University Amateur Radio Club Elmer 101

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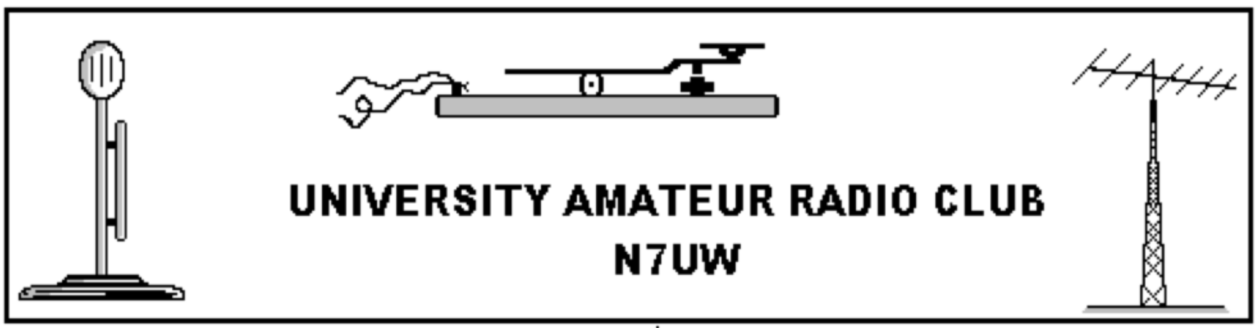
July 2021



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1 Introduction

1.1 UARC Elmer 101

At the July 6th, 2021 club meeting, we decided to go forth with a club project! We will be building the ME40+ 40M CW transceiver and following the "Elmer 101" course that was done by the NorCal QRP Club.

How the project will work: Those that are interested will obtain a ME40+ kit (more information below). We will not build the kit as per the supplier's recommendation but rather by functional block. For instance, we will start with the power supply, test it and learn why the components were picked to make up that part of the radio. We will proceed through the build in this manner until we have a great little radio. We plan on beginning the actual build in the Fall time frame and it will last throughout the Winter. During the build, we plan to have corresponding workshops on soldering, using test equipment and troubleshooting. Towards the end of the build, we will look at small 40M antenna designs and key options for your radio. Following the build, we will plan an exam session as the radio theory will be fresh for those who participate.

Communication and coordination: We will use this email reflector with the subject line "Elmer 101" for our project. We will send out weekly build information to include what to populate on the board, what to test, and why that part of the radio works the way it does. Chris, N7NAV will coordinate the project efforts and answer questions to the best of his abilities, but I strongly encourage other hams to also help with technical questions. Questions are absolutely welcome and can be posted to the reflector or to N7NAV@arrl.net. I will keep a running document throughout the build process and work with the clubs' webmaster to see if we can add the documentation to our web page. If there are hams that want to participate and do not use email then please let Chris, N7NAV know so that a digest can be prepared and delivered to those hams.

Logistics: I'm working with Midway Electronics to see what is available and to give him a ballpark estimate on how many folks are interested. They have been kind enough to offer some discounts. After I have more information about the kits I will let everyone know via the reflector.

Please email N7NAV@arrl.net if you want to participate in this project or have questions.

1.2 Elmer 101 History by Chris, N7NAV

In Winter of 1997-98 QRP operators on the QRP-L mailing list were looking for project that was more than just building. They wanted something educational and something for all to learn more about the wonderful hobby we enjoy. A fair amount of the designers you see producing kits for the Ham community hang out on the QRP-L list and one of those designers was Dave Benson, NN1G. He offered up his SW40 which was modified and updated to the SW40+. Over the Winter of 1997-98 the course unfolded at a pace suitable for participants to build and learn about what they were doing.

The Elmer 101 course was compiled and published by the NorCal QRP club in thier publication QRPp QRPp Volume 06 Autumn.

Many hams since have used the Elmer 101 course to learn radio theory. The SW40+ has been retired and permission was granted to Midway Electronics to carry on the popular rig. It is now known as the ME40+. The rig continues to be a great field radio and educational project. In 2016 another group Chat With The Designers (CWTD) did an Elmer 101 series revolving around the 30M model.

