DISCOVERY
SERIES

K-2802 Function Generator Kit

Assembly Manual

This kit allows you to build a versatile, good quality function generator at a low cost.

Both the amplitude and frequency are voltage controlled which gives the experimenter a variety of useful options. For example, by using two of these kits, an audio sweep generator or amplitude modulated audio generator can be produced.

The circuit includes a voltage regulator for good stability against varying supply voltage and loading. A trimming facility is provided for frequency allignment when a calibrated dial is used.

The function generator can be powered from a single 9V battery (not included) for portability, or any DC supply between 8.5V and 15V. A 216 type 9V battery connector is provided.

To facilitate construction of the function generator, the PCB has been designed to slide directly into a zippy box (D.S.E. cat. no. H-2851). Sockets for output and modulation connections are not provided as these should be selected to suit the particular application.

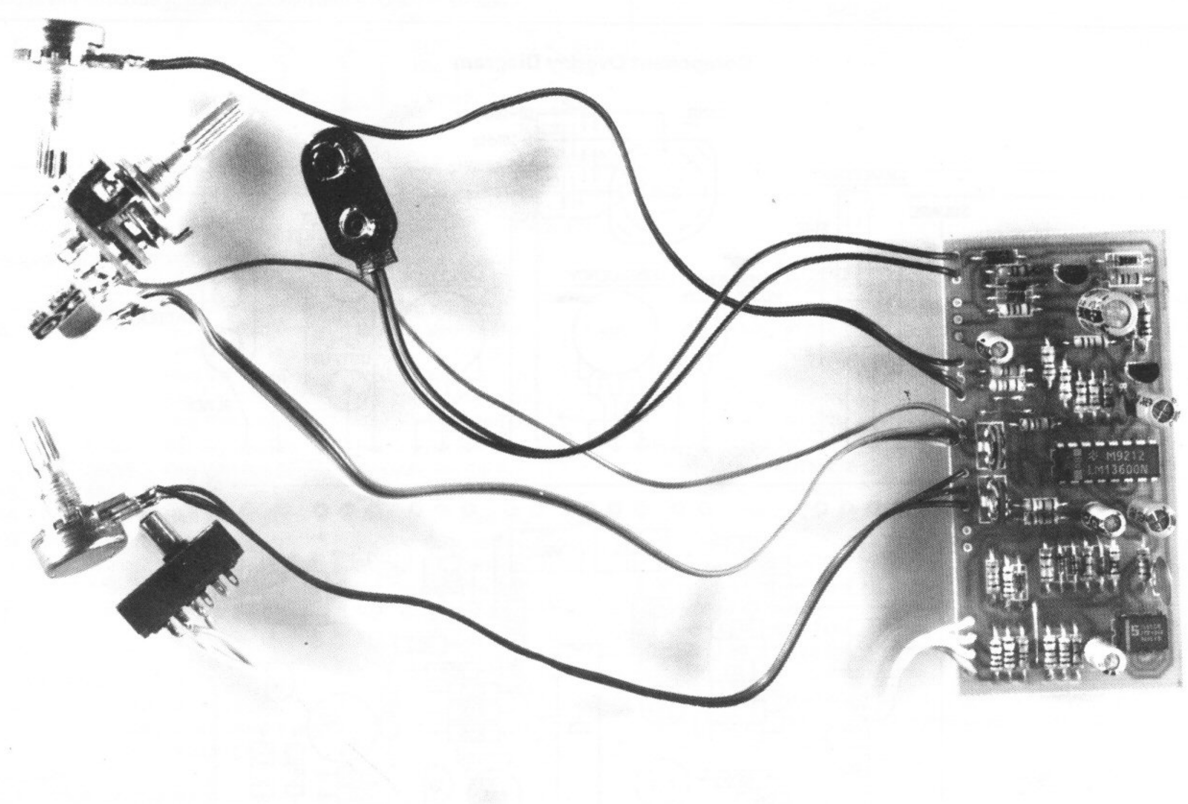
Please read Disclaimer & Guarantee carefully before commencing construction.

