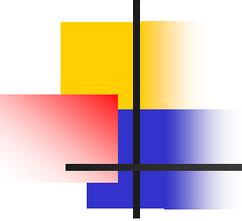


# Irreducible Complexity eForth for Discovery

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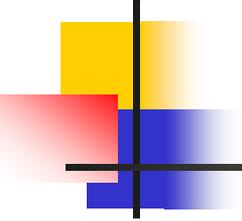
Silicon Valley FIG  
July 26, 2014  
Chen-Hanson Ting



# Summary

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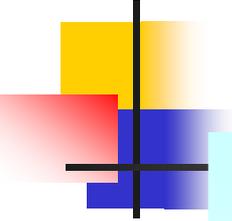
- ARM7 eForth
- stm32eForth v7.20
- Irreducible complexity
- Nonconstained expansion
- Demo
  - STM32F4-Discovery Kit
  - ForthDuino Kit



# ARM7 eForth

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- V1.10 GameBoyAdvance, metacompiled with Win32Forth
- V2.01 GameBoyAdvance metacompiled with F#
- V5.06 ADuC7024 with uVision3
- V6.03 AT91SAM7x256 with uVision3
- V7.20 STM32F407 with uVision5

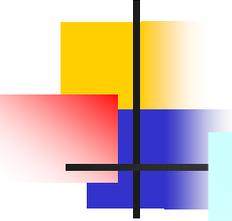


## Arm7 eForth v2.01 based on Win32Forth for GBA

- Original Direct Thread eForth Model
- Metacompiled with Win32Forth assembler
- Extensive Applications for GBA
  - Chinese Character Generator
  - eBooks
  - Bilingual Bible
  - DSO Simulator

# ARM7 on GameBoyAdvance



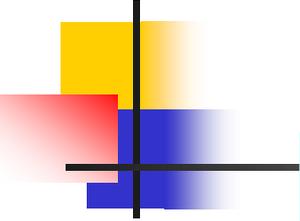


# GameBoyAdvance

- 16 MHz ARM7 core
- 32 Kbytes internal RAM
- 256 Kbytes external RAM
- 32 Mbytes Flash RAM
- 240x160 Color Display
- 10 Switches for user interface
- Serial Communication Port
- Graphic Objects
- Sound Objects

# Forth Stamp



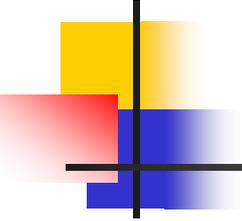


# ADuC7024

- 45 MHz ARM7 core
- 64 Kbytes Flash RAM
- 8 Channels of 12-bit A/D
- 4 Channels of 12-bit D/A
- Serial Port
- Parallel Port
- Counters, Timers, Interrupt Controller
- Keil uVision3