This project taken up by UARC will consist mainly of the original text written by Mike Maiorana, KU4QO and Glenn Leinweber, VE3DNL. Chris, N7NAV will make updates to links and component information as appropriate for the ME40+. The Layout of the build instructions will be akin to the Heathkit style, but otherwise the content will remain unchanged. Further resources will be added to aid the ham in construction and learning as well as a summary of questions and answers by UARC members.

1.3 Recommended Prerequisites from the Authors

Prerequisites:

Ok folks, here are the prerequisites for the elmer project. This list was compiled with the help of the "elmers" so we can get a head start on the theory. Please read this carefully if you plan on participating in the class.

1) All posts regarding the elmer project must have a subject that starts with Elmer101:
2) Students are recommended to have access to the ARRL Handbook, 1995 or later.
The following references are extremely helpful but not required.
a) Experimental Methods in RF Design by the ARRL
b) Databook for homebrewers and QRPers by NA5N (Out of print)
3) Access to a scientific calculator (or pc program equivalent)
4) Graph paper
5) Access to a Digital Volt Meter (DVM) of reasonable quality
6) 50 ohm dummy load
7) RF probe (plans are in the ARRL HB)
8) Soldering equipment (iron, solder, solder wick, etc.)
9) Diagonal cutters, long nose pliers, screwdrivers, wire strippers, exacto knife.
10) A good magnifying glass

The student must learn the following concepts before the project starts in late March. The technical posts will assume this level of knowledge. The info can be found in the ARRL Handbook. If you need help ASK!!!!
1) Ohm's Law
2) Kirchoff's law for voltage and current.
3) Capacitive and inductive reactance X(c) and X(l)
4) Resonance and Q
5) AC and DC voltages and power, phase, p-p, RMS, etc.
6) Electronic component recognition
7) Basic soldering (Practice!)

1.4 Resources

Midway Electronics:
https://midwayelectronics.us/qrp/index.html
ME40+ Manual:
https://midwayelectronics.us/qrp/me40.pdf
Elmer 101:
https://www.qsl.net/kf4trd/index.html
QRPp Autumn 1998:
http://www.ncqrpp.org/files/qrpp$_{v}olume_{0}6.pdf$
CWTD Elmer 101:
https://www.cwtd.org

2 Power Supply

This section will cover the DC power supply section of the radio. It has the job of supplying the radio with a usable D.C. power source for the different circuit modules. There are two basic voltage supplies on the rig. There is the unregulated D.C. supply and there is a regulated 8 volt supply.

☐ First find the following components in your kit.

☐D13 1N4001 Diode, black case.

☐C112 220 microfarad 16 V electrolytic capacitor, banded end is neg.

☐C102 .01 microfarad ceramic capacitor, '103M' or U01.

☐U2 78L08 three terminal voltage regulator, plastic case (TO-92).

☐ Install D13

- Install upright with the band facing the up.
- The base of the diode should be installed on the round circle screen printed on the circuit board.

☐ Install C112

- Install with the band away from the "+" symbol on the circuit board.

☐ Install C102

- The footprint for C102 may be wider than the leads on the capacitor.
- Be careful when forming the leads not to crack the case of the capacitor.

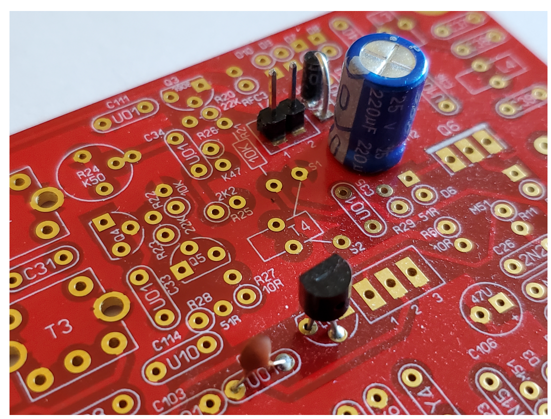
☐ Install U2

- Make sure to orient the case profile with the shape printed on the board.

