Wiring Manual NEScaf August 2006

Switched Capacitive Audio Filter

The NEScaf is a **s**witched **c**apacitive **a**udio **f**ilter (acronym SCAF) built around a National scaf chip. The scaf will take the audio from any source (rig) and filter it to suit your listening…which is called a bandpass filter. The filter has two controls:

1. the center frequency control allows the user to raise or lower the received frequency (the CW note) in the bandpass filter. The pitch can be set to a default value anywhere between 450-1000 Hz. range.
2. the bandwidth control will vary the width of the received CW pitch from about 90 Hz to about 1500 Hz.

The NEScaf is made up of four sections and it is recommended that builder constructs it in stages to test each as it is completed. The sections are:

1. *power supply*: supplies raw power, 4.5v and 9v to the various stages
2. *audio amplifier*: an LM386 IC audio amplifier
3. *clock generator*: a 555 timer generating a clock pulse whose frequency divided by 100 will equal the center frequency for the filter. For example--if the 555 clock timer is generating 70 kHz, the center frequency will be 700 Hz.
4. *the SCAF IC chip*. This section is built using a National Semiconductor MF10 **s**witched **c**apacitive **a**udio **f**ilter chip.

Theory

The MF10 is made up of two CMOS active filters. The filters are easily configurable (low pass, band pass, notch, etc.), and builders are encouraged to experiment with them in other uses. We have configured both filters as Butterworth band pass filters, cascaded for optimum results. Butterworth filters have constant amplitude in the band pass region, while the cutoff knee is not be as sharp if the filter were configured as a Chebychev design. This is an acceptable tradeoff wanting constant volume out, regardless of the bandwidth or center frequency setting of the filter. Additional information about the National Semiconductor MF10 can be found in the application notes: http://www.national.com/apnotes/ActiveFilters.html.

Building Tips

- As with any electronic kit, be sure the part you have in your hand is the part you want to solder onto the PC board. Check the markings for all components. We have gone through pains to make you a very fine circuit board and supply you with good components. We would like to stress that the importance of care in assembly and construction so that you will end up with a project we can all be proud of.
- Work slowly and carefully, inserting a component, soldering it, clipping the leads, and finally inspecting each joint as you build your SCAF project. The vast majority of problems with kit projects is poor solder joints. Heat first…count to 3 and then add solder. Apply a small amount of solder to the angle formed by the soldering tip, component lead and the circuit board. Do not remove the tip until solder

has flowed completely around the circuit board pad and the component lead, and then slide the tip away from the board a short distance as you remove your iron. If you're new to soldering, practice makes perfect.

- A few of the parts for the NEScaf are sensitive to static discharge which include the integrated circuits (ICs). Take precautions to ground yourself prior to and while handling those sensitive parts.
- When describing orientation for part insertion, we assume that the builder is looking at the PC board with the "audio in" via to the builder's left, and audio out to the right.

Stage Ø: The Layout

If IC sockets are used (highly recommended), insert them first. When inserting the socket for IC1, be careful to move it away from R1, R2, and R3 and toward R4 to make soldering easier later. Also check each joint on this socket very carefully (measure it with an ohm meter if needed) to ensure all pins are soldered well. A few minutes spent here may save anguished time later.

Stage 1: The Power Supply

Insert the following components (recommended in this order) onto the PC board. Foil side is down and stencil side is up. Insert components on the stencil side.

[ ] R15 4.7k Ω (yellow, violet, red)
[ ] C15 .33µF (334)
[ ] R11 10 Ω (brown, black, black)
[ ] C1 4.7µF electrolytic (observe polarity-short leg is negative)
[ ] C2 4.7µF electrolytic (observe polarity-short leg is negative)
[ ] C5 .1µF (104)
[ ] R17 10k Ω (brown, black, orange)
[ ] R18 10k Ω (brown, black, orange)
[ ] C16 .1µF (104)
[ ] C11 100µF electrolytic (observe polarity-short leg is negative)
[ ] C19 .1µF (104)
[ ] IC4 78L09 9v regulator - handle carefully and insert with correct orientation.

Prior to applying voltage power, check the resistance with an ohm meter between the Vcc (positive side of power) and GND (ground) connections. The resistance reading should indicate some amount of resistance other than a short (the exact value will depend on your meters impedance). If the reading is shorted (zero ohms), *do not apply power* but check your work for solder bridges to ground!

Connect a red wire to the Vcc via on the circuit board, and black wire to the ground via. The length will be determined by the builder's enclosure needs. Note also that the NEScaf has no reverse polarity protection or fusing. Builders are advised to exercise great care when connecting power to the circuit.

