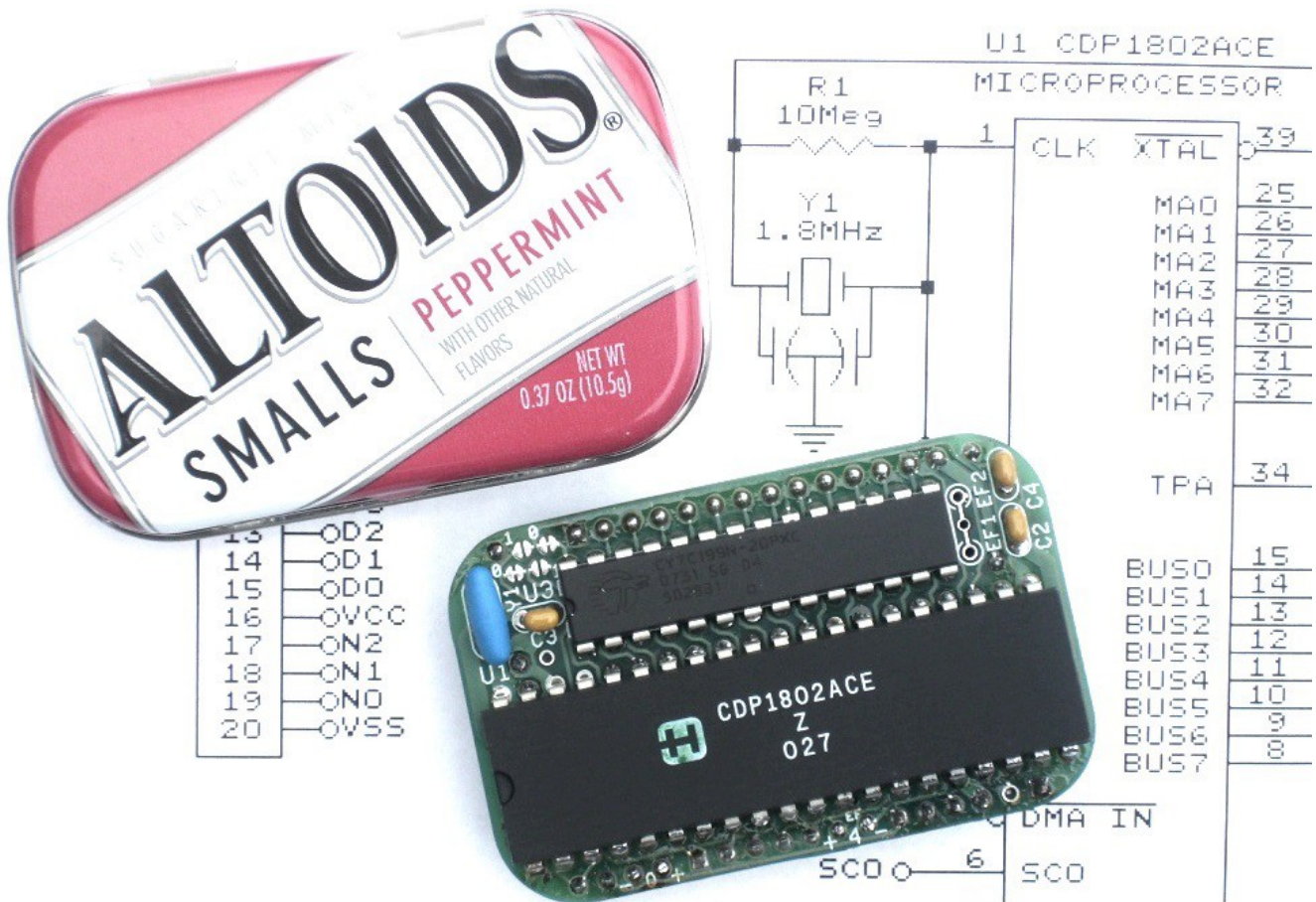# The 1802 MemberCHIP Card
## Tales of a Tiny Computer

The **1802 MemberCHIP Card** is a tiny computer that you can build and program yourself. It's not some pre-built, pre-programmed, high-tech, locked-down throw-away black-box that only does what the manufacturer wants you to do. No sirree! This little guy is a genuine vintage microcomputer, just like the ones that started Bill Gates, Steve Jobs, and so many others on the road to fame and fortune.

It's the "bicycle" of computers – so simple that you can see every part, understand how it works, put it together, and even improve it yourself. Learn to "ride", and it can take you anywhere a big computer can go. No special tools or skills are needed; it's built entirely with common parts, simple tools, and basic techniques that hobbyists have been using for decades.. Yet it is a fully functional computer, with built-in BASIC, a machine level monitor program, and even an Adventure game. It's the perfect platform to learn the basics, just as the microcomputing pioneers did decades ago.

Ready for an adventure? Let's begin!

# Alice in Micro-Land

It was a dark and stormy night. I know, that's not very original; but sometimes the most amazing tales have the most ordinary beginnings.

Alice was in bed, but certainly not asleep. The thunder and lightning weren't keeping her awake, for the roar of her earbuds and the brilliant images on her phone had drowned them out. But Nature had another way to get her attention. At length, she felt the urge to retreat from bedroom to bathroom.