☐ Connect a 2 pieces of hookup wire between the power supply connections on the circuit board and your power source.

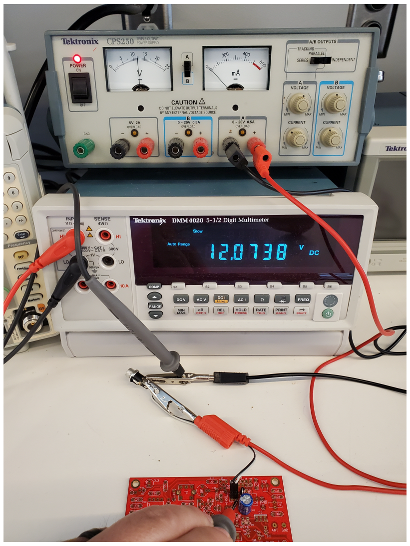
- The "-" supply goes to ground (J4 pin 1).
- The "+" supply goes to the +12 volts (J4 pin 2).
- You need to be able to easily turn this on and off, so make sure these connections are easily removed.

Don't build with the power on!!!!

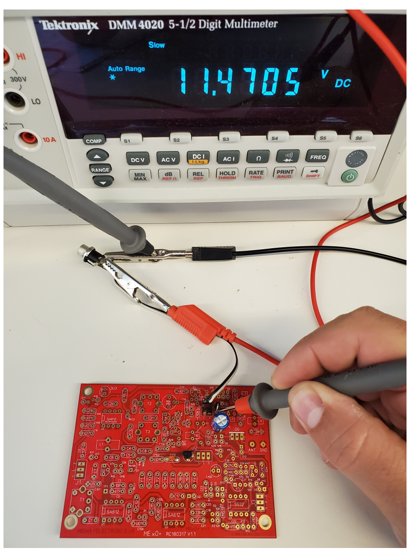


Voltages are measured with reference to ground unless otherwise specified. This means that the black (-) lead of your volt meter should be connected to the board ground, along with the power source - connection. You can connect the meter black lead to the power supply - connection to make the following measurements.

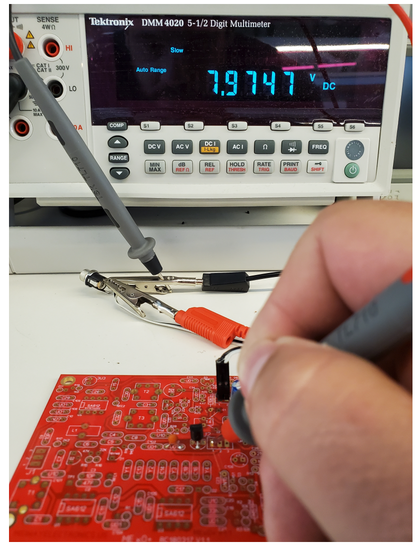
J4 pin 2 should be the same as the power source + terminal.



Cathode of D13 should measure the Power source voltage (Vps) - D13 dropping voltage (about 0.7 volts). The diode dropping voltage will vary with device and with the amount of current passing through it.



Output of the U2 voltage regulator should be about 8 volts (between 7.7 and 8.3 volts). A convenient place to measure this is at pin 1 of J2.



If you get these readings, you have built the power supply section correctly. Now on to the circuit description.

As you all know, a diode allows electrical current to pass in one direction but not in the reverse direction. When a diode cathode is more negative than the anode, it will conduct current. In this circuit, D13 is in series with the power source as it feeds the rest of the circuit. It's function is to protect the board from damage if the power leads are connected backwards. If the power leads are reversed the diode will be reverse biased and no current will flow into the circuit, saving all those little components from certain death ;-)

The disadvantage to using a series diode for polarity protection is that you lose voltage (and power) in your power supply. There are other methods of polarity protection that don't significantly affect the supply voltage or power, but are significantly more complex or use a fuse. For a simple circuit this is an excellent solution.

C102 and C112 provide decoupling on the power rail. They provide a low impedance path for any AC on the internal power system. This keeps the supply a clean D.C. voltage with a very small A.C. component.