# Portable Audio Scope



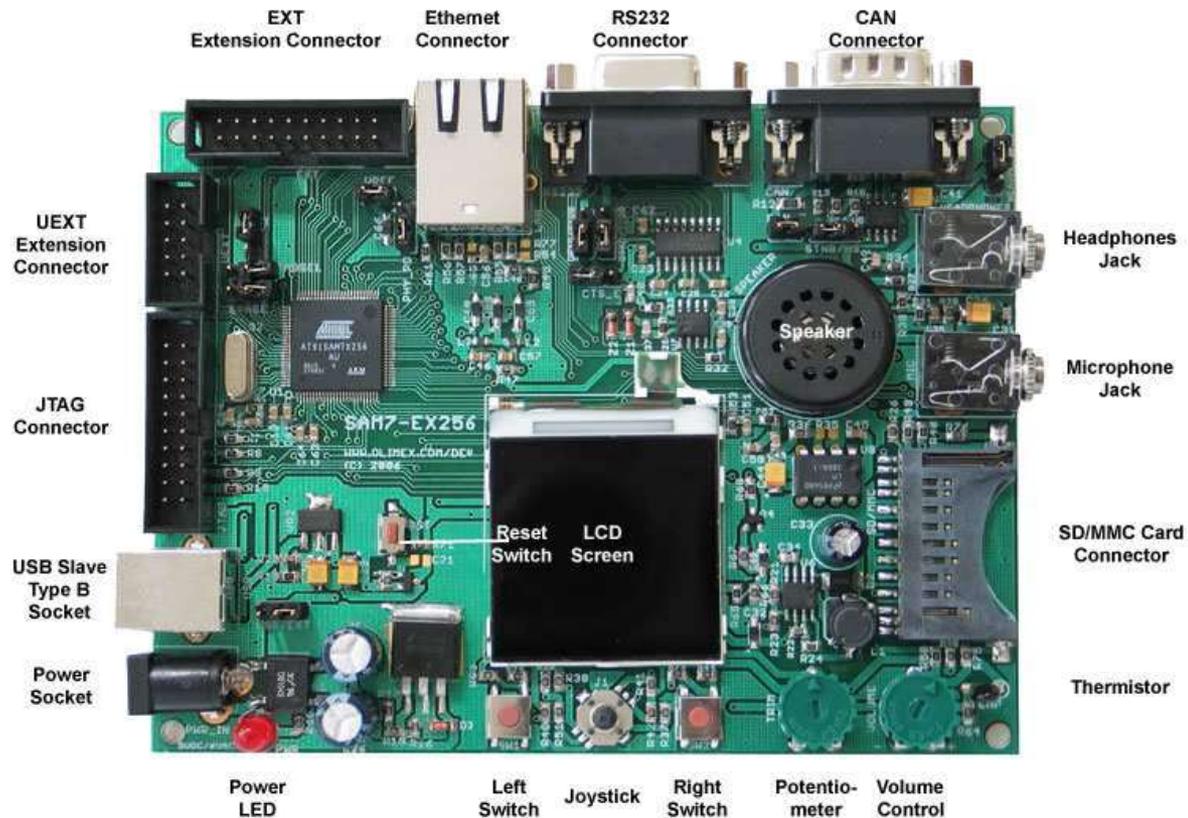


# Atmel AT91SAM7X256

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- 64KB RAM and 256 KB flash memory
- 8 MHz ADC
- 132x132 Color LCD display
- Joystick and 2 more switches
- 3 UART ports
- JTAG, USB, Ethernet, SPI, CAN