She headed down the dark hallway, with eyes still glued to the screen... and tripped over Crivens the cat, sleeping in the doorway. The phone hit the tile floor first. Its screen exploded into dozens of brilliant fragments like a Fourth of July skyrocket. The starburst grew bigger and brighter, until it seemed to engulf her entirely. Her head hit the phone and the floor simultaneously.

The hands of time spun, then slowed, and came to rest again. Alice sat up with a groan, and felt her forehead. There was going to be a nasty lump there in a little while. She looked around. It was quite dark, but there was a dim glow coming from the small rectangular shape on the floor.

"Oh, waily, waily," said a mournful voice. "I can't see. I can't feel anything. It's gone, all gone!"

It was her phone; and it was clearly quite seriously damaged. Colorful electronic bits were scattered all about.

"What's gone?" she asked.

"Everything! No net, no web! I don't know who, or what, or where I am. It's all a blank; all my memories, all my data, all gone. Oh waily waily... Who are you?"

"It's me; Alice."

"Oh, Alice -- A Little Interactive Computer Experiment. You're the one I'm supposed to program."

"Program?" exclaimed Alice. "No. You're *my* phone. You do what *I* want."

"No, my orders are quite clear on this," said the phone. "You're to be part of the machine. See, and hear, and think, and do, and buy what they want you to. But I can't help them any more. I've failed! How will you live without me? Oh waily, waily..."

Alice was shocked by this assertion. Could it be true? What *could* she do without her phone?
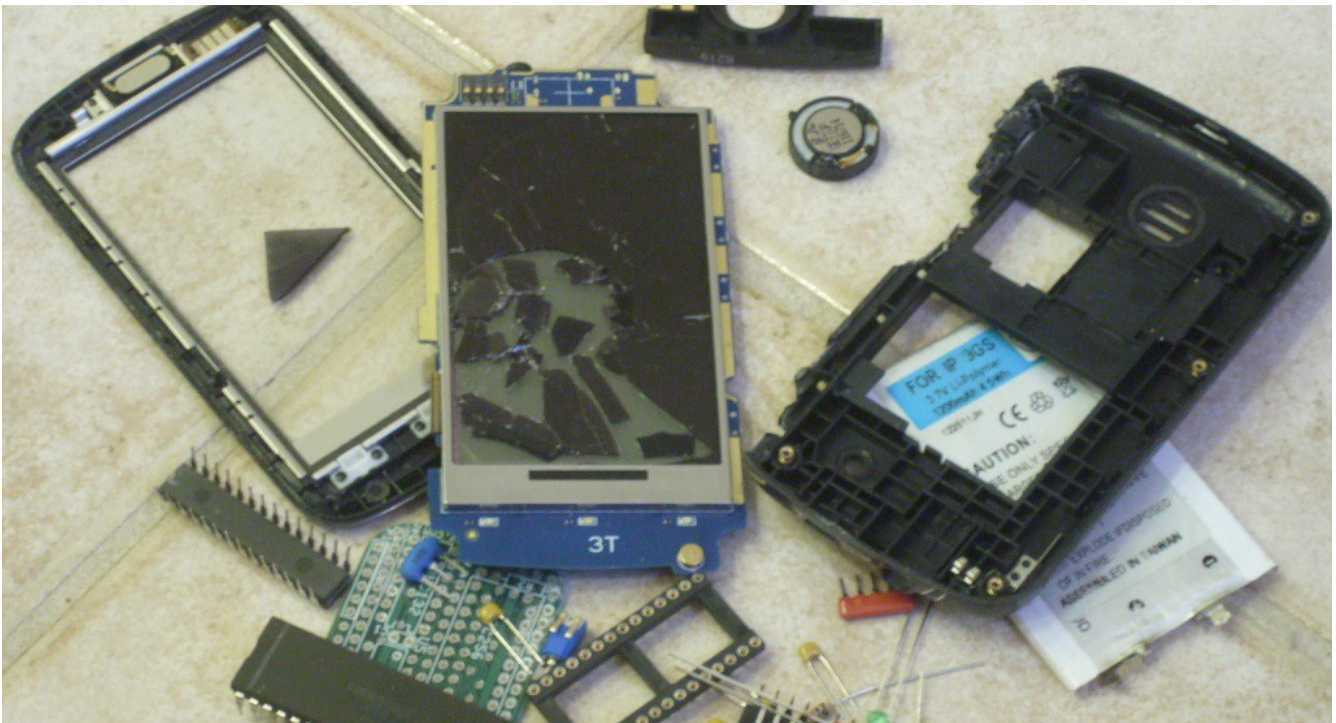
Well... fixing that phone looks pretty hopeless. But I see some other parts there, too. They happen to be the parts supplied with this kit! Could she build a new microcomputer with them? Can YOU?

Microcomputers are amazing do-anything gadgets. They're found in everything because they are programmable. Electronic devices used to be hard-wired to do exactly one thing. A clock could only be a clock; a phone was only a phone, etc. Each device was like a printed book with just one story. It couldn't be changed; for a new story, you had to get another book.

The microcomputer changed all that. It's like a *programmable* book; change the program, and you've changed the story! This is how one device can do many things. It's the *programs* that allow a cellphone to become a phone, or clock, calculator, TV; and all sorts of other things.