U2 is a low power three terminal voltage regulator. It is there to provide sensitive circuits a constant voltage. The input voltage to the board is not regulated. It can be anywhere between 12 and 15 volts. Lets just say we are using a battery for the power source. All power sources have an internal resistance (usualy small). As more current is drawn from the supply, the voltage drop across the internal resistance increases, decreasing the output voltage. So when we key up the transmit section and the current draw from the power source jumps, the voltage provided drops. There are certain circuit components that require a very stable voltage source. The VFO is one example of this. Imagine what the radio would sound like if the VFO frequency changed depending on how long the key was held down. (We call that chirp). This is a bad thing. So we use a linear voltage regulator to isolate the sensitive circuits from variations in the supply voltage.

The 78L08 device can take anywhere from 10.5 volts to 23 volts at its input and provide an 8 volt output. It provides overcurrent protection, short circuit protection and thermal protection (shut down if it gets too hot).

Remember that these devices are not perfect. We have looked at them up till now as a "perfect" device. They can only supply 100mA maximum. They can only dissipate a total of 700mW assuming the ambient temperature is $<$ 25 degees C. Power dissipated by the device is equal to the voltage dropped by the device (15-8= 7 volts) times the current delivered. Notice that in this design that if the maximum current was drawn out of the device (100mA) at the maximum supply voltage (15 volts), the max power dissipation on the device is 700mW. Coincidence? I think not!

Also, variations on the input do appear at the output, although greatly attenuated. The spec is 48dB at 120Hz (full wave rectified line ripple). If my math is correct, a one volt change in input voltage will cause a 15.8 microvolt change in the output.

In addition, the device itself uses a certain amount of power. Bias current is about 4mA. At 15 volts that equals 60 mW.

If you are curious, you can view the data sheet if your browser has a PDF reader. 78L08AC Data Sheet.

2.1 Why these parts?

I've received several emails with questions on the power supply circuit. I don't know if I can answer them completely, but this should serve to start the discussion.

Please, read all your email before you reply to any, just to be sure that there are no duplicate answers.

The questions in the original Elmer 101 course centered on a theme. WHY did the designer choose this particular component?

Lets also keep in mind that many components are chosen for reasons other than function. There are many parts that could be replaced with a number of parts and function properly. Often the choice comes to economy, availability and stock. Dave may have 10,000 1N4001 diodes in his stock. That would move him to use these components in his designs anywhere possible. Physical size is also a consideration, will it fit on the board? Component choice can also be "designers preference".

D13, why a 1N4001? I think I can answer this one. What characteristics do you need in this particular application? It must be able to carry all of the power supply current through it (up to .5 amps). It must have a reverse voltage rating greater than the supply voltage (15 volts). It does not have to be fast, as it is not a detector or a switching diode. Capacitance really does not matter as it is normally forward biased. It should be inexpensive and readily available. So, the 1N4001 fits these characteristics perfectly. It handles up to 1 amp forward current, 100 volts reverse voltage, characterized as a rectifier. And they are really cheap. You could replace this component with any rectifier diode that has a PIV of 30 volts or more(input voltage plus the charged Power supply capacitor) and a forward current rating of 1 amp (0.5 amps plus surge current) or more.

C112 and C102 Why these types and values? I think I can answer part of this question. C112 is a 220 microfarad electrolytic. C102 is a .01 microfarad ceramic. C112 is for filtering low frequencies and C102 is for filtering high frequencies (RF). The electrolytic has a low impedance to lower frequencies (120Hz) but has a substantial impedance to high frequencies, due to it's construction. This is why C102 is there. There are lot's of different types of capacitors with widely varying characteristics. Does anyone have a summary of different capacitor types and their characteristics? That would be a good post.

U2 78L08 Why? I believe this one was already answered in the original post. It keeps a steady 8 volts on sensitive circuits even if the supply drops to 10.4 volts. Why this particular part? It is a standard three terminal regulator. They have been around a while. Take a look at the date on the top of the data sheet (January, 1976). From what I understand there are two types, the L series in the TO92 (plastic transistor) case, and the standard series is in a TO-220 (like the final output transistor, Q6). The standard series can supply lots more current. It is also more expensive, larger and has a higher bias current. Since the circuit requirements are for <100mA , the 78L08 is the correct choice. You could "roll your own" regulator with discrete components. However, at $0.25 each, and such a small size, I don't think you can beat the 78Lxx series.