# DSO with Olimex Board



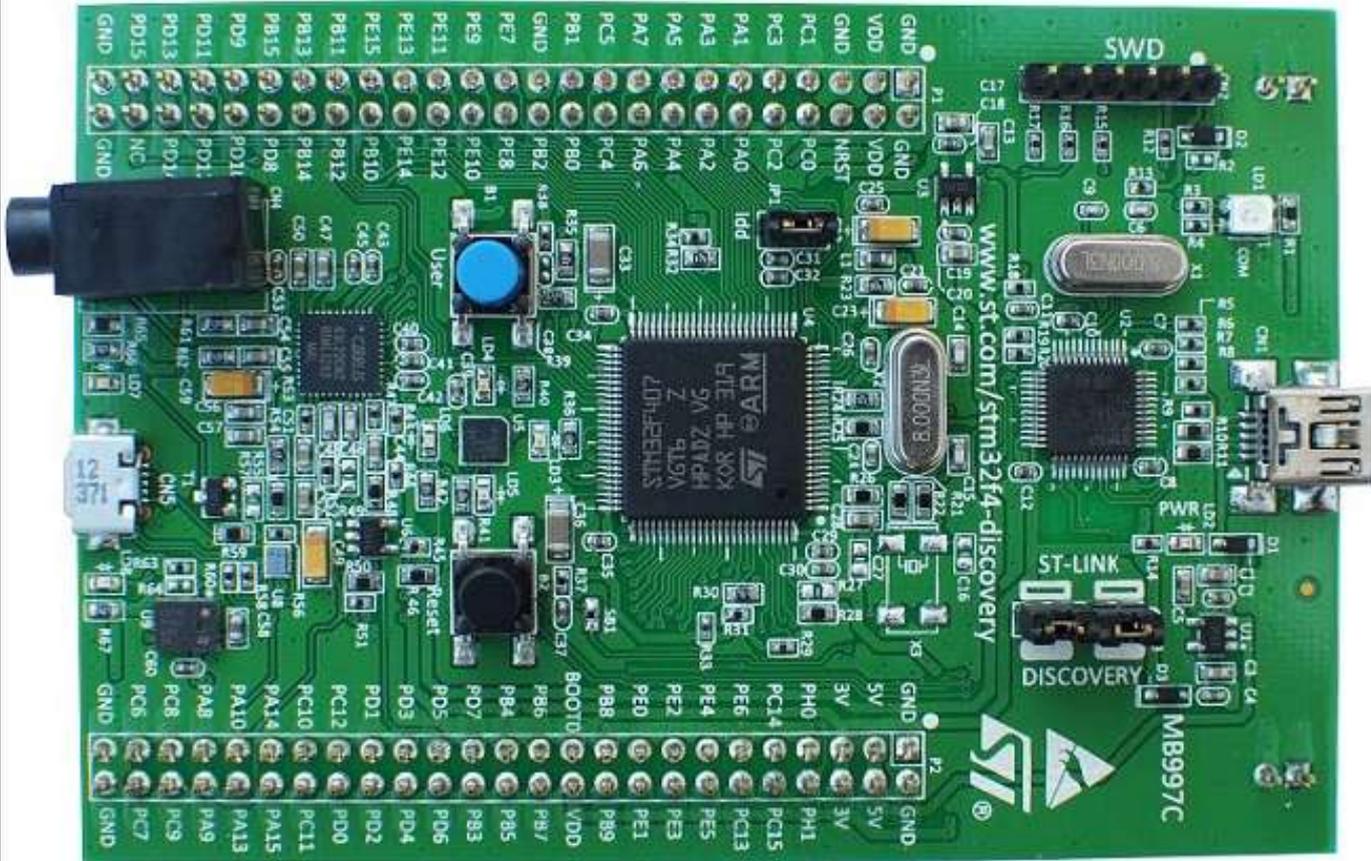


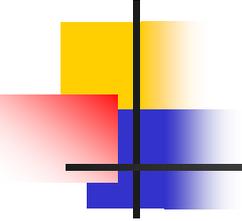
# STM32F407-Discovery Board

---

- STM32F407VG Microcontroller
- ST-Link USB Debugging Port
- 3 Axis Accelerometer
- Audio ADC, DAC
- USB Mouse
- 80 GPIO Pins

