Testing 678 Chips & Counting

Evie Salomon
VCF West 2024

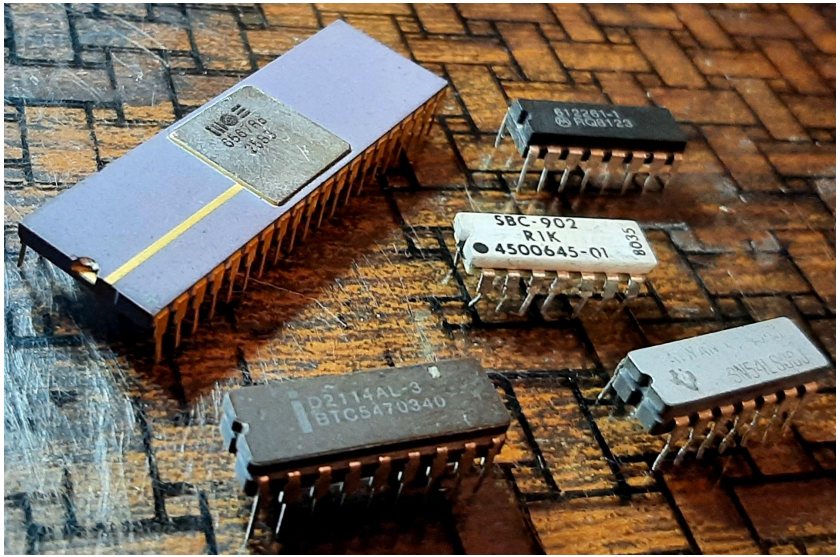
Testing 789 Chips & Counting

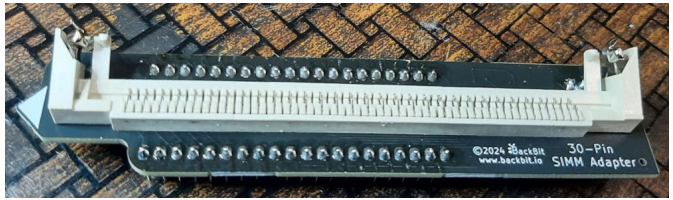
Evie Salomon
VCF West 2024

What Kind of Chips?

What Kind of Chips?

- Dual Inline Package (DIP) Integrated Circuits (ICs)
- 8 to 48 Pins
- Width 0.3” to 0.6”
- Tests Digital Outputs Only
- 3.3V or 5V power rail
- More chips w/ adapters






GTIA
ANTIC
POKEY
PIA
CPU

Why Test Chips?

Why Test Chips?

- Repair Vintage Machines

Why Test Chips?

- Repair Vintage Machines
- Building “Retro” Machines / Interfaces

Why Test Chips?

- Repair Vintage Machines
- Building “Retro” Machines / Interfaces
- Catalog / Sort Collection

Why Test Chips?

- Repair Vintage Machines
- Building “Retro” Machines / Interfaces
- Catalog / Sort Collection
- Buying & Selling

Why Test Chips?

- Repair Vintage Machines
- Building “Retro” Machines / Interfaces
- Catalog / Sort Collection
- Buying & Selling
- Detect Variations / Fakes

