Beginning Digital Electronic Engineering

Rev. 003 (MLK Day/2026)
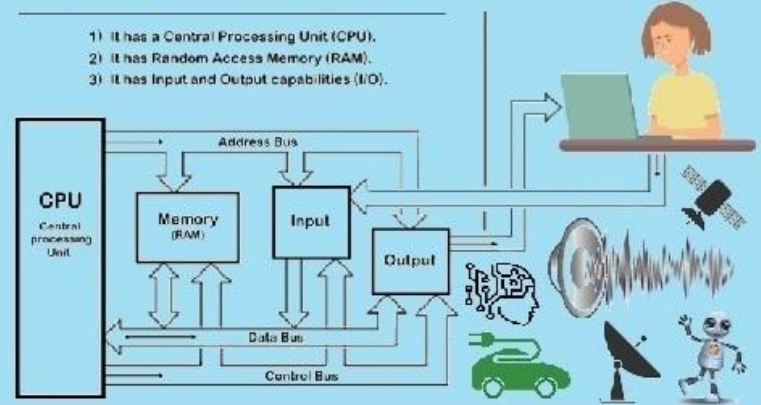
Course Resources

AW AutomatedWord.com
Where word becomes deed with a little help from humans

1) It has a Central Processing Unit (CPU).
2) It has Random Access Memory (RAM).
3) It has Input and Output capabilities (I/O).

Table of Contents

Are you tired of losing your place in a document when you click on a link?
Right-Click or press the "Ctrl" key when you click on a link and it will open the content in a new Tab.

# Lessons for Beginning Digital Electronic Engineering

(What is a computer made of and how does it work?)

Section 01 – The Electronic Transistor

Covers the fundamentals of electricity, the electronic transistor and solid-state electronic systems to include integrated circuits. Also, we begin training and using the breadboard testing and development kit to demonstrate the basics of electronic logic including building and testing actual digital logic circuits.

Section 02 – Basics of Chip Based Components
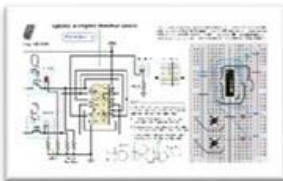
Covers the fundamental concept of bus architecture from small integrated circuit chips to printed circuit boards and how they connect to each other to form a basic computer system. Includes more advanced work on the breadboard kit as well. Also, we cover why digital systems use 1's and 0's instead of base-ten.

Section 03 – Learning More Advanced Logic

Covers a number of the most used logic circuits. First, starting with concepts of separate internal mechanisms of the computer's central processing unit (CPU). This will include arithmetic and logical (ALU) operations and principles of input and output (I/O). Finally, proceeding with more advanced computer memory logic.

Section 04 – The CPU and Computer System
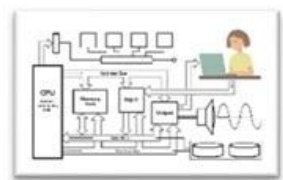
Covers the computer's CPU. Here, we bring all of the pieces of the course together for an in-depth understanding of exactly what the computer is doing in order to run software and applications. We start by exploring the Clock mechanism that is the computer's engine and wind up with a holistic view of a computer's operation.

A Message From The Instructor:

This is a **FREE** course. It is brand new and has been designed in a modern way as to bring real college level material to younger age groups (teenagers and above). Whether you are school-age, college level, seeking a career, changing a career direction or just plain curious, you are invited to attend these four sessions and receive this electronic development kit used during the course for hands-on workshops. The kit is free if you receive federal housing assistance otherwise, there is a small fee.

BDEE Starter Kit Specifications

The BDEE Test and Development Starter Kit

is a combination of a basic electronic breadboard kit and a special digital components add-on package...

The initial kit has plenty of rudimentary parts for experimenting with and learning basic analog electronic concepts. However, it did not include enough components to fulfill the requirements of the BDEE course for digital electronics. Fortunately, a wise benefactor has seen to it to provide the necessary digital components to make this course come alive with a superior hands-on experience!

If you receive federal housing assistance, then you will receive the starter kit (including a multimeter) at no cost. Otherwise, the starter kit cost is $40. Whether or not you qualify for the FREE starter kit program, you must come to the first session of the course with two 9-Volt batteries. The batteries will be used to provide power to the electronic starter kit and multimeter throughout the course. Although the breadboard power supply can be powered by a 9-Volt wall plug-in or a USB connection, the premises of the BDEE course may not have enough outlets for each student - it is just simpler to run the breadboard included in the electronics kit with a battery.

Here is a quick breakdown of the kit that will provide real world hands-on training experience throughout the BDEE journey of course workshops…

BDEE Electronic Test and Development Starter Kit
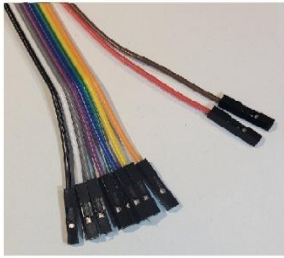
BDEE Starter Kit Provided By: www.automatedword.com

Watch this video for a complete explanation of your breadboard: **YouTube - How to Use a Breadboard**

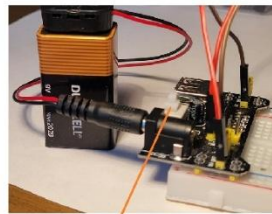# Instructions for Preparing the BDEE Electronic Starter Kit

1 Locate the female-female ribbon cable and peel off the red and brown wires keeping them together as a 2-wire ribbon.

3 Connect the 9-Volt battery to the battery connector and then insert its barrel connector to the power supply module...

Finally, insert the module into the breadboard where all 4 prong-pairs are in the top 5 holes of the power and ground rails.

It should look just like this...

Power ON/OFF push-button

Breadboard and 9-Volt Power Supply

POWER SUPPLY

Snaps into the breadboard and steps voltage down to +5V DC...

2 insert the color-coded wires onto the pins of the power supply to make connections for 5-Volt operation.
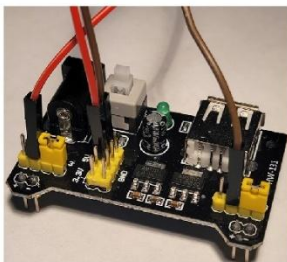
It should look just like this...

NOTE--------------------
It is OK to spread the two wires apart a little to make a good fit.

The holes in the surface of the breadboard are connected to each other through metal rails embedded inside the breadboard.
The rails run either vertically or horizontally.

