Forth In Your Shirt Pocket

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Forth Interest Group

What Is Arduino?

- A Family Of Atmel Based Processors
- Open Source C Compiler, Assembler, Boot Loader, Programmer and Library
- High Impact In Maker Community
- Many Second Sources and Add-ons
- AVR Is Name Of Atmel RISC Architecture

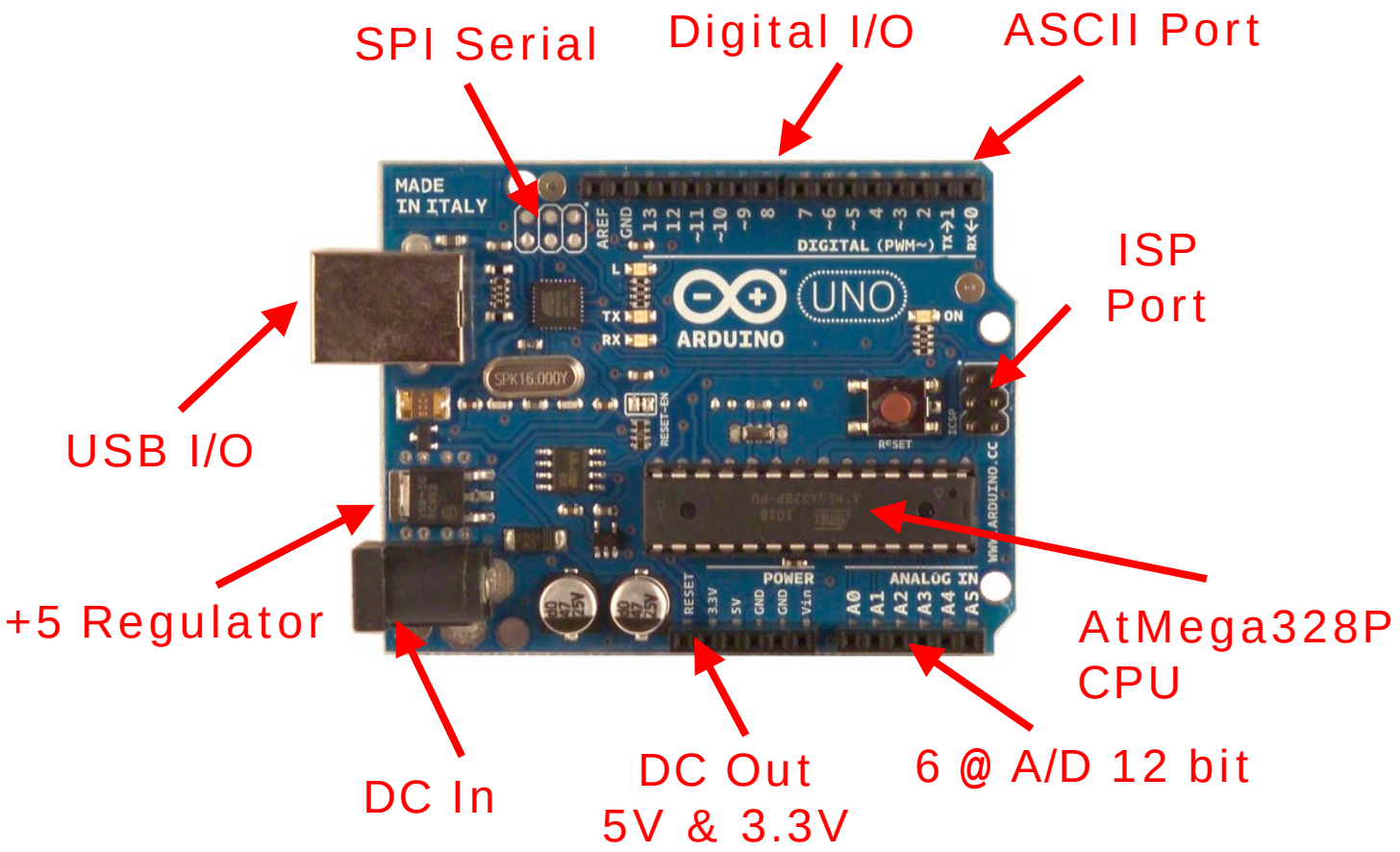
Current Arduino Status

- As of February 2010, 120,000 Arduino boards shipped.
- Named after the local bar: “ar-Dwee-no”
- The name is an Italian masculine first name, meaning "strong friend".
- "Duemilanove" means 2009 after the year of its release. Upgraded processor into Uno