Connect power to the circuit board—Vcc (11.5 to 13.8 v). Nominal power of 12v. is expected for the NEScaf, but voltage down to 11.5 volts should still work. Positive voltage is connected to the red lead, and black lead negative (GND) is attached to the ground lead.

Check the following pin connections to ground.

[ ] IC1 pin 6 = 9vdc
[ ] IC1 pin 7 = 9vdc
[ ] IC1 pin 8 = 9vdc
[ ] IC1 pin 5 = 4.5vdc
[ ] IC1 pin 12 = 4.5vdc
[ ] IC1 pin 15 = 4.5vdc
[ ] IC1 pin 16 = 4.5vdc
[ ] IC2 pin 6 = Vcc supplied to board
[ ] IC3 pin 4 = 9vdc

Turn off the power and move on to stage two—audio amplifier.

Stage 2: Audio Amplifier

Insert the following components--

[ ] C18 4700pf (472)
[ ] R20 15k Ω (brown, green, orange)
[ ] C9 1µF (105) This is a tantalum cap and is polarized. The hard to see black stripe points to the positive lead. Insert with the positive lead closest to IC1. Do not clip the leads on this capacitor after soldering, as they will be used to test the circuit when done.
[ ] C10 .01µF (103)
[ ] C3 10µF electrolytic (observe polarity-short leg is negative)
[ ] C12 .1µF (104)
[ ] R12 10 Ω (brown, black, black)
[ ] R14 10k Ω pot (you may need to gently move the legs to position this on the board)
[ ] IC2 LM386 – Makes sure IC pins are parallel to each other when inserting into socket, if used. Pin one is marked by a circular indentation on the top of the IC package and it should be placed toward the middle of the circuit board.

**If you have an audio oscillator near by, connect it to the lead of C9 farthest away from IC1. Should an audio oscillator not be available, any audio source will do (audio from another rig for instance). Connect a speaker or low impedance headphones between the 'audio out' connection and ground; apply power. You should hear an audio tone. Now apply the same audio tone to pin 19 on IC1, (IC 1 MP10 should *not* be inserted yet). Audio should be heard in the speaker. Adjust R14 to ensure it varies the volume and set to approximately ¼ turn cw.

Once the SCAF filter is completed, R14 will adjust the volume output of the filter. We chose a design which would provide for unity gain, inasmuch, when the filter is turned on or off, the volume output does not change. If SW1 is wired as recommended, the NEScaf may be left inline between the rig of choice and the user's speaker or headphones, and audio will bypass the NEScaf to the output when the SCAF filter is off. Some builders may choose to replace R14 with a panel mounted potentiometer to allow controlling the NEScaf volume.Stage 3: Clock Generator

Insert the following components--

[ ] C6 .001 µF (102) - This is an NPO capacitor and is critical in the design. Substituting a non-

NPO capacitor may allow the filter center frequency to shift.

[ ] C8 .01µF(103)
[ ] C7 1µF (105) Tantalum - observe polarity with positive away from IC1.
[ ] R8 2k Ω (red, black, red)
[ ] R9 10k Ω pot (perform component leads to positioned onto PC board)
[ ] IC3 555 timer IC. Makes sure pins are parallel to each other when inserting into socket, if used.
[ ] R10 10k Ω off-board potentiometer with detent.. Center connection (wiper) connects to **R10_w** and left hand connection, looking from front, connects to **R10** on PC board. This will cause *cw* (clockwise) turning to correspond decreasing resistance, and as a result increasing frequency.

Applying power should produce about 70kHz on pins 10 and 11 of IC1 (*without* MF10 IC chip inserted). This should be easily detected with a scope or a frequency counter. The clock will be about 9v peak-to-peak so be careful connecting the leads to a frequency counter that it does not overload or damage the input.

A careful observation will show that there are two potentiometers setting the frequency of the oscillator and by extension, the center frequency of the band pass of the filter. The frequency of the 555 is 100x the center frequency of the filter. A frequency of 70 kHz for the 555 circuit will result in a center frequency of 700 Hz. for the filter overall The two potentiometers are used to allow the center frequency, selected by the user, to correspond to the detent position of the off-board potentiometers. Further discussion follows for setting the center frequency once the SCAF filter is completed.