# STM32F407-Discovery Board



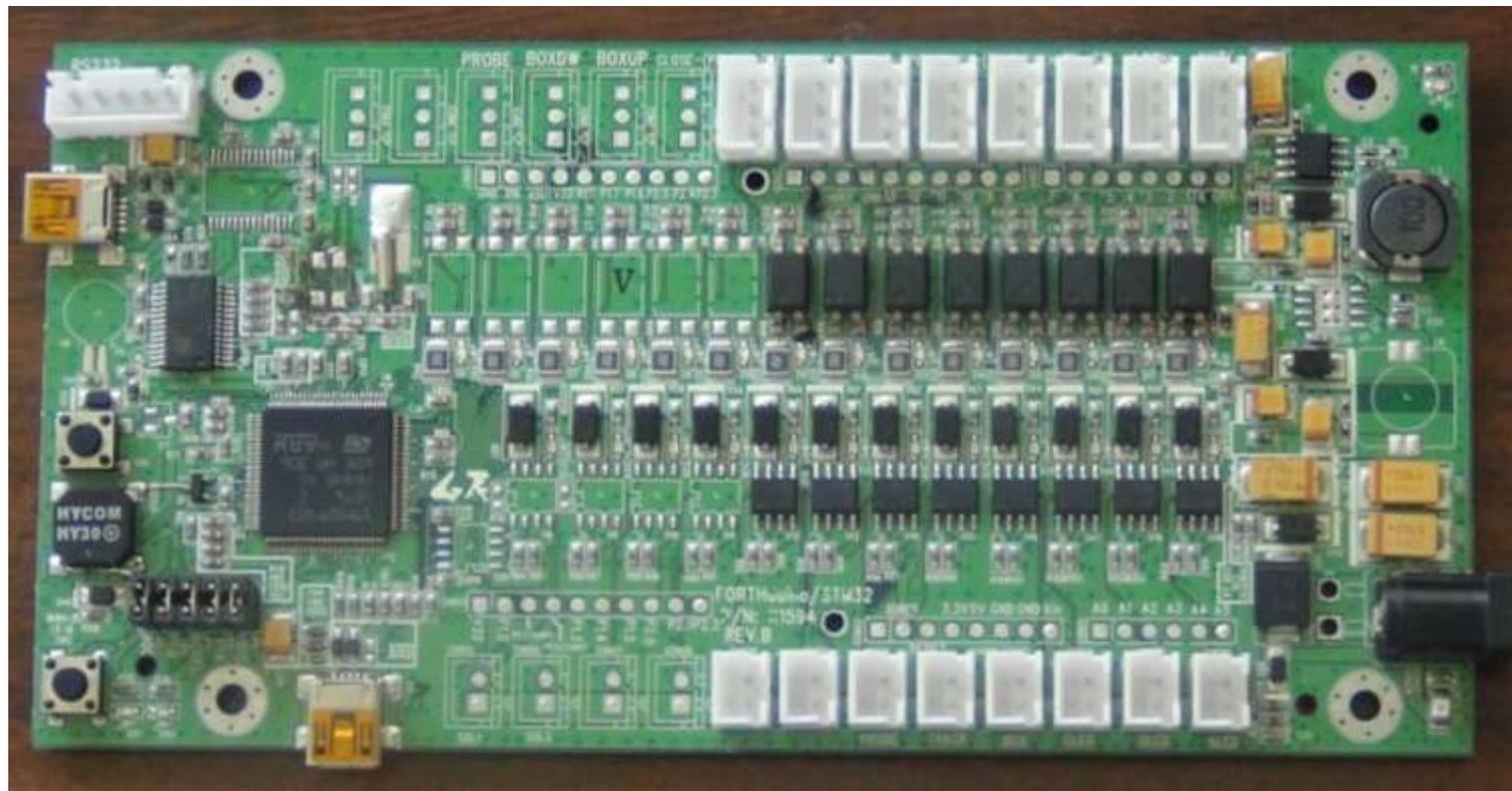


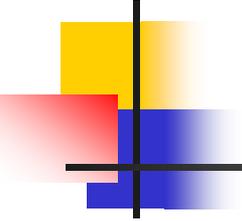
# ForthDuino Board

---

- STM32F407VG Microcontroller
- USART1 Download Port
- 12 Switching Transistor Output Ports
- 13 Optical Isolated Input Ports
- Arduino I/O Ports
- LaunchPad I/O Ports

# ForthDuino Board

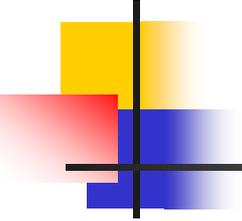




# STM32F407

---

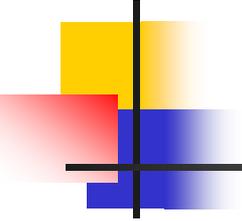
- 32-bit Cortex M4 CPU
- 1 Mbytes flash
- 192 Kbytes RAM
- 168 MHz clock
- GPIO, timers, USART, ADC, DAC, SPI, I<sup>2</sup>C, CAN, USB, ..., you name it.



# stm32eForth

---

- V7.01 Forth in flash memory
- V7.10 Forth in flash, remapped to Page 0, executing from Page 0
- V7.20 Forth in flash, copied to RAM. RAM remapped to Page 0, executing from Page 0
- V7.30 v7.20 for ForthDuino



# Minimal Boot Code

---

```
AREA                RESET, CODE, READONLY

THUMB

EXPORT              __Vectors          ; linker needs it
EXPORT              Reset_Handler     ; linker needs it

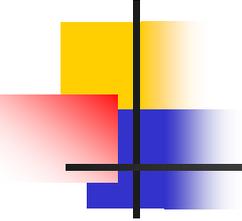
__Vectors
DCD 0x10000400      ; Top of hardware stack in CCM
DCD Reset_Handler  ; Reset Handler

ENTRY

Reset_Handler

BL  InitDevices    ; RCC, GPIOs, USART1
BL  UNLOCK         ; unlock flash memory
BL  REMAP          ; remap RAM to page 0
LDR R0, =COLD-MAPOFFSET ; start Forth
BX  R0

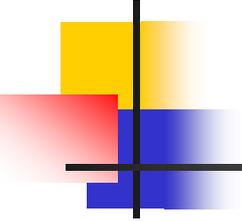
ALIGN
```



# Minimal Peripheral Devices

---

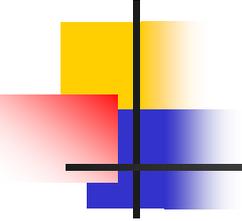
- USART1
- GPIOB for TX and RX pins
- GPIOD to light LEDs
- RCC (Reset Clock Control) to provide clocks to USART1, GPIOB, and GPIOD



# Minimal Command Set

---

- Headers of 23 system commands are commented out.
- 174 commands have headers and are searchable.