The power rails on both the left and right side of the board run vertically to make the 5V power source and ground conveniently available to components plugged into the component holes in the center of the board...

Power: (+) 5V DC otherwise labelled (Vcc)
Ground: (−) otherwise labelled (GND)

Electronic components all have metal leads that are pushed into the holes on the left and right center portion of the board and are connected to each other typically with jumper wires.

Each component hole is connected by a horizontal rail in groups of 5 holes on either the left or right side of the center portion of the board.
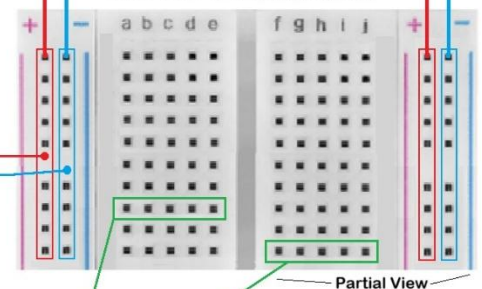
MB-102 Breadboard

Partial View

BDEE Starter Kit Provided By: www.automatedword.com

Watch this video for a complete explanation of your breadboard: **YouTube - How to Use a Breadboard**

BDEE Electronic Starter Kit: Component Inventory

Component	Qty
Power Supply Module	1pcs
9-Volt Battery Cable	1pcs
MB-102 Breadboard	1pcs
Connector Wires	140pcs
Jumper Wires	65pcs
M/F Dupont Wire	20pcs
40Pin Header	2pcs
Active Buzzer	1pcs
Passive Buzzer	1pcs
4N35	1pcs
Temporary Push-Button	2pcs
Precision Potentiometer	1pcs
Photoresistor	2pcs
Thermistor	1pcs
Electrolytic Capacitor 10UF 50V	5pcs
Electrolytic Capacitor 100UF 50V	5pcs
Resistor	120pcs
NPN Transistor (PN2222)	5pcs
RGB LED	1pcs
Diode Rectifier (1N4007)	5pcs
100NF Ceramic Capacitor	10pcs
22PF Ceramic Capacitor	10pcs
1- 8-Bit Shift Register	1pcs
LED (White/Red/Yellow/Green/Blue)	50pcs

The basic starter kit has several components which are great for discovering and learning the rudimentary concepts of electronics in general however, there are not enough digital components in order to really have a good hands-on experience in digital electronics.

So, for this reason, we have included a special digital electronic add-on package of components needed to experiment and test real world digital circuirty...

The BDEE course will be primarily interested in the components listed in the orange outlined areas from the initial starter kit as well as the digital electronic add-on package.

Digital Electronic Add-On Package: Includes Chips, Switches and LED's...

Component	Qty
4- 2-Input NAND (74LS00)	2pcs
6- Inverters (74LS04)	1pcs
2- D Flip-Flops (74LS74)	2pcs
1- 4-Bit Full Adder (74LS283)	2pcs
1- 4-Bit Magnitude Comparator (74LS85)	2pcs
1- 3-Bit to 8-Line Decoder (74LS138)	2pcs
1- 8-Bit Transparent Latch (74LS373)	1pcs
NE555 Timer	1pcs
1- Digital to Analog Converter (DAC08)	1pcs
1- Analog to Digital Converter (ADC0804)	1pcs
8-Bit DIP Switch	2pcs
8-Bit LED Panel	2pcs

Whether interested in analog or digital or both fields of electronics, this test and development kit package is an excellent starting point for either field.

Provided By: www.automatedword.com

     (Back to TOC)

Digital Components Add-on Package   (Click to drill down to specifications)

7400 Series TTL Logic Chips...

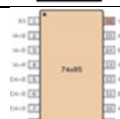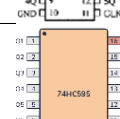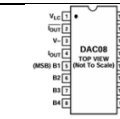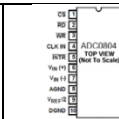| Component	Qty			LS Datasheet	F Datasheet
TTL 74x00	(2)		Quad 2-input NAND gate: An IC with four standard NAND gates.	74LS00	74F00
TTL 74x04	(1)		Hex inverter/NOT-gate: An IC with six inverters (or NOT-gates)	74LS04	74F04
TTL 74x74	(2)		Dual D flip-flop: An IC containing two D flip-flops with set and reset	74LS74	74F74
TTL 74x283	(2)		4-bit full adder: An IC with a 4-bit binary full adder	74LS283	74F283
TTL 74x85	(2)		4-bit magnitude comparator: An IC that can compare two 4-bit numbers	74LS85	74F85
TTL 74x138	(2)		3-to-8 decoder: An IC with 3-to-8 inverting decoder/demultiplexer	74LS138	74F138
TTL 74x373	(1)		Octal D Transparent Latch: D-Type Flip-Flops (Tri-State output)	74LS373	74F373
TTL 74x595	(1)		8-Bit Shift Register (with output latch)	74LS595	74F595

Miscellaneous Components...

DAC08	(1)	8-Bit Digital to Analog Converter	ADC0804	(1)	8-Bit Analog to Digital Converter
555 Timer	(1)	555 Timer Chip	Sockets	(4)	Machined DIP Sockets 3- 16 Pin 1- 20 Pin
LED Panel	(2)	8-Line LED Panel 1- Red Light (common anode) 1- Blue Light (common cathode)	Resistor-Array	(2)	8-Line Resistor Network (1K Ω)
Switches	(2)	8-Line DIP Switch (SPST)	Pliers	(1)	6-Inch Needle-nose Pliers
Multimeter	(1)	ANENG SZ308 Digital multimeter Measures: Resistance, Continuity Voltage and Amperes			View Detailed Multimeter Page

Copyright © 2024-2026   (Back to TOC)

Troubleshooting Digital Electronics

This page is all about solving problems in digital electronic circuitry and there are three major types of concerns involved with a little overlap between them. When troubleshooting a problem there is generally a hierarchy of steps that you go through in order to most efficiently arrive at determining what the problem is. It is important to follow these steps because it can be a time consuming process if you have miss-determined which type your difficulty lies in so the best way to tackle a problem is by an efficient process of elimination. So, here is how it works…

First, try to determine what type of problem exists – the first type of problem is "Electrical/Mechanical". This is where you might see fluttering or flickering in the LED lights and usually, it might seem that it is so intermittent and delicate that it looks like the circuit is so sensitive that a butterfly would upset it. In general, you need to determine whether the power supply module has well fitted wiring (including the battery components and wires) and that it is properly seated into the breadboard. Sometimes there might simply be mechanical problems like loose connections of jumper wires or even surface wires not seated well into the breadboard rail holes. Are the pins or leads of all components, switches, chips, transistors, LEDs and so on properly seated into breadboard rail holes. Do you see flickering lights when brushing your hands against certain groups of jumper wires or, when you handle the breadboard a certain way?

