Before the introduction of electricity, hand tools were really the only way for most people to build anything, and they built a lot of amazing things. So can you, as long as you are willing to take the time to do it correctly. We won't look at techniques here, as there are other books that cover that, but I will describe some tools you might want to consider, and where to find them.

Screwdrivers

For most projects involving an Arduino all you need in the way of screwdrivers is a good set of the miniature types or a combination kit, such as the one shown in Figure A-1, and a set of larger screwdrivers. You can find various sets of miniature

screwdrivers at most well-stocked hardware stores, some big-box home improvement stores, and just about any electronics store that specializes in components and tools.



Figure A-1. A set of miniature screwdrivers

Full-size screwdrivers, like those shown in Figure A-2, can be found in numerous places, including the home repair aisle of a large grocery store. Avoid the very large tools, and look for a kit that has smaller tip sizes. You will need those, but the large tools not so much (unless you also need to do residential power wiring or work on an automobile).



Figure A-2. A set of standard full-size screwdrivers

Pliers and Cutters

Needle-nosed pliers, diagonal cutters, and a pair of good flush cutters are essential. You might also want to consider a pair of standard pliers and perhaps even lineman's pliers, but these aren't absolutely necessary. Figure A-3 shows a selection of basic pli-

ers and cutters that can be purchased as a set. You can also pick and choose from individual tools to suit your needs.



Figure A-3. A set of basic pliers and cutters

Resist the temptation to try to use the wire cutters that come with the bundled selections from some hardware and home improvement stores for doing PCB-level electronics work. Flush cutters are made specifically for trimming component leads and cutting small-gauge wire, and they do a fine job of it. Figure A-4 shows a typical flush cutter tool.



Figure A-4. Typical flush cutters for electronics work

Wire Strippers

Another essential tool is a wire stripper. Although you may be tempted to use a pair of cutters to do this, it's generally not a good idea. It's very easy to cut one or more of the fine wires that make up a strand, and a nick on a solid conductor is where it will usually break if it is flexed. I keep two types on hand, and which one I pick up depends largely on how many wires I need to strip and which tool happens to be the easiest to reach.

The simplest wire stripper consists of a pair of blades with an adjustable stop, like the tool shown in Figure A-5. The downside to this tool is that you have to adjust the stop each time you use a different gauge of wire. But if you always use the same wire, then it's really not a problem (I use #24 gauge insulated twisted strand wire for almost everything, so I seldom need to adjust my tool).



Figure A-5. Basic wire strippers

My favorite wire strippers are sold by Klein, and they not only handle different wire gauges but also pull off the cut insulation, all in one motion. Figure A-6 shows an example of this type of tool. These are surprisingly affordable, and you can purchase an additional cutter blade for even more wire gauges. The downside is that they are big and somewhat bulky, so they won't fit into tight spaces.



Figure A-6. Fancy wire strippers

Connector Crimping Tools

One of the main annoyances encountered when working with Arduino boards, shields, and the various available modules is connecting everything. Jumper wires with pins and sockets are fine for assembling something on the bench (or kitchen table) to see how it works, but this can present some long-term reliability issues. A better approach is to use an I/O extension shield (like those described in Chapter 9) that provides multiconductor connectors. Figure A-7 shows such a shield with cables attached.



Figure A-7. I/O extension shield with connectors attached

The metallic connectors attach to wires by crimping, and that means you will need a special tool (and the correct connector bodies and inserts). Fortunately the price of these tools has dropped dramatically over the past few years. You can now buy a tool for about \$30 that does the same basic job as a tool that used to cost \$200. Figure A-8 shows a selection of crimping tools.

Once the contacts (either pins or sockets) have been crimped onto the wires, the next step is to insert them into a connector housing, also called a shell or a body. These are available in 0.1 inch (2.54 mm) pitch (spacing), which is a de facto industry standard and is what is commonly found on Arduino components. Figure A-9 shows 1-, 2-, 3-, and 4-position connector housings. The pin or socket connectors lock into the plastic housings and can be easily removed by gently lifting a small locking tab using a miniature screwdriver.

Some Arduino shields and modules use connectors similar to those found on the ends of telephone or network cables. These can be assembled with tools available at most big-box home improvement stores, electronics distributors, and of course from online suppliers. Figure A-10 shows a shield that uses these types of connectors.



Figure A-8. Various types of low-cost crimping tools

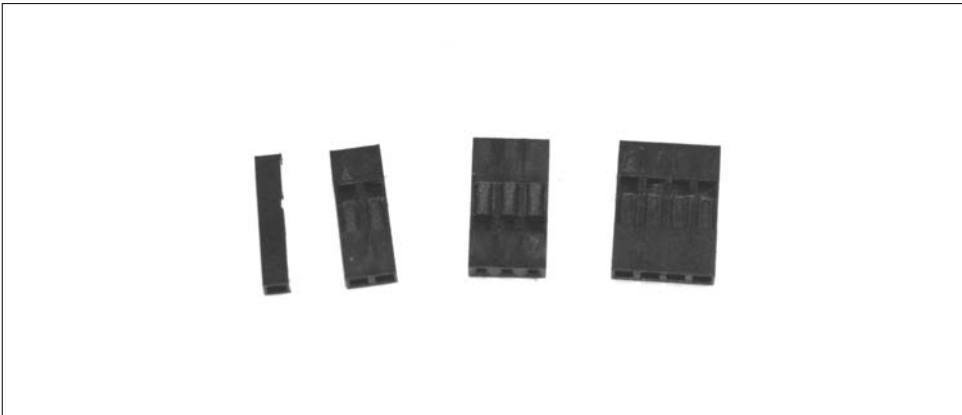


Figure A-9. 0.1 inch (2.54 mm) connector housings

Lastly, there are the so-called lug connectors used in electrical systems and vehicles, like the part shown in Figure A-11. These are readily available, but not very commonly used with Arduino projects (although they are used in the signal generator in Chapter 11). The connectors come in a variety of styles and types, and the crimping tools are available from many different sources.

Figure A-12 shows one type of tool used with lug connectors. Do not attempt to use this type of crimping tool with the small connectors used for the pins and sockets on a PCB like an Arduino—the end result will just be a smashed and useless connector.

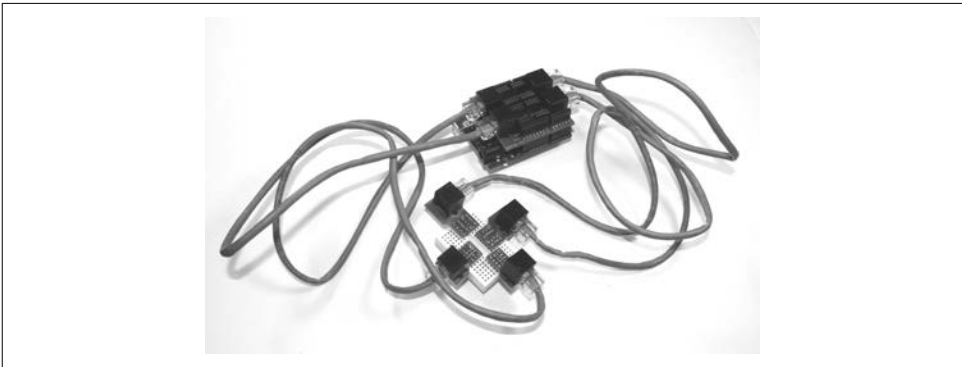


Figure A-10. I/O extension shield with RJ45 (8P8C) connectors



Figure A-11. A spade lug-type connector



Figure A-12. A common spade lug crimping tool

Crimped connectors are easy to install, reliable (if done correctly—it can take some practice), and cheap. The downside is the initial investment in the tools. If you are

willing to make that investment, then your soldering iron will spend most of its time in your toolbox and your projects will have a polished and professional look.

Saws

A couple of types of small saws are handy to have on hand when you need to trim a circuit board, cut out a small section of a plastic enclosure, or cut a section of plastic tubing. Nothing else can do those things as quickly and easily as a saw.

A jeweler's saw like the one shown in Figure A-13 is useful for doing very fine precision cuts, but it's not very good at cutting large items. The trick to using a jeweler's saw is to let the saw do the work without forcing it into the cut (this can generally be said of any saw, by the way). The thin blades won't take much in the way of stress, but they will cut through almost anything with enough care and patience.



Figure A-13. Jeweler's saw

For larger jobs, particularly those involving metal, a hacksaw is the way to go. A typical generic hacksaw is shown in Figure A-14. Newer models may have a more streamlined look, but the basic idea is the same. You can also buy hacksaws that are little more than a blade with a handle at one end.

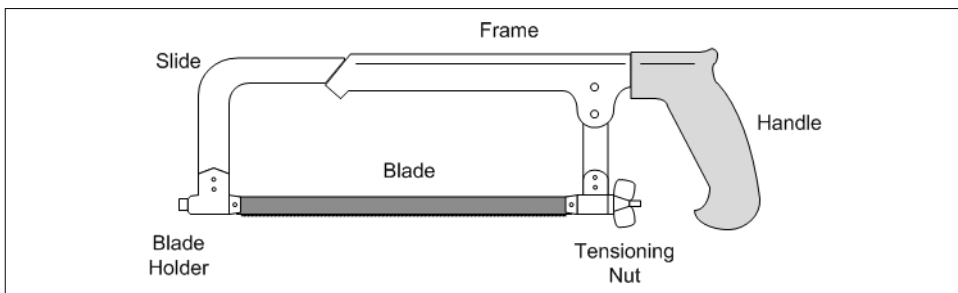


Figure A-14. Common hacksaw design

When using a hacksaw remember that the saw will only cut in one direction, either push or pull. It depends on how the blade is installed. I prefer to mount the blade so that the saw cuts when pulled, but some people like to do it the other way.

Power Tools

For many tasks some good hand tools will get the job done and, if used correctly, do it nicely as well. But other tasks might need more power than a hand tool can deliver without causing muscle cramps. Drilling and grinding are two examples.

Drills

An electric hand drill is great for many things. Drilling precise holes is generally not one of those things, but when you need just one 1/8 inch hole in a panel, and it doesn't have to be super-precise, then a hand drill is very useful. I recommend a cordless drill, like the one shown in Figure A-15, if for no other reason than that it is less of a hassle without a power cord. Although a battery-operated cordless drill might not have the same amount of torque as a drill that plugs into a wall outlet, most small projects involve plastic, thin wood or wood-like materials, and thin metal, and a cordless drill will work just fine.



Figure A-15. Cordless drill with interchangeable battery pack

Miniature Grinder

Although a grinder isn't actually an essential tool, it is a very useful and handy tool to have around. A miniature grinder, like the one shown in Figure A-16, can be used to sharpen screwdrivers, take the rough edges and burrs off of the end of a metal rod after it is cut, clean up the edges of plastic pieces, and even trim up a PCB.



Figure A-16. Miniature grinder

This particular grinder is from Harbor Freight, and it includes a rotary tool attachment. It might not do everything a standalone rotary tool will do, but it does come in handy for lightweight jobs.

Miniature Drill Press

If you need some precisely sized holes, in precise locations, then you really need a drill press. Although a full-sized drill press can be used for jobs like this, they tend to be large things that don't easily tuck away into a closet when you don't need them. The solution is a miniature drill press like the one shown in Figure A-17.

In addition to drilling holes for switches and LEDs in a small plastic enclosure, you can also drill holes in a PCB. Accessories such as a miniature vise are available to hold the work steady while drilling.



Figure A-17. Miniature drill press

Soldering

If any one activity could be said to characterize electronics, it would have to be soldering. Soldering is not really necessary if you are using ready-made PCBs and modules with an Arduino, but if you want to integrate an Arduino into a larger system, then soldering may be required. And if you happen to purchase a shield with a packet of pin and socket connectors and empty holes on the PCB, then soldering is no longer optional.