The guarantee on this kit is limited to the replacement of faulty parts only, as we cannot guarantee the labour content you provide.

It is recommended that if a kit builder does not have enough knowledge to diagnose faults, that the project should not be started unless assistance can be obtained. (Unfortunately, one small faulty solder joint or wiring mistake can take many hours to locate and at normal service rates, the service charge could well be more than the total cost of the kit!).

If you believe that you will have difficulty in building this kit and you cannot get assistance from a friend, we suggest you return the kit to us in its original condition, accompanied by receipt of purchase, for a full refund under our satisfaction guarantee.

Unfortunately, kits cannot be replaced under our satisfaction guarantee once construction has been commenced.



Specifications

• Output Waveforms	Sine, Square, Triangle
• Output Level	0-5Vp-p (load 250 W) 0-1Vp-p (load = 50 W)
• Output Impedance	<10 W at 1kHz (independent of level setting)
• Output Level Control	linear voltage control
• Amplitude Modulation Input	AC coupled
max. input	1.4Vrms (for 5Vp-p 100% mod. output)
• Output Frequency	10Hz-100kHz in 4 bands
• Output Frequency Control	linear voltage control
• Frequency Modulation Input	AC coupled
max. input	1.3Vrms (for 1 decade sweep)
• Supply voltage	8.5-15V DC
• Supply current	25mA at 9V

Construction

The complete function generator except for main controls, band capacitors and battery, is mounted on a single printed circuit board (PCB). To mount components, first look at the overlay diagram to find the component name e.g. D3 then look down the parts list to find the value required. Some of the components must be mounted in a particular direction as described in this section.

Begin construction by installing all the resistors on the PCB. There is a special list for the resistors which shows the colour code for the particular resistance value required. The last band of the colour code is the one furthest from the other bands. Resistors can be mounted in either direction, but it is good practise to mount them with their colour codes all in the same direction for ease of reading the values.

Next mount the diodes D1-7 and ZD1. These have to be mounted in the right direction, with the stripe on the very end of the diode corresponding to the striped end shown on the overlay diagram.

Next mount integrated circuits IC1and 2.

CAUTION: The TLC555 IC is a CMOS type which is sensitive to static electricity. Note the following precautions.

- Do not remove it from its protective foam until you are ready to install it.
- Avoid touching the pins with your fingers.
- Make sure that your soldering iron is properly earthed.
- Solder the power and earth pins of the IC to the board first.

Mount the IC's so that the end with the notch in it is at the same end n as shown on the overlay.

Next mount the transistors Q1and 2. Position them so that the flat face faces the same direction as on the overlay. Do not push them down too hard into the PCB as this will spread the leads excessively and may damage the internal connections.

Now mount the capacitors C1and C6-12. Note that C1, 7 and 9-12 are electrolytic types which must be mounted in the right direction. The negative lead is marked on the side of the capacitor with a negative (-) sign and the other lead, which is not marked, goes to the position that is marked with a positive sign (+) on the overlay. The two ceramic capacitors C6 and 8 can be mounted in either direction.

Next mount the two trimpots VR1and 3. It's a good idea to bend the leads over after they are inserted into the board to give them a better mechanical hold on the board, rather than just relying on the solder.

After you have decided how to mount the PCB, controls and sockets, the overlay diagram shows the rear of the controls, just as you would see when soldering wires to them.

The layout of the wiring is not critical but the wires to the waveform and band selection switches (SW1 & SW2) should be kept as short as possible to reduce the risk of picking up interference from external sources. Capacitors C2-5 should be mounted with their leads cut short, directly onto the band selection switch with just a twin wire running back to the PCB.

When mounting the 9V battery, make sure that its metal case cannot come into contact with any of the controls or the PCB. If the function generator is built into a zippy box, you could use a cardboard partition to contain the battery at one end of the box.