The next type of problem is typically when the circuit seems to be fairly stable but a particular LED or set of LEDs are not lit when they should be – or, they should be OFF but they are ON. Or, is any component in your circuit not behaving as expected. These types of problems are generally categorized as "Power Distribution / Configuration" problems. Make sure that each component or wire is seated in the correct breadboard rail hole. Sometimes this means you might have plugged a wire into the rail next door instead of the intended rail. Does each component in your circuit that requires power and ground wires are actually wired to power and ground (or, they might be reversed). A very common mistake is to mis-configure components that have a specific polarity – like an LED or other diode is accidently reversed.

Finally, the circuit looks very stable – there is no flickering/fluttering but the circuit is just not behaving as it is expected to – for example, the wrong lights are reacting to your switch settings – or not reacting. Well, you have finally (hopefully) arrived at the third category which we call simply "Logic/Connection" problems. If there is any fun at all in troubleshooting, it is in this last layer of problems – for example…

You change a switch from OFF to ON and the wrong LED light comes on or goes off. At least you're getting some indication that something is getting through the circuitry – that's good so far. But now, you might think to yourself that: "I must have connected a wire from the output of the chip to the wrong light". Well, not so fast. Remember the old adage about computer programs: "Garbage In – Garbage out"? That applies to the hardware side of things also. So, the first rule about troubleshooting this layer of problems is to make sure that you first check the input side of chips before the outputs. It is very common to have switched a wire to correct something on the output side only to run across the error again in further testing. And then you will find yourself wasting time undoing your work on the output side when the problem was a miss-connection on the input side. Follow steps below for all problem types…

Using the Multimeter as your Primary Test and Measurement Tool…

When using the multimeter for any testing or measuring, make sure that the Black test-lead is connected to the "COM" socket on the multimeter and the Red test-lead is connected to the "VΩmA" socket. To save battery power, make sure you turn off your multimeter when not in use. Leaving it on overnight will kill the battery for sure.

When testing / measuring voltage… Make sure your circuit is turned on. Make sure your Black test-lead is connected to a ground rail on the breadboard – this way you should see something close to either 0 volts or 5 volts wherever you touch the Red test-lead to. Keep in mind that there is a fairly wide voltage tolerance range for TTL chips. This means that, at its input pins, the typical 7400 series chip will consider as much as a single volt to be zero voltage (or, the value 0) and 4-volts could be considered a 1 (meaning: 5-volts or, even higher). It should be extremely rare that you would see a voltage between 1 and 4 volts of higher than 6 volts – If you do, it usually means there is still some sort of electrical problem. And, this could happen if you have chip outputs connected together by mistake – this sort of miss connection can also cause that flickering/fluttering in a circuit – so check it.

When testing / measuring continuity or resistance, you don't have to worry about polarity however, if you are measuring resistance across a resistor or a diode (LED) that is actually in a circuit or testing for continuity in the circuit, make sure your circuit is turned OFF. Remember a diode should show continuity in only one direction.

SZ308 Digital multimeter

High precision | Electrician maintenance

Basic Usage (BDEE Course)…

When measuring resistance, set the dial to 20KΩ (see image below) - unless you are expecting to measure more than 20KΩ or less than 2KΩ. If you are measuring simple **continuity from point A to point B** in a circuit, you should set the dial to 2KΩ.

Image – Measuring a 2KΩ resistor

When measuring voltage, set the dial to 20V DC (see image below) - unless you are expecting to measure in the milli-volt range.

IMPORTANT NOTE: We will never measure anything more than 20-volts (DC). It can be dangerous to measure more than 50-volts DC or AC without proper training.
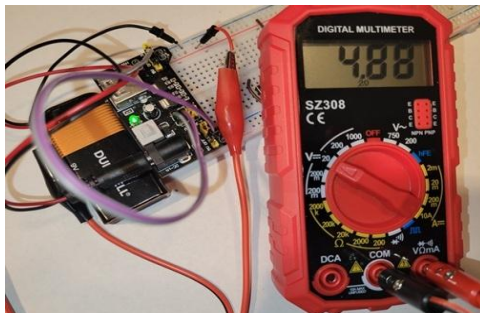
Image – Measuring the 5-Volt Power

Package Information:

SAFTEY INFORMATION
This multimeter has been desighed according to IEC-1010 concerning electronic measuringinstruments with an overvoltage category(CAT II) and pollution 2.Follow all safety and operting instructions to ensure that the meter is used safely and is kept ingood operating condition.
Full compliance with safety stardards can be guaranteed only with test leads supplied ifnecessary,they must be ruplaecd with the type specified in this manual

SAFETY SYMBOLS
⚠ Important safety information,refer to the operating manual.

⚠ Dangerous volatge may be presented

⏚ Earth ground

▣ Double insulation(Protection class II).

MAINTENANCE
Before Opening the case, always disconnect test leads from all energied circuits.
Never use the meter unless the back cover is in place and fastened completely.
Do not use abrasives or solvents on the metet.To clean it using a damp cloth and mild detergent only.

DURING USE
1.Never exceed the protection limit values indicated in specifications for each range of measurement.
2.When the meter is linked to measurement circuit, do not touch unused terminals.
3.Never use the meter to measure voltages that might exceed 1000V DC or 750V AC above earth ground in category II installations.
4.When the value scale to be measured is unkown beforehand, set the range selectdir at the ahighest position.
5.Before rotating the range selector to change functions, disconnect test leads from the circuit under test.
6.When carrying out measurements on TV or switching power circuits always remember that there may be high amplitude voltages pulses at test points, which can damage the meter.
7.Always be careful when working with voltages above 60V DC or 30V AC rms. Keep fingers behind the prode barriers while measuring.
8.Before at tmepting to insert transistors for testing, always be sure that test leads have been disconnected from any measurement circuits.
9.Components should not be connected to the hFE socket when making voltage measurments with test leads.
10.Never perform resistance measurements on live circuits.