Soldering Irons

Soldering irons come in a range of prices, from ultra-low-cost tools with no temperature control and tips of dubious quality, to soldering stations with interchangeable tips and integrated temperature control costing hundreds of dollars. Avoid the cheap tools, as they can do some serious damage to a circuit board and the components soldered onto it. Spend as much as you can afford, but at least consider something like the iron shown in Figure A-18, which sells for about \$15.



Figure A-18. Inexpensive soldering iron

If you can afford it, consider a soldering station like the one shown in Figure A-19. These tools range in price from about \$50 to somewhere around \$300. A good soldering station is a good investment, but you really need to have some serious soldering work to do in order to justify a pricey model.

Soldering Accessories

A soldering iron or soldering station is nice to have, but without some basic accessories it won't be very useful. At a minimum you'll need some solder. Don't buy solder for electronics at the local hardware store unless it specifically states that it is for electronics work. A good electronics-grade solder will have a flux core (usually rosin), and most are on the thin side. I like to purchase solder in one-pound (454 g) spools, like the one shown in Figure A-20.



Figure A-19. Soldering station



Figure A-20. Spool of rosin-core solder

Other useful accessories include solder wick (copper braid for removing solder), liquid or paste flux, and solder paste. You can learn more about the tools and accessories, and find soldering tutorials, in numerous texts and in online videos.

Tool Sources

Table A-1 lists some sources for the tools covered in this appendix. This is a very short list, as there are a large number of suppliers selling tools of all kinds.

Table A-1. Tool suppliers

Distributor/vendor	URL	Distributor/vendor	URL
Adafruit	www.adafruit.com	Maker Shed	www.makershed.com
Apex Tool Group	www.apexhandtools.com	MCM Electronics	www.mcmelectronics.com
CKB Products	www.ckbproducts.com	SainSmart	www.sainsmart.com
Circuit Specialists	www.circuitspecialists.com	SparkFun	www.sparkfun.com
Electronic Goldmine	www.goldmine-elec-products.com	Stanley	www.stanleysupplyservices.com
Harbor Freight Tools	www.harborfreight.com	Velleman	www.vellemanusa.com

Don't overlook your local used tool shop. Many cities have one or more shops that specialize in used tools, with selections that include everything from buckets full of used screwdrivers to used machine shop tools like vertical mills. Other places to look include organizations that accept donations, such as Goodwill (here in the US). They may not have much of a selection when it comes to tools, but if you have a moment to spare they can sometimes yield up some amazingly good deals.

AVR ATmega Control Registers

The register summaries in this appendix are intended as a quick reference. This appendix is not a comprehensive description of each control register. For detailed descriptions of each control register for a particular MCU type, see the Atmel documentation. Pay special attention to the notes included with the control register summaries in the Atmel documents. Each MCU has a slightly different set of things to watch out for.

In general, reserved bits (marked with a “–”) should not be accessed. Registers in the range of 0x00 to 0x1F are directly bit-accessible with the SBI and CBI instructions (set I/O bit and clear I/O bit, respectively). Register addresses in parentheses are the SRAM addresses of the control registers, whereas the addresses not in parentheses reside in the 64-byte address space reserved for I/O control registers. The reserved locations can be used with the IN and OUT instructions, and the SRAM addresses must be accessed with the ST/STS/STD and LD/LDS/LDD instructions.

The information in this appendix was derived from the following Atmel technical documents, all of which are available from Atmel.com:

Document number	Title
Atmel-8271I-AVR- ATmega-Datasheet_10/2014	Atmel ATmega48A/PA/88A/PA/168A/PA/328/P
2549Q-AVR-02/2014	Atmel ATmega640/V-1280/V-1281/V-2560/V-2561/V
7766F-AVR-11/10	Atmel ATmega16U4/ATmega32U4

ATmega168/328

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0xFF)	Reserved	—	—	—	—	—	—	—	—
(0xFE)	Reserved	—	—	—	—	—	—	—	—
(0xFD)	Reserved	—	—	—	—	—	—	—	—
(0xFC)	Reserved	—	—	—	—	—	—	—	—
(0xFB)	Reserved	—	—	—	—	—	—	—	—
(0xFA)	Reserved	—	—	—	—	—	—	—	—
(0xF9)	Reserved	—	—	—	—	—	—	—	—
(0xF8)	Reserved	—	—	—	—	—	—	—	—
(0xF7)	Reserved	—	—	—	—	—	—	—	—
(0xF6)	Reserved	—	—	—	—	—	—	—	—
(0xF5)	Reserved	—	—	—	—	—	—	—	—
(0xF4)	Reserved	—	—	—	—	—	—	—	—
(0xF3)	Reserved	—	—	—	—	—	—	—	—
(0xF2)	Reserved	—	—	—	—	—	—	—	—
(0xF1)	Reserved	—	—	—	—	—	—	—	—
(0xF0)	Reserved	—	—	—	—	—	—	—	—
(0xEF)	Reserved	—	—	—	—	—	—	—	—
(0xEE)	Reserved	—	—	—	—	—	—	—	—
(0xED)	Reserved	—	—	—	—	—	—	—	—
(0xEC)	Reserved	—	—	—	—	—	—	—	—
(0xEB)	Reserved	—	—	—	—	—	—	—	—
(0xEA)	Reserved	—	—	—	—	—	—	—	—
(0xE9)	Reserved	—	—	—	—	—	—	—	—
(0xE8)	Reserved	—	—	—	—	—	—	—	—
(0xE7)	Reserved	—	—	—	—	—	—	—	—
(0xE6)	Reserved	—	—	—	—	—	—	—	—
(0xE5)	Reserved	—	—	—	—	—	—	—	—
(0xE4)	Reserved	—	—	—	—	—	—	—	—
(0xE3)	Reserved	—	—	—	—	—	—	—	—
(0xE2)	Reserved	—	—	—	—	—	—	—	—
(0xE1)	Reserved	—	—	—	—	—	—	—	—
(0xE0)	Reserved	—	—	—	—	—	—	—	—
(0xDF)	Reserved	—	—	—	—	—	—	—	—
(0xDE)	Reserved	—	—	—	—	—	—	—	—
(0xDD)	Reserved	—	—	—	—	—	—	—	—

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0xDC)	Reserved	–	–	–	–	–	–	–	–
(0xDB)	Reserved	–	–	–	–	–	–	–	–
(0xDA)	Reserved	–	–	–	–	–	–	–	–
(0xD9)	Reserved	–	–	–	–	–	–	–	–
(0xD8)	Reserved	–	–	–	–	–	–	–	–
(0xD7)	Reserved	–	–	–	–	–	–	–	–
(0xD6)	Reserved	–	–	–	–	–	–	–	–
(0xD5)	Reserved	–	–	–	–	–	–	–	–
(0xD4)	Reserved	–	–	–	–	–	–	–	–
(0xD3)	Reserved	–	–	–	–	–	–	–	–
(0xD2)	Reserved	–	–	–	–	–	–	–	–
(0xD1)	Reserved	–	–	–	–	–	–	–	–
(0xD0)	Reserved	–	–	–	–	–	–	–	–
(0xCF)	Reserved	–	–	–	–	–	–	–	–
(0xCE)	Reserved	–	–	–	–	–	–	–	–
(0xCD)	Reserved	–	–	–	–	–	–	–	–
(0xCC)	Reserved	–	–	–	–	–	–	–	–
(0xCB)	Reserved	–	–	–	–	–	–	–	–
(0xCA)	Reserved	–	–	–	–	–	–	–	–
(0xC9)	Reserved	–	–	–	–	–	–	–	–
(0xC8)	Reserved	–	–	–	–	–	–	–	–
(0xC7)	Reserved	–	–	–	–	–	–	–	–
(0xC6)	UDR0	USART I/O Data Register							
(0xC5)	UBRR0H	USART Baud Rate Register High							
(0xC4)	UBRR0L	USART Baud Rate Register Low							
(0xC3)	Reserved	–	–	–	–	–	–	–	–
(0xC2)	UCSROC	UMSEL01	UMSEL00	UPM01	UPM00	USBS0	UCSZ01/ UDORD0	UCSZ00/ UCPHA0	UCPOL0
(0xC1)	UCSROB	RXCIE0	TXCIE0	UDRIE0	RXEN0	TXEN0	UCSZ02	RXB80	TXB80
(0xC0)	UCSROA	RXC0	TXC0	UDRE0	FE0	DOR0	UPE0	U2X0	MPCM0
(0xBF)	Reserved	–	–	–	–	–	–	–	–
(0xBE)	Reserved	–	–	–	–	–	–	–	–
(0xBD)	TWAMR	TWAM6	TWAM5	TWAM4	TWAM3	TWAM2	TWAM1	TWAM0	–
(0xBC)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	–	TWIE
(0xBB)	TWDR	2-wire Serial Interface Data Register							
(0xBA)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE
(0xB9)	TWSR	TWS7	TWS6	TWS5	TWS4	TWS3	–	TWPS1	TWPS0
(0xB8)	TWBR	2-wire Serial Interface Bit Rate Register							

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0xB7)	Reserved	–	–	–	–	–	–	–	–
(0xB6)	ASSR	–	EXCLK	AS2	TCN2UB	OCR2AUB	OCR2BUB	TCR2AUB	TCR2BUB
(0xB5)	Reserved	–	–	–	–	–	–	–	–
(0xB4)	OCR2B	Timer/Counter2 Output Compare Register B							
(0xB3)	OCR2A	Timer/Counter2 Output Compare Register A							
(0xB2)	TCNT2	Timer/Counter2 (8-bit)							
(0xB1)	TCCR2B	FOC2A	FOC2B	–	–	WGM22	CS22	CS21	CS20
(0xB0)	TCCR2A	COM2A1	COM2A0	COM2B1	COM2B0	–	–	WGM21	WGM20
(0xAF)	Reserved	–	–	–	–	–	–	–	–
(0xAE)	Reserved	–	–	–	–	–	–	–	–
(0xAD)	Reserved	–	–	–	–	–	–	–	–
(0xAC)	Reserved	–	–	–	–	–	–	–	–
(0xAB)	Reserved	–	–	–	–	–	–	–	–
(0xAA)	Reserved	–	–	–	–	–	–	–	–
(0xA9)	Reserved	–	–	–	–	–	–	–	–
(0xA8)	Reserved	–	–	–	–	–	–	–	–
(0xA7)	Reserved	–	–	–	–	–	–	–	–
(0xA6)	Reserved	–	–	–	–	–	–	–	–
(0xA5)	Reserved	–	–	–	–	–	–	–	–
(0xA4)	Reserved	–	–	–	–	–	–	–	–
(0xA3)	Reserved	–	–	–	–	–	–	–	–
(0xA2)	Reserved	–	–	–	–	–	–	–	–
(0xA1)	Reserved	–	–	–	–	–	–	–	–
(0xA0)	Reserved	–	–	–	–	–	–	–	–
(0x9F)	Reserved	–	–	–	–	–	–	–	–
(0x9E)	Reserved	–	–	–	–	–	–	–	–
(0x9D)	Reserved	–	–	–	–	–	–	–	–
(0x9C)	Reserved	–	–	–	–	–	–	–	–
(0x9B)	Reserved	–	–	–	–	–	–	–	–
(0x9A)	Reserved	–	–	–	–	–	–	–	–
(0x99)	Reserved	–	–	–	–	–	–	–	–
(0x98)	Reserved	–	–	–	–	–	–	–	–
(0x97)	Reserved	–	–	–	–	–	–	–	–
(0x96)	Reserved	–	–	–	–	–	–	–	–
(0x95)	Reserved	–	–	–	–	–	–	–	–
(0x94)	Reserved	–	–	–	–	–	–	–	–
(0x93)	Reserved	–	–	–	–	–	–	–	–