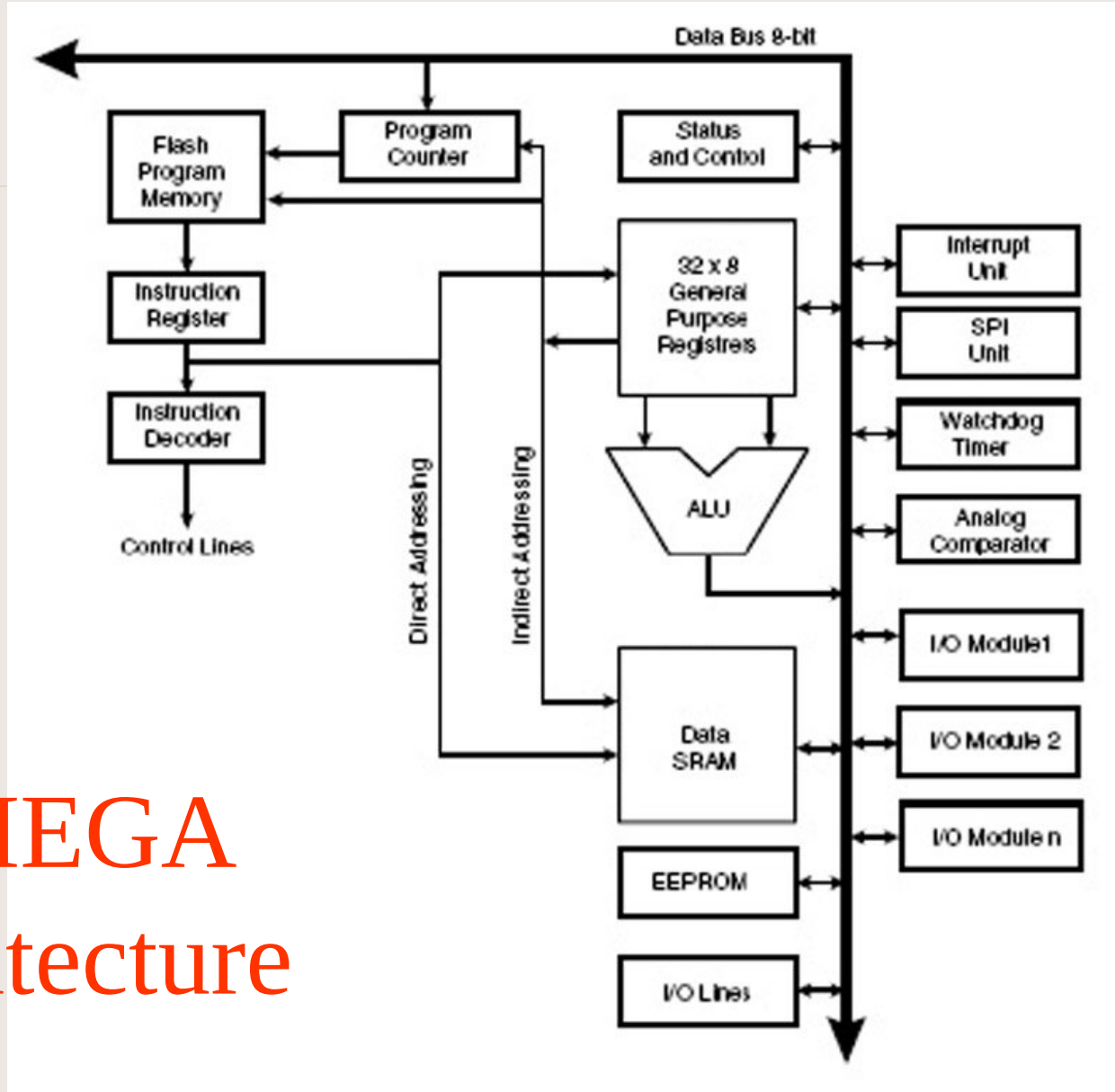
328P Processor

- **Atmel ATmega328P, 28 pin DIP**
- **16 MHz clock**
- **RISC Design, One Command Per Cycle**
- **20 Input Output Lines, Programmable**
- **6 Analog to Digital Converters, 12 bit**
- **2 Counter/Timers, 8/16 Bit w/Prescaler**
- **ASCII UART, SPI High Speed Serial.**
- **Costs $4.00**
- **Power: up to 4 mA at 5 Volts.**

Arduino Uno


SPI Serial
Digital I/O
ASCII Port
ISP Port
USB I/O
+5 Regulator
AtMega328P CPU
DC In
DC Out 5V & 3.3V
6 @ A/D 12 bit
MADE IN ITALY
DIGITAL (PWM~)
UNO
ARDUINO
POWER
ANALOG IN