Stage 4 The Scaf Filter

Insert the following components--

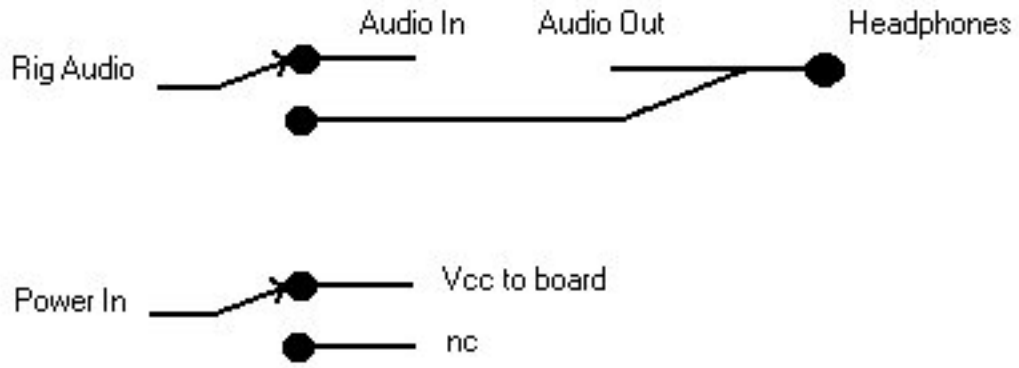
[ ] R2 27k Ω (red, violet, orange)-- red and orange are easy to confuse, so measure these with an ohm meter prior to soldering to be sure.
[ ] R1 2.7k Ω (red, violet, red)
[ ] R3 27k Ω (red, violet, orange)
[ ] R5 27k Ω (red, violet, orange)
[ ] R4 2.7k Ω (red, violet, red)
[ ] R6 27k Ω (red, violet, orange)
[ ] C17 1µF (105)
[ ] R7 Panel mounted, dual gang 50k Ω potentiometer--Take care that the wiper connection (middle pin on pot.) goes to the designated *W* connections on circuit board. The circuit board is labeled **R7a** and **R7a_w** for the first gang, and **R7b** and **R7b_w** for the second. Looking at the front of the potentiometers, connect the right tab of each gang to the correct circuit board location. Twist the leads to each pot separately as it makes it easier to keep track. Some components already mounted on the circuit board might 'hide' the *W* so be familiar with the PC board layout.
[ ] IC1 MF10 IC chip (National) Makes sure pins are parallel to each other when inserting (if using sockets) and pin 1 is toward the top of the PC board.

The SCAF filter at this point could be connected to an audio generator at the SCAF audio input point. Connect a small speaker to the audio output (using the appropriate grounds); connect power; the tone should be audible to your ear. If there is no audio, turn the bandwidth potentiometer (double pot) extreme left or right, and then turn the center frequency pot to hear audio At this point, you should hear an audio signal..

Stage 5 Final Things

The NEScaf should now be fully populated. Some panel connections need to be made.

- **DPDT SW1:** This switch is two switches in parallel: one to control power to the NEScaf and the other to control audio to the headphones. (See diagram below.) Section A controls power, with the center connection coming from the battery to the unit. The lower contact of section A will be connected to Vcc on the PC board. The upper contact of section A is not connected--*nc*. Section B controls audio with the center connection coming from the 'audio in' connector--from the rig. The lower connection of section B will connect to 'audio in' on the circuit board. The upper connection of section B will go to the 'audio out' connector to the headphones. The 'audio out' of the circuit board should also be connected to the 'audio out' connector to the headphones. Connected this way, and when power is on, 'audio in' is routed from the rig through the switch to the audio input of the NEScaf. When power is off, 'audio in' is routed directly to the 'audio out' connector to the headphones.



Review your wiring.
[ ] Mount audio connectors: as desired.
[ ] Mount LED power indicator.

- **LED POWER INDICATOR**. An LED is provided in the standard kit and can be connected to the PC board. Observe polarity (longer lead to the circuit board). The LED can be panel mounted, board mounted, or omitted altogether. It will light when DC power is on and the SCAF is functional.
- **AUDIO CONNECTORS**: Two portable radio size, female audio connectors are supplied in the optional connector kit. One audio connector soldered to the audio input of the DPDT switch and the other audio connector is soldered to the 'audio output' on the PC board. Ground connections should be made to the appropriate points on the circuit board.