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0x92)	Reserved	–	–	–	–	–	–	–	–
(0x91)	Reserved	–	–	–	–	–	–	–	–
(0x90)	Reserved	–	–	–	–	–	–	–	–
(0x8F)	Reserved	–	–	–	–	–	–	–	–
(0x8E)	Reserved	–	–	–	–	–	–	–	–
(0x8D)	Reserved	–	–	–	–	–	–	–	–
(0x8C)	Reserved	–	–	–	–	–	–	–	–
(0x8B)	OCR1BH	Timer/Counter1: Output Compare Register B High Byte							
(0x8A)	OCR1BL	Timer/Counter1: Output Compare Register B Low Byte							
(0x89)	OCR1AH	Timer/Counter1: Output Compare Register A High Byte							
(0x88)	OCR1AL	Timer/Counter1: Output Compare Register A Low Byte							
(0x87)	ICR1H	Timer/Counter1: Input Capture Register High Byte							
(0x86)	ICR1L	Timer/Counter1: Input Capture Register Low Byte							
(0x85)	TCNT1H	Timer/Counter1: Counter Register High Byte							
(0x84)	TCNT1L	Timer/Counter1: Counter Register Low Byte							
(0x83)	Reserved	–	–	–	–	–	–	–	–
(0x82)	TCCR1C	FOC1A	FOC1B	–	–	–	–	–	–
(0x81)	TCCR1B	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10
(0x80)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	–	–	WGM11	WGM10
(0x7F)	DIDR1	–	–	–	–	–	–	AIN1D	AIN0D
(0x7E)	DIDR0	–	–	ADC5D	ADC4D	ADC3D	ADC2D	ADC1D	ADC0D
(0x7D)	Reserved	–	–	–	–	–	–	–	–
(0x7C)	ADMUX	REFS1	REFS0	ADLAR	–	MUX3	MUX2	MUX1	MUX0
(0x7B)	ADCSRB	–	ACME	–	–	–	ADTS2	ADTS1	ADTS0
(0x7A)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0
(0x79)	ADCH	ADC Data Register High Byte							
(0x78)	ADCL	ADC Data Register Low Byte							
(0x77)	Reserved	–	–	–	–	–	–	–	–
(0x76)	Reserved	–	–	–	–	–	–	–	–
(0x75)	Reserved	–	–	–	–	–	–	–	–
(0x74)	Reserved	–	–	–	–	–	–	–	–
(0x73)	Reserved	–	–	–	–	–	–	–	–
(0x72)	Reserved	–	–	–	–	–	–	–	–
(0x71)	Reserved	–	–	–	–	–	–	–	–
(0x70)	TIMSK2	–	–	–	–	–	OCIE2B	OCIE2A	TOIE2
(0x6F)	TIMSK1	–	–	ICIE1	–	–	OCIE1B	OCIE1A	TOIE1
(0x6E)	TIMSK0	–	–	–	–	–	OCIE0B	OCIE0A	TOIE0

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x6D	PCMSK2	PCINT23	PCINT22	PCINT21	PCINT20	PCINT19	PCINT18	PCINT17	PCINT16
0x6C	PCMSK1	–	PCINT14	PCINT13	PCINT12	PCINT11	PCINT10	PCINT9	PCINT8
0x6B	PCMSK0	PCINT7	PCINT6	PCINT5	PCINT4	PCINT3	PCINT2	PCINT1	PCINT0
0x6A	Reserved	–	–	–	–	–	–	–	–
0x69	EICRA	–	–	–	–	ISC11	ISC10	ISC01	ISC00
0x68	PCICR	–	–	–	–	–	PCIE2	PCIE1	PCIE0
0x67	Reserved	–	–	–	–	–	–	–	–
0x66	OSCCAL	Oscillator Calibration Register							
0x65	Reserved	–	–	–	–	–	–	–	–
0x64	PRR	PRTWI	PRTIM2	PRTIM0	–	PRTIM1	PRSPI	PRUSART0	PRADC
0x63	Reserved	–	–	–	–	–	–	–	–
0x62	Reserved	–	–	–	–	–	–	–	–
0x61	CLKPR	CLKPCE	–	–	–	CLKPS3	CLKPS2	CLKPS1	CLKPS0
0x60	WDTCR	WDIF	WDIE	WDP3	WDCE	WDE	WDP2	WDP1	WDPO
0x3F (0x5F)	SREG	I	T	H	S	V	N	Z	C
0x3E (0x5E)	SPH	–	–	–	–	–	(SP10)	SP9	SP8
0x3D (0x5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0
0x3C (0x5C)	Reserved	–	–	–	–	–	–	–	–
0x3B (0x5B)	Reserved	–	–	–	–	–	–	–	–
0x3A (0x5A)	Reserved	–	–	–	–	–	–	–	–
0x39 (0x59)	Reserved	–	–	–	–	–	–	–	–
0x38 (0x58)	Reserved	–	–	–	–	–	–	–	–
0x37 (0x57)	SPMCSR	SPMIE	(RWWSB)	–	(RWWSRE)	BLBSET	PGWRT	PGERS	SELFPRGEN
0x36 (0x56)	Reserved	–	–	–	–	–	–	–	–
0x35 (0x55)	MCUCR	–	BODS	BODSE	PUD	–	–	IVSEL	IVCE
0x34 (0x54)	MCUSR	–	–	–	–	WDRF	BORF	EXTRF	PORF
0x33 (0x53)	SMCR	–	–	–	–	SM2	SM1	SM0	SE

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x32 (0x52)	Reserved	–	–	–	–	–	–	–	–
0x31 (0x51)	Reserved	–	–	–	–	–	–	–	–
0x30 (0x50)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0
0x2F (0x4F)	Reserved	–	–	–	–	–	–	–	–
0x2E (0x4E)	SPDR	SPI Data Register							
0x2D (0x4D)	SPSR	SPIF	WCOL	–	–	–	–	–	SPI2X
0x2C (0x4C)	SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0
0x2B (0x4B)	GPOR2	General Purpose I/O Register 2							
0x2A (0x4A)	GPOR1	General Purpose I/O Register 1							
0x29 (0x49)	Reserved	–	–	–	–	–	–	–	–
0x28 (0x48)	OCROB	Timer/Counter0 Output Compare Register B							
0x27 (0x47)	OCROA	Timer/Counter0 Output Compare Register A							
0x26 (0x46)	TCNT0	Timer/Counter0 (8-bit)							
0x25 (0x45)	TCCR0B	FOCOA	FOCOB	–	–	WGM02	CS02	CS01	CS00
0x24 (0x44)	TCCR0A	COM0A1	COM0A0	COM0B1	COM0B0	–	–	WGM01	WGM00
0x23 (0x43)	GTCCR	TSM	–	–	–	–	–	PSRASY	PSRSYNC
0x22 (0x42)	EEARH	EEPROM Address Register High Byte							
0x21 (0x41)	EEARL	EEPROM Address Register Low Byte							
0x20 (0x40)	EEDR	EEPROM Data Register							
0x1F (0x3F)	EECR	–	–	EPM1	EPM0	EERIE	EEMPE	EEPE	EERE
0x1E (0x3E)	GPOR0	General Purpose I/O Register 0							
0x1D (0x3D)	EIMSK	–	–	–	–	–	–	INT1	INT0

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x1C (0x3C)	EIFR	–	–	–	–	–	–	INTF1	INTF0
0x1B (0x3B)	PCIFR	–	–	–	–	–	PCIF2	PCIF1	PCIF0
0x1A (0x3A)	Reserved	–	–	–	–	–	–	–	–
0x19 (0x39)	Reserved	–	–	–	–	–	–	–	–
0x18 (0x38)	Reserved	–	–	–	–	–	–	–	–
0x17 (0x37)	TIFR2	–	–	–	–	–	OCF2B	OCF2A	TOV2
0x16 (0x36)	TIFR1	–	–	ICF1	–	–	OCF1B	OCF1A	TOV1
0x15 (0x35)	TIFR0	–	–	–	–	–	OCF0B	OCF0A	TOV0
0x14 (0x34)	Reserved	–	–	–	–	–	–	–	–
0x13 (0x33)	Reserved	–	–	–	–	–	–	–	–
0x12 (0x32)	Reserved	–	–	–	–	–	–	–	–
0x11 (0x31)	Reserved	–	–	–	–	–	–	–	–
0x10 (0x30)	Reserved	–	–	–	–	–	–	–	–
0x0F (0x2F)	Reserved	–	–	–	–	–	–	–	–
0x0E (0x2E)	Reserved	–	–	–	–	–	–	–	–
0x0D (0x2D)	Reserved	–	–	–	–	–	–	–	–
0x0C (0x2C)	Reserved	–	–	–	–	–	–	–	–
0x0B (0x2B)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0
0x0A (0x2A)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0
0x09 (0x29)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0
0x08 (0x28)	PORTC	–	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0
0x07 (0x27)	DDRC	–	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x06 (0x26)	PINC	–	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0
0x05 (0x25)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0
0x04 (0x24)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0
0x03 (0x23)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0
0x02 (0x22)	Reserved	–	–	–	–	–	–	–	–
0x01 (0x21)	Reserved	–	–	–	–	–	–	–	–
0x00 (0x20)	Reserved	–	–	–	–	–	–	–	–

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Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0x1FF)	Reserved	–	–	–	–	–	–	–	–
...	Reserved	–	–	–	–	–	–	–	–
(0x137)	Reserved	–	–	–	–	–	–	–	–
(0x136)	UDR3	USART3 I/O Data Register							
(0x135)	UBRR3H	–	–	–	–	USART3 Baud Rate Register High Byte			
(0x134)	UBRR3L	USART3 Baud Rate Register Low Byte							
(0x133)	Reserved	–	–	–	–	–	–	–	–
(0x132)	UCSR3C	UMSEL31	UMSEL30	UPM31	UPM30	USBS3	UCSZ31	UCSZ30	UCPOL3
(0x131)	UCSR3B	RXCIE3	TXCIE3	UDRIE3	RXEN3	TXEN3	UCSZ32	RXB83	TXB83
(0x130)	UCSR3A	RXC3	TXC3	UDRE3	FE3	DOR3	UPE3	U2X3	MPCM3
(0x12F)	Reserved	–	–	–	–	–	–	–	–
(0x12E)	Reserved	–	–	–	–	–	–	–	–
(0x12D)	OCR5CH	Timer/Counter5: Output Compare Register C High Byte							
(0x12C)	OCR5CL	Timer/Counter5: Output Compare Register C Low Byte							
(0x12B)	OCR5BH	Timer/Counter5: Output Compare Register B High Byte							
(0x12A)	OCR5BL	Timer/Counter5: Output Compare Register B Low Byte							
(0x129)	OCR5AH	Timer/Counter5: Output Compare Register A High Byte							
(0x128)	OCR5AL	Timer/Counter5: Output Compare Register A Low Byte							
(0x127)	ICR5H	Timer/Counter5: Input Capture Register High Byte							
(0x126)	ICR5L	Timer/Counter5: Input Capture Register Low Byte							
(0x125)	TCNT5H	Timer/Counter5: Counter Register High Byte							