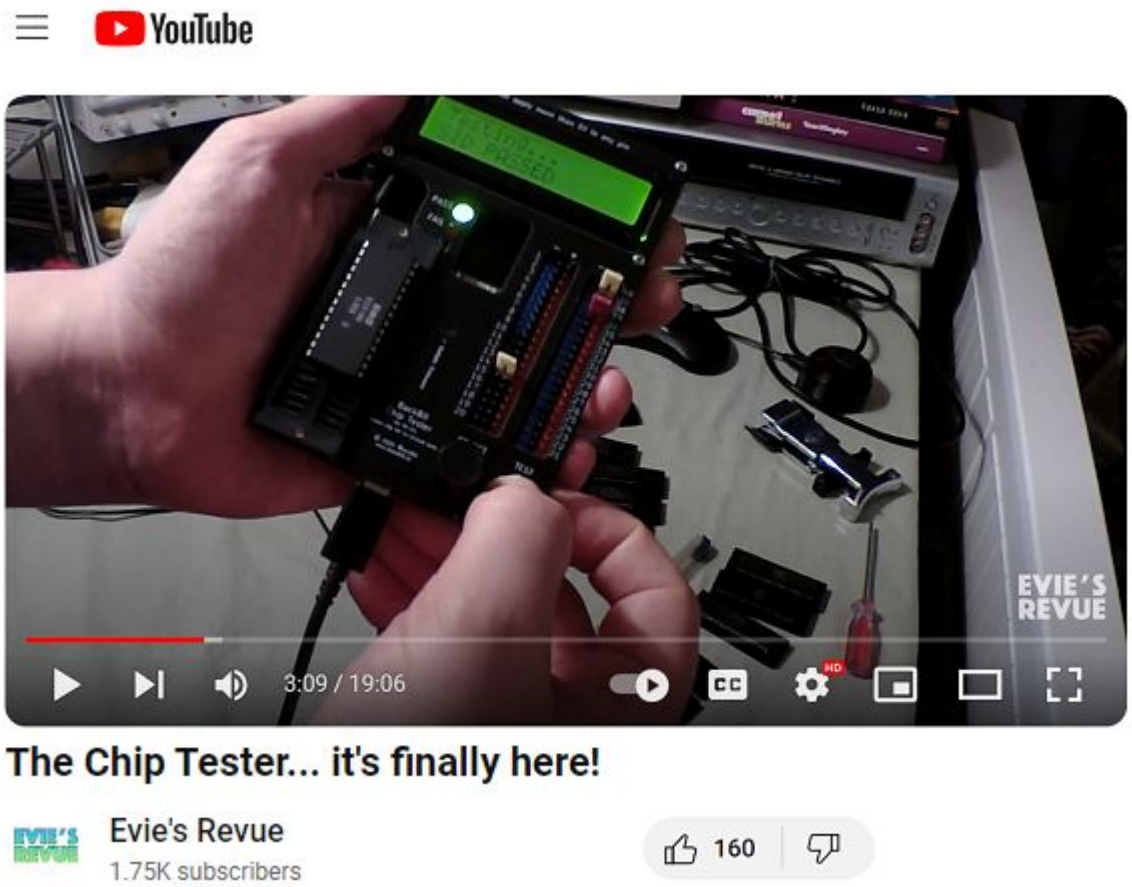
Why Test Chips?

- Repair Vintage Machines
- Building “Retro” Machines / Interfaces
- Catalog / Sort Collection
- Buying & Selling
- Detect Variations / Fakes
- Education / Learning

The Chip Tester

First Available

July 23, 2020



Legacy Version

What's Inside?

- Teensy 3.5
- Arudino API
- 5V tolerant I/O
- Jumpers to route power

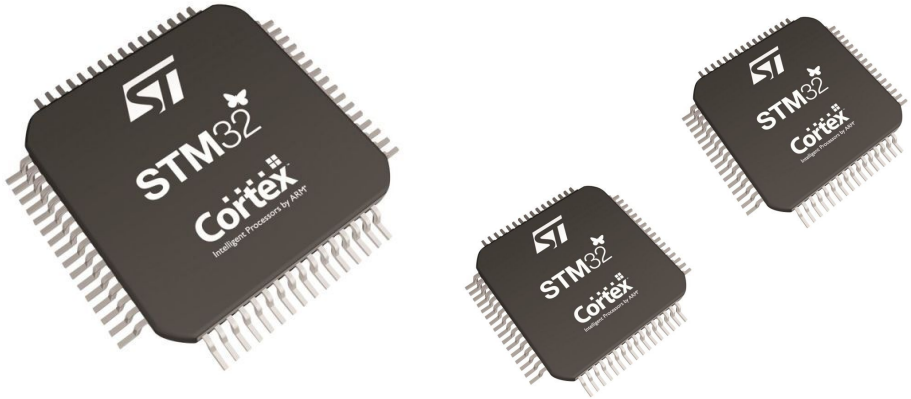
Pro Version

What's Inside?