I hope this is a start in the right direction to answer the questions posed. Let's hear from those "in the know" on the details I missed.

2.2 More Whys

Here are the answers to the capacitor selection questions. I got this info from Dave Benson, the designer.
>>Why do we use a 220 mF instead of a 100mF to filter the low freq junk?

>The 220 microfarad cap was the largest value available in that size package.

>> Why do we use a .01 mF instead of a .1mF to filter the RF?

>Yes, they'd all work, the .01 is cheapest.- I buy caps in lots of a thousand-
>the difference between $.02 and .05 fills up my car's gas tank a couple times. ¿;-)
>
>I do remember someone asking why the bypass caps on U1 and U2 were different
>values, and I saw some good explanations. The real story is that they would
>have both been the cheaper .01s but one of the locations was physically too
>tight and I upgraded to the smaller-package .1 cap!

I hope this clears this all up. Thanks Dave for the feedback. So, it should be clear that often a component choice is not made only on it's function. Economy and size are also a large factor.
Power supply rejection ratio error
>Also, variations on the input do appear at the output, although greatly
>attenuated. The spec is 48dB at 120Hz (full wave rectified line ripple).
>If my math is correct, a one volt change in input voltage will cause a
>15.8 microvolt change in the output.

Sorry .... the power supply rejection ratio is in units of power, so the power is indeed reduced by 48 db. But, this corresponds to a 4 mV change in voltage. This is one of those famous 'db voltage' vs. 'db power' problems.

$$10^{(-48/20)} = 0.004$$

Lesson is very good! At least, for an engineer :-)

A Component List

The following list is from Glen Leinweber. He has graciously compiled a list of all the components in the SW-40+ and included a description.

A.1 Capacitors

C102.. .01uf Bypass capacitor to keep RF out of U2.
C112..220uf Big current reservoir on 12V DC input supply.

A.2 Diodes

D13...1N4001 DC supply protection diode, prevents damage should input DC supply be connected with wrong polarity.

A.3 Integrated Circuits

U2...78L08 Three-pin low-current voltage regulator outputs +8v DC.

B 78L08 Voltage Regulator Data Sheet

The following data sheet is for the 78L08 voltage regulator U2.

PLANETA 78L00A Series

The Linear IC's

Three-Terminal Low Current Positive Voltage Regulators

DESCRIPTION

The 78L00A Series of three terminal positive voltage regulators is available with several fixed output voltages making them useful in a wide range of applications. These regulators are inexpensive, vise-to-use devices suitable for a multitude of applications that require a regulated supply of up to 100 mA. These regulators feature internal current limiting and thermal shutdown making them remarkably rugged. No external components are required with the 78L00A devices in many applications.

These devices offer a substantial performance advantage over the traditional zener diode-resistor combination, as output impedance and quiescent current are substantionally reduced.

The voltages available allow the 78L00A to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment.

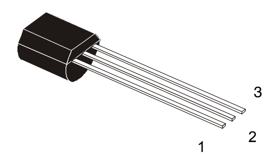
The 78L00A is available in 3-Pin plastic package SOT54 (Z), 3-Pin mini power plastic package SOT89 (F) and the 8-Pin plastic package SO8 (D) offers superior quality and performance at low cost.