POWER CONNECTION: A standard 2.1mm x 5.5mm power connector is provided in the optional connector kit. Note that often the GND is connected to the outside pin and positive to the interior pin. Also note that no fusing or reverse power protection is provided with the NEScaf. *Caveat* builder and be careful! Once the filter has all the appropriate connections, the two on board potentiometers can be adjusted for optimal use:

- **R10** adjusts the center frequency of the filter. Connect the filter to the audio output of your favorite rig, and set the rig to produce its side tone. Set the bandwidth of the filter to its widest position. Now, set the center frequency panel potentiometer to its detent position. The side tone should be heard on the output speaker or headphones. Slowly narrow the bandwidth with the **BW** (bandwidth) potentiometer, and adjust **R10** to keep the side tone audible. When the bandwidth is its narrowest setting, peak the

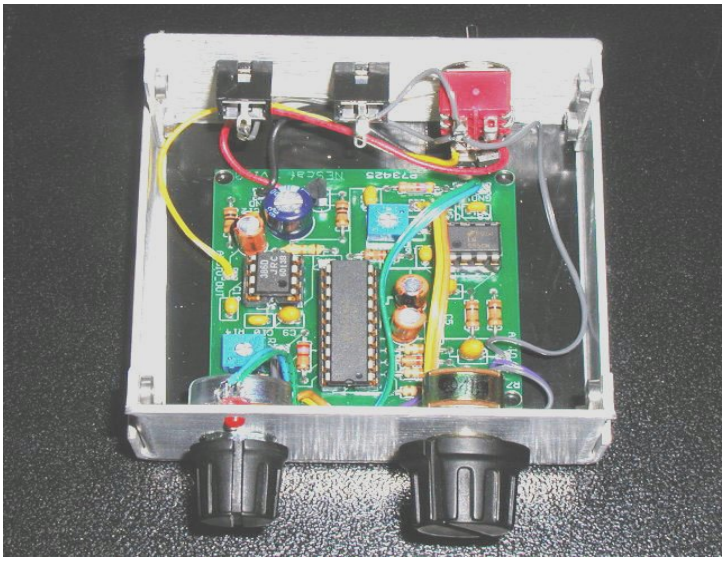
audio heard with **R10**. The filter is now centered for the rig of choice. The NEScaf can also be used as a 'zero beat' tool at its narrowest setting.

- **R14** adjusts the audio volume out from the NEScaf. If **SW1** is wired as above, audio from the rig of choice should be audible directly from the rig when the NEScaf is off, and should be filtered and audible when the NEScaf is on. We have found it convenient to adjust **R14** so that the audio volume is the same whether the filter is on or off.

What if the SCAF does not work. [Troubleshooting] Suggestions…

- Take a break and come back to it when you're ready. Other hams have built the SCAF filter and have it working. You can too!
- Reheat every connection on the bottom of the board to be certain you do not have a cold solder joint. Unfortunately, however, cold solder joints or a solder bridge are two of the most common mistakes in kit building. Be careful and work slowly and you'll be rewarded!
- Recheck the voltages on the ICs and reread the resistor placement for any unexpected placement.
- Check each stage for proper operation:
    - Power is okay?
    - With IC1 removed, does the audio amp work properly?
    - With IC1 removed, does the 555 clock generator work properly?
    - Check each of the connections from IC1.