GENERAL DESCRIPTION
The meter is hand held 3 1/2 digital multimeter for measuring DC and AC voltage , DC and AC current, Resistance, Diode , Transitor , Temperature, Capacitance and Continuity Test with battery operated.

SPECIFICATTONS
Accuracy is specified for a period of one year after calibration and at 18°C to 28°C (64°Fto 82°F)with relative humidity to 75%.

GENERAL
Maximum voltage between terminals and earth groud:1000V DC or 750V AC
Power:9V 6f22
Display : LCD.1999 counts,updates 2~3/sec
Measuring method : Dual-slope integration A/D converter
Overrange Indication:Only figure" I"on the display
Polaity indication:"_"display for negative polarity
Operating Environment:0°Cto 40°C
Storage temperature:-10°Cto 50°C
Low battery indication: appears on the display
Size:31x66x121mm
Weight:210g

DC VOLTAGE

Range	Resolution	Accuracy
200mV	0.1mV	±(1.0%+5)
2V	0.001V	
20V	0.01V	
200V	0.1V	
1000V	1V	±(1.0%+10)

Overload Protection:250V rms for 200mV range and 1000V DC or AC Rms for other ranges.

AC VOLTAGE

Range	Resolution	Accuracy
200V	0.1V	±(1.0%+15)
600V	1V	

Overload Protection:750V DC or AC rms

DC CURRENT

Range	Resolution	Accuracy
20mA	0.01mA	±(1.5%+5)
200mA	0.1mA	
10A	0.01A	

Overload Protection:250V DC or AC rms.

RESISTANCE

Page 1

Range	Resolution	Accuracy
200Ω	0.1Ω	±(1.2%+5)
2000Ω	1Ω	
20kΩ	0.01kΩ	
200kΩ	0.1kΩ	
2000kΩ	1kΩ	

Overloadrotection:250V DC or AC rms

CONTINUITY TEST

·)))	The meter beep wile resistance <50Ω	Open-circuit voltage:About 2V Overload Protection:250V

DIODE TEST

▶|	Display diode forward voltage	Backward voltage:2V Overload Protection:250V

OPERATING INSTRUCTIONS
DC VOLTAGE MEASURMENT
1.Connect the red test lead to the" V.Ω.mA" jack and the black lead to the "COM "jack.
2.Set range switch at DCV position, !f the voltage to be mesured is unkonwn beforehand,set range switch ai the highest range position and then reduce ituntil satisfactory resolution is obtained.
3.Connect test leads across the source or load being measured.
4.Read voltage on the ID display along with the polarity of the red lead connection.

AC VOLTAGE MEASURMENT
1.Connect the red test lead to the"V.Ω.mA" jack and the black lead to the"COM" jack.
2.Set rotary switch at ACV position.If the voltage to be mesured is unkonwn before hand,set range switch ai the highest range position and then reduce ituntil satisfactory resolution is obtained.
3.Connect test leads across the source or load being measured.
4.Read voltage on the ID display along with the polarity of the red lead connection.

CURRENT MEASUREMENT
1.Connect the red test lead to the" V.Ω.mA " jack and the black lead to the" COM "jack.(For measurements beween 200mA and 10A,remove red lead to " DCA"jack.)
2.Set rotary switch at DCA position.
3.Open the circuit in witch the current is to be measuremed and connect test leads in series with the circuit.
4.Read current value on LCD display along with the polarity of red lead connection.

RESISTANCE MEASUREMENT
1.Connect the red test lead to the" V.Ω.mA" jack and the black lead to the" COM" jack.
2.Set the rotary switch at desired"range position.
3.Connect test leads across the resistor to be measured and read LCD display.
4.If the Resistance being measured is connected to a circuit,turn off power and discharge all capacitors befor applying test probes.

DIODE TEST
1.Connect the red test lead to the" V.Ω.mA" jack and the black lead to the" COM" jack.
2.Set the rotary switch at"▶|"position.
3.Connect the read lead to the anode of the diode to be tested and the black test Lead to the cathode of the diode. The approx forward voltage drop of the diode will be displayed.If the connection is reversed. Only"1" will be shown.

TRANSISTOR TEST
1.Set the rotary switch at"hFE " position.
2.Determine whether the transistor under testing is NPN or PNP and locate the emitter,base and collector leads.Insert the leads into proper holes of the hFE socket on the front of panel.
3.Read the approximate hFE value at the test condition of base current 10uA and Vce 3V.
NOTE: To avoid electrical shock,remove test leads form measurement circuits before test a transistor.

CONTINUITY TEST
1.Connect the red test lead to the "V.Ω.mA"jack and the black lead to the"COM " jack.
2.Set the rotary switch at" ·))) "position.
3.Connect test leads to two points of circuit to be tested. If continuity exists,built-in buzzer will beep.

⚠AWARNING
TO avoid electrical shock,be sure the test leads has been removed before changing to another fuction measruement.

BATTERY REPLACEMENT
If" "appeared on LCD display, it indicates that the battery need to be replaced.