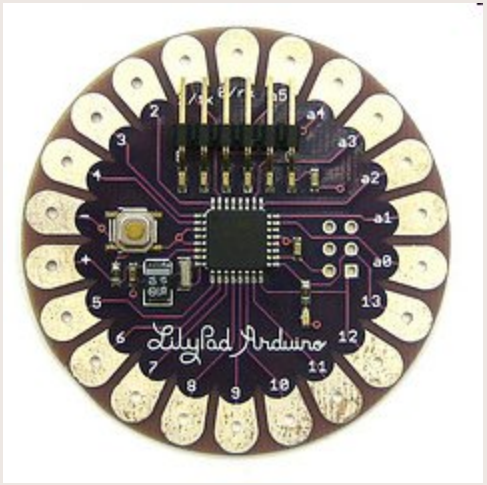
AtMEGA Architecture

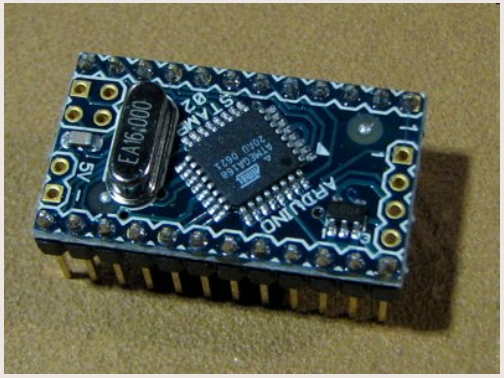


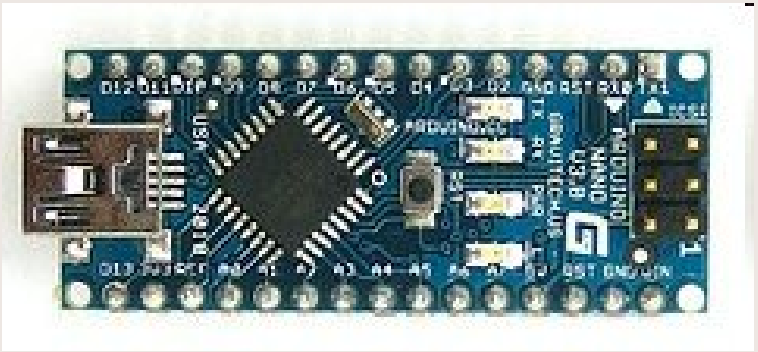
Processor Quirks

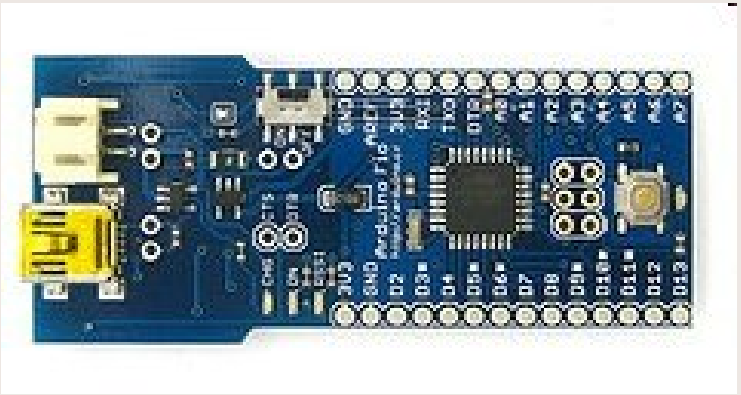
- Flash Writes 1->0 directly.
- Flash Writes 0-> 1 via a full page write.
- 16 Bit Registers/I-O: Read Low Byte and then High Byte.
- 16 Bit Registers/I-O: Write High Byte and then Low Byte.

Arduino Board Family









Support Items

AVR Studio 4, Atmel Development System

AVR ISP MkII Programmer, $65

Arduino-0021 Host Software, Compiler

RealTerm or Hyperterm

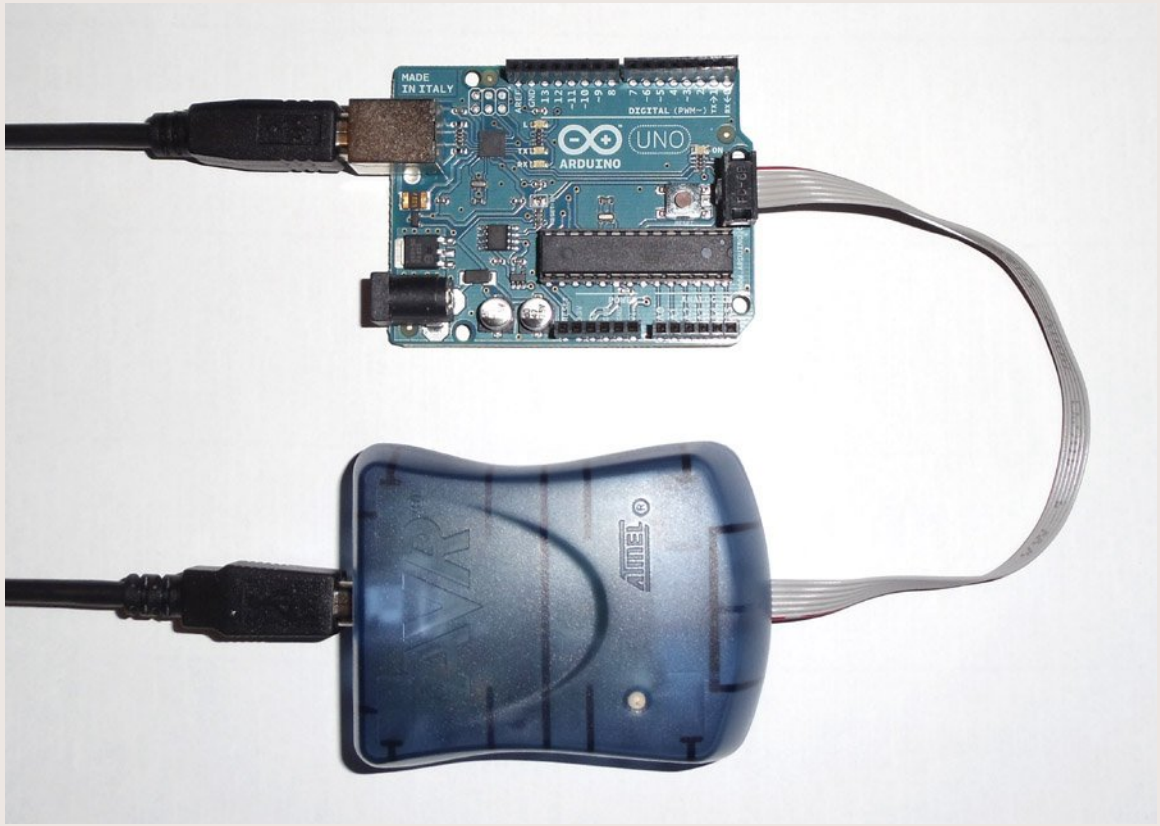
AmForth-4.2, sourceforge.com

AVRdude Programming Software

Atmel Assembly Manual

AtMega328 Manual (550 pages!)