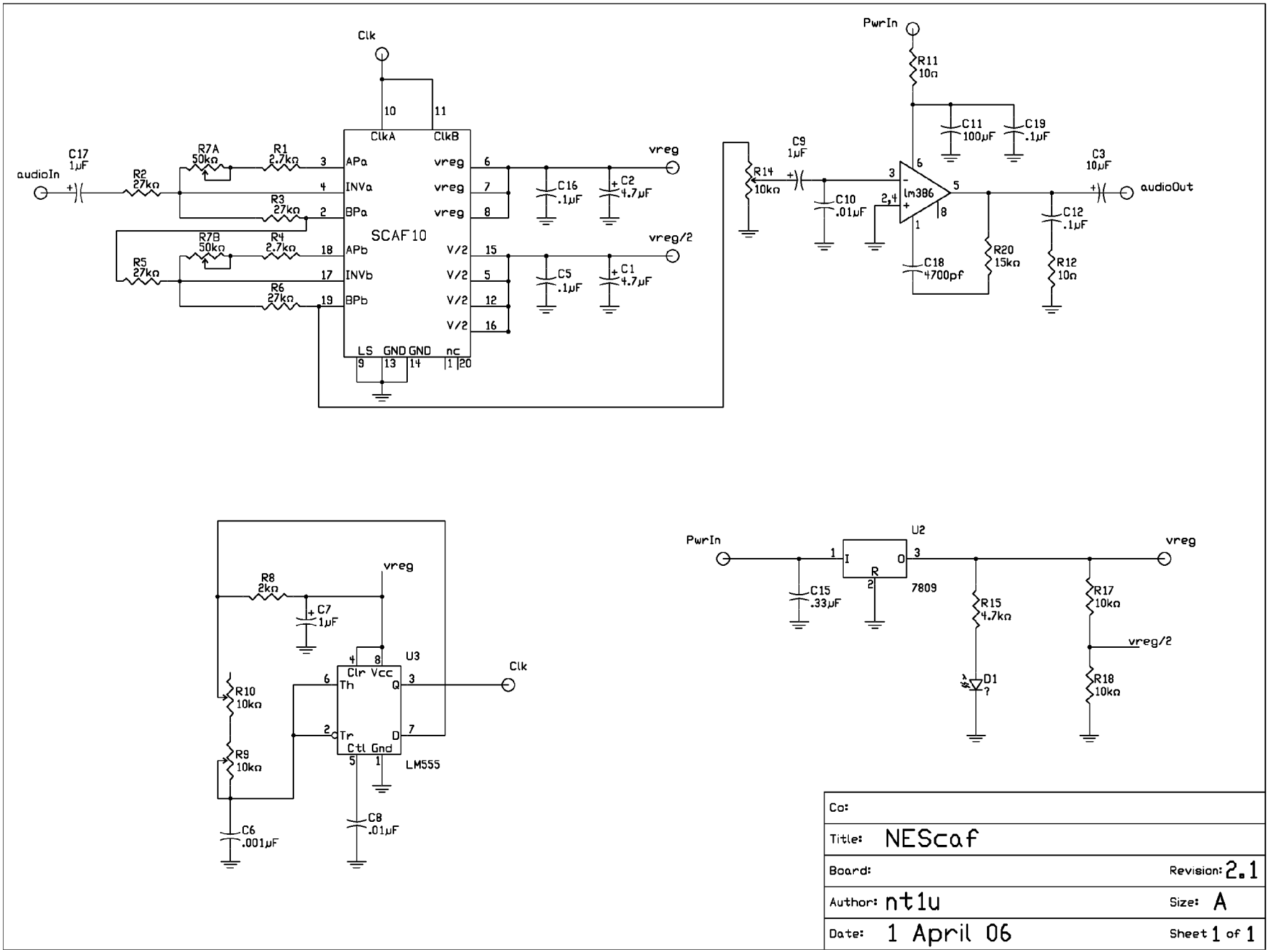
Beyond this builders have two resources: There will be a forum for discussing problems (and accolades) on www.newenglandqrp.org. The exact location has not been determined at this writing. For problems beyond that scope, the NEQrp has a online email NEScafhelp@optoline.net. We do ask that email be sent there only when the forum has been tried first.



August 2006 Parts List

Part	Value	Part	Value
C1	4.7µF 50v electrolytic	R1	2.7k Ω 1/4w (all resistors 1/4w)
C2	4.7µF 50v electrolytic	R2	27k Ω
C3	10µF 50v electrolytic	R3	27k Ω
C5	.1µF	R4	2.7k Ω
C6	.001µF (NPO)	R5	27k Ω

C7 1µF tantalum C8 .01µF C9 1µF Tantalum C10 .01µF C11 100µF 50v electrolytic C12 .1µF C15 .33µF C16 .1µF C17 1µF Tantalum C18 4700pf C19 .1µF **NOTE**: C4, C13, and C14 were removed during design revisions.	R6 27k Ω R7 Dual gang 50k Ω panel mounted potentiometers R8 2k Ω R9 10k Ω on board potentiometer R10 10k Ω panel mounted potentiometer, with center detent R11 10 Ω R12 10 Ω R14 10k Ω panel mounted potentiometer, with center detent R15 4.7k Ω R17 10k Ω R18 10k Ω R20 15k Ω **NOTE**: R13, R16, and R19 were removed during design revisions.
IC1 MF10BN switched capacitive filter (National Semiconductor, available from Digi-Key) IC2 LM386 Op amp IC3 555 timer IC4 78L09 regulator LED Green SW1 DPDT panel mounted switch	



Co:	
Title:	NEScaf
Board:	Revision: 2.1
Author: nt1u	Size: A
Date: 1 April 06	Sheet 1 of 1

Not included in basic kit:

Audio connectors, (optional kit)
Power connectors, (optional kit)
IC sockets: 1 ea. 20 pin, 2 ea. 8 pins
Enclosure

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K1LGQ 23Aug06

Stencil Layout