- STM32 ARM Cortex-M Processor
- Custom Bootloader (SD update)
- 48-Pin Normally Closed Socket
- Voltage & Current Limiting

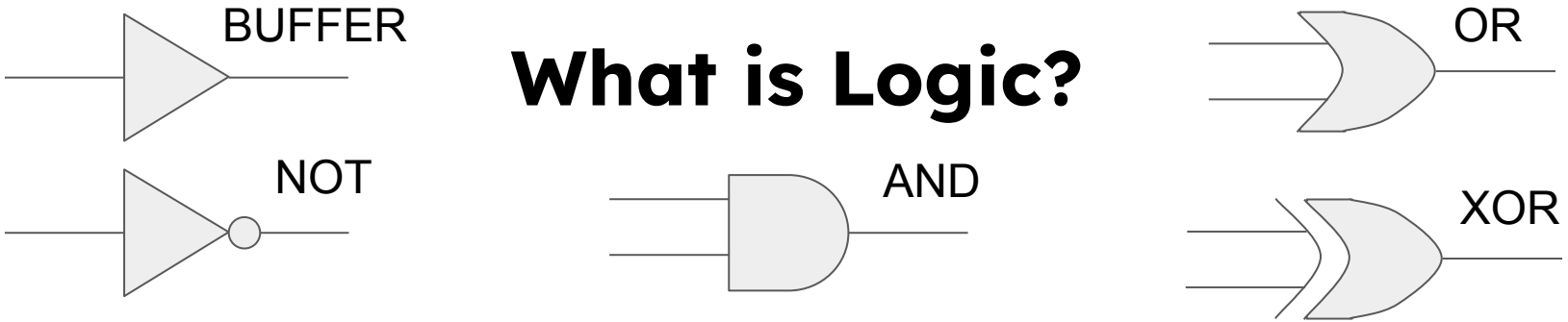
Pro V2

What's Inside?



- No jumpers!
- Automated power routing
- MPUs for multiplexing
- Transistor pairs for power

What is Logic?



- Inputs & Outputs (I/O)
- Low level (zero), High level (one), Floating (Hi-Z)
- Unary (one input, one output) – buffer or inverter
- Binary (two inputs, one output) – AND, OR, XOR
- Bistable (two possible states) – flip flop, memory cell
- Synchronous (edge triggered, clocked)

Digital Logic Families

- RTL (Resistor-Transistor Logic)
- ECL (Emitter-Coupled Logic)
- DTL (Diode-Transistor Logic)
- TTL (Transistor-Transistor Logic)
- MOS (Metal-Oxide Semicon. Logic)

Digital Logic Families

- RTL (Resistor-Transistor Logic)
- ECL (Emitter-Coupled Logic)
- DTL (Diode-Transistor Logic)
- TTL (Transistor-Transistor Logic)
- MOS (Metal-Oxide Semicon. Logic)

Digital Logic Families

- RCA, 1974

- Texas Instruments, 1969

Electronic Design Magazine
(scans courtesy BitSavers.org)

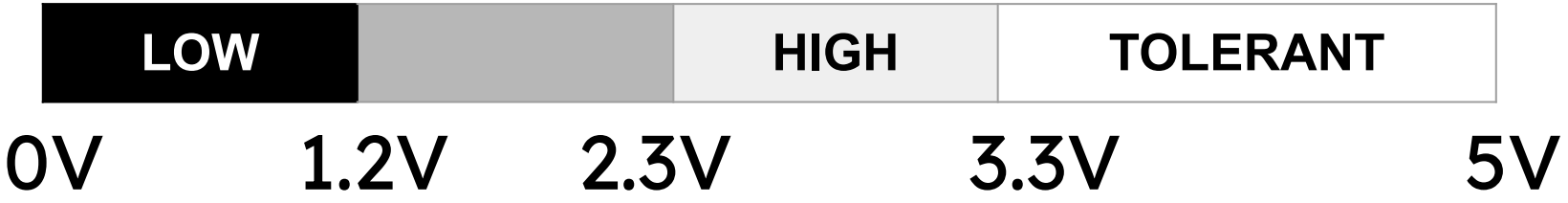
Digital Logic Families

- In the 1970's, TTL became the most common family of digital logic chips
  (*TI 7400 series)*