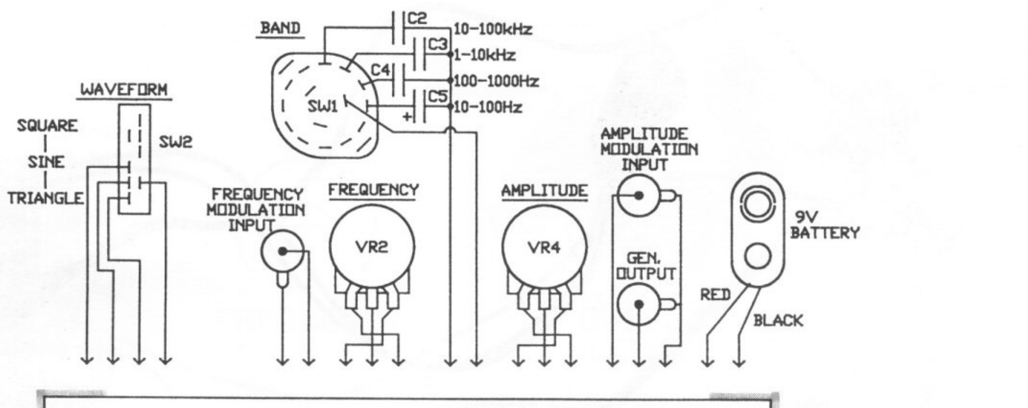
How it works

This function generator is based on a type of integrated circuit called an Operational Transconductance Amplifier or OTA for short. The particular device used here is the National Semiconductor LM13600. This device contains two OTA's, each with a darlington buffer stage that can be externally connected if required.

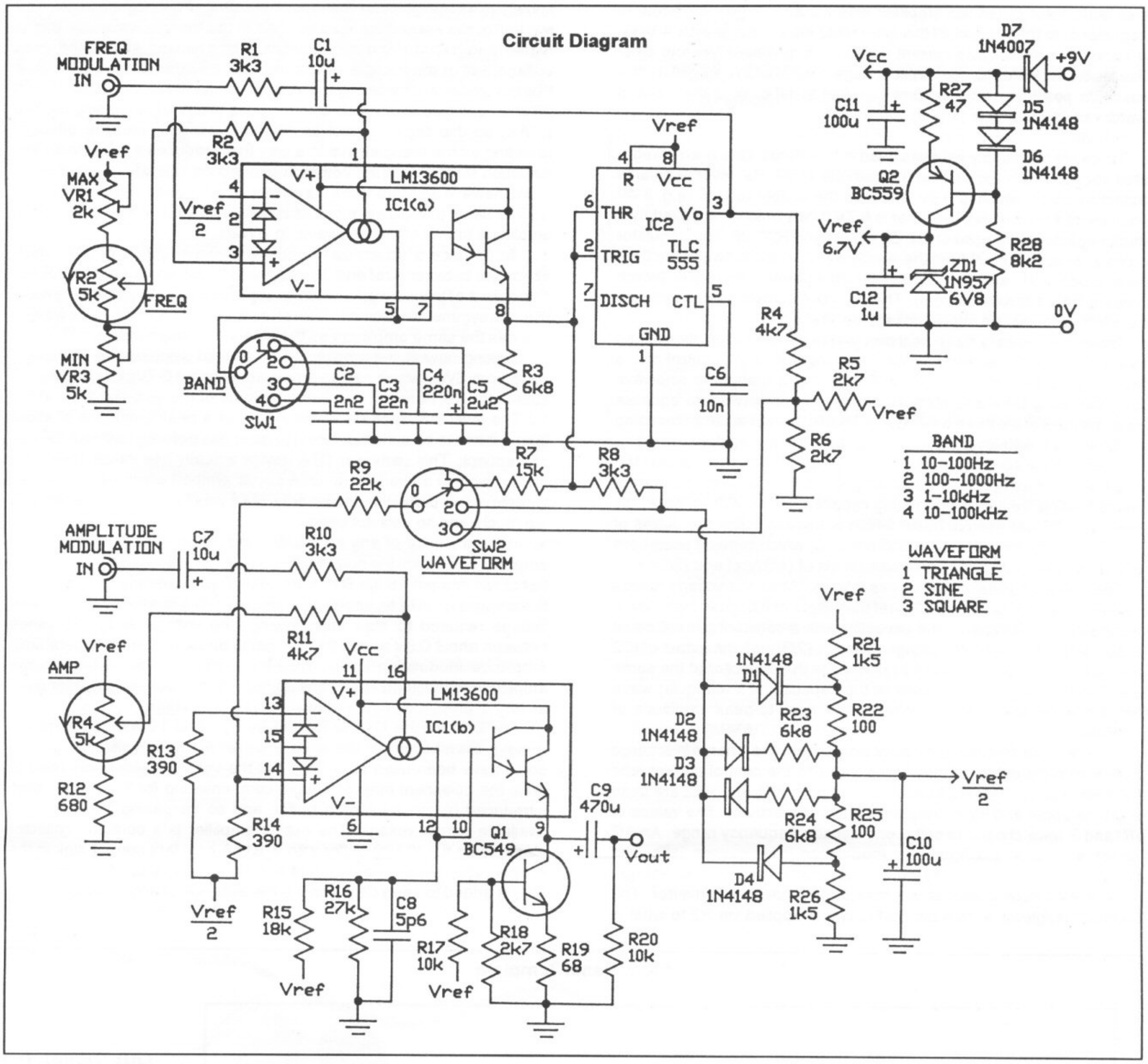
The main difference between an OTA and the more common types of op-amps like the 741 is that the OTA provides an output current that is proportional to the differential input voltage, whereas the others provide an output voltage that is proportional to the differential input voltage.