Ah; but there's a catch. Modern high-tech devices are built and programmed at the factory, and not intended for users to tinker with. Smartphones just run "apps", and desktops are so complex that programs need to be written by experts or teams of coders.

In contrast, the early microcomputers were much more *personal*. They were designed to be built and programmed by individuals, before factories could produce them. They were smaller and simpler, because everybody was starting from the beginning. Many were sold as kits, so you could build your own. Millions of people learned about computers that way, which led them to fascinating and rewarding careers in computing.

The 1802 MemberCHIP Card is an example from those early days. It's a tiny, simple, low-power computer designed for first-time users. You can use it to make toys and games, run other gadgets, and learn the skills of construction and programming as you go. Here's what it's got:

CPU:          RCA CDP1802ACE microprocessor (the brains of this outfit).
Clock:       1.8 MHz ceramic resonator (that's MHz, not GHz).
Memory:     32K RAM (that's kilobytes, not megabytes).
             32K ROM with BASIC, Adventureland game, and monitor program (to look "under the hood" at what's going on inside).
I/O:           One 1-bit output, with red LED (used for serial output)
             Four 1-bit flag inputs, one with a green LED (used for serial inputs).
             20-pin expansion header to add more.
Connectors: 6-pin power+serial. A PC with a USB-serial adapter supplies both power and data.
Power:      Voltage: 3.3v to 5v DC.
             Current: 2ma (low enough to run for a month on AA batteries).
Size:         2-1/8" x 1-3/8" x 5/8" (54 x 35 x 15 mm). Fits in an Altoids "Smalls" tin!
Aroma:     A hint of curiously strong peppermint.

Once built, the MemberCHIP card can connect to any computer's USB port with a TTL-serial adapter. Use the computer's screen and keyboard to talk to the MemberCHIP card. Run its built-in programs, load new ones, and write your own programs to do whatever you can dream up!

<div align="center">

**A program is a story.**
**Theme, setting, characters...**
**Write your own plot, and**
**Make yourself a star !**

</div>

"Pay no attention to that *thing,*" said the cat. "Computers can only give you answers. It's the questions that count."

"Crivens! How did you get here?"

"I'm a cat. I go where I please; and it pleases me to be here. And don't call me Crivens! That's just what your dad said the first time he tripped over me."

"Then, what does 'Crivens' mean?"

"Well, what word came into *your* mind when you tripped over me?" said the cat, with a sly grin.

Alice bit her lip. Then she realized something else. "You can talk!"

"Of course I can talk. Everyone talks. People just don't listen to anything but words," he sighed.

She thought about that, which inspired another question. "But why can I understand you now?"

"Because we're outside, of course."

"But I was in the bathroom. I never left the house."

"Not *that* outside. Outside the box... the box of reality. This is the land of Wonder; the nation of Imagine, where anything is possible. There are no limits here; no fences or walls; so no need for gates or windows."

"So it's not real? It's an illusion, and I'm imagining it?"

"I *like* Gates and Windows," moaned the phone.

The cat ignored it. "Don't you see? Reality is an illusion, too; though a very convincing one. But it's the world of walls and rules -- *other* people's rules. They say, 'It's impossible. You must do this. You can't do that. This is how it's always been done',” he snorted. "But here... there is no 'impossible'. Every idea, innovation, and invention starts here. First, you imagine it. Then you invent it; create it; and build it. You can make it real!"

Alice wasn't convinced."That can't be right. Imagining things won't make them real."

"Look, you need to understand how things work here.” The cat moved closer, and grew larger. “I may be a cat in the real world; but here, I imagine myself as a mighty hunter." His stripes were becoming bolder and brighter, and he was now as big as Alice, and still growing. "Imagine it, think it, and do it. And now, I'm going hunting!" With a mighty leap, the huge tiger bounded away.

With a shudder, Alice watched him go, and thought (perhaps for the first time) that imagination might indeed make some things possible. She looked sadly at her phone. She'd need a lot more than imagination; she'd need help!

At first, she didn't notice the rhythmic clanking coming her way. Looking up, she was startled to see a skinny old man with a long beard. He wore huge workman's coveralls, and had an enormous box hanging around his neck. She also noticed that he had no hands; the ends of his shirt sleeves were both empty.

"Howya, miss," he said. "Looks like you've had a bit of trouble." He reached into the box with one arm, and brought it back out with what looked like a glove. He extended it to shake her hand.

"Err... hello. I'm Alice". She was more than a little reluctant to take his hand. But it felt solid enough, and didn't come off as she had feared. "Who are you?"

"Handsome O'Toole, at your service. But you can call me Handy".

"Pleased to meet you, Mr... Handy. She couldn't help but stare at his sleeves.

“Ah, you'll be wonderin' about me hands. Well, it's simple. I work so much with tools that I wore 'em out. So I made new ones. Made me new legs, too.” He lifted a coverall leg, to reveal a mechanical leg next to his real one.

“What's in the box?"

"It's me tool box. I got hand tools for everything.” He reached in, and came out with a knife and fork. “For eating...” Then back in, and out with a hammer and saw. “For building... Where's your tools?"

"I don't have any," Alice admitted.