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0x124)	TCNT5L	Timer/Counter5: Counter Register Low Byte							
(0x123)	Reserved	–	–	–	–	–	–	–	–
(0x122)	TCCR5C	FOC5A	FOC5B	FOC5C	–	–	–	–	–
(0x121)	TCCR5B	ICNC5	ICES5	–	WGM53	WGM52	CS52	CS51	CS50
(0x120)	TCCR5A	COM5A1	COM5A0	COM5B1	COM5B0	COM5C1	COM5C0	WGM51	WGM50
(0x11F)	Reserved	–	–	–	–	–	–	–	–
(0x11E)	Reserved	–	–	–	–	–	–	–	–
(0x11D)	Reserved	–	–	–	–	–	–	–	–
(0x11C)	Reserved	–	–	–	–	–	–	–	–
(0x11B)	Reserved	–	–	–	–	–	–	–	–
(0x11A)	Reserved	–	–	–	–	–	–	–	–
(0x119)	Reserved	–	–	–	–	–	–	–	–
(0x118)	Reserved	–	–	–	–	–	–	–	–
(0x117)	Reserved	–	–	–	–	–	–	–	–
(0x116)	Reserved	–	–	–	–	–	–	–	–
(0x115)	Reserved	–	–	–	–	–	–	–	–
(0x114)	Reserved	–	–	–	–	–	–	–	–
(0x113)	Reserved	–	–	–	–	–	–	–	–
(0x112)	Reserved	–	–	–	–	–	–	–	–
(0x111)	Reserved	–	–	–	–	–	–	–	–
(0x110)	Reserved	–	–	–	–	–	–	–	–
(0x10F)	Reserved	–	–	–	–	–	–	–	–
(0x10E)	Reserved	–	–	–	–	–	–	–	–
(0x10D)	Reserved	–	–	–	–	–	–	–	–
(0x10C)	Reserved	–	–	–	–	–	–	–	–
(0x10B)	PORTL	PORTL7	PORTL6	PORTL5	PORTL4	PORTL3	PORTL2	PORTL1	PORTL0
(0x10A)	DDRL	DDL7	DDL6	DDL5	DDL4	DDL3	DDL2	DDL1	DDL0
(0x109)	PINL	PINL7	PINL6	PINL5	PINL4	PINL3	PINL2	PINL1	PINL0
(0x108)	PORTK	PORTK7	PORTK6	PORTK5	PORTK4	PORTK3	PORTK2	PORTK1	PORTK0
(0x107)	DDRK	DDK7	DDK6	DDK5	DDK4	DDK3	DDK2	DDK1	DDK0
(0x106)	PINK	PINK7	PINK6	PINK5	PINK4	PINK3	PINK2	PINK1	PINK0
(0x105)	PORTJ	PORTJ7	PORTJ6	PORTJ5	PORTJ4	PORTJ3	PORTJ2	PORTJ1	PORTJ0
(0x104)	DDRJ	DDJ7	DDJ6	DDJ5	DDJ4	DDJ3	DDJ2	DDJ1	DDJ0
(0x103)	PINJ	PINJ7	PINJ6	PINJ5	PINJ4	PINJ3	PINJ2	PINJ1	PINJ0
(0x102)	PORTH	PORTH7	PORTH6	PORTH5	PORTH4	PORTH3	PORTH2	PORTH1	PORTH0
(0x101)	DDRH	DDH7	DDH6	DDH5	DDH4	DDH3	DDH2	DDH1	DDH0
(0x100)	PINH	PINH7	PINH6	PINH5	PINH4	PINH3	PINH2	PINH1	PINH0

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0xFF)	Reserved	–	–	–	–	–	–	–	–
(0xFE)	Reserved	–	–	–	–	–	–	–	–
(0xFD)	Reserved	–	–	–	–	–	–	–	–
(0xFC)	Reserved	–	–	–	–	–	–	–	–
(0xFB)	Reserved	–	–	–	–	–	–	–	–
(0xFA)	Reserved	–	–	–	–	–	–	–	–
(0xF9)	Reserved	–	–	–	–	–	–	–	–
(0xF8)	Reserved	–	–	–	–	–	–	–	–
(0xF7)	Reserved	–	–	–	–	–	–	–	–
(0xF6)	Reserved	–	–	–	–	–	–	–	–
(0xF5)	Reserved	–	–	–	–	–	–	–	–
(0xF4)	Reserved	–	–	–	–	–	–	–	–
(0xF3)	Reserved	–	–	–	–	–	–	–	–
(0xF2)	Reserved	–	–	–	–	–	–	–	–
(0xF1)	Reserved	–	–	–	–	–	–	–	–
(0xF0)	Reserved	–	–	–	–	–	–	–	–
(0xEF)	Reserved	–	–	–	–	–	–	–	–
(0xEE)	Reserved	–	–	–	–	–	–	–	–
(0xED)	Reserved	–	–	–	–	–	–	–	–
(0xEC)	Reserved	–	–	–	–	–	–	–	–
(0xEB)	Reserved	–	–	–	–	–	–	–	–
(0xEA)	Reserved	–	–	–	–	–	–	–	–
(0xE9)	Reserved	–	–	–	–	–	–	–	–
(0xE8)	Reserved	–	–	–	–	–	–	–	–
(0xE7)	Reserved	–	–	–	–	–	–	–	–
(0xE6)	Reserved	–	–	–	–	–	–	–	–
(0xE5)	Reserved	–	–	–	–	–	–	–	–
(0xE4)	Reserved	–	–	–	–	–	–	–	–
(0xE3)	Reserved	–	–	–	–	–	–	–	–
(0xE2)	Reserved	–	–	–	–	–	–	–	–
(0xE1)	Reserved	–	–	–	–	–	–	–	–
(0xE0)	Reserved	–	–	–	–	–	–	–	–
(0xDF)	Reserved	–	–	–	–	–	–	–	–
(0xDE)	Reserved	–	–	–	–	–	–	–	–
(0xDD)	Reserved	–	–	–	–	–	–	–	–
(0xDC)	Reserved	–	–	–	–	–	–	–	–
(0xDB)	Reserved	–	–	–	–	–	–	–	–

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0xDA)	Reserved	–	–	–	–	–	–	–	–
(0xD9)	Reserved	–	–	–	–	–	–	–	–
(0xD8)	Reserved	–	–	–	–	–	–	–	–
(0xD7)	Reserved	–	–	–	–	–	–	–	–
(0xD6)	UDR2	USART2 I/O Data Register							
(0xD5)	UBRR2H	–	–	–	–	USART2 Baud Rate Register High Byte			
(0xD4)	UBRR2L	USART2 Baud Rate Register Low Byte							
(0xD3)	Reserved	–	–	–	–	–	–	–	–
(0xD2)	UCSR2C	UMSEL21	UMSEL20	UPM21	UPM20	USBS2	UCSZ21	UCSZ20	UCPOL2
(0xD1)	UCSR2B	RXCIE2	TXCIE2	UDRIE2	RXEN2	TXEN2	UCSZ22	RXB82	TXB82
(0xD0)	UCSR2A	RXC2	TXC2	UDRE2	FE2	DOR2	UPE2	U2X2	MPCM2
(0xCF)	Reserved	–	–	–	–	–	–	–	–
(0xCE)	UDR1	USART1 I/O Data Register							
(0xCD)	UBRR1H	–	–	–	–	USART1 Baud Rate Register High Byte			
(0xCC)	UBRR1L	USART1 Baud Rate Register Low Byte							
(0xCB)	Reserved	–	–	–	–	–	–	–	–
(0xCA)	UCSR1C	UMSEL11	UMSEL10	UPM11	UPM10	USBS1	UCSZ11	UCSZ10	UCPOL1
(0xC9)	UCSR1B	RXCIE1	TXCIE1	UDRIE1	RXEN1	TXEN1	UCSZ12	RXB81	TXB81
(0xC8)	UCSR1A	RXC1	TXC1	UDRE1	FE1	DOR1	UPE1	U2X1	MPCM1
(0xC7)	Reserved	–	–	–	–	–	–	–	–
(0xC6)	UDR0	USART0 I/O Data Register							
(0xC5)	UBRR0H	–	–	–	–	USART0 Baud Rate Register High Byte			
(0xC4)	UBRR0L	USART0 Baud Rate Register Low Byte							
(0xC3)	Reserved	–	–	–	–	–	–	–	–
(0xC2)	UCSR0C	UMSEL01	UMSEL00	UPM01	UPM00	USBS0	UCSZ01	UCSZ00	UCPOL0
(0xC1)	UCSR0B	RXCIE0	TXCIE0	UDRIE0	RXEN0	TXEN0	UCSZ02	RXB80	TXB80
(0xC0)	UCSR0A	RXC0	TXC0	UDRE0	FE0	DOR0	UPE0	U2X0	MPCM0
(0xBF)	Reserved	–	–	–	–	–	–	–	–
(0xBE)	Reserved	–	–	–	–	–	–	–	–
(0xBD)	TWAMR	TWAM6	TWAM5	TWAM4	TWAM3	TWAM2	TWAM1	TWAM0	–
(0xBC)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	–	TWIE
(0xBB)	TWDR	2-wire Serial Interface Data Register							
(0xBA)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE
(0xB9)	TWSR	TWS7	TWS6	TWS5	TWS4	TWS3	–	TWPS1	TWPS0
(0xB8)	TWBR	2-wire Serial Interface Bit Rate Register							
(0xB7)	Reserved	–	–	–	–	–	–	–	–
(0xB6)	ASSR	–	EXCLK	AS2	TCN2UB	OCR2AUB	OCR2BUB	TCR2AUB	TCR2BUB

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0xB5)	Reserved	–	–	–	–	–	–	–	–
(0xB4)	OCR2B	Timer/Counter2 Output Compare Register B							
(0xB3)	OCR2A	Timer/Counter2 Output Compare Register A							
(0xB2)	TCNT2	Timer/Counter2 (8 Bit)							
(0xB1)	TCCR2B	FOC2A	FOC2B	–	–	WGM22	CS22	CS21	CS20
(0xB0)	TCCR2A	COM2A1	COM2A0	COM2B1	COM2B0	–	–	WGM21	WGM20
(0xAF)	Reserved	–	–	–	–	–	–	–	–
(0xAE)	Reserved	–	–	–	–	–	–	–	–
(0xAD)	OCR4CH	Timer/Counter4: Output Compare Register C High Byte							
(0xAC)	OCR4CL	Timer/Counter4: Output Compare Register C Low Byte							
(0xAB)	OCR4BH	Timer/Counter4: Output Compare Register B High Byte							
(0xAA)	OCR4BL	Timer/Counter4: Output Compare Register B Low Byte							
(0xA9)	OCR4AH	Timer/Counter4: Output Compare Register A High Byte							
(0xA8)	OCR4AL	Timer/Counter4: Output Compare Register A Low Byte							
(0xA7)	ICR4H	Timer/Counter4: Input Capture Register High Byte							
(0xA6)	ICR4L	Timer/Counter4: Input Capture Register Low Byte							
(0xA5)	TCNT4H	Timer/Counter4: Counter Register High Byte							
(0xA4)	TCNT4L	Timer/Counter4: Counter Register Low Byte							
(0xA3)	Reserved	–	–	–	–	–	–	–	–
(0xA2)	TCCR4C	FOC4A	FOC4B	FOC4C	–	–	–	–	–
(0xA1)	TCCR4B	ICNC4	ICES4	–	WGM43	WGM42	CS42	CS41	CS40
(0xA0)	TCCR4A	COM4A1	COM4A0	COM4B1	COM4B0	COM4C1	COM4C0	WGM41	WGM40
(0x9F)	Reserved	–	–	–	–	–	–	–	–
(0x9E)	Reserved	–	–	–	–	–	–	–	–
(0x9D)	OCR3CH	Timer/Counter3: Output Compare Register C High Byte							
(0x9C)	OCR3CL	Timer/Counter3: Output Compare Register C Low Byte							
(0x9B)	OCR3BH	Timer/Counter3: Output Compare Register B High Byte							
(0x9A)	OCR3BL	Timer/Counter3: Output Compare Register B Low Byte							
(0x99)	OCR3AH	Timer/Counter3: Output Compare Register A High Byte							
(0x98)	OCR3AL	Timer/Counter3: Output Compare Register A Low Byte							
(0x97)	ICR3H	Timer/Counter3: Input Capture Register High Byte							
(0x96)	ICR3L	Timer/Counter3: Input Capture Register Low Byte							
(0x95)	TCNT3H	Timer/Counter3: Counter Register High Byte							
(0x94)	TCNT3L	Timer/Counter3: Counter Register Low Byte							
(0x93)	Reserved	–	–	–	–	–	–	–	–
(0x92)	TCCR3C	FOC3A	FOC3B	FOC3C	–	–	–	–	–
(0x91)	TCCR3B	ICNC3	ICES3	–	WGM33	WGM32	CS32	CS31	CS30