- The main outlier: CMOS gained market share in mid to late 70's
  (RCA CD4000 series)

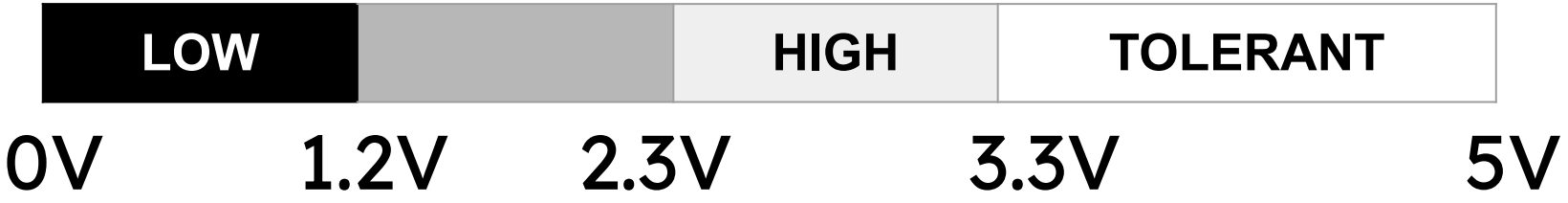
Transistor Transistor Logic

Chip Tester Logic



Complementary (Symmetry) Metal-Oxide Semiconductor Logic

Chip Tester Logic



Complementary (Symmetry) Metal-Oxide Semiconductor Logic

0V 1V 2.3V 3.3V

Chip Tester Logic

0V 1V 2.3V 3.3V

How do you know if tests are accurate?

How do you know if tests are accurate?

- “Trust me, I know what I’m doing.”

How do you know if tests are accurate?

- “Trust me, I know what I’m doing.”
- Test accuracy is limited by sample size

How do you know if tests are accurate?

- “Trust me, I know what I’m doing.”
- Test accuracy is limited by sample size
- Cross-check with other tester hardware

How do you know if tests are accurate?

- “Trust me, I know what I’m doing.”
- Test accuracy is limited by sample size
- Cross-check with other tester hardware
- Perform real-world test

How do you know if tests are accurate?

- “Trust me, I know what I’m doing.”
- Test accuracy is limited by sample size
- Cross-check with other tester hardware
- Perform real-world test
- Increase granularity to pinpoint issues

Individual Test Results / Revision Detection

CLOCK: PASS
LOGIC: PASS
INT: FAIL
OVER: PASS
WALK: PASS
SYNC: PASS

PASSED SALLY

PASSED 65C02

PASSED 6502

Ideas for the Next Hardware Revision

- Support multi-voltage chips
  -12V, -10V, -5V, 10V, 12V, 24V
- Relays (either physical or solid-state) to prevent mixing of power signals outside of 0V-5V range
- True 5V CMOS support (level shifters)
- Analog inputs, FPGA-based time analysis
- User-definable tests

Writing a Test

- Get the Datasheet, or at least a pinout
- Assign Power & Ground Pins (Vdd, Vss, etc)
- Configure Inputs & Outputs (Reversed on tester!)
- Apply (master) reset
- Apply clock (or crystal) input (sometimes reversed from datasheet)
- Stateless Chips: Loop through all possible inputs, verify correct outputs
- Chips with Registers: Loop through all possible values
- If millions (2^20), skip a few
- Lots of buried logic: Write at least one test per pin, if possible
- Pin mutations (ZIP, PLCC)

Call to Action

- I retired from the software industry in 2018
- My vision quest led me to YouTube, at least for a while
- I’ve been doing BackBit full-time since 2019
- My goal is to simplify processes and provide good value
- I’m a bit overwhelmed: BackBit Cartridge & other products
- Writing tests alone requires me to have chips on hand
- I have more ideas than I have ability to execute
- Human interaction is my fuel!
- I want this to be fun! Ask me about music, nerdy things