FEATURES

- High Output Current
  I_o= 100 mA
- Fixed Output Voltage
  V_O= 5 V, 6 V, 8 V, 12 V, 15 V
- Complementary Negative Regulators 79L00A Series
- Available in either ±5% (AC) Selection

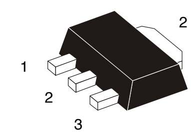
DEVICE TYPE / NOMINAL VOLTAGE

5% Output Voltage Accuracy	Voltage	Package		
		Z Suffix	F Suffix	D Suffix
78L05AC	5	78L05ACZ	78L05ACF	78L05ACD
78L06AC	6	78L06ACZ	78L06ACF	78L06ACD
78L08AC	8	78L08ACZ	78L08ACF	78L08ACD
78L09AC	9	78L09ACZ	78L09ACF	78L09ACD
78L12AC	12	78L12ACZ	78L12ACF	78L12ACD
78L15AC	15	78L15ACZ	78L15ACF	78L15ACD



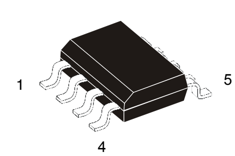
1 – Output
2 – Common
3 – Input

	SOT54
JEDEC	TO-92
EIAJ	SC-43
GOST	KT-26
Weight:	0.3g



1 – Output
2 – Common
3 – Input

	SOT89
JEDEC	TO-243
EIAJ	SC-62
GOST	KT-47
Weight:	0.055g



	SOT96-1
JEDEC	MS-012
EIAJ	–
GOST	4303.8-1
Weight:	0.08 ã

1 – Output, 2 – Common,
3 – Common, 4 – No Connect,
5 – No Connect, 6 – Common,
7 – Common, 4 – Input

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ABSOLUTE MAXIMUM RATINGS (T_A = 25 °C)

Rating	Symbol	Value	Unit
Input Voltage V_O = 5 V to 9 V V_O = 12 V to 15 V	V_I	 **30** **35**	V
Output Current	I_O	**100**	mA
Maximum Power Dissipation Case KT-26 (TO-92) Z Suffix Case KT-47 (SOT-89) F Suffix Case 4303.8-1 (SO-8) D Suffix	P_D	 **500** **350** **500**	mW
Junction Temperature	T_{JMAX}	**150**	°C
Operating Junction Temperature Range	T_{OPR}	**-30** to **+85**	°C
Storage Temperature Range	T_{STG}	**-40** to **+150**	°C

ORDERING INFORMATION

Device	Marking	Package	Quantity	Packing Style
78LXXACZ*	78LXXACZ*	SOT-54	1 Kpcs / plastic bags / carton box	In bulk
78LXXACF*	8LXX*	SOT-89	5 Kpcs / plastic bags / carton box	In bulk
78LXXACF-T1*	8LXX*	SOT-89	1 Kpcs / Reel	Embossed tape 12-mm wide 7" dia. Pin 2 (Common) towards the windung. Perforation on the right.
78LXXACD*	78LXXACD*	SO-8	5 Kpcs / plastic bags / carton box	In bulk
78LXXACD-R1*	78LXXACD*	SO-8	500 pcs / Reel	Embossed tape 12-mm wide 7" dia. Pin 1 (Output) face to perforation side of the tape.
78LXXACD-R2*	78LXXACD*	SO-8	2.5 Kpcs / Reel	Embossed tape 12-mm wide 13" dia. Pin 1 (Output) face to perforation side of the tape.

Note 1:
XX indicates nominal voltage
*Available in 5, 6, 8, 9, 12 and 15 V devices.

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78L05AC ELECTRICAL CHARACTERISTICS

(V_I = 10 V, I_O = 40 mA, C_I = 0.33 μF, C_O = 0.1 μF, T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage	V_O	**4.8**	**5.0**	**5.2**	V
Output Voltage, 7.0V < V_I < 20.0V, 1mA < I_O < 40mA	V_O	**4.75**	–	**5.25**	V
Line Regulation, 7.0V < V_I < 20.0V		–	–	**150**	mV
Load Regulation, 1mA < I_O < 100mA 1mA < I_O < 40mA		– –	– –	**60** **30**	mV
Input Bias Current	I_{IB}	–	–	**6**	mA
Input Bias Current, 8.0V < V_I < 20.0V, 1mA < I_O < 40mA	ΔI_{IB}	–	–	**1.5**	mA
Ripple Rejection, 8.0V < V_I < 18.0V, I_O=40mA, f=120Hz	RR	**41**	–	–	dB
Dropout Voltage	$V_I - V_O$		**1.7**	–	V