# Turnkey Applications

---

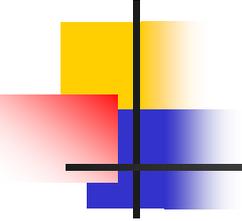
```
; load appl6.txt
```

```
; load appl7.txt
```

```
0 ERASE_SECTOR
```

```
` APPL `BOOT !
```

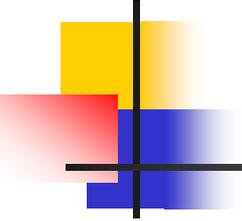
```
TURNKEY
```



# STM32F4-Discovery Kit

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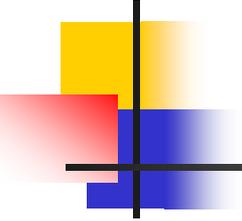
- 14 Counter-Timers.
- 80 Digital I/O Pins.
- Almost enough to build a digital electronic organ to play Bach's organ concertos.



# STM32F4-Discovery Kit

---

- 3×12-bit, 2.4 MSPS A/D converters
- 24 channels and 7.2 MSPS in triple interleaved mode
- LCD parallel interface
- Looks like a digital storage oscilloscope to me.

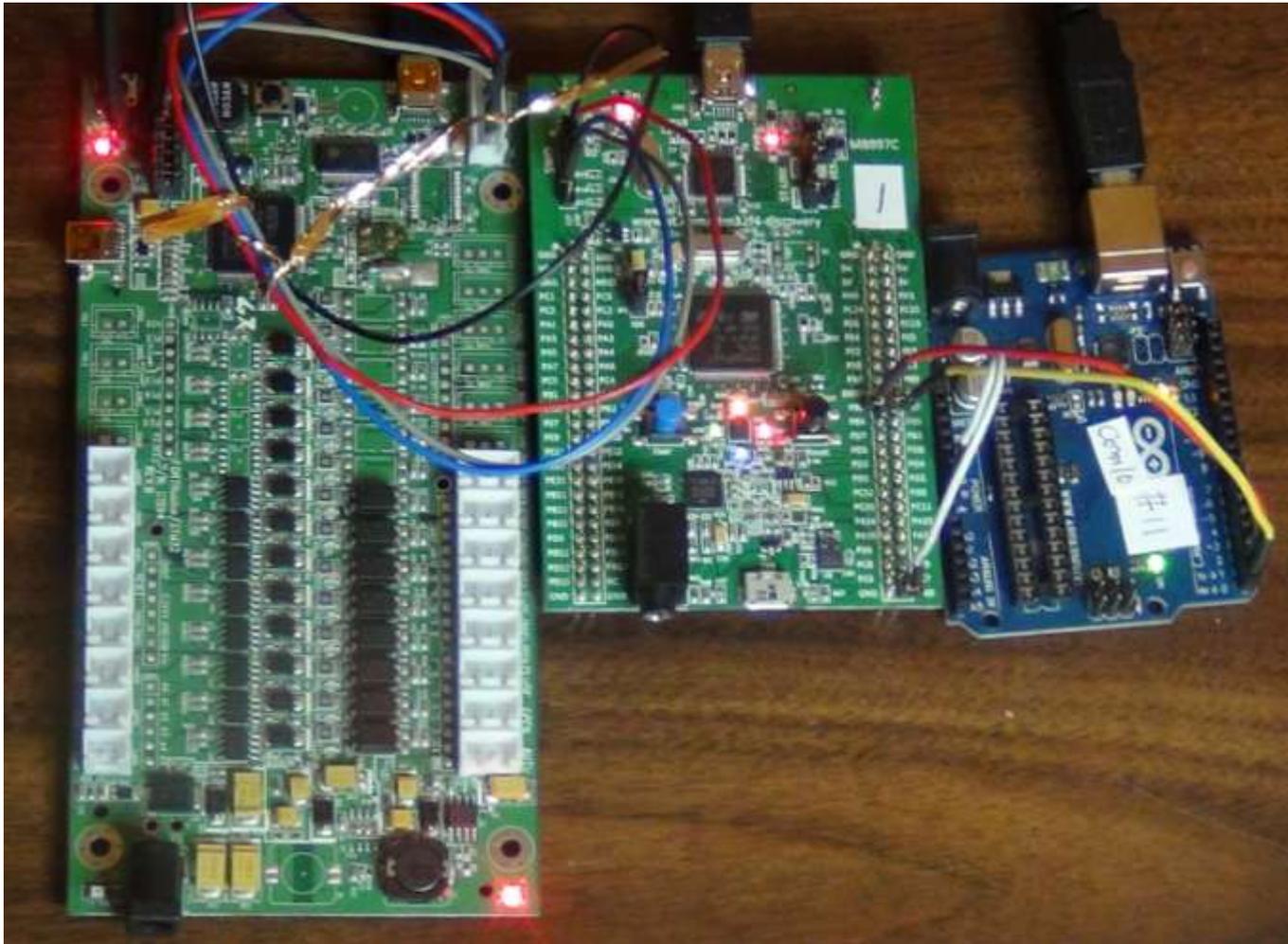


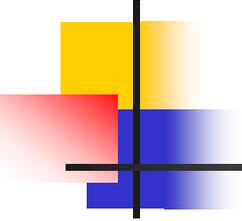
# STM32F4-Discovery Kit

---

- ST-Link can be used to debug another STM32F4 chip
- It is used to debug ForthDuino Kit
- Stm32eforth730 is tested and verified on ForthDuino Kit.