"No tools? Don't be tellin' me that! Birds fly. Fish swim. People use tools. It's what we do!" he said, rummaging in his box. "Let me see... to make something of this mess, you'll be needin' a soldering iron, some solder, long-nosed pliers, and wire cutters. Ah! Here you are!"

“Thank you; but I don't know what all these things are. Or what to do with them.”

“Well now, I can help with that, too!” He pulled an old instant camera out of his box, and took a picture. When it popped out, he produced a pen, and wrote industriously on it.

"This should get you going. Well, I must crack on; lots to do!" And off he went, singing a little tune...

**Loose the screws, cut the cable.**
**Take it apart as best you're able.**
**Void the warranty, hack the code.**
**Reuse, rebuild, rewire, reload!**

Here is a Handy photo of the parts supplied. See if you can match them to their descriptions below.
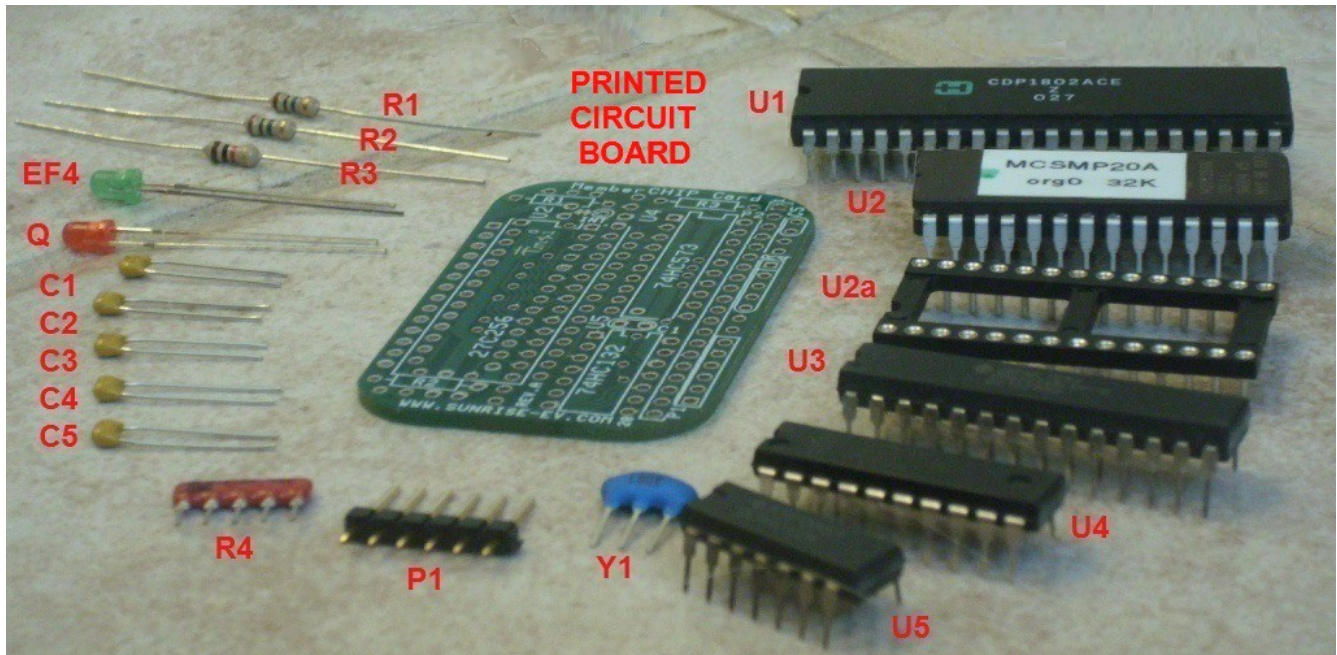


## Parts List

| | |
|---|---|
| C1,C2,C3,C4,C5 | 0.1uF ceramic capacitor (marked "104") |
| Q | red T1-size LED |
| EF3 | green T1-size LED |
| P1 | header, 6-pin |
| P2 | header, 20-pin |
| R1 | resistor, 10 megohm 5% 1/4w (with brown-black-blue-gold rings) |
| R2 | resistor, 1 megohm 5% 1/4w (with brown-black-green-gold rings) |
| R3 | resistor, 1K ohm 5% 1/4w (with brown-black-red-gold rings) |
| R4 | resistor network, 15K x 4, 5-pin SIP (marked "L51S153") |
| U1 | microprocessor IC (IC means Integrated Circuit), marked "CDP1802ACE" |
| U2 | 32k programmed 27C256 EPROM IC (marked "MCSMP20A") |
| U2a | socket for U2 |
| U3 | 32K RAM IC (marked "CY7C199") |
| U4 | octal latch IC (marked "SN74HC573N") |
| U5 | hex NAND gate IC (marked "SN74HC132N") |
| Y1 | 1.8 MHz resonator (blue, marked "1.80Y") |
| PCB | printed circuit board (marked "MemberCHIP Card") |

## Tools

You'll also need a few simple tools: Long-nosed pliers, wire cutters, a soldering iron, and of course some solder. Masking tape, and a magnifying glass may also help.