78L06AC ELECTRICAL CHARACTERISTICS

(V_I = 12 V, I_O = 40 mA, C_I = 0.33 μF, C_O = 0.1 μF, T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage	V_O	**5.75**	**6.0**	**6.25**	V
Output Voltage, 8.5V < V_I < 20.0V, 1mA < I_O < 40mA	V_O	**5.7**	–	**6.3**	V
Line Regulation, 8.5V < V_I < 20.0V		–	–	**175**	mV
Load Regulation, 1mA < I_O < 100mA 1mA < I_O < 40mA		– –	– –	**80** **40**	mV
Input Bias Current	I_{IB}	–	–	**6**	mA
Input Bias Current, 9.0V < V_I < 20.0V, 1mA < I_O < 40mA	ΔI_{IB}	–	–	**1.5**	mA
Ripple Rejection, 10.0V < V_I < 20.0V, I_O=40mA, f=120Hz	RR	**40**	–	–	dB
Dropout Voltage	$V_I - V_O$		**1.7**	–	V

78L08AC ELECTRICAL CHARACTERISTICS

(V_I = 14 V, I_O = 40 mA, C_I = 0.33 μF, C_O = 0.1 μF, T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage	V_O	**7.7**	**8.0**	**8.3**	V
Output Voltage, 10.5V < V_I < 23.0V, 1mA < I_O < 40mA	V_O	**7.6**	–	**8.4**	V
Line Regulation, 10.5V < V_I < 23.0V		–	–	**175**	mV
Load Regulation, 1mA < I_O < 100mA 1mA < I_O < 40mA		– –	– –	**80** **40**	mV
Input Bias Current	I_{IB}	–	–	**6**	mA
Input Bias Current, 11.0V < V_I < 23.0V, 1mA < I_O < 40mA	ΔI_{IB}	–	–	**1.5**	mA
Ripple Rejection, 13.0V < V_I < 23.0V, I_O=40mA, f=120Hz	RR	**37**	–	–	dB
Dropout Voltage	$V_I - V_O$		**1.7**	–	V

78L09AC ELECTRICAL CHARACTERISTICS

(V_I = 16 V, I_O = 40 mA, C_I = 0.33 μF, C_O = 0.1 μF, T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage	V_O	**8.6**	**9.0**	**9.4**	V
Output Voltage, 12.0V < V_I < 24.0V, 1mA < I_O < 40mA	V_O	**8.55**	–	**9.45**	V
Line Regulation, 12.0V < V_I < 24.0V		–	–	**175**	mV
Load Regulation, 1mA < I_O < 100mA 1mA < I_O < 40mA		– –	– –	**90** **40**	mV
Input Bias Current	I_{IB}	–	–	**6**	mA
Input Bias Current, 13.0V < V_I < 24.0V, 1mA < I_O < 40mA	ΔI_{IB}	–	–	**1.5**	mA
Ripple Rejection, 15.0V < V_I < 25.0V, I_O=40mA, f=120Hz	RR	**37**	–	–	dB
Dropout Voltage	$V_I - V_O$		**1.7**	–	V

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78L12AC ELECTRICAL CHARACTERISTICS

(V_I = 19 V, I_O = 40 mA, C_I = 0.33 μF, C_O = 0.1 μF, T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage	V_O	**11.5**	**12.0**	**12.5**	V
Output Voltage, 14.0V < V_I < 27.0V, 1mA < I_O < 40mA	V_O	**11.4**	–	**12.6**	V
Line Regulation, 14.5V < V_I < 27.0V		–	–	**250**	mV
Load Regulation, 1mA < I_O < 100mA 1mA < I_O < 40mA		– –	– –	**100** **50**	mV
Input Bias Current	I_{IB}	–	–	**6.5**	mA
Input Bias Current, 16.0V < V_I < 27.0V, 1mA < I_O < 40mA	ΔI_{IB}	–	–	**1.5**	mA
Ripple Rejection, 15.0V < V_I < 25.0V, I_O=40mA, f=120Hz	RR	**37**	–	–	dB
Dropout Voltage	$V_I – V_O$		**1.7**	–	V