A feature of the OTA that makes it specially suited for this application

Component Overlay Diagram



Circuit Diagram



PARTS LIST

Resistors (all 0.25W/ 1% metal film unless otherwise stated)

		4 Band 1%	5 Band 1%
4 R1,2,8,10	3.3k	Org Org Red Brn	Org Org Blk Brn Brn
3 R3,23,24	6.8k	Blu Gry Red Brn	Blu Gry Blk Brn Brn
2 R4,11	4.7k	Yel Vio Red Brn	Yel Vio Blk Brn Brn
3 R5,6,18	2.7k	Red Vio Red Brn	Red Vio Blk Brn Brn
1 R7	15k	Brn Grn Org Brn	Brn Grn Blk Red Brn
1 R9	22k	Red Red Org Brn	Red Red Blk Red Brn
1 R12	680Ω	Blu Gry Brn Brn	Blu Gry Blk Blk Brn
2 R13,14	390Ω	Org Wht Brn Brn	Org Wht Blk Blk Brn
1 R15,	18k	Brn Gry Org Brn	Brn Gry Blk Red Brn
1 R16	27k	Red Vio Org Brn	Red Vio Blk Red Brn
1 R19	68Ω	Blu Gry Blk Brn	Blu Gry Blk Gld Brn
2 R17,20	10k	Brn Blk Org Brn	Brn Blk Blk Red Brn
2 R21,26	1.5k	Brn Grn Red Brn	Brn Grn Blk Brn Brn
2 R22,25	100Ω	Brn Blk Brn Brn	Brn Blk Blk Blk Brn
1 R27	47Ω	Yel Vio Blk Brn	Yel Vio Blk Gld Brn
1 R28	8.2k	Gry Red Red Brn	Gry Red Blk Brn Brn

Potentiometers

1 VR1	2k	5mm vertical trimpot
2 VR2,4	5k	16mm linear potentiometer
1 VR3	5k	5mm vertical trimpot

Capacitors

2 C1,7	10uF 16/35V RB electrolytic
1 C2	2.2nF (.0022uF, 2200pF, 222) 100V MKT
1 C3	22nF (.022uF, 223) 100V MKT
1 C4	220nF (0.22uF, 224) 100V MKT
1 C5	2.2uF 100V RB electrolytic
1 C6	10nF (0.01uF, 103) 50V ceramic
1 C8	5.6pF 50V ceramic
1 C9	470uF 10V RB electrolytic
2 C10,11	100uF 16V RB electrolytic
1 C12	1uF 50V RB electrolytic