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0x90)	TCCR3A	COM3A1	COM3A0	COM3B1	COM3B0	COM3C1	COM3C0	WGM31	WGM30
(0x8F)	Reserved	–	–	–	–	–	–	–	–
(0x8E)	Reserved	–	–	–	–	–	–	–	–
(0x8D)	OCR1CH	Timer/Counter1: Output Compare Register C High Byte							
(0x8C)	OCR1CL	Timer/Counter1: Output Compare Register C Low Byte							
(0x8B)	OCR1BH	Timer/Counter1: Output Compare Register B High Byte							
(0x8A)	OCR1BL	Timer/Counter1: Output Compare Register B Low Byte							
(0x89)	OCR1AH	Timer/Counter1: Output Compare Register A High Byte							
(0x88)	OCR1AL	Timer/Counter1: Output Compare Register A Low Byte							
(0x87)	ICR1H	Timer/Counter1: Input Capture Register High Byte							
(0x86)	ICR1L	Timer/Counter1: Input Capture Register Low Byte							
(0x85)	TCNT1H	Timer/Counter1: Counter Register High Byte							
(0x84)	TCNT1L	Timer/Counter1: Counter Register Low Byte							
(0x83)	Reserved	–	–	–	–	–	–	–	–
(0x82)	TCCR1C	FOC1A	FOC1B	FOC1C	–	–	–	–	–
(0x81)	TCCR1B	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10
(0x80)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	COM1C1	COM1C0	WGM11	WGM10
(0x7F)	DIDR1	–	–	–	–	–	–	AIN1D	AIN0D
(0x7E)	DIDR0	ADC7D	ADC6D	ADC5D	ADC4D	ADC3D	ADC2D	ADC1D	ADC0D
(0x7D)	DIDR2	ADC15D	ADC14D	ADC13D	ADC12D	ADC11D	ADC10D	ADC9D	ADC8D
(0x7C)	ADMUX	REFS1	REFS0	ADLAR	MUX4	MUX3	MUX2	MUX1	MUX0
(0x7B)	ADCSRB	–	ACME	–	–	MUX5	ADTS2	ADTS1	ADTS0
(0x7A)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0
(0x79)	ADCH	ADC Data Register High Byte							
(0x78)	ADCL	ADC Data Register Low Byte							
(0x77)	Reserved	–	–	–	–	–	–	–	–
(0x76)	Reserved	–	–	–	–	–	–	–	–
(0x75)	XMCRB	XMBK	–	–	–	–	XMM2	XMM1	XMM0
(0x74)	XMCRA	SRE	SRL2	SRL1	SRL0	SRW11	SRW10	SRW01	SRW00
(0x73)	TIMSK5	–	–	ICIE5	–	OCIE5C	OCIE5B	OCIE5A	TOIE5
(0x72)	TIMSK4	–	–	ICIE4	–	OCIE4C	OCIE4B	OCIE4A	TOIE4
(0x71)	TIMSK3	–	–	ICIE3	–	OCIE3C	OCIE3B	OCIE3A	TOIE3
(0x70)	TIMSK2	–	–	–	–	–	OCIE2B	OCIE2A	TOIE2
(0x6F)	TIMSK1	–	–	ICIE1	–	OCIE1C	OCIE1B	OCIE1A	TOIE1
(0x6E)	TIMSK0	–	–	–	–	–	OCIE0B	OCIE0A	TOIE0
(0x6D)	PCMSK2	PCINT23	PCINT22	PCINT21	PCINT20	PCINT19	PCINT18	PCINT17	PCINT16
(0x6C)	PCMSK1	PCINT15	PCINT14	PCINT13	PCINT12	PCINT11	PCINT10	PCINT9	PCINT8

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0x6B)	PCMSK0	PCINT7	PCINT6	PCINT5	PCINT4	PCINT3	PCINT2	PCINT1	PCINT0
(0x6A)	EICRB	ISC71	ISC70	ISC61	ISC60	ISC51	ISC50	ISC41	ISC40
(0x69)	EICRA	ISC31	ISC30	ISC21	ISC20	ISC11	ISC10	ISC01	ISC00
(0x68)	PCICR	–	–	–	–	–	PCIE2	PCIE1	PCIE0
(0x67)	Reserved	–	–	–	–	–	–	–	–
(0x66)	OSCCAL	Oscillator Calibration Register							
(0x65)	PRR1	–	–	PRTIM5	PRTIM4	PRTIM3	PRUSART3	PRUSART2	PRUSART1
(0x64)	PRR0	PRTWI	PRTIM2	PRTIM0	–	PRTIM1	PRSPI	PRUSARTOPRADC	
(0x63)	Reserved	–	–	–	–	–	–	–	–
(0x62)	Reserved	–	–	–	–	–	–	–	–
(0x61)	CLKPR	CLKPCE	–	–	–	CLKPS3	CLKPS2	CLKPS1	CLKPS0
(0x60)	WDTCR	WDIF	WDIE	WDP3	WDCE	WDE	WDP2	WDP1	WDPO
0x3F (0x5F)	SREG	I	T	H	S	V	N	Z	C
0x3E (0x5E)	SPH	SP15	SP14	SP13	SP12	SP11	SP10	SP9	SP8
0x3D (0x5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0
0x3C (0x5C)	EIND	–	–	–	–	–	–	–	EIND0
0x3B (0x5B)	RAMPZ	–	–	–	–	–	–	RAMPZ1	RAMPZ0
0x3A (0x5A)	Reserved	–	–	–	–	–	–	–	–
0x39 (0x59)	Reserved	–	–	–	–	–	–	–	–
0x38 (0x58)	Reserved	–	–	–	–	–	–	–	–
0x37 (0x57)	SPMCSR	SPMIE	RWWSB	SIGRD	RWWSRE	BLBSET	PGWRT	PGERS	SPMEN
0x36 (0x56)	Reserved	–	–	–	–	–	–	–	–
0x35 (0x55)	MCUCR	JTD	–	–	PUD	–	–	IVSEL	IVCE
0x34 (0x54)	MCUSR	–	–	–	JTRF	WDRF	BORF	EXTRF	PORF
0x33 (0x53)	SMCR	–	–	–	–	SM2	SM1	SM0	SE
0x32 (0x52)	Reserved	–	–	–	–	–	–	–	–
0x31 (0x51)	OCDR	OCDR7	OCDR6	OCDR5	OCDR4	OCDR3	OCDR2	OCDR1	OCDR0

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x30 (0x50)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0
0x2F (0x4F)	Reserved	–	–	–	–	–	–	–	–
0x2E (0x4E)	SPDR	SPI Data Register							
0x2D (0x4D)	SPSR	SPIF	WCOL	–	–	–	–	–	SPI2X
0x2C (0x4C)	SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0
0x2B (0x4B)	GPOR2	General Purpose I/O Register 2							
0x2A (0x4A)	GPOR1	General Purpose I/O Register 1							
0x29 (0x49)	Reserved	–	–	–	–	–	–	–	–
0x28 (0x48)	OCROB	Timer/Counter0 Output Compare Register B							
0x27 (0x47)	OCROA	Timer/Counter0 Output Compare Register A							
0x26 (0x46)	TCNT0	Timer/Counter0 (8 Bit)							
0x25 (0x45)	TCCR0B	FOCOA	FOCOB	–	–	WGM02	CS02	CS01	CS00
0x24 (0x44)	TCCR0A	COM0A1	COM0A0	COM0B1	COM0B0	–	–	WGM01	WGM00
0x23 (0x43)	GTCCR	TSM	–	–	–	–	–	PSRASY	PSRSYNC
0x22 (0x42)	EEARH	–	–	–	–	EEPROM Address Register High Byte			
0x21 (0x41)	EEARL	EEPROM Address Register Low Byte							
0x20 (0x40)	EEDR	EEPROM Data Register							
0x1F (0x3F)	EECR	–	–	EPM1	EPM0	EERIE	EEMPE	EEPE	EERE
0x1E (0x3E)	GPOR0	General Purpose I/O Register 0							
0x1D (0x3D)	EIMSK	INT7	INT6	INT5	INT4	INT3	INT2	INT1	INT0
0x1C (0x3C)	EIFR	INTF7	INTF6	INTF5	INTF4	INTF3	INTF2	INTF1	INTF0
0x1B (0x3B)	PCIFR	–	–	–	–	–	PCIF2	PCIF1	PCIF0

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x1A (0x3A)	TIFR5	–	–	ICF5	–	OCF5C	OCF5B	OCF5A	TOV5
0x19 (0x39)	TIFR4	–	–	ICF4	–	OCF4C	OCF4B	OCF4A	TOV4
0x18 (0x38)	TIFR3	–	–	ICF3	–	OCF3C	OCF3B	OCF3A	TOV3
0x17 (0x37)	TIFR2	–	–	–	–	–	OCF2B	OCF2A	TOV2
0x16 (0x36)	TIFR1	–	–	ICF1	–	OCF1C	OCF1B	OCF1A	TOV1
0x15 (0x35)	TIFR0	–	–	–	–	–	OCF0B	OCF0A	TOV0
0x14 (0x34)	PORTG	–	–	PORTG5	PORTG4	PORTG3	PORTG2	PORTG1	PORTG0
0x13 (0x33)	DDRG	–	–	DDG5	DDG4	DDG3	DDG2	DDG1	DDG0
0x12 (0x32)	PING	–	–	PING5	PING4	PING3	PING2	PING1	PING0
0x11 (0x31)	PORTF	PORTF7	PORTF6	PORTF5	PORTF4	PORTF3	PORTF2	PORTF1	PORTF0
0x10 (0x30)	DDRF	DDF7	DDF6	DDF5	DDF4	DDF3	DDF2	DDF1	DDF0
0x0F (0x2F)	PINF	PINF7	PINF6	PINF5	PINF4	PINF3	PINF2	PINF1	PINF0
0x0E (0x2E)	PORTE	PORTE7	PORTE6	PORTE5	PORTE4	PORTE3	PORTE2	PORTE1	PORTE0
0x0D (0x2D)	DDRE	DDE7	DDE6	DDE5	DDE4	DDE3	DDE2	DDE1	DDE0
0x0C (0x2C)	PINE	PINE7	PINE6	PINE5	PINE4	PINE3	PINE2	PINE1	PINE0
0x0B (0x2B)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0
0x0A (0x2A)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0
0x09 (0x29)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0
0x08 (0x28)	PORTC	PORTC7	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0
0x07 (0x27)	DDRC	DDC7	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0
0x06 (0x26)	PINC	PINC7	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0
0x05 (0x25)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x04 (0x24)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0
0x03 (0x23)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0
0x02 (0x22)	PORTA	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0
0x01 (0x21)	DDRA	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0
0x00 (0x20)	PINA	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0