⚠AWARNING
Before open the case ,always be sure that test leads have been removed from measurement circuits.
Close case and tighten screws completely before using the meter to avoid electrical shock hazard.
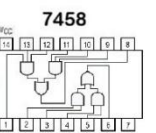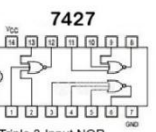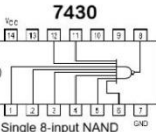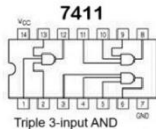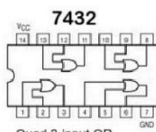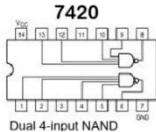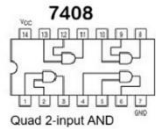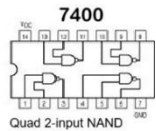The parameters of this manual are subject to change without notice.
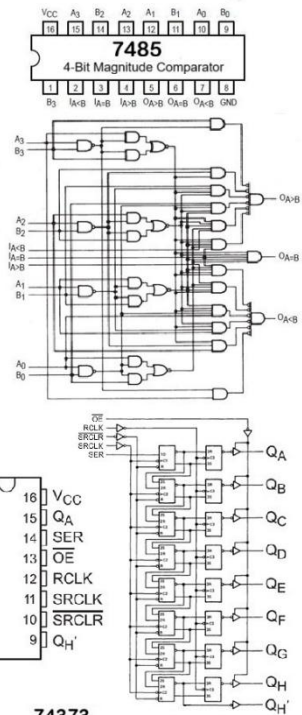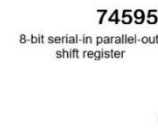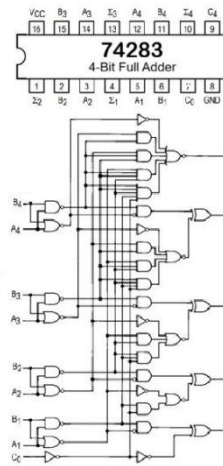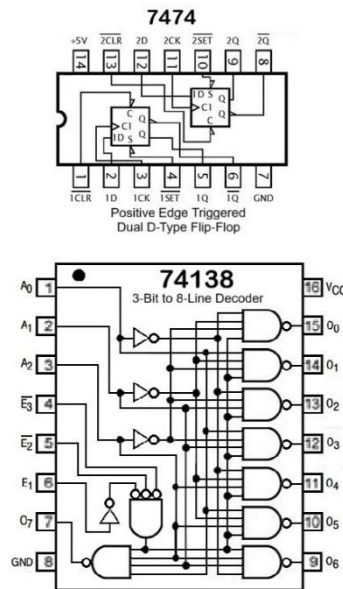The company is not responsible for accidents and hazards caused by user error.

Page 2

7400 Series TTL Chips — Discrete Logic Gates, Combinatorial Logic, TRI-State Buffers and Latches
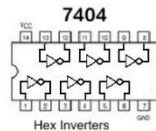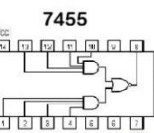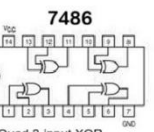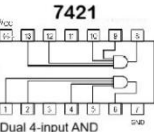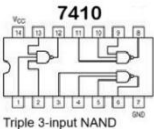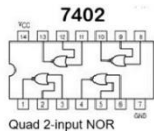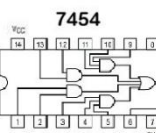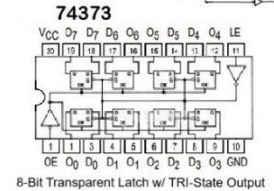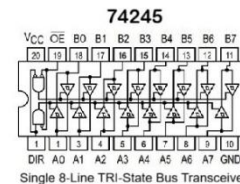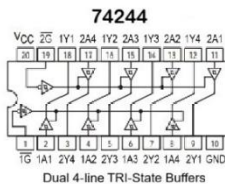
Starting in about the mid-1960s the 7400 family of chips had grown to several hundred by the 1980s and is roughly categorized into two groups. The first group of chips were fairly simple and is comprised of mostly "discrete logic" gates. As the technology of chip manufacturing matured, chips were able to hold many more transistors and more sophisticated logic structures packed into them – these would be called the group of "combinatorial logic" chips.

Here are some links to descriptions, specification sheets and other information on how some chips are used…

Discrete Logic Gates

7400   7402   7404

7408   7410   7411

7420   7421   7430

7432   7486   7451

7454   7455   7458

Combinatorial Logic Structures

7474	Dual D-Type Flip-Flop (Rising Edge Triggered)
74283	4-Bit Full Adder (with Lookahead Fast Carry)
7485	4-Bit Magnitude Comparator
74595	8-Bit Serial-in Parallel-out Shift Register
74138	3-Bit to 8-Line Decoder
74139	Dual 2-Bit to 4-Line Decoders
74244	Dual 4-Line TRI-State Buffers
74245	Single 8-Line TRI-State Bus Transceiver
74373	8-Bit Transparent Latch (with TRI-State output)

List of 7400-series - Wikipedia   7400-family ICs - Wikipedia   Transistor–Transistor Logic - Wikipedia

YouTube - Digital electronics basics: 7400 logic chips   7400 Series ICs - Pinouts, Examples, and More
Understanding Digital Logic ICs — Part 1 | Nuts & Volts Magazine   Logic ICs Part 2 | Nuts & Volts Magazine

An All-inclusive Guide: 74LS74 Dual Flip-flop – Flex PCB   74 Series Logic ICs | Electronics Club
74LS138 Application Circuits - Kynix   YouTube - Tutorial | Building the 74LS283 4-BIT FULL ADDER
YouTube - Introduction To The 7400 Series Logic Chips   YouTube - Quiz Buzzer Circuit: 74LS373

YouTube - You can learn Arduino in 15 minutes   How a 74HC595 Shift Register Interfaces with Arduino
YouTube - The Shift Register (74HC595N)   Serial to Parallel Shifting with a 74HC595 | Arduino Docs

Websites for Learning Digital Electronics & Other Resources…

This variety of websites offers lots of information about digital and analog electronics as well as how they work together. For example, robotics, automation, sensory inputs and controlling outputs. There are many projects from simple to complex so when you go to a particular site, it may start off aimed at a beginner but, check out all their menus and resources. You might be amazed! …

Some Fundamentals…

Build Electronic Circuits: Home Page - Tutorials - www.build-electronic-circuits.com
Maker Lessons (ELECTRICITY) - www.makerlessons.com/electricity
Builtin (What is a Transistor? – If You Are Interested) - www.builtin.com/hardware/transistor
Analog vs. Digital (3 Ways) - YouTube - Does it Matter?   YouTube - Vman Builds   YouTube - Tech Explorations
Penguin Tutor: YouTube - Introduction to Logic Gates - www.youtube.com/watch?v=hp0eoiP_v3c
Alison (Digital Electrical Circuits) - alison.com/course/intelligence-electrical-devices-and-digital-electrical-circuits
Geeks For Geeks - www.geeksforgeeks.org/digital-logic/digital-electronics-logic-design-tutorials

7400 Series TTL Chips List - www.build-electronic-circuits.com/7400-series-integrated-circuits
4000 Series CMOS Chips List - www.build-electronic-circuits.com/4000-series-integrated-circuits

YouTube (Digital Electronics Classroom) - www.youtube.com/@DigitalElectronicsClassroom/featured
YouTube (Skill-Lync) - www.youtube.com/watch?v=ViEnnOhp-Mc   Skill-Lync Course List 30 Episodes Playlist
YouTube (Basic Electronic Components) -   Resistors   Diodes   Transistors   Capacitors   Inductors