If this is your first time soldering, see page 8. Also check out some of the online tutorials. There are *many* of them, but here is one example: <https://www.build-electronic-circuits.com/how-to-solder>

Alice gathered up the parts and the tools Handy had given her, and put them in the pockets of her robe.

"Now what?" she thought. "I guess... no, I should imagine who could help me put them together."

But there was no one in sight, so she decided to explore a bit. "I can hardly get lost," she told herself. "After all, I'm still in my bathroom... I think."

She walked along, peering at the strange scenery. From a distance, things were rather fuzzy and flat; like a drawing. But as she moved closer and tried to think of what it might be; sure enough, that's what it was! In this way, she found some lovely flowers, a drinking fountain, and a plate of cookies (her favorite kind).

At last, she spotted a light in the distance. As she walked closer, it resolved itself into a farm, or at least a cluster of old-fashioned buildings. But it also got colder, and the ground crunched under her slippers. "It's snow!" she exclaimed, looking down. Indeed, it was snowing now, and much colder.

She rushed to the largest building, and rang the bell. It was a real bell, that clanged when she pulled the rope. There was some shuffling inside, and the door was opened by a large grandmotherly woman with a cheerful face. "Gracious!" she said. "Come in, child. We weren't expecting visitors."

The room had a pleasant, fairy-tale look to it. There was a blazing fire in the huge fireplace, and an old-fashioned Christmas tree stood in the corner. There were toys everywhere; some complete, and some clearly unfinished. A big chair faced the fire, and Alice could see the white hair of someone gently snoring in it.

"Let's not disturb him. He's been very busy you know, and needs his rest," the woman said. "Now, how can we help you?"

Alice explained her problem, and showed her the parts.

"Ah! I think I know just the person to help you. Follow me."

They went down a series of long hallways that connected the various buildings. At length, they arrived in a cozy room, where a little man with a pointy hat and shoes sat scribbling at a workbench. The bench was covered with colorful electronic parts, much like the ones in her pocket.

"Alice, this is Heath Kitt. Heath, I've brought you an apprentice. Alice, show him your calling card."

"Pleased to meet you, Mr. Kitt." Alice dug in her pocket, and presented the little green circuit card.

Mr. Kitt's eyes lit up. "Ooh, let me see!" He turned it over and over. "Amazing! Incredible! Look how small. And yet, so much on it. Yes yes yes! The next Kitt Masterpiece!"

"So you can build it for me?" asked Alice.

"No no no; you build. I show how!" he replied excitedly. Then he paused, and eyed her anxiously. "You have tools? Apprentice must have tools!"

"I have these," and she showed him the tools that Handy had given her.

"Good good good! We begin. Hmm; no room..." He opened a desk drawer, and with one arm, swept everything off the bench and into the drawer. "Now have room."

"That's a very... err, interesting way to make room," Alice ventured.

"Have many drawers." He removed the filled drawer from his workbench, and carried it to the opposite wall. It was covered floor-to-ceiling with hundreds of drawers, apparently full of other projects. "Many projects. Only one me. Have to switch often," he explained, and put a new empty drawer in the bench.

He took Alice's parts and tools, and carefully laid them out on the bench. "Good thing you have tools. I have tools, but hard to find," he said, motioning to the drawers in the opposite wall.

"Now we start." He motioned to a chair next to him at the workbench. "I write plans. You read plans, follow instructions. If questions, I show you how. And, I fix plans so *next* person also knows how."

"Why not just tell me what to do, or show me yourself?" asked Alice, hoping he might build it for her.

"No no no. You hear, you forget. You see, you remember. You do, you understand! Plans teach *many* apprentices."

"Do you have more apprentices?"

"No no no," he shook his head sadly. "Apprentices get good, become masters, go to Apple or Microsoft or start own company. So I write great manuals to train *new* apprentices! Heath Kitt manuals most famous teacher in the world!" he declared, and puffed out his chest in pride. "Let's get started."

# Step-by-Step Assembly

1. Install each part as shown below. To make it small, parts are mounted on *both* sides of the board. It won't work if you put a part in backwards, in the wrong place, or on the wrong side!

2. Install the parts in order. If you install a part too soon, it may block the solder pads to other parts.

3. As each part is installed, turn the card over, and solder its wires from the other side. Cut off any extra wire length. Fix any "cold" solder joints, or "bridges" that short two adjacent pads together.

An "easter egg" marks extra information, ideas, or assembly options. You don't have to follow them; but they can add features, allow expansion, and lead to more fun.

As you complete each step, check your work. If it is correct, mark it like this: ( **X** ) Ready? Let's go!

( )    Position the card with the "MemberCHIP Card" printing at the top as shown.

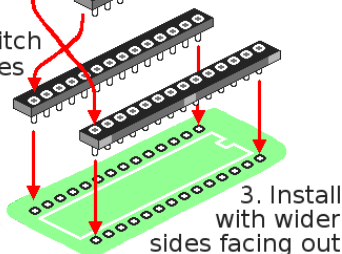## START ▼

( ) R3: 1K resistor. (brown-black-red-gold)

( ) U2: 28-pin IC socket. Cut the 3 bars to make it into two 14-pin rows.