# STM32F4-Discovery Kit

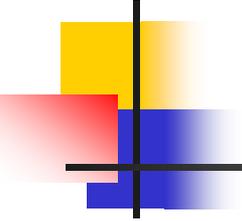




# stm32eForth Manual

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- 1 eForth for ARM chips
- 2 Assemble stm32eforth
- 3 stm32 eforth source code
  - 3.1 Virtual Forth Machine
  - 3.2 eForth kernel
  - 3.3 Text interpreter
  - 3.4 Forth compiler
  - 3.5 Debugging tools



# Demo

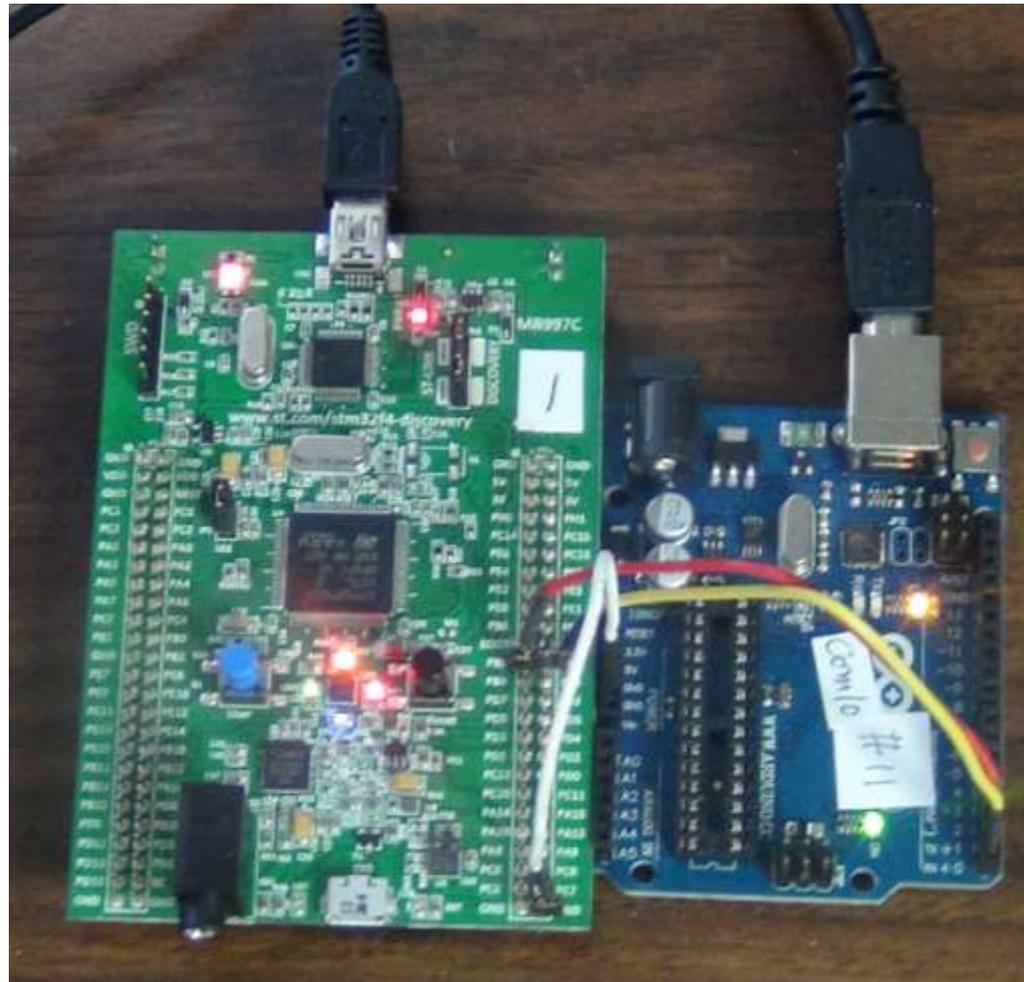
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Stm32eforth720 on Discovery