Keys Robots - www.kevsrobots.com/resources/how_it_works/breadboards
Electronicsforu - https://www.electronicsforu.com/electronics-projects/hardware-diy/25-robotics-project-ideas
Barnabas Robotics - www.barnabasrobotics.com/robotics-kits/bot-basics-intro-to-arduino

Breadboarding Projects…

sciencebuddies.org - **YouTube - How to Use a Breadboard** - www.sciencebuddies.org/electronics
ElectroViz - www.electroviz.com/essential-tools/mastering-breadboard-projects-a-guide-for-absolute-beginners
Build Electronic Circuits: Beginner's Guide - www.build-electronic-circuits.com/breadboard
Open Circuit Shop - www.opencircuit.shop/blog/breadboards-beginners-tips-tricks
CircuitBread - www.circuitbread.com/ee-faq/what-is-a-breadboard
AUTODESK Instructables - www.instructables.com/3-EASY-TRANSISTOR-PROJECTS-FOR-BEGINNERS
AUTODESK (Breadboard Robotics) - www.instructables.com/Simple-Robotics-Breadboard
DroneBot Workshop - www.dronebotworkshop.com/prototyping
sciencebuddies.org - www.sciencebuddies.org/blog/breadboard-get-started
letsmakeprojects.com - www.letsmakeprojects.com/breadboard-tutorial-for-beginners
Skifi Labs - www.skyfilabs.com/project-ideas/latest-projects-based-on-breadboard

YouTube (Fun with Transistors) - www.youtube.com/watch?v=5vRAACeebjI
YouTube (Cool Electronic Projects) - www.youtube.com/@SaiyamAgrawal/videos
YouTube (Elonics Playlist) - www.youtube.com/playlist?list=PLtnycejpkuLVTm90psICBK5kSXb1_6J9z

makerlessons.com - www.makerlessons.com/maker-labs/tool-box/breadboarding
all3dp.com - www.all3dp.com/2/easy-simple-arduino-projects
makerspaces.com - www.makerspaces.com/15-simple-arduino-uno-breadboard-projects
Simply Smarter Circuitry Blog - www.circuitspecialists.com/blog/top-4-breadboard-projects
Circuits DIY (Simple Electronic Circuits) - www.circuits-diy.com/category/simple-electronic-circuits
Programming Electronics Academy - www.programmingelectronics.com/how-to-breadboard-with-arduino
Programming Electronics Academy - www.programmingelectronics.com/arduino-breadboard-projects

YouTube – How Can You 3D Print Functional Electronic Circuits? - www.youtube.com/watch?v=yGRXcdNWqxs
YouTube – Robotix with Sina (Starting Robotics)   YouTube – Simple Circuits (DIY Robot Kit for Beginners)

Websites – Advanced Tutorials & Other Tools…

Electronics Tutorials - www.electronics-tutorials.ws   **AutomatedWord.com** - BDEE Computer Conceptual Design
Home Made Circuits - www.homemade-circuits.com
learnabout-electronics.org - www.learnabout-electronics.org/Digital_Number_Systems
GG: Boolean Algebra - www.geeksforgeeks.org/digital-logic/basics-of-boolean-algebra-in-digital-electronics

AUTODESK Tinkercad - www.tinkercad.com   Electronic Circuits - Tinkercad   3D Design - Tinkercad
Cirkit Designer Tutorials - Components   Projects   Getting Started   Launch The Cirkit Designer App
Logic.ly (Home Page) - www.logic.ly   FREE Demo - www.logic.ly/demo
CircuitVerse - www.circuitverse.org   Learn | CircuitVerse   FREE - Digital Circuit Simulator online

YouTube – Paul McWhorter (Robotics for Absolute Beginners) - www.youtube.com/watch?v=eqXQ80vlgqE
YouTube – Every Flavor of Robot | The BEST intro to robotics! - www.youtube.com/watch?v=EAyzRmAKueE
YouTube – BMonster Laboratory | How to Start with Robotics? - www.youtube.com/watch?v=ia9tVbOW5AQ
YouTube – Tech Valley Science Centre (Robotics & FAQ) - www.youtube.com/watch?v=WjSFlO82V7c
Alison (FREE Courses) - Robotic Process Automation | Free Online Course | Alison

YouTube – element14 (DAC - Digital to Analog Conversion) - www.youtube.com/watch?v=YAxrmoVtEtE
Deep Blue MBedded (DAC) - deepbluembedded.com/digital-to-analog-converter-dac-waveform-generation
Flex PCB (DAC) - flexpcb.org/diy-digital-analog-converter-the-complete-guide
Tutorials Point (DAC) - www.tutorialspoint.com/digital-electronics/digital-to-analog-converter.htm
AUTODESK Instructables (DAC) - www.instructables.com/Practical-DACs
AUTODESK Instructables (DAC) - www.instructables.com/R2R-Digital-Analog-Converter-DAC
YouTube – Kanto (DAC - Beginner's Guide to DACs) - www.youtube.com/watch?v=mDngoCbDQyM

YouTube – element14 (ADC - Analog to Digital Conversion) - www.youtube.com/watch?v=g4BvbAKNQ90
Electronics Tutorials (ADC) - www.electronics-tutorials.ws/combination/analogue-to-digital-converter.html
ELPROCUS (ADC) - www.elprocus.com/analog-to-digital-converter
Electrical 4 U (ADC) - www.electrical4u.com/analog-to-digital-converter
Microcontrollers Lab (ADC) - www.microcontrollerslab.com/analog-to-digital-adc-converter-working
Analog Devices (ADC) - wiki.analog.com/university/courses/electronics/text/chapter-20
YouTube – iMooX (ADC - Beginner's Guide to ADCs) - www.youtube.com/watch?v=0y8AD8maAHo

Arduino - www.arduino.cc   Documentation - www.arduino.cc/en/Guide
YouTube – Joed Goh (Arduino Basics) - www.youtube.com/watch?v=OLGDlPZrZCU
YouTube – Glenn McCall (Arduino Intermediate) - www.youtube.com/watch?v=iPH5A42i4mQ
YouTube – Paul McWhorter (Advanced) - www.youtube.com/playlist?list=PLGs0VKk2DiYw-L-RibttcvK-WBZm8WLEP
Arduino Tutorials - www.arduino-tutorials.net

Raspberry Pi - www.raspberrypi.com   Documentation - www.raspberrypi.com/documentation
YouTube – Crosstalk Solutions (Raspberry Pi 4 Intro) - www.youtube.com/watch?v=BpJCAafw2qE
YouTube – Jeff Geerling (Raspberry Pi 5 Everything) - www.youtube.com/watch?v=nBtOEmUqASQ
YouTube – Zac Builds (Pushing Raspberry Pi 5 to the Limit) - www.youtube.com/watch?v=HIcGbEoqBDo
Raspberry Pi Tutorials - www.raspberrypi.com/tutorials

Video Library - Basic Electronic Components & Advanced Technology…

YouTube - What is Voltage, Current & Resistance?   Math and Science Library | Binary Digital Information
YouTube - How LED's Work!   YouTube - How Resistors Work!   YouTube - Transistors Explained!
YouTube - Diodes Explained!   YouTube - Inductors Explained!   YouTube - Capacitors Explained!