ISP Programmer



Atmel Downloads

- Requires ISP Interface
- Atmel Studio 4: Supports C++ and Assembler
- Loads Any Hex Files.
- Loads Ardunio Flash Loader
- Loads AmForth Hex Files

Arduino Download

- Loading Flash Loader:

  Uses ISP Programmer & AVRdude
- Load C Programs Via USB Port.

Forth Download

- Download Forth Hex Via ISP Port.
- Download Forth Source Via USB Port Using A Terminal Interface Program
- Hyperterm or
- RealTerm (better)
- Need Text End Of Line Delay.

Loading AmForth

- AVR ISP MkII cable to Uno ISP header, red wire to dot.
- AVR ISP MkII USB to the computer.
- Uno USB To The Computer For Power.
- In AVR Studio 4 Left Icon Like An Integrated Circuit.
- Select AVRISP MkII & USB
- On MAIN Pick Device ATmega 328P
- Move To PROGRAM.
- Flash Window, Navigate To ArduinoUno.hex
- EEPROM Window Navigate To ArduionUno.eep.hex
- Click On Flash, Program & Then EEPROM, Program
- See A Dialog At The Lower Left As These Are Loaded.

Arduino C Support

HTML Help Library at

Arduino-0021\. . .
libraries\reference\index.html

Arduino-0021\. . . Examples\1. Basics\Blink

Capability Comparison

Function	"C"	Forth
Storage	Host	Host/Target
Editing	Host	Host/Target
Compiler	Host	Target
Labels	Host	Target
Extensible	Sometimes	Yes
Interactive	No	Yes
I/O Direct Access	No	Yes
Floating Point	Yes	Option
Pocket Portable	No	Yes

Software Comparison

```
/*   Blink, flash the LED on and off  */

void setup() { pinMode(13, OUTPUT) }
void loop() {digitalWrite(13, HIGH); delay(500);
             digitalWrite(13, LOW);  delay(500); }
```

```
$23 value PortB   5 value LED
: 1-cycle   PortB LED PoBiHi   dup ms
            PortB LED PoBiLo       ms ;
: blink ( delay count)  PortB  LED  PoBiOut
         0 ?do  dup 1-cycle loop  drop ;
```

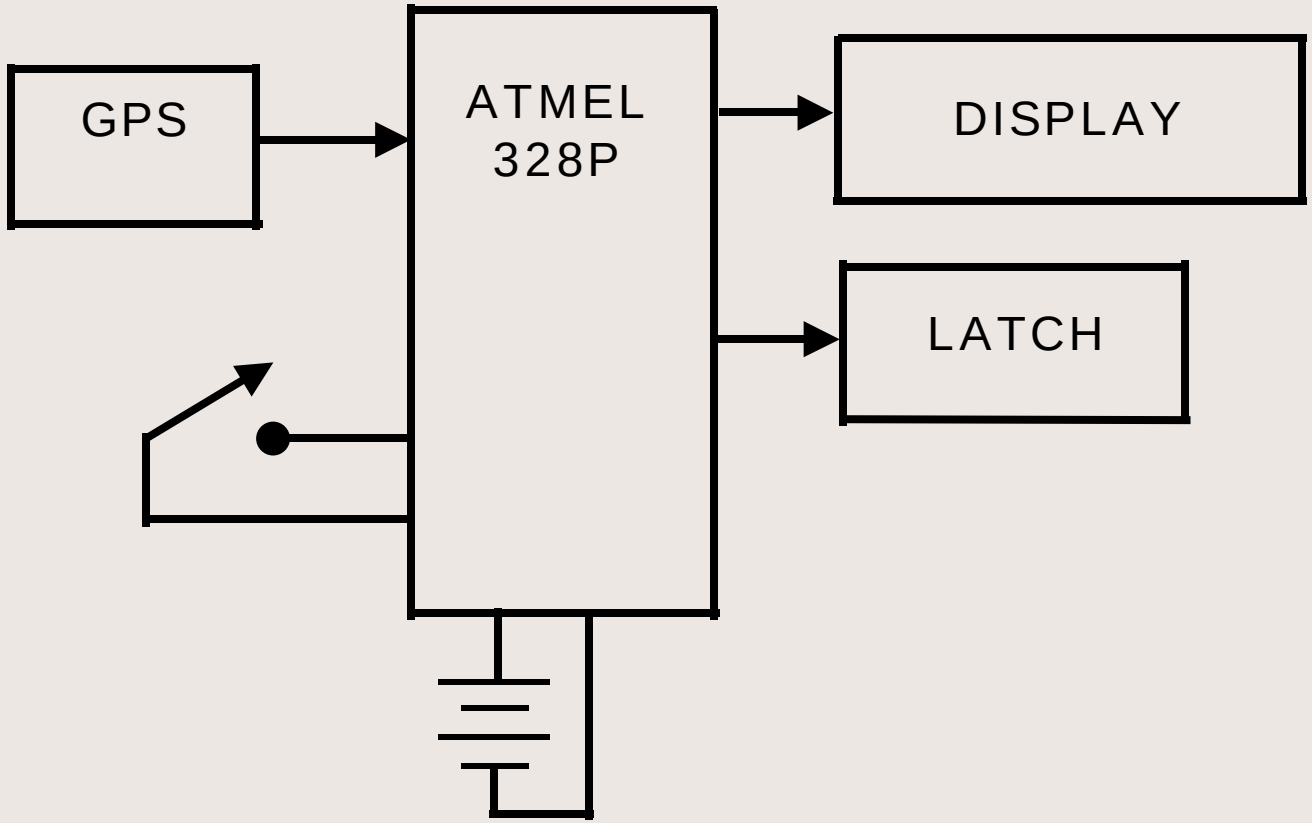
Arduino Shields

SD Card For $20

GPS for $20+$60

GPS Mystery Box

Open The Mystery Box



Break

Bill's Archive Posted At:

http://tinyurl.com/5sp327u

[AmForth HEX & Source, Tools, Glossary, USB Drivers, RealTerm, These Slides]