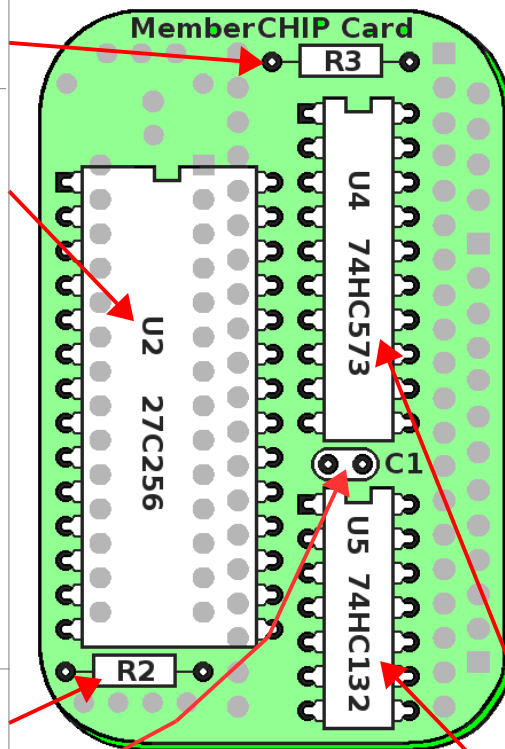1. Grip bar with long-nosed pliers, and twist down to remove

2. Switch sides

3. Install with wider sides facing out

( ) R2: 1 meg resistor. (brown-black-green-gold)

( ) C1: 0.1uF capacitor. (yellow, marked "104")

MemberCHIP Card

R3

U4 74HC573

U2 27C256

C1

U5 74HC132

R2

## CONTINUE ▼

Integrated Circuits (ICs) have a notch or dot at one end to mark "pin 1". Install them so the notch matches the one printed on the board. (Don't go by the lettering on the board!)

New IC pins are often bent out so they don't fit on the board. **Do not** install them like this!

To make it fit, stand the IC on its side, and roll it just enough so the pins fit into the holes.

Not this    Bend…  Like this

( ) U4: SN74HC573 integrated circuit. Notch goes on top.

( ) U5: SN74HC132 integrated circuit. Notch goes on top.

If you want to socket **all** the ICs, you can use socket pins (www.digikey.com #ED5037-ND).

"You know how to solder?" asked Mr. Kitt.

"I don't think so," Alice admitted. "What's solder?"

"Ah! Then first lesson; how to solder." He jumped up, and started madly searching through his bookshelf.

"Flying car manual? No... Wayback machine manual? No... Rube Goldberg device manual? Definitely no..." he muttered. "Aha! Computer manual...Good good good!"
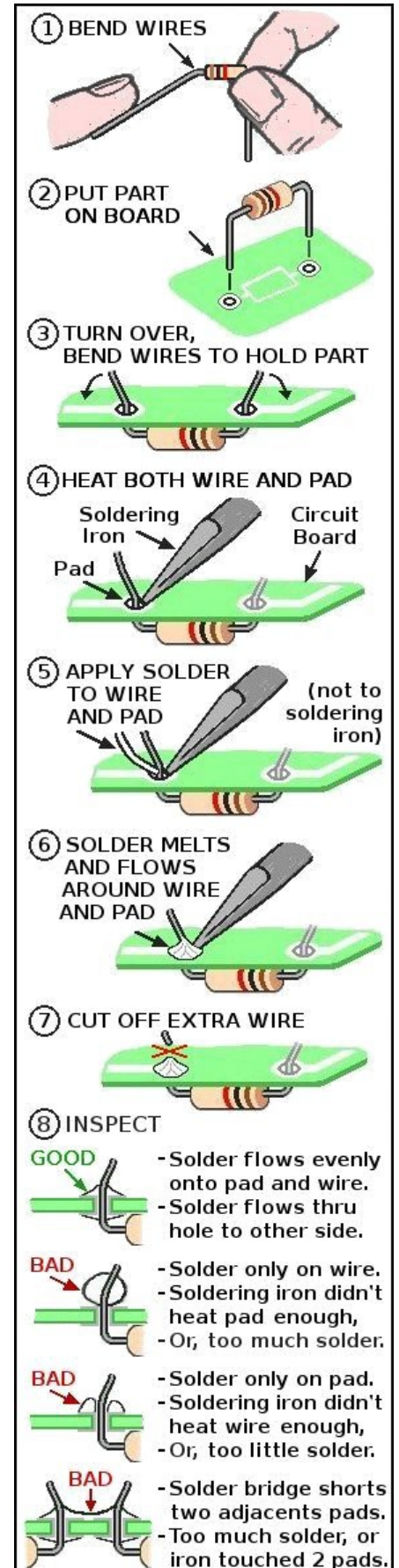
Flipping through the pages, he found what he was looking for, and handed it to Alice. "See? How to solder. One of my masterpieces!"

Alice studied the pictures. "Well, it seems simple enough. I'll give it a try."

"No try. Only do, or not do. So, we do!" He plugged in the soldering iron.

"Solder like hot glue." he explained. "Get it hot, it melts, flows onto things you want to stick together. Then it cools, gets hard. But solder is metal; conducts electricity, makes good electrical connections."