MUST SEE VIDEOS => YouTube - Anatomy of a Central Processing Unit (CPU) **&** YouTube - How do CPUs Work?

Websites - Video Library for Learning Electronics…

The CodeNMore Channel – Electronic Tutorials, Projects, Game & Web Programming…

YouTube - Beginner Electronics -   1 - Introduction
YouTube - Beginner Electronics -   2 - AC vs. DC
YouTube - Beginner Electronics -   3 - Closed/Open Circuits
YouTube - Beginner Electronics -   4 - Flow + Resistance
YouTube - Beginner Electronics -   5 - Resistors
YouTube - Beginner Electronics -   6 - LED's
YouTube - Beginner Electronics -   7 - How Much Resistance?
YouTube - Beginner Electronics -   8 - First Circuit!
YouTube - Beginner Electronics -   9 - Necessities!
YouTube - Beginner Electronics - 10 - Bread Boards
YouTube - Beginner Electronics - 11 - The Multimeter
YouTube - Beginner Electronics - 12 - Schematic Basics
YouTube - Beginner Electronics - 13 - Switches
YouTube - Beginner Electronics - 14 - Circuit Design, Build, and Measuring!
YouTube - Beginner Electronics - 15 - Ohm's Law
YouTube - Beginner Electronics - 16 - Clarify & Power / Wattage
YouTube - Beginner Electronics - 17 - Series and Parallel
YouTube - Beginner Electronics - 18 - Potentiometers and Buttons
YouTube - Beginner Electronics - 19 - Capacitors
YouTube - Beginner Electronics - 20 - Diodes
YouTube - Beginner Electronics - 21 - Relays
YouTube - Beginner Electronics - 22 - NPN Transistors
YouTube - Beginner Electronics - 23 - Relay Oscillator & Speaker
YouTube - Beginner Electronics - 24 - Integrated Circuits: 555 Timer
YouTube - Beginner Electronics - 25 - Microcontrollers and Arduino

Leo's Bag of Tricks – Exploring electronics, mechanical design, coding, and general science…

YouTube - How to Learn Electronics: Start Here
YouTube - Learning Electronics: Lesson 1 - The Fundamentals
YouTube - Learning Electronics: Lesson 2 - More Fundamentals
YouTube - Learning Electronics: Lesson 3 - Yet More Fundamentals
YouTube - Learning Electronics: Lesson 4 - More Impedance Stuff
YouTube - Learning Electronics: Lesson 5 - Diodes
YouTube - All Transistor Clock (A Digital App. Using Analog Components – ref. Techniques and Strategies)
YouTube - Techniques and Strategies for Building Electronic Circuits

The Digital Dozen – 12 of the most popular channels covering Projects, Components, Reviews and more…

Adafruit
Adafruit by MIT engineer, Limor "Ladyada" Fried

GreatScott!
Awesome Electronics Tutorials, Projects and How To's

EEVblog
Off-the-cuff Video Blog about Electronics Engineering

Foolish Engineer
Demystify complex electronic concepts and systems

element14
Tackle fun projects using 3D printing, microcontrollers…

SparkFun
Videos by the geeks at Spark Fun Electronics

DroneBot
Interested: Arduino, Raspberry Pi, Electronics, Robotics?

Neso Academy
Library of FREE Computer Science & Digital Electronics

Ben Eater
Let's build an 8-bit breadboard computer & more…

misperry
This channel will show how to build electronic projects

ElectroBOOM
Want to subconsciously learn while being entertained?

All About Circuits
An Industry Backed Compendium of Video Information

Websites - Video Library of Digital Technology Concepts…

Branch Education & Other Contributors: Digital Electronics Hardware…

YouTube - How do CPUs Work? The Engineering that Runs the Digital World
YouTube - How are Microchips Made?
YouTube - How does Computer Hardware Work?
YouTube - How does Computer Memory Work?
YouTube - What are PCBs (Printed Circuit Boards)?

YouTube - How do Graphics Cards Work?
YouTube - How do Video Game Graphics Work?
YouTube - How do Video Game Controllers Work?
YouTube - How does Starlink Satellite Internet Work?

YouTube - Inside the System on a Chip (SOC)
YouTube - The Intricate Engineering Inside Foldable Smartphones
YouTube - How does your Smartphone SSD storage work?
YouTube - How do smartphones take pictures?

YouTube - How do Hard Disk Drives Work?
YouTube - Exploring Solid State Drives/How does NAND Flash Work?
YouTube - How does a Solid State Drive (SSD) store 8TB of Data?
YouTube - How are SSDs using Quantum Mechanics?

YouTube - How do Computer Keyboards Work?
YouTube - How Does a Computer Mouse Work?
YouTube - How does Bluetooth Work?
YouTube - How does Multitouch work?

YouTube - How Do Touchscreens Work?
YouTube - How do incredibly small speakers work?
YouTube - How do Wireless Earbuds and Audio Codecs Work?
YouTube - How Do Noise Canceling Headphones Work?

YouTube - Evolution Of CPU Processing Power Part 1: The Mechanics Of A CPU
YouTube - Evolution Of CPU Processing Power Part 2: Rise Of The x86
YouTube - Evolution Of CPU Processing Power Part 3: The Origin Of Modern Operating Systems
YouTube - Evolution Of CPU Processing Power Part 4: The 32 Bit Processor - Pipelines and Caches

YouTube - How Does a Transistor Work?
YouTube - Evolution of Transistor Innovation | Intel Technology
YouTube – How do Transistors Build into a CPU?
YouTube - The Insane Mechanism of a Quantum Computer?