Background On The GPS Puzzle Box.

http://tinyurl.com/5u25ryu

AmForth At: SourceForge.com

Introduction To Forth

- Developed In 1960s By Charles Moore
- Totally Stand-alone; Needs No Host Resources
- Ideal For Microprocessor Development.
- You Build An Application Language
- Every Command Is A “Word” You Can Execute By Name.
- Very Interactive; Easy To Test

AmForth Major Elements

- 3 Memory Spaces
- Dictionary in Flash
- Variables in RAM
- Values in EEPROM
- Hooks: Multi-tasking, Vocabularies, Turn-key, Interrupts.

AmForth Architecture

- **Indirect Threaded Code**
- **16-bit Data Stack**
- **16-bit Return/Loop Stack**
- **Cache Top Stack Value**
- **Full Access For Three Memory Spaces**
- **Flash=Cells; RAM & EEPROM=Bytes**
- **No Mass Storage**

AmForth Words

@ ! I@ I! E@ E! , ALLOT

: ; CREATE DOES>

IF ELSE THEN BEGIN UNTIL etc.

+ / M/MOD D+ D*

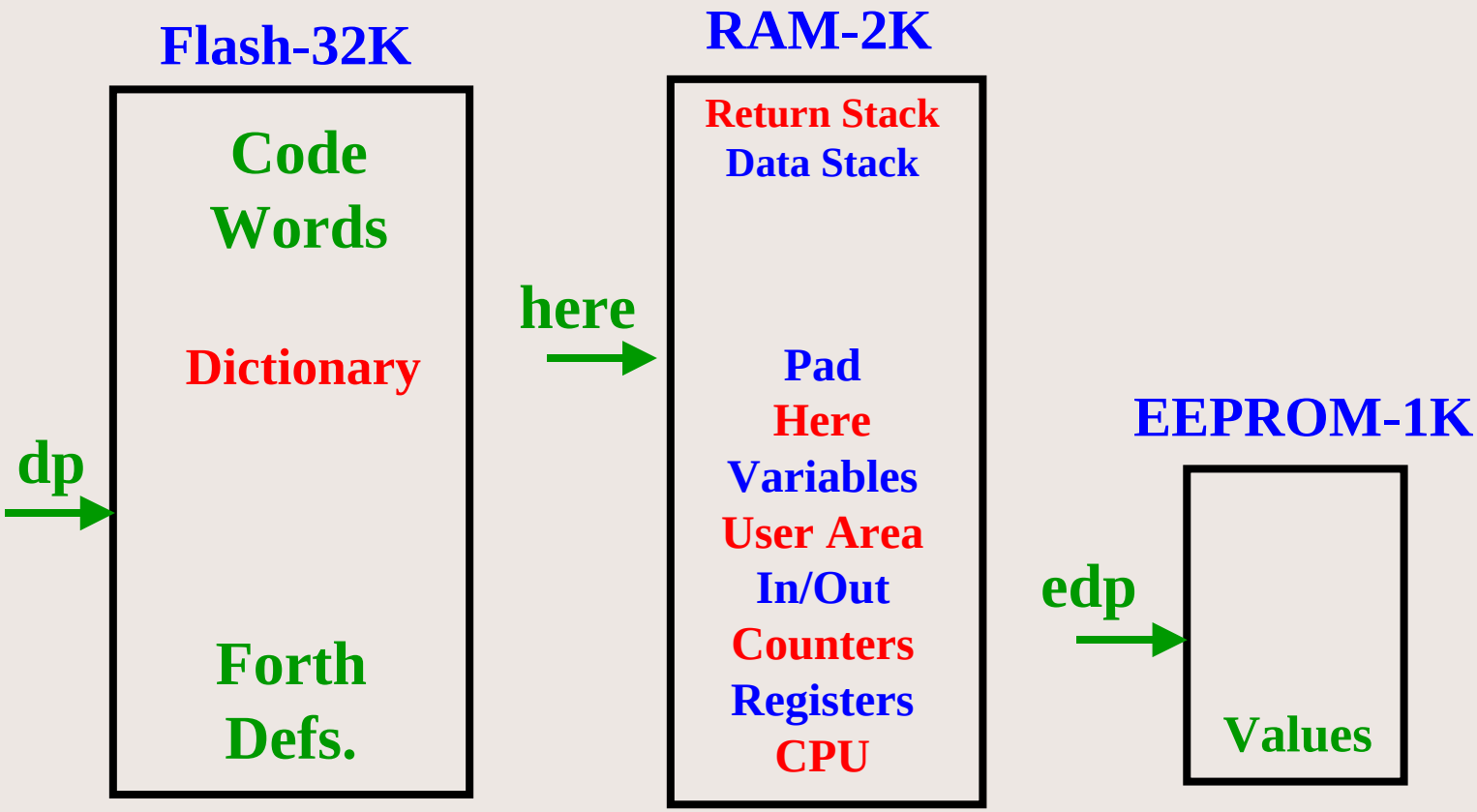
<# # #S #> TYPE

WORDS ONLY ALSO DEFINITIONS

AmForth Quirks

- **OK Appears On Next Line**
- **Unknown Word Error Message, Odd**
- **No SHIFT; Observes Case.**
- **No Redefinition Warning**
- **No Compiler Security (THEN Kills!)**
- **No FORGET; Use MARKER**
- **Host Supplies Mass Storage**