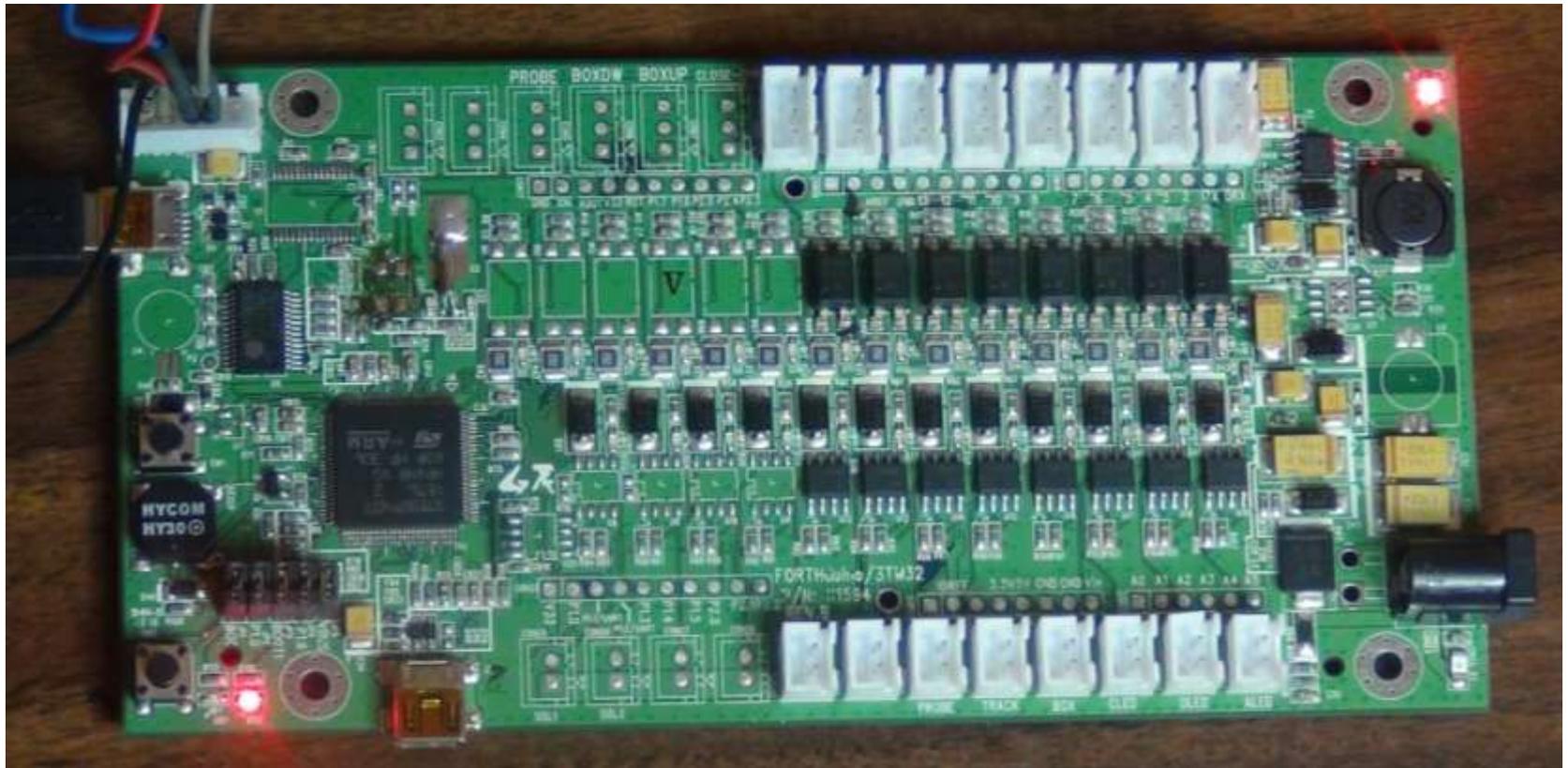
Stm32eforth730 on ForthDuino

Use ST-Link on Discovery to debug  
ForthDuino

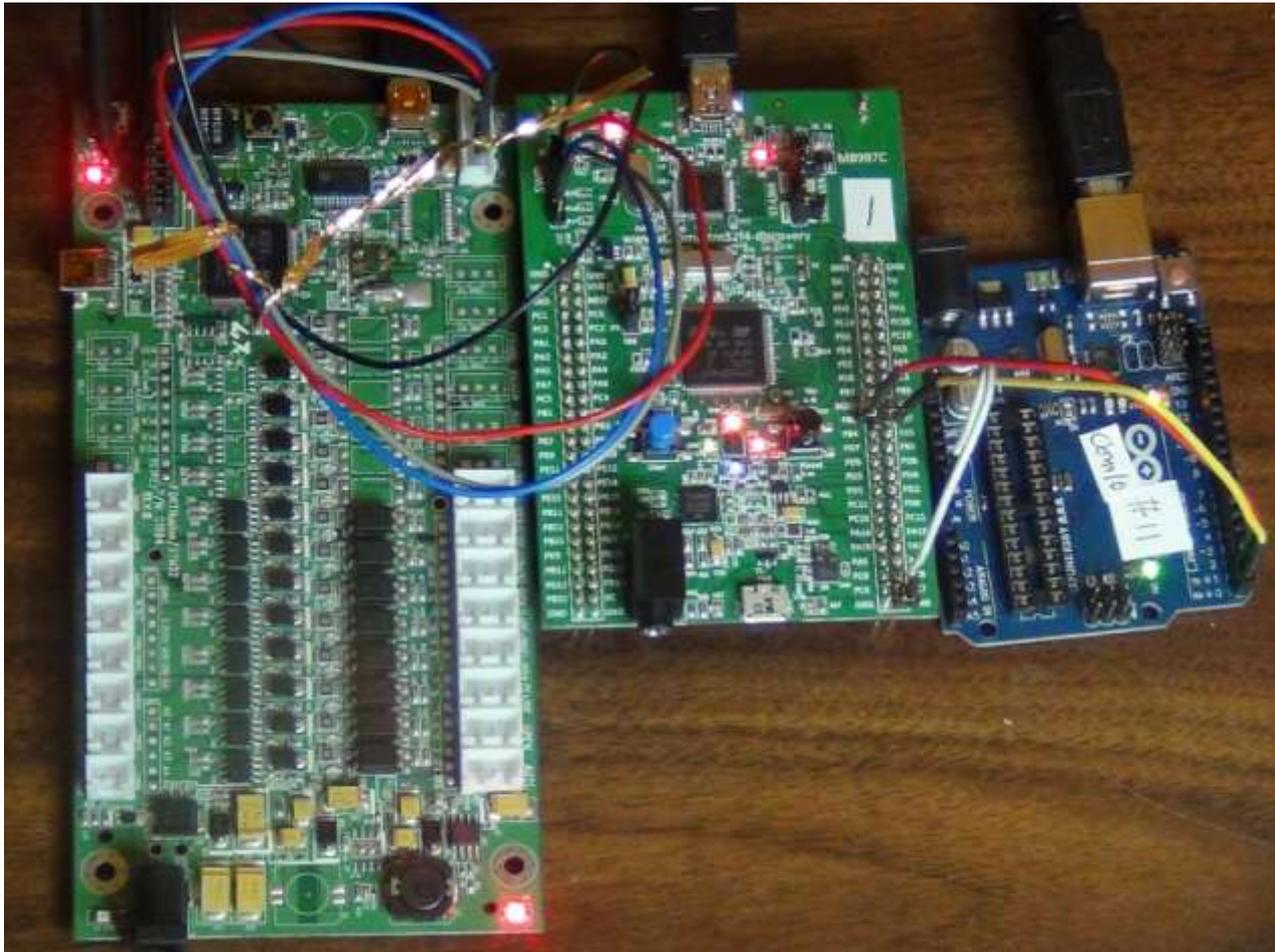
# Demo

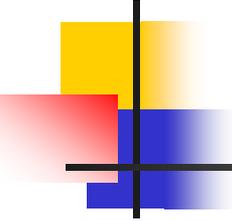


# Demo



# Demo

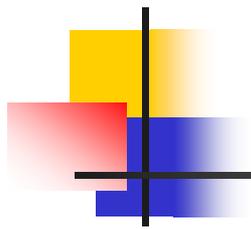




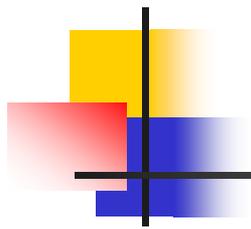
# Conclusions

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- Discovery is the cheapest ARM microcontroller board ever.
- It is the first microcontroller I don't feel constrained by RAM memory.
- Its peripherals are overwhelming.
- It is a very good platform for firmware engineering.



Questions?



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Thank You.