YouTube - How do LEDs work and why was it so hard to make a Blue LED?
YouTube - Why Is MIT Making Robot Insects?
YouTube - How Electrostatic Motors are Breaking All the Rules
YouTube – What is Field Programmable Gate Array (FPGA)?

YouTube - How do Electron Microscopes Work?
YouTube - How do Lithium-ion Batteries Work?
YouTube - How does Ray Tracing Work in Video Games and Movies?
YouTube - How are Images Compressed in JPEG format?

YouTube - Why The First Computers Were Made Out Of Light Bulbs
YouTube - What is electricity? How does it work? Nikola Tesla's AC vs DC
YouTube - The Big Misconception About Electricity
YouTube - How Electricity Actually Works

Websites - Career Path Education & Employment...

Branch Education - [Branch Education (Home)](#)   [YouTube - Videos](#)   [YouTube - Playlists](#)
Brilliant.org (Learn by Doing, Concepts that click, Guided bite-sized lessons) - [Brilliant.org (Home)](#)
Veritasium - [YouTube - Veritasium (Home)](#)   [YouTube - Videos](#)   [YouTube - Playlists](#)

Women in Robotics - [Project Advance](#)   [Project Inspire](#)   [Project Connect](#)   [Current & Past Events](#)
Maker Lessons - [MAKER LESSONS (Home)](#)
Electronics Lab - [Electronic Projects, Embedded News and Online Community - Electronics-Lab](#)

Learn Computer Science Online - [Learn Computer Science | Free Computer Science Education Online](#)
TutorialsPoint (FREE Libraries) - [Basic Electronics](#)   [Electronic Circuits](#)   [Microprocessors](#)
TutorialsPoint - [Best Online Courses with Certificates 2025](#)

Kevin Wood | Robotics & AI - [YouTube - Robotics Software Engineer Roadmap 2026!](#)
Learn Robotics - [Go from $65K to $100K with the Robotics Career Accelerator](#)
Pluralsight Robotics Course - [Creating Basic Robots with Robotic Process Automation](#)

Learn.org - [What Career Options are available in the Digital Electronics Field?](#)
Easy Electronics - [YouTube - Courses & Preparation](#)   [YouTube - Top Job Updates for Electronics 2025](#)

Laney Collage - [Electrical and Electronics Technology | Programs at Laney College](#)
Laney Collage - [Artificial Intelligence Career Opportunities | Programs at Laney College](#)

Coursera - [Top Electronics Courses - Learn Electronics Online](#)
Udemy - [Crash Course Electronics and PCB Design | Udemy](#)

Joblist - [Electronics Engineer Jobs in Berkeley, CA | Joblist](#)
Built In - [Best Tech Jobs & Startup Jobs 2025 | Built In](#)
Upwork - [Digital Electronics Engineering](#)   [Digital Electronics Engineer Freelance Jobs: Work Remote & Earn Online](#)

Altium - [PCB Design Courses by Altium | Altium Education](#)

Electronics Teacher - [Electronics Teacher – Empowering Electronics Enthusiasts](#)
Teaching Electronics - [Links to education websites](#)
EduTek - [Edutek Electronic Projects](#)   Sanfoundry - [www.sanfoundry.com](#)

Intel - [2025 Instruction Set and Programmers Guide](#)

Websites - Where to Buy Electronic Stuff…

eBay –	www.ebay.com	(US / Worldwide)	- Favorite 1 !!!
Anchor Electronics –	www.anchor-electronics.com	(Santa Clara, CA / US)	- Favorite 2 !!
Anchor (Inventory) –	www.anchor-electronics.com/price-list.pdf		
Alibaba –	www.alibaba.com	(China)	- Favorite 3 !
Aliexpress –	www.aliexpress.us	(China)	
Made In China –	www.made-in-china.com	(China)	

Adafruit –	www.adafruit.com	(US)
DigiKey –	www.digikey.com	(US / Worldwide)
SparkFun –	www.sparkfun.com	(US)
Jameco –	www.jameco.com	(US)
AREtronics –	https://www.aretronics.com	(US)
Lee's Electronic –	leeselectronic.com	(Canada)
Bitsbox –	www.bitsbox.co.uk	(UK)
Rapid Electronics –	www.rapidonline.com	(UK)
Planeta Electrónico –	www.planetaelectronico.com	(Spain)
Electrokit –	www.electrokit.com	(Sweden)
Protostack –	www.protostack.com	(Australia)
Seeed Studio –	www.seeedstudio.com	(China)
Farnell –	www.farnell.com	(Worldwide)
Mouser –	www.mouser.com	(Worldwide)

Arduino -	www.arduino.cc	(Worldwide)
Raspberry Pi -	magazine.raspberrypi.com	(Worldwide)

RLS 3d (printing) –	www.rls3d.com	(US)
Robomaterial –	www.robomaterial.com	(Worldwide)
BC Robotics –	www.bc-robotics.com	(US)
Robotics BD –	www.roboticsbd.com	(US)
Robotics5 –	www.robots5.com	(US)
IEM Robotics –	www.iemrobotics.com	(Worldwide)

GlobalSpec - Engineering Webinars and Connections

Components101 - Latest Component Articles

GNS Components - www.ictransistors.com/info

Microcontrollers Lab (Robotics) - www.microcontrollerslab.com   Components - Robotic Parts

Jameco Robots - www.jameco.com/jameco/content/gifts-by-pricerange.html   - Learning Center - Electronics

          (**Back to TOC**)

Some Future Page (To Be Determined)

This Page is reserved for some future content…

101computing.net: The Flip-Flop - www.101computing.net/4-bit-counter-using-d-type-flip-flop-circuits
Jameco: The 555 Timer - www.jameco.com/Jameco/workshop/TechTip/555-timer-tutorial.html
Build Electronic Circuits: 555 Timer Tutorial - www.build-electronic-circuits.com/555-timer
circuitspedia.com (555 Timer) - www.circuitspedia.com/555-timer-astable-multivibrator

Wison Mines Co. (Garth Wilson) - wilsonminesco.com
Wison Mines Co. (WM-1 4Mx8 SRAM Module) - www.wilsonminesco.com/WM-1_4Mx8SRAMmodule4-23-20.pdf

         (Back to TOC)

Another Future Page (To Be Determined)

This Page is reserved for some future content…