Three Memories



A Peek At Flash

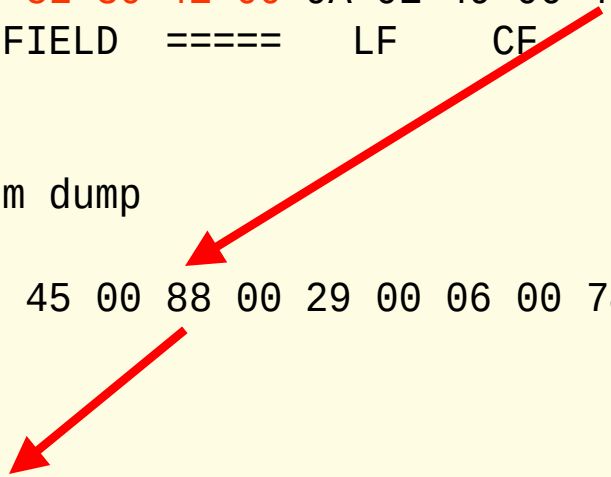
```
> flash  ' dup 30 - 200 dump
 flash
3896 89 91'99 91'75 CF'02 FF'63 21'8D 38'9D 38'FC 01' ....u...c!.8.8..
389E 89 91'99 91'80 83'89 91'99 91'6A CF'02 FF'63 40' .........j...c@
38A6 99 38'A8 38'FC 01'99 27'80 81'62 CF'03 FF'64 75' .8.8...'..b...du
38AE 70 00'A4 38'B1 38'9A 93'8A 93'5A CF'04 FF'3F 64' p..8.8....Z...?d
38B6 75 70'AC 38'B9 38'08 2F'09 2B'11 F0'9A 93'8A 93' up.8.8./.+......
38BE 4F CF'04 FF'73 77'61 70'B4 38'C4 38'8C 01'89 91' O...swap.8.8....
38C6 99 91'1A 93'0A 93'44 CF'04 FF'6F 76'65 72'BF 38' ......D...over.8
38CE CF 38'9A 93'8A 93'8A 81'9B 81'3A CF'04 FF'64 72' .8........:...dr
38D6 6F 70'CA 38'D9 38'89 91'99 91'32 CF'03 FF'72 6F' op.8.8....2...ro
38DE 74 00'D4 38'E1 38'8C 01'29 91'39 91'89 91'99 91' t..8.8..).9.....
38E6 3A 93'2A 93'1A 93'0A 93'23 CF'02 FF'72 3E'DC 38' :.*.....#...r>.8
38EE EF 38'9A 93'8A 93'8F 91'9F 91'1A CF'02 FF'3E 72' .8............>r
38F6 EB 38'F8 38'9F 93'8F 93'89 91'99 91'11 CF'02 FF' .8.8............
38FE 72 40'F4 38'01 39'9A 93'8A 93'8F 91'9F 91'9F 93' r@.8.9..........
3906 8F 93'06 CF'02 FF'3C 3E'FD 38'0C 39'29 91'39 91' ......<>.8.9).9.
390E 82 17'93 07'99 F1'3B C0'01 FF'3D 00'08 39'16 39' ......;...=..9.9
3916 29 91'39 91'82 17'93 07'49 F5'31 C0'02 FF'30 3D' ).9.....I.1...0=
```