78L15AC ELECTRICAL CHARACTERISTICS

(V_I = 23 V, I_O = 40 mA, C_I = 0.33 μF, C_O = 0.1 μF, T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage	V_O	**14.4**	**15.0**	**15.6**	V
Output Voltage, 17.5V < V_I < 30.0V, 1mA < I_O < 40mA	V_O	**14.25**	–	**15.75**	V
Line Regulation, 17.5V < V_I < 30.0V		–	–	**300**	mV
Load Regulation, 1mA < I_O < 100mA 1mA < I_O < 40mA		– –	– –	**150** **75**	mV
Input Bias Current	I_{IB}	–	–	**6.5**	mA
Input Bias Current, 19.0V < V_I < 30.0V, 1mA < I_O < 40mA	ΔI_{IB}	–	–	**1.5**	mA
Ripple Rejection, 18.5V < V_I < 28.5V, I_O=40mA, f=120Hz	RR	**34**	–	–	dB
Dropout Voltage	$V_I – V_O$		**1.7**	–	V

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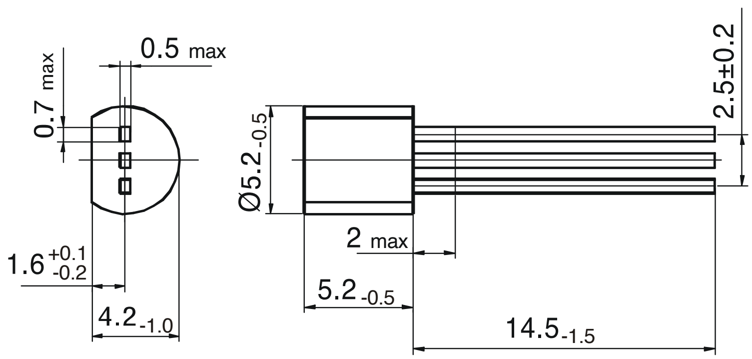
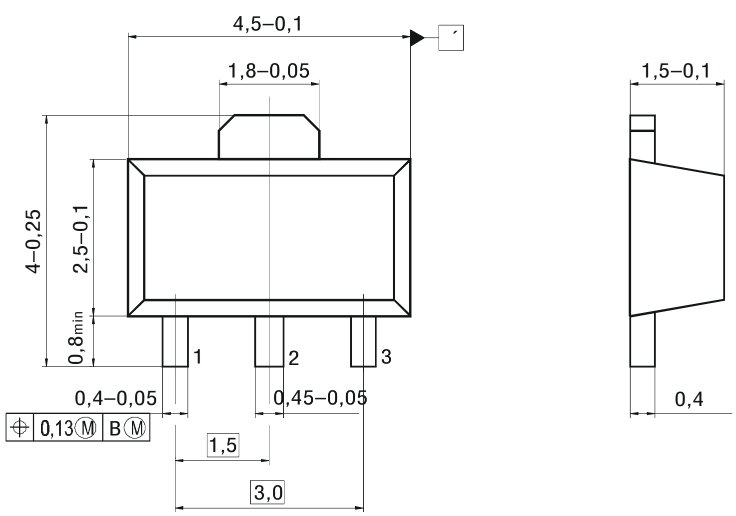
PACKAGE DIMENSIONS of 78L00ACZ in mm



PLASTIC CASE KT-26

PACKAGE DIMENSIONS of 78L00ACF in mm



PLASTIC CASE KT-47

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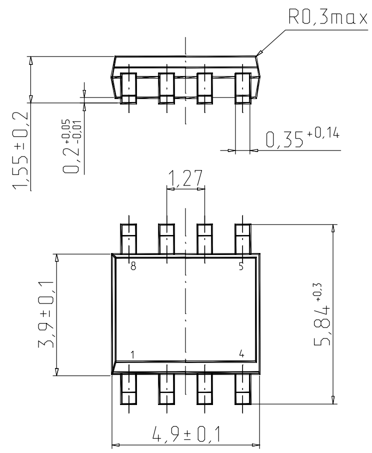
PACKAGE DIMENSIONS of 78L00ACD in mm



PLASTIC CASE 4303-8.1