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Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0xFF)	Reserved	–	–	–	–	–	–	–	–
(0xFE)	Reserved	–	–	–	–	–	–	–	–
(0xFD)	Reserved	–	–	–	–	–	–	–	–
(0xFC)	Reserved	–	–	–	–	–	–	–	–
(0xFB)	Reserved	–	–	–	–	–	–	–	–
(0xFA)	Reserved	–	–	–	–	–	–	–	–
(0xF9)	Reserved	–	–	–	–	–	–	–	–
(0xF8)	Reserved	–	–	–	–	–	–	–	–
(0xF7)	Reserved	–	–	–	–	–	–	–	–
(0xF6)	Reserved	–	–	–	–	–	–	–	–
(0xF5)	Reserved	–	–	–	–	–	–	–	–
(0xF4)	UEINT	–	EPINT6:0						
(0xF3)	UEBCHX	–	–	–	–	–	BYCT10:8		
(0xF2)	UEBCLX	BYCT7:0							
(0xF1)	UEDATX	DAT7:0							
(0xF0)	UEIENX	FLERRE	NAKINE	–	NAKOUTE	RXSTPE	RXOUTE	STALLEDE	TXINE
(0xEF)	UESTA1X	–	–	–	–	–	CTRLDIR	CURRBK1:0	
(0xEE)	UESTA0X	CFGOK	OVERFI	UNDERFI	–	DTSEQ1:0		NBUSYBK1:0	
(0xED)	UECFG1X	–	EPSIZE2:0			EPBK1:0		ALLOC	–
(0xEC)	UECFG0X	EPTYPE1:0		–	–	–	–	–	EPDIR
(0xEB)	UECONX	–	–	STALLRQ	STALLRQC	RSTDT	–	–	EPEN
(0xEA)	UERST	–	EPRST6:0						
(0xE9)	UENUM	–	–	–	–	–	EPNUM2:0		
(0xE8)	UEINTX	FIFOCON	NAKINI	RWAL	NAKOUTI	RXSTPI	RXOUTI	STALLEDI	TXINI
(0xE7)	Reserved	–	–	–	–	–	–	–	–

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0xE6)	UDMFN	–	–	–	FNCERR	–	–	–	–
(0xE5)	UDFNUMH	–	–	–	–	–	FNUM10:8	–	–
(0xE4)	UDFNUML	FNUM7:0							
(0xE3)	UDADDR	ADDEN	UADD6:0						
(0xE2)	UDIEN	–	UPRSME	EORSME	WAKEUPE	EORSTE	SOFE	MSOFE	SUSPE
(0xE1)	UDINT	–	UPRSMI	EORSMI	WAKEUPI	EORSTI	SOFI	MSOFI	SUSPI
(0xE0)	UDCON	–	–	–	–	RSTCPU	LSM	RMWKUP	DETACH
(0xDF)	Reserved	–	–	–	–	–	–	–	–
(0xDE)	Reserved	–	–	–	–	–	–	–	–
(0xDD)	Reserved	–	–	–	–	–	–	–	–
(0xDC)	Reserved	–	–	–	–	–	–	–	–
(0xDB)	Reserved	–	–	–	–	–	–	–	–
(0xDA)	USBINT	–	–	–	–	–	–	–	VBUSTI
(0xD9)	USBSTA	–	–	–	–	–	–	ID	VBUS
(0xD8)	USBCON	USBE	–	FRZCLK	OTGPADE	–	–	–	VBUSTE
(0xD7)	UHWCON	–	–	–	–	–	–	–	UVREGE
(0xD6)	Reserved	–	–	–	–	–	–	–	–
(0xD5)	Reserved	–	–	–	–	–	–	–	–
(0xD4)	DT4	DT4H3	DT4H2	DT4H1	DT4H0	DT4L3	DT4L2	DT4L1	DT4L0
(0xD3)	Reserved	–	–	–	–	–	–	–	–
(0xD2)	OCR4D	Timer/Counter4: Output Compare Register D							
(0xD1)	OCR4C	Timer/Counter4: Output Compare Register C							
(0xD0)	OCR4B	Timer/Counter4: Output Compare Register B							
(0xCF)	OCR4A	Timer/Counter4: Output Compare Register A							
(0xCE)	UDR1	USART1 I/O Data Register							
(0xCD)	UBRR1H	–	–	–	–	USART1 Baud Rate Register High Byte			
(0xCC)	UBRR1L	USART1 Baud Rate Register Low Byte							
(0xCB)	UCSR1D	–	–	–	–	–	–	CTSEN	RTSEN
(0xCA)	UCSR1C	UMSEL11	UMSEL10	UPM11	UPM10	USBS1	UCSZ11	UCSZ10	UCPOL1
(0xC9)	UCSR1B	RXCIE1	TXCIE1	UDRIE1	RXEN1	TXEN1	UCSZ12	RXB81	TXB81
(0xC8)	UCSR1A	RXC1	TXC1	UDRE1	FE1	DOR1	PE1	U2X1	MPCM1
(0xC7)	CLKSTA	–	–	–	–	–	–	RCON	EXTON
(0xC6)	CLKSEL1	RCCKSEL3	RCCKSEL2	RCCKSEL1	RCCKSELO	EXCKSEL3	EXCKSEL2	EXCKSEL1	EXCKSELO
(0xC5)	CLKSELO	RCSUT1	RCSUT0	EXSUT1	EXSUT0	RCE	EXTE	–	CLKS
(0xC4)	TCCR4E	TLOCK4	ENHC4	OC4OE5	OC4OE4	OC4OE3	OC4OE2	OC4OE1	OC4OE0
(0xC3)	TCCR4D	FPIE4	FPEN4	FPNC4	FPES4	FPAC4	FPF4	WGM41	WGM40
(0xC2)	TCCR4C	COM4A1S	COM4A0S	COM4B1S	COM4B0S	COM4D1S	COM4D0S	FOC4D	PWM4D

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0xC1)	TCCR4B	PWM4X	PSR4	DTPS41	DTPS40	CS43	CS42	CS41	CS40
(0xC0)	TCCR4A	COM4A1	COM4A0	COM4B1	COM4B0	FOC4A	FOC4B	PWM4A	PWM4B
(0xBF)	TC4H	–	–	–	–	–	Timer/Counter4 High Byte		
(0xBE)	TCNT4	Timer/Counter4: Counter Register Low Byte							
(0xBD)	TWAMR	TWAM6	TWAM5	TWAM4	TWAM3	TWAM2	TWAM1	TWAM0	–
(0xBC)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	–	TWIE
(0xBB)	TWDR	2-wire Serial Interface Data Register							
(0xBA)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE
(0xB9)	TWSR	TWS7	TWS6	TWS5	TWS4	TWS3	–	TWPS1	TWPS0
(0xB8)	TWBR	2-wire Serial Interface Bit Rate Register							
(0xB6)	Reserved	–	–	–	–	–	–	–	–
(0xB5)	Reserved	–	–	–	–	–	–	–	–
(0xB4)	Reserved	–	–	–	–	–	–	–	–
(0xB3)	Reserved	–	–	–	–	–	–	–	–
(0xB2)	Reserved	–	–	–	–	–	–	–	–
(0xB1)	Reserved	–	–	–	–	–	–	–	–
(0xB0)	Reserved	–	–	–	–	–	–	–	–
(0xAF)	Reserved	–	–	–	–	–	–	–	–
(0xAE)	Reserved	–	–	–	–	–	–	–	–
(0xAD)	Reserved	–	–	–	–	–	–	–	–
(0xAC)	Reserved	–	–	–	–	–	–	–	–
(0xB7)	Reserved	–	–	–	–	–	–	–	–
(0xAB)	Reserved	–	–	–	–	–	–	–	–
(0xAA)	Reserved	–	–	–	–	–	–	–	–
(0xA9)	Reserved	–	–	–	–	–	–	–	–
(0xA8)	Reserved	–	–	–	–	–	–	–	–
(0xA7)	Reserved	–	–	–	–	–	–	–	–
(0xA6)	Reserved	–	–	–	–	–	–	–	–
(0xA5)	Reserved	–	–	–	–	–	–	–	–
(0xA4)	Reserved	–	–	–	–	–	–	–	–
(0xA3)	Reserved	–	–	–	–	–	–	–	–
(0xA2)	Reserved	–	–	–	–	–	–	–	–
(0xA1)	Reserved	–	–	–	–	–	–	–	–
(0xA0)	Reserved	–	–	–	–	–	–	–	–
(0x9F)	Reserved	–	–	–	–	–	–	–	–
(0x9E)	Reserved	–	–	–	–	–	–	–	–
(0x9D)	OCR3CH	Timer/Counter3: Output Compare Register C High Byte							

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0x9C)	OCR3CL	Timer/Counter3: Output Compare Register C Low Byte							
(0x9B)	OCR3BH	Timer/Counter3: Output Compare Register B High Byte							
(0x9A)	OCR3BL	Timer/Counter3: Output Compare Register B Low Byte							
(0x99)	OCR3AH	Timer/Counter3: Output Compare Register A High Byte							
(0x98)	OCR3AL	Timer/Counter3: Output Compare Register A Low Byte							
(0x97)	ICR3H	Timer/Counter3: Input Capture Register High Byte							
(0x96)	ICR3L	Timer/Counter3: Input Capture Register Low Byte							
(0x95)	TCNT3H	Timer/Counter3: Counter Register High Byte							
(0x94)	TCNT3L	Timer/Counter3: Counter Register Low Byte							
(0x93)	Reserved	–	–	–	–	–	–	–	–
(0x92)	TCCR3C	FOC3A	–	–	–	–	–	–	–
(0x91)	TCCR3B	ICNC3	ICES3	–	WGM33	WGM32	CS32	CS31	CS30
(0x90)	TCCR3A	COM3A1	COM3A0	COM3B1	COM3B0	COM3C1	COM3C0	WGM31	WGM30
(0x8F)	Reserved	–	–	–	–	–	–	–	–
(0x8E)	Reserved	–	–	–	–	–	–	–	–
(0x8D)	OCR1CH	Timer/Counter1: Output Compare Register C High Byte							
(0x8C)	OCR1CL	Timer/Counter1: Output Compare Register C Low Byte							
(0x8B)	OCR1BH	Timer/Counter1: Output Compare Register B High Byte							
(0x8A)	OCR1BL	Timer/Counter1: Output Compare Register B Low Byte							
(0x89)	OCR1AH	Timer/Counter1: Output Compare Register A High Byte							
(0x88)	OCR1AL	Timer/Counter1: Output Compare Register A Low Byte							
(0x87)	ICR1H	Timer/Counter1: Input Capture Register High Byte							
(0x86)	ICR1L	Timer/Counter1: Input Capture Register Low Byte							
(0x85)	TCNT1H	Timer/Counter1: Counter Register High Byte							
(0x84)	TCNT1L	Timer/Counter1: Counter Register Low Byte							
(0x83)	Reserved	–	–	–	–	–	–	–	–
(0x82)	TCCR1C	FOC1A	FOC1B	FOC1C	–	–	–	–	–
(0x81)	TCCR1B	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10
(0x80)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	COM1C1	COM1C0	WGM11	WGM10
(0x7F)	DIDR1	–	–	–	–	–	–	–	AIN0D
(0x7E)	DIDR0	ADC7D	ADC6D	ADC5D	ADC4D	–	–	ADC1D	ADC0D
(0x7D)	DIDR2	–	–	ADC13D	ADC12D	ADC11D	ADC10D	ADC9D	ADC8D
(0x7C)	ADMUX	REFS1	REFS0	ADLAR	MUX4	MUX3	MUX2	MUX1	MUX0
(0x7B)	ADCSRB	ADHSM	ACME	MUX5	–	ADTS3	ADTS2	ADTS1	ADTS0
(0x7A)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0
(0x79)	ADCH	ADC Data Register High byte							
(0x78)	ADCL	ADC Data Register Low byte							