A Peek At RAM

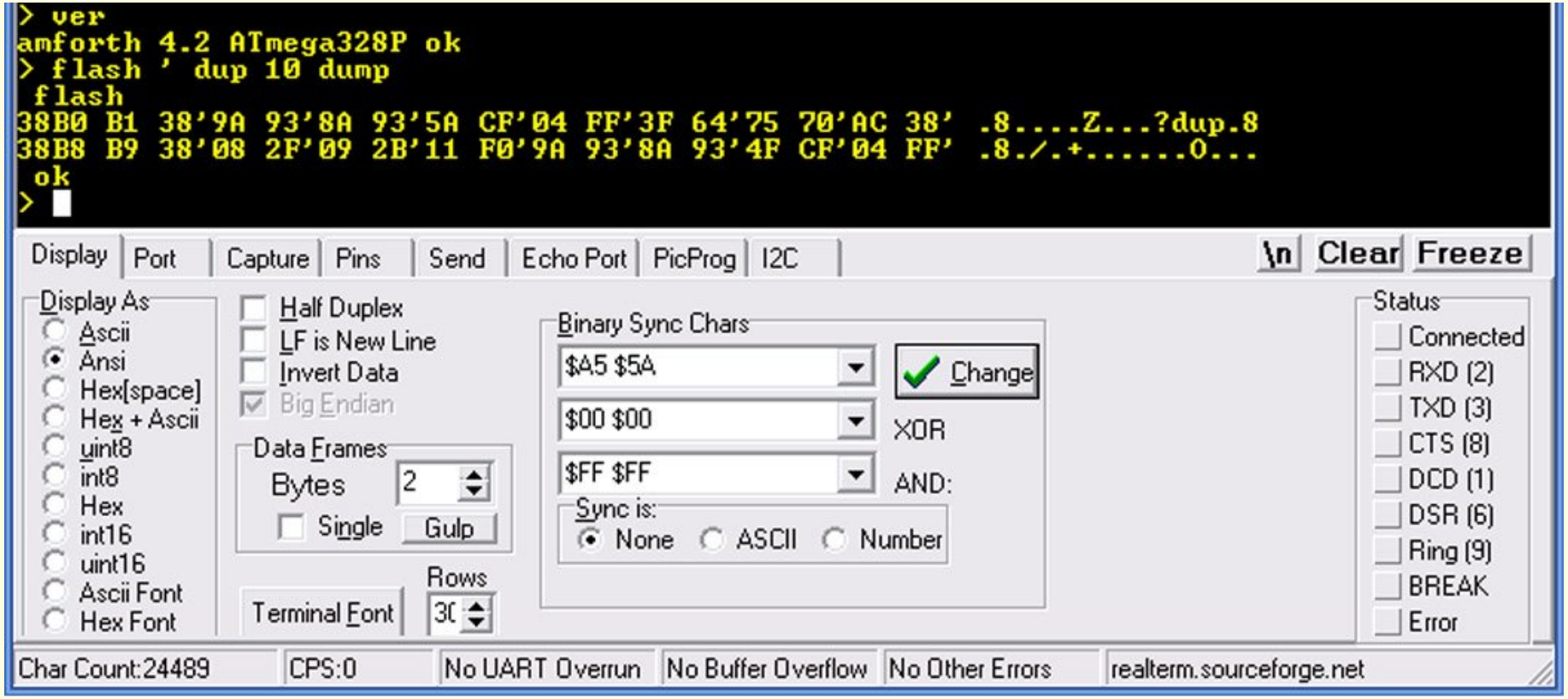
```
> ram here 100 – 200 dump
 ram
0177 70 75 6D 70 21 20 20 3B 69 20 6F 76 65 72 20 2E  pump!  ;i over .
0187 6D 65 6D 6F 72 79 20 20 20 69 20 6F 76 65 72 20  memory   i over
0197 2E 61 6C 70 68 61 20 63 72 20 68 69 20 62 79 74  .alpha cr hi byt
01A7 65 29 20 74 68 65 6E 20 5B DB 85 F2 9D 82 E8 DD  e) then [.......
01B7 B8 0A D1 FF F9 3B CF CB 27 09 5D BD BB BF CB 0D  .....;..'.].....
01C7 CF 0D 01 01 0D 20 31 30 30 20 2D 20 32 30 30 20  ..ram 100 - 200
01D7 64 75 6D 70 04 64 75 6D 70 73 64 61 73 6E 74 20  dump.dumpsdas
01E7 2D 2D 2D 20 20 66 6F 72 6D 3A 20 31 32 33 34 20  ---  form: 1234
01F7 78 78 20 78 78 20 78 78 20 78 78 20 78 78 20 61  xx xx xx xx xx a
0207 62 63 64 65 66 67 65 73 68 61 72 61 63 74 65 72  bcdefgesharacter
0217 73 6D 6E A6 69 F7 C7 FB BD 9B BB BC A3 B8 64 E9  smn.i.........d.
0227 B7 CF 42 FE 40 25 DC CB 47 E7 D7 FB FB 73 EF E9  ..B.@%..G....s..
0237 AC 5B 30 30 32 33 33 20 6F 7B 97 BB 76 3B 64 25  .[00225 o{..v;d%
```

A Peek At EEPROM

```
>  $88 value OCR0A

> flash ' OCR0A 5 - 6 dump
  flash
0EA1 05 FF'4F 43'52 30'41 00'9A 0E'49 06'46 00'     ..OCR0A...I.
ADDR  ==== NAME FIELD  =====   LF    CF    PF


> hex 40 5 eeprom dump
 prom
0040 FF FF 44 00 45 00 88 00 29 00 06 00 78 00 04 00  ..D.E.G.)...x...



> OCR0A hex .  88  ok
```



Using RealTerm Program



Tools To Add

- Add 2DUP & FALSE
- Add MARKER Then CHOP
  i.e. CHOP-IO marker CHOP-IO
- Add Smart DUMP For Address Spaces
- Add I/O Words
- Add Chronometer For Testing

My Applications

- Smart DUMP for flash, ram, eeprom.
- I/O-core Support Words
- Flasher for LED
- Chronometer, Timer
- Tone Generator
- Keyer for Morse Iambic Keyer