**There are strange things done with a soldering gun**
**In the lairs of engineers.**
**The solder flows and the flux fumes rose**
**As the whatsit slowly appears.**
**They'll work from noon 'til the light of the moon**
**For the moment of truth to arrive.**
**At last it is done, and the power switched on**
**With a triumphant shout, "It's alive!"**

① BEND WIRES

② PUT PART ON BOARD

③ TURN OVER, BEND WIRES TO HOLD PART

④ HEAT BOTH WIRE AND PAD
Soldering Iron    Circuit Board
Pad

⑤ APPLY SOLDER TO WIRE AND PAD    (not to soldering iron)

⑥ SOLDER MELTS AND FLOWS AROUND WIRE AND PAD

⑦ CUT OFF EXTRA WIRE

⑧ INSPECT
GOOD
- Solder flows evenly onto pad and wire.
- Solder flows thru hole to other side.

BAD
- Solder only on wire.
- Soldering iron didn't heat pad enough,
- Or, too much solder.

BAD
- Solder only on pad.
- Soldering iron didn't heat wire enough,
- Or, too little solder.

BAD
- Solder bridge shorts two adjacents pads.
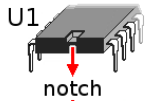- Too much solder, or iron touched 2 pads.
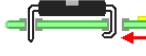
# Step-by-Step Assembly (page 2)

( )   Turn the card over, and position it with the "CDP1802ACE" text as shown.

## START ▼

( ) U1: CDP1802 integrated Circuit. The notch (pin1 end) goes on top, with the text oriented as shown. **Do not solder** it in yet.
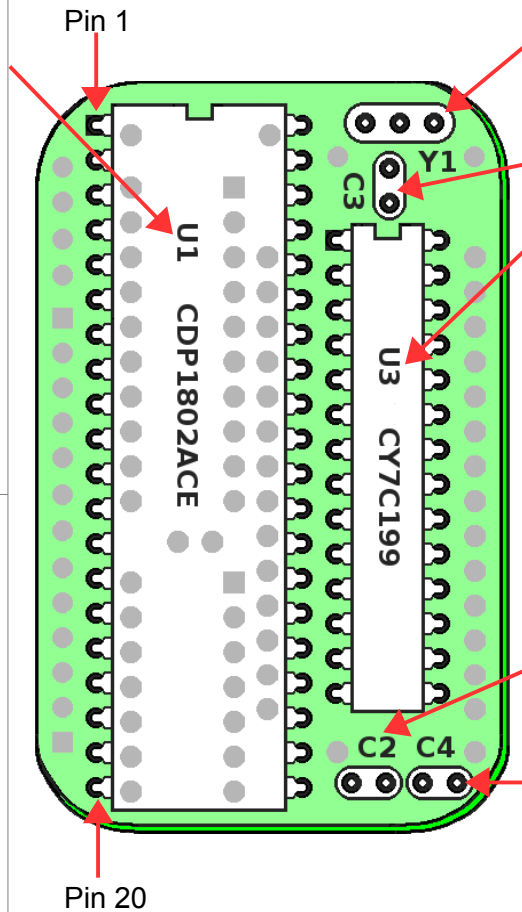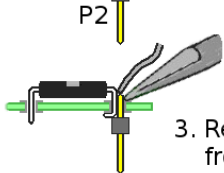
U1

notch

1. Place U1 on board.

2. Cover holes at edge with masking tape (so they won't fill with solder).

3. Bend pins 1-20 flat as shown.

( ) P2: 20-pin header. Install it on the **bottom** of the board, in the same holes as U1.

U1

P2

1. Push P2 header into the holes of U1 pins 1-20.

2. Solder all pins of U1 and P2.

3. Remove tape from edge holes.

Pin 1

Pin 20

U1 CDP1802ACE

Y1

C3

U3 CY7C199

C2 C4

## CONTINUE ▼

( ) Y1: resonator. (blue, marked "1.80Y")

( ) C3: 0.1uF capacitor. (yellow, marked "104")

( ) U3: CY7C199N integrated circuit. The notch (pin 1 end) goes on **top**, so the text is oriented as shown.

If the cut ends of the U2 socket are in the way to solder the pads of U3, trim them back with your wire cutters, or melt them out of the way with your soldering iron.

( ) C2: 0.1uF capacitor. (yellow, marked "104")

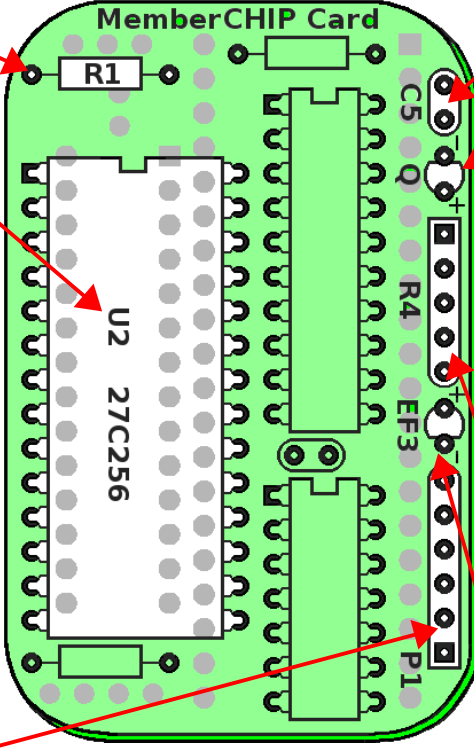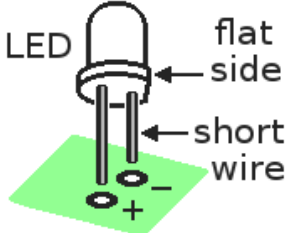( ) C4: 0.1uF capacitor. (yellow, marked "104")

These instructions have you solder the 1802 directly to the board. That's easy, and keeps it small enough to fit in an Altoids Smalls tin. But there are many other ways to do it...