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
(0x77)	Reserved	–	–	–	–	–	–	–	–
(0x76)	Reserved	–	–	–	–	–	–	–	–
(0x75)	Reserved	–	–	–	–	–	–	–	–
(0x74)	Reserved	–	–	–	–	–	–	–	–
(0x73)	Reserved	–	–	–	–	–	–	–	–
(0x72)	TIMSK4	OCIE4D	OCIE4A	OCIE4B	–	–	TOIE4	–	–
(0x71)	TIMSK3	–	–	ICIE3	–	OCIE3C	OCIE3B	OCIE3A	TOIE3
(0x70)	Reserved	–	–	–	–	–	–	–	–
(0x6F)	TIMSK1	–	–	ICIE1	–	OCIE1C	OCIE1B	OCIE1A	TOIE1
(0x6E)	TIMSK0	–	–	–	–	–	OCIE0B	OCIE0A	TOIE0
(0x6D)	Reserved	–	–	–	–	–	–	–	–
(0x6C)	Reserved	–	–	–	–	–	–	–	–
(0x6B)	PCMSK0	PCINT7	PCINT6	PCINT5	PCINT4	PCINT3	PCINT2	PCINT1	PCINT0
(0x6A)	EICRB	–	–	ISC61	ISC60	–	–	–	–
(0x69)	EICRA	ISC31	ISC30	ISC21	ISC20	ISC11	ISC10	ISC01	ISC00
(0x68)	PCICR	–	–	–	–	–	–	–	PCIE0
(0x67)	RCCTRL	–	–	–	–	–	–	–	RCFREQ
(0x66)	OSCCAL	RC Oscillator Calibration Register							
(0x65)	PRR1	PRUSB	–	–	PRTIM4	PRTIM3	–	–	PRUSART1
(0x64)	PRR0	PRTWI	–	PRTIM0	–	PRTIM1	PRSPI	–	PRADC
(0x63)	Reserved	–	–	–	–	–	–	–	–
(0x62)	Reserved	–	–	–	–	–	–	–	–
(0x61)	CLKPR	CLKPCE	–	–	–	CLKPS3	CLKPS2	CLKPS1	CLKPS0
(0x60)	WDTCR	WDIF	WDIE	WDP3	WDCE	WDE	WDP2	WDP1	WDPO
0x3F (0x5F)	SREG	I	T	H	S	V	N	Z	C
0x3E (0x5E)	SPH	SP15	SP14	SP13	SP12	SP11	SP10	SP9	SP8
0x3D (0x5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0
0x3C (0x5C)	Reserved	–	–	–	–	–	–	–	–
0x3B (0x5B)	RAMPZ	–	–	–	–	–	–	RAMPZ1	RAMPZ0
0x3A (0x5A)	Reserved	–	–	–	–	–	–	–	–
0x39 (0x59)	Reserved	–	–	–	–	–	–	–	–
0x38 (0x58)	Reserved	–	–	–	–	–	–	–	–

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x37 (0x57)	SPMCSR	SPMIE	RWWSB	SIGRD	RWWSRE	BLBSET	PGWRT	PGERS	SPMEN
0x36 (0x56)	Reserved	–	–	–	–	–	–	–	–
0x35 (0x55)	MCUCR	JTD	–	–	PUD	–	–	IVSEL	IVCE
0x34 (0x54)	MCUSR	–	–	USBRF	JTRF	WDRF	BORF	EXTRF	PORF
0x33 (0x53)	SMCR	–	–	–	–	SM2	SM1	SM0	SE
0x32 (0x52)	PLLFREQ	PINMUX	PLLUSB	PLLT1	PLLT0	PDIV3	PDIV2	PDIV1	PDIV0
0x31 (0x51)	OCDR/ MONDR	OCDR7	OCDR6	OCDR5	OCDR4	OCDR3	OCDR2	OCDR1	OCDR0
Monitor Data Register									
0x30 (0x50)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0
0x2F (0x4F)	Reserved	–	–	–	–	–	–	–	–
0x2E (0x4E)	SPDR	SPI Data Register							
0x2D (0x4D)	SPSR	SPIF	WCOL	–	–	–	–	–	SPI2X
0x2C (0x4C)	SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0
0x2B (0x4B)	GPOR2	General Purpose I/O Register 2							
0x2A (0x4A)	GPOR1	General Purpose I/O Register 1							
0x29 (0x49)	PLLCSR	–	–	–	PINDIV	–	–	PLLE	PLOCK
0x28 (0x48)	OCROB	Timer/Counter0 Output Compare Register B							
0x27 (0x47)	OCROA	Timer/Counter0 Output Compare Register A							
0x26 (0x46)	TCNT0	Timer/Counter0 (8 Bit)							
0x25 (0x45)	TCCR0B	FOCOA	FOCOB	–	–	WGM02	CS02	CS01	CS00
0x24 (0x44)	TCCR0A	COM0A1	COM0A0	COM0B1	COM0B0	–	–	WGM01	WGM00
0x23 (0x43)	GTCCR	TSM	–	–	–	–	–	PSRASY	PSRSYNC

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x22 (0x42)	EEARH	–	–	–	–	EEPROM Address Register High Byte			
0x21 (0x41)	EEARL	EEPROM Address Register Low Byte							
0x20 (0x40)	EEDR	EEPROM Data Register							
0x1F (0x3F)	EECR	–	–	EPM1	EPM0	EERIE	EEMPE	EEPE	EERE
0x1E (0x3E)	GPOR0	General Purpose I/O Register 0							
0x1D (0x3D)	EIMSK	–	INT6	–	–	INT3	INT2	INT1	INT0
0x1C (0x3C)	EIFR	–	INTF6	–	–	INTF3	INTF2	INTF1	INTF0
0x1B (0x3B)	PCIFR	–	–	–	–	–	–	–	PCIF0
0x1A (0x3A)	Reserved	–	–	–	–	–	–	–	–
0x19 (0x39)	TIFR4	OCF4D	OCF4A	OCF4B	–	–	TOV4	–	–
0x18 (0x38)	TIFR3	–	–	ICF3	–	OCF3C	OCF3B	OCF3A	TOV3
0x17 (0x37)	Reserved	–	–	–	–	–	–	–	–
0x16 (0x36)	TIFR1	–	–	ICF1	–	OCF1C	OCF1B	OCF1A	TOV1
0x15 (0x35)	TIFR0	–	–	–	–	–	OCF0B	OCF0A	TOV0
0x14 (0x34)	Reserved	–	–	–	–	–	–	–	–
0x13 (0x33)	Reserved	–	–	–	–	–	–	–	–
0x12 (0x32)	Reserved	–	–	–	–	–	–	–	–
0x11 (0x31)	PORTF	PORTF7	PORTF6	PORTF5	PORTF4	–	–	PORTF1	PORTF0
0x10 (0x30)	DDRF	DDF7	DDF6	DDF5	DDF4	–	–	DDF1	DDF0
0x0F (0x2F)	PINF	PINF7	PINF6	PINF5	PINF4	–	–	PINF1	PINF0
0x0E (0x2E)	PORTE	–	PORTE6	–	–	–	PORTE2	–	–
0x0D (0x2D)	DDRE	–	DDE6	–	–	–	DDE2	–	–

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x0C (0x2C)	PINE	–	PINE6	–	–	–	PINE2	–	–
0x0B (0x2B)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0
0x0A (0x2A)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0
0x09 (0x29)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0
0x08 (0x28)	PORTC	PORTC7	PORTC6	–	–	–	–	–	–
0x07 (0x27)	DDRC	DDC7	DDC6	–	–	–	–	–	–
0x06 (0x26)	PINC	PINC7	PINC6	–	–	–	–	–	–
0x05 (0x25)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0
0x04 (0x24)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0
0x03 (0x23)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0
0x02 (0x22)	Reserved	–	–	–	–	–	–	–	–
0x01 (0x21)	Reserved	–	–	–	–	–	–	–	–
0x00 (0x20)	Reserved	–	–	–	–	–	–	–	–

Arduino and Compatible Products Vendors

Note that the inclusion of any particular company in this appendix does not constitute an endorsement (except for the Arduino folks, of course). It is provided as a resource only.

Arduino Products

The main source of official Arduino products is, of course, Arduino. You can find out what is available at the official website, Arduino.cc. There are also distributors that carry Arduino boards, shields, and add-on accessories.

Hardware-Compatible Boards and Shields

Name	URL	Name	URL
Adafruit	www.adafruit.com	ITEAD Studio	store.iteadstudio.com
Arduino	store.arduino.cc	Macetech	www.macetech.com/store/
Arduino Lab	www.arduinolab.us	Mayhew Labs	mayhewlabs.com
Circuit@tHome	www.circuitsathome.com	Nootropic Design	nootropicdesign.com
CuteDigi	store.cutedigi.com	Numato	numato.com
DFRobot	www.dfrobot.com	RobotShop	www.robotshop.com
DealeXtreme (DX)	www.dx.com	Rugged Circuits	www.ruggedcircuits.com
ElecFreaks	www.elecFreaks.com	SainSmart	www.sainsmart.com
Elehouse	www.elehouse.com	Seeed Studio	www.seeedstudio.com
excamera	www.excamera.com	SparkFun	www.sparkfun.com
Iowa Scaled Engineering	www.iascaled.com	Tindie	www.tindie.com
iMall	imall.itead.cc	Tronixlabs	tronixlabs.com

Software-Compatible Boards

Name	URL
Adafruit	www.adafruit.com
Circuit Monkey	www.circuitmonkey.com
BitWizard	www.bitwizard.nl

Sensors, Add-on Boards, and Modules

Name	URL	Name	URL
Adafruit	www.adafruit.com	Seeed Studio	www.seeedstudio.com
CuteDigi	store.cutedigi.com	TinyCircuits	www.tiny-circuits.com
DealExtreme (DX)	www.dx.com	Trossen Robotics	www.trossenrobotics.com
KEYES	en.keyes-robot.com	Vetco	www.vetco.net

Electronics Software

Open Source Schematic Capture Tools

Name	URL
ITeCAD	http://www.itecad.it/en/index.html
Oregano	https://github.com/marc-lorber/oregano
Open Schematic Capture (OSC)	http://openschcapt.sourceforge.net
TinyCAD	http://sourceforge.net/apps/mediawiki/tinycad
XCircuit	http://opencircuitdesign.com/xcircuit

CAE Software Tools

Name	Description	URL
DesignSpark	Free, not open source	http://www.rs-online.com/designspark/electronics/
Eagle	Free, not open source	http://www.cadsoftusa.com
Fritzing	Free CAE tool	http://fritzing.org/home
gEDA	Open source CAE tools	http://www.geda-project.org
KiCad	Open source CAE tool	http://www.kicad-pcb.org

PCB Layout Tools

Name	Description	URL
FreePCB	Windows (only) PCB layout	http://www.freepcb.com
FreeRouting	Web-based PCB autorouter	http://www.freerouting.net
PCB	Linux open source layout	http://sourceforge.net/projects/pcb/

Hardware, Components, and Tools

Electronic Component Manufacturers

Name	URL	Name	URL
Allegro	http://www.allegromicro.com	Micrel	http://www.micrel.com
Analog Devices	http://www.analog.com	Microchip	http://www.microchip.com
ASIX	http://www.asix.com.tw	NXP	http://www.nxp.com
Atmel	http://www.atmel.com	ON Semiconductor	http://www.onsemi.com
Bluegiga	http://www.bluegiga.com	Panasonic	http://www.panasonic.com
Cypress	http://www.cypress.com	Silicon Labs	http://www.silabs.com
Digi International	http://www.digi.com	STMicrotechnology	http://www.st.com
Fairchild	http://www.fairchildsemi.com	Texas Instruments	http://www.ti.com
FTDI	http://www.ftdichip.com	WIZnet	http://www.wiznet.co.kr
Linear Technology	http://www.linear.com	Zilog	http://www.zilog.com

Electronics Distributors (USA)

Name	URL
Allied	http://www.alliedelec.com
Digi-Key	http://www.digikey.com
Jameco	http://www.jameco.com
Mouser	http://www.mouser.com
Newark/Element14	http://www.newark.com
Parts Express	http://www.parts-express.com
State	http://www.potentiometer.com