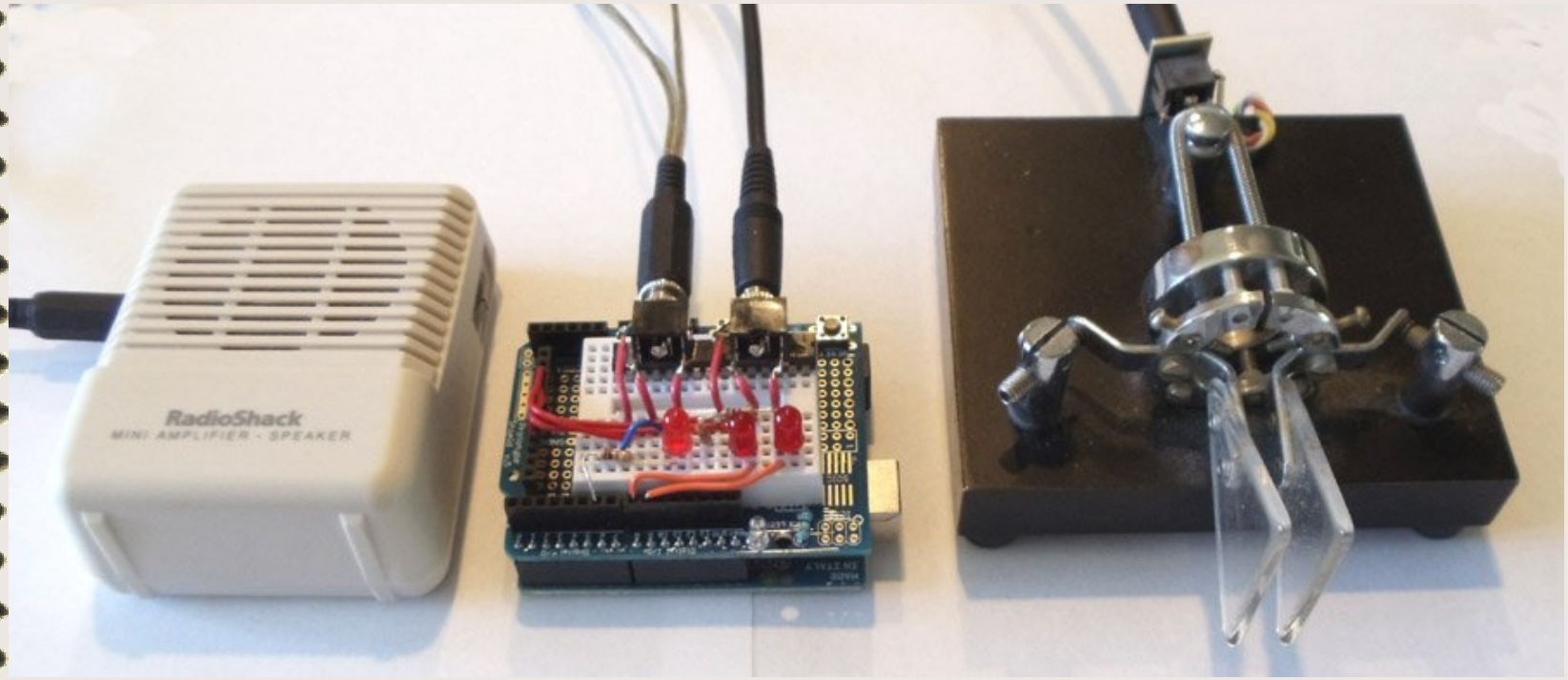
Morse Code Language

```
: V   dit dit dit dah next-character ;

: sos   dit dit dit next-character
        dah dah dah next-character
        dit dit dit next-word ;
```

Morse Code Language, more

```
: dit tone-on 1 element-delay tone-off
                1 element-delay ;
: dah tone-on 3 element-delay tone-off
                1 element-delay ;
: next-character 2 element-delay ;
: next-word      6 element-delay ;
: element-delay  1200 * WPM / ms ;
10 value WPM  \ words per minute
```

Uno As Morse Keyer



Iambic Keyer

```
: demo    setup-iambic
    begin
      sense-iambic
      if  1 and if dah else dit then then
      key?
    until ;
```

Iambic Keyer, details

```
: setup-key
   PortB  dah-in PoBiInPu
   PortB  dit-in PoBiInPu    ;

: sense-key
   PortB 3 RegFrom  3 xor
   dup  if last? true else drop false then
   ;
```

Iambic Keyer, details

```
: last?   \ sensed ---- dit or dah
\ if both, change to opposite of Last-in
  dup 3 = if drop Last-in  3 xor then
  dup to Last-in ( save )  ;

 1 value Last-in  \ hold last dit/dah sent
```

Summary

- AmForth Is Very Close To ANSI Standard
- Eminently Useful.
- Very Wide Range Of Accessories.
- Future: Convert Assembly Source Into Forth Source For Target Compiling.
- Complete A Full Glossary; I Made A Start
- Need Drivers For Arduino Accessories.

Sushi Nemo

Master Index

1. An overview of the Arduino board/processor family. Italian names and Uno.
2. The Atmel Mega328P processor architecture, registers, memory space, I/O, counters.
3. Serial interface using USB and COM#
4. ISP MkII and adafruit loader ISP Programmers, what you need with Atmel Studio 4, Ardunio C++ and AmForth.
5. Look at Arduino Host, flash loader via COM# and AVERdude
6. Loading AmForth via Studio 4 ISP MkII from hex files.
7. Arduino Shields
8. Using and need for a terminal interface program, RealTerm, Hyperterm.
9. Lunch
10. Quick summary, RealTerm and getting to OK.
11. Survey of AmForth, using 3 mem spaces, flash, ram, eeprom, interrupts, headers. Demo with dump of the three memory spaces.
12. Hooks for vocabularies, interrupts, multi-tasking.
13. Quirks of AmForth to our usual domestic Forths. No compiler security, the FORGET problem and solution. No SHIFT, no redefinition warning. Numeric input formats.
14. Support documentation at system and user levels. Where located
15. Needed utilities: a smart dump,. marker, vocabulary
16. A set of utility I/O words.
17. Applications: chronometer to measure internal speeds and clock cycles
18. A tone generator.
19. Demo of a Morse code sender. Audible and visual.
20. The challenges of interfacing to Arduino peripherals, SD memory card, LCD display, I2C ram interface.
21. Optional A project to convert the assembler listing to be target compiled Forth to Forth.
22. The Future: Workshop questions and possibilities