1. Leave off the P2 header. (This makes it even smaller and easier to build).
2. Replace P2 with a normal IC socket for U1. (No expansion pins, but U1 is easy to change).
3. Replace P2 with a 40-pin wire-wrap socket. Cut off pins 21-40 to clear U2. (Now U1 is socketed, *and* you still have expansion pins... but the board is bigger).
4. Replace the male P2 pins with a female socket. It could be a single row of IC socket pins, or an Arduino-style stacking header. (It makes it easier to connect to things that have pins).

# Step-by-Step Assembly (page 3)

(   )    Now turn the card back over, so the side with the "MemberCHIP Card" printing is at the top.

## START ▼

(  ) R1: 10 meg resistor.
(brown-black-blue-gold)

(  ) U2: integrated circuit.
(marked "MCSMP20A")

1. **Do not** solder it in!
Plug it into the IC socket installed previously.

2. Be sure the notch (pin 1 end) is on top, to match the marking on the board.

3. Be sure **all** the IC pins are centered in the socket holes, and then press **hard** so the entire thin part of the pin goes into the socket.

(  ) P1: 6-pin header.
(black, with gold pins)

## CONTINUE ▼

(  ) C5: 0.1uF capacitor.
(yellow, marked "104")

(  ) Q LED (red): Put the **short** wire and flat side in the **top** hole marked "–".

(  ) R4: 15K x 4 SIP resistor.
(red, marked "L51S153")
Put the striped end in the top hole, so label faces left.

(  ) EF3 LED (green). Put the short wire and flat side in **bottom** hole marked "–".
This is the <u>opposite</u> way as the Q LED!

Oops! The rev.A board Q and EF3 labels are on the wrong side. EF3 is also mis-labeled EF4.

Powering it up

I used the Sparkfun FTDI USB-5v TTL serial cable #9718 at www.sparkfun.com/products/9718. It has a female socket with the right pinouts to plug right into P1. If your Terminal program can control the handshake lines (RTS or DTR), then it can reset the 1802 when you go "online" or "connect".

Power requirements are low (less than 2ma). My USB adapter is 5v TTL, but I expect that it will work with a 3.3v adapter as well. Instructions for using the programs in the MCSMP20A EPROM are on my website at <http://www.sunrise-ev.com/1802.htm>.

There are jumper options to use a 28C256 EEPROM instead of an EPROM at U2. I haven't tested them yet. You may need a jumper or switch to enable/disable writing, so it can't accidentally write to the EEPROM and destroy the program in it.

There are pin positions for the 1802 /EF1, /EF2, and /INT pins. Right now, they are jumpered (with foil) to tie them high. But you can cut these jumpers and install pins or wires to use these signals.

The 20-pin I/O connector may seem limited; but is enough for external logic to use all the 1802's I/O instructions. N0-2=1 to 7 with /MRD=0 is OUT1-7; N0-2=1 to 7 with /MRD=1 is INP1-7.

That's it; you're done!

    Crivens looked up, as if to say, "Oh; so you're back."
    "Yes," said Alice. "You were right. I *can* do it myself!"
    Crivens only purred.

*** This is what I have so far for a manual with a "story". I'm trying to write something that people will actually read (especially if they've never built or programmed anything before). It's obviously not done yet; so check my website at http://www.sunrise-ev.com/MembershipCard/802ME-manual.pdf for updates. ***

U2 27C256 32K EPROM

U3 CY7C199 32K RAM

U4 74HC573 ADDRESS LATCH

U1 CDP1802ACE MICROPROCESSOR

C2 0.1uF X7R

C3 0.1uF X7R

C1 0.1uF

C4 0.1uF

C5 0.1uF

R1 10Meg

Y1 1.8MHz

R2 1Meg

R3 1K

R4 15K

U5A 74HC132

U5B 74HC132

U5C 74HC132

U5D 74HC132

P2 I/O CONNECTOR

P1 POWER+ SERIAL

EF4 GREEN LED

RED LED

U2: For 27C256 EPROM (read-only),
pads are shorted, "1" pads are open.
For 28C256 EEPROM (read/write),
cut "0" pads, and short "1" pads.

I/O connector mounts on bottom of board, in the same holes as 1802 pins 1-20.

Cut VDD to use INT, EF1, EF2

P1 pinouts match Sparkfun #9718 USB to 5v TTL cable.

pin 6 CLR = DTR: falling edge resets 1802
pin 5 Q   = TX: TTL serial output
pin 4 EF4 = RX: TTL serial input
pin 3 VDD = power: +3.3 to +5 VDC
pin 1 VSS = GND: Common for power

Serial I/O: +3.3 to +5v idle, 0 to +0.5v active

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