Discount and Surplus Electronics

Name	URL
All Electronics	http://www.allelectronics.com
Alltronics	http://www.alltronics.com
American Science & Surplus	http://www.sciplus.com
BGMicro	http://www.bgmicro.com
Electronic Surplus	http://www.electronicssurplus.com
Electronic Goldmine	http://www.goldmine-elec-products.com

Mechanical Parts and Hardware (Screws, Nuts, Bolts)

Name	URL	Name	URL
All Electronics	http://www.allelectronics.com	McMaster-Carr	http://www.mcmaster.com
Alltronics	http://www.alltronics.com	Micro Fasteners	http://www.microfasteners.com
Bolt Depot	http://www.boltdepot.com	SDP/SI	http://www.sdp-si.com
Fastenal	http://www.fastenal.com	WM Berg	http://www.wmberg.com

Electronic Enclosures and Chassis

Name	URL	Name	URL
Bud Industries	http://www.budind.com	LMB Heeger	http://www.lmbheeger.com
Context Engineering	http://contextengineering.com/index.html	METCASE/OKW Enclosures	http://www.metcaseusa.com
ELMA	http://www.elma.com	Polycase	http://www.polycase.com
Hammond Manufacturing	http://www.hammondmfg.com/index.htm	Serpac	http://www.serpac.com
iProjectBox	http://www.iprojectbox.com	TEKO Enclosures	http://www.tekoenclosures.com/en/home

Tools

Name	URL	Name	URL
Adafruit	http://www.adafruit.com	Maker Shed	http://www.makershed.com
Apex Tool Group	http://www.apexhandtools.com	MCM Electronics	http://www.mcmelectronics.com
CKB Products	http://www.ckbproducts.com	SainSmart	http://www.sainsmart.com
Circuit Specialists	http://www.circuitspecialists.com	SparkFun	http://www.sparkfun.com
Electronic Goldmine	http://www.goldmine-elec-products.com	Stanley	http://www.stanleysupplyservices.com
Harbor Freight Tools	http://www.harborfreight.com	Velleman	http://www.vellemanusa.com

Test Equipment

Name	URL	Name	URL
Adafruit	http://www.adafruit.com	SparkFun	http://www.sparkfun.com
Electronic Goldmine	http://www.goldmine-elec-products.com	Surplus Shed	http://www.surplushed.com
MCM Electronics	http://www.mcmelectronics.com	Velleman	http://www.vellemanusa.com

Printed Circuit Board Supplies and Fabricators

Most major electronics distributors sell things like etchant and single- and double-sided copper clad PCB blanks with photoresist applied. If you aren't comfortable with the chemicals and procedures, consider using a commercial prototype PCB house.

Prototype and Fast-Turnaround Fabricators

Name	URL
Advanced Circuits	http://www.4pcb.com
ExpressPCB	http://www.expresspcb.com
Gold Phoenix PCB Co.	http://www.goldphoenixpcb.com
Sunstone Circuits	http://www.sunstone.com/
Sierra Circuits	https://www.protoexpress.com

PCB Kit Sources

Vendor name	URL	Products
Jameco Electronics	http://www.jameco.com	Conventional acid etch and supplies
Think & Tinker, Ltd.	http://www.thinkink.com	Various supplies for making PCBs
Vetco Electronics	http://www.vetco.net	Conventional acid etch kit

Other Sources

The companies in this appendix are just a sampling of what you can find with a little bit of searching. Distributors like Amazon and Mouser carry various Arduino and Arduino-compatible products. eBay is always a good place to look for bargains from Asian vendors (be sure to check the vendor ratings, but they are almost always good). And last but not least, there is Google. A search for “Arduino” on Google returned nearly 40 million results at the time of writing.

Recommended Reading

The Arduino is a popular subject for technical authors (myself included), and there are numerous books available. Some describe a specific range of applications, and others are more along the lines of a collection of projects. In addition to some titles that specifically deal with the Arduino, I have also included books on the AVR microcontroller, C and C++ programming, general electronics, interfaces, instrumentation, and printed circuit boards.

Arduino

- Massimo Banzi. *Getting Started with Arduino*. O'Reilly. 2009. ISBN 978-0596155513
- Patrick Di Justo and Emily Gertz. *Atmospheric Monitoring with Arduino*. (Maker Media). 2013. ISBN 978-1449338145
- Emily Gertz and Patrick Di Justo. *Environmental Monitoring with Arduino*. (Maker Media). 2012. ISBN 978-1449310561
- Simon Monk. *Programming Arduino: Getting Started with Sketches*. McGraw-Hill. 2011. ISBN 978-0071784221
- Jonathan Oser and Hugh Blemings. *Practical Arduino*. Apress. 2009. ISBN 978-1430224778

AVR

- Timothy Margush. *Some Assembly Required*. CRC Press. 2011. ISBN 978-1439820643

- Elliot Williams. *Make: AVR Programming*. Maker Media. 2014. ISBN 978-1449355784

C and C++ Programming

- Brian Kernighan and Dennis Ritchie. *The C Programming Language*. Prentice Hall. 1988. ISBN 978-0131103627
- K. N. King. *C Programming: A Modern Approach*. Norton. 1996. ISBN 978-0393969450
- Stanley Lippman. *C++ Primer*. Addison-Wesley. 2012. ISBN 978-0321714114
- Stephen Prata. *C++ Primer Plus*. Addison-Wesley. 2011. ISBN 978-0321776402

General Electronics

- Analog Devices. *Data Conversion Handbook*. Newnes. 2004. ISBN 978-0750678414
- Howard Berlin. *The 555 Timer Applications Sourcebook*. Howard W. Sams. 1976. ISBN 978-0672215381
- Richard Dorf (Ed.) *The Electrical Engineering Handbook*. CRC Press LLC. 1997. ISBN 978-0849385741
- Allan Hambley. *Electronics*, 2nd Edition. Prentice Hall, 1999. ISBN 978-0136919827
- Paul Horowitz and Winfield Hill. *The Art of Electronics*, 2nd Edition. Cambridge University Press. 1989. ISBN 978-0521370950
- J. M. Hughes. *Practical Electronics: Components and Techniques*. O'Reilly. 2015. ISBN 978-1449373078
- Walter G. Jung. *IC Op-Amp Cookbook*. Howard W. Sams. 1986. ISBN 978-0672224534
- Randy Katz. *Contemporary Logic Design*, 2nd Edition. Prentice Hall. 2004. ISBN 978-0201308570
- William Kleitz. *Digital Electronics: A Practical Approach*. Regents/Prentice Hall. 1993. ISBN 978-0132102870
- Charles Platt. *Make: Electronics*. Maker Media. 2009. ISBN 978-0596153748
- Arthur Williams and Fred Taylor. *Electronic Filter Design Handbook*, 4th Edition. McGraw-Hill. 2006. ISBN 978-0071471718

Interfaces

- Jan Axelson. *Parallel Port Complete*. Lakeview Research LLC. 2000. ISBN 978-0965081917
- Jan Axelson. *Serial Port Complete*. Lakeview Research LLC. 2007. ISBN 978-1931448062
- Jan Axelson. *USB Complete*. Lakeview Research LLC. 2007. ISBN 978-1931448086
- Nick Hunn. *Essentials of Short-Range Wireless*. Cambridge University Press. 2010. ISBN 978-0521760690
- Benjamin Lunt. *USB: The Universal Serial Bus*. CreateSpace. 2012. ISBN 978-1468151985
- Charles E. Spurgeon and Joann Zimmerman. *Ethernet: The Definitive Guide*, 2nd Edition. O'Reilly Media, Inc. 2014. ISBN 978-1449361846

Instrumentation

- J. M. Hughes. *Real World Instrumentation with Python*. O'Reilly. 2010. ISBN 978-0596809560

Printed Circuit Boards

- Jan Axelson. *Making Printed Circuit Boards*. Tab Books. 1993. ISBN 978-0830639519
- Simon Monk. *Fritzing for Inventors*. McGraw-Hill. 2016. ISBN 978-0071844635
- Simon Monk. *Make Your Own PCBs with Eagle*. McGraw-Hill. 2014. ISBN 978-0071819251
- Matthew Scarpino. *Designing Circuit Boards with EAGLE*. Prentice Hall. 2014. ISBN 978-0133819991

Arduino and AVR Software Development Tools

This book has focused primarily on the Arduino IDE and the AVR-GCC toolchain, but those aren't the only tools available, by any means. There are many different tools for assembling, compiling, linking, and loading executable code into an AVR MCU. Some are open source, others are commercial, and some are more capable and polished than others.

Compilers/Assemblers

Atmel AVR Toolchain for Windows (<http://bit.ly/atmel-avr>)

An open source suite of tools, including an assembler, ported to Windows. Includes both GNU-licensed software and tools developed by Atmel.

AVR-GCC (<http://www.nongnu.org/avr-libc>)

A full suite of toolchain components for cross-compiling AVR executable code from C or C++ sources. See Chapter 6 for an overview.

SDCC (<http://sdcc.sourceforge.net>)

An open source ANSI C compiler targeted for a variety of microcontrollers.

WinAVR (<http://winavr.sourceforge.net>)

An open source ports of components from the AVR-GCC toolchain to the Windows environment. See Chapter 6 for an overview.

Integrated Development Environments (IDEs)

Arduino IDE (<https://www.arduino.cc>)

The official IDE for Arduino hardware from the Arduino.cc team. Runs on Windows, Linux, and Mac OS X. Open source and free to download. See Chapter 5 for an overview.

Atmel Studio 7 (<http://bit.ly/atmel-studio-7>)

Integrated C/C++ compiler and IDE. Free to download; for Windows 7 or later only. See Chapter 6 for an overview.

Eclipse Plugin (<http://bit.ly/avr-eclipse>)

An open source AVR-oriented plug-in for the popular Eclipse (<https://eclipse.org>) open source IDE. Eclipse is Java-based and runs on Windows, Linux, and Mac OS X.

IAR Embedded Workbench (<http://bit.ly/iar-workbench>)

Highly integrated suite of proprietary tools. License pricing by quotation, trial version available (30 days). Windows only.

MikroElektronika mikroC (<http://www.mikroe.com/mikroc/avr>)

Commercial ANSI C compiler with IDE. Single-user license is \$249; for Windows XP and later.

ImageCraft JumpStart (https://www.imagecraft.com/devtools_AVR.html)

Commercial ANSI C compiler. Based partly on GPL open source software. \$249 for a “standard” license for Windows. License dongle available.

Rowley CrossWorks (<http://www.rowley.co.uk/avr>)

Commercial multiplatform ANSI C compiler with IDE. License cost varies from \$150 to \$2,250, depending on use of the product. Will run on Windows, Mac OS X, and Linux.

Programming Tools

PlatformIO (<http://platformio.org>)

Command line-based AVR-GCC toolchain interface for Windows, Linux, and Mac OS X. See Chapter 6 for a brief description.

Ino (<http://inotool.org>)

Command line-based AVR-GCC toolchain interface for Linux and Mac OS X. See Chapter 6 for a brief description.

Simulators

AMC VMLAB (<http://www.amctools.com/vmlab.htm>)

Freeware graphical AVR simulator for Windows.

GNU AVR Simulator (<http://sourceforge.net/projects/avr>)

Open source AVR simulator with Motif-based graphical interface. Runs on Linux/Unix.

Labcenter Proteus (<http://www.labcenter.com/products/vsm/avr.cfm>)

Novel schematic capture-based AVR simulator. Full graphical interface. Licenses start at \$248. Windows only.

OshonSoft AVR Simulator (<http://www.oshonsoft.com/avr.html>)

Graphical AVR simulator with optional add-on modules. Personal license is \$32.

SimulAVR (<http://www.nongnu.org/simulavr>)

Open source command line-based AVR simulator for Linux/Unix systems.