Diodes

6 D1-6	1N4148/1N914 small signal
1 D7	1N4007power
1 ZD1	1N957 6.8V 400mW zener

Transistors

1 Q1	BC549 NPN small signal
1 Q2	BC559 PNP small signal

Integrated Circuits

1 IC1	LM13600 dual OTA
1 IC2	TLC555 timer CMOS

Miscellaneous

1 3 pole/4 position rotary switch; 1 2 pole/3 position slide switch; 1 9 volt battery snap connector; rainbow cable 30cm; solder; 1 PCB ZA1202 42.9 x 87.8mm.

is an extra input called the amplifier bias input. The output current is proportional to the product of the differential input voltage (Vin = V(+)-V(-) and the amplifier bias current (Iabc) i.e. it multiplies Vin and Iabc. This facility allows us to use direct voltage control of the amplifier. The maximum possible output current is equal to Iabc, so if the input is overdriven, the output is (+/-)Iabc for (+/-)Vin .

There are two supply voltages used in this circuit. One is an unregulated voltage which appears on the cathode of D7, the reverse polarity protection diode, which is 0.6V less than the supply voltage (e.g. 8.4V when using a 9V supply), the other is 6.7V (Vref) which is supplied by a shunt regulator comprised of Q2,ZD1,D5-6 and R27-28. This regulator draws a constant current from the supply which is split between the 6.8V zener diode ZD1, and the circuitry which operates from Vref (which draws a fairly constant current). The constant current source reduces the effects of a varying supply voltage on Vref.

There are basically three sections to this circuit. Firstly, there is an oscillator using IC1(a) and IC2 with variable frequency control and a frequency modulation input. Secondly, there is a triangle to sinewave converter using D1-4 and R21-26, and a resistor network to equalise the amplitudes of the three waveforms. Thirdly there is an amplifier using IC1(b) and Q1, with level control and an amplitude modulation input.

The oscillator itself consists of three sections. Firstly there is the OTA in IC1(a) which is not used as an amplifier but as a switched current source feeding the band determining capacitor (one of C2-4). Secondly there is the IC1(a) internal buffer which is used to buffer the output of the OTA. Thirdly there is IC2, a 555 timer IC, which is being used here as a comparator with input hysteresis levels of (1/3)Vref and (2/3)Vref.

The way the oscillator works is as follows. When the voltage across the band capacitor is below (1/3)Vref the output of IC2 goes high (Vref), causing the OTA to charge the capacitor with a constant current equal to Iabc. When the capacitor voltage exceeds (2/3)Vref, the output of IC2 goes low (0V) causing the OTA to discharge the capacitor at the same rate. The resulting waveform across the capacitor is a triangular wave that is symmetrical about (1/2)Vref with a peak-to-peak amplitude of (1/3)Vref.

If there is no frequency modulation applied, the charge/discharge current from the output of the OTA is equal to the control current Iabc that flows into pin 1 via R2 from VR2. Trimpots VR1 and VR2 are used to set the upper and lower frequency limits respectively. The values of VR1and 3 were chosen to suit a one decade frequency range. An AC voltage applied to the frequency modulation input causes Iabc, and hence the oscillator frequency, to vary in proportion to the signal voltage.

Next we'll take a look at the triangle to sinewave converter. The buffered trianglewave from pin 8 of IC1(a) is applied via R8 to what is known as a breakpoint waveshaper consisting of D1-4 and R21-26. The top half of the network shapes the half of the triangle waveform that is higher than (1/2)Vref and the bottom half of the network shapes the lower voltage half of the triangle waveform. The way the converter works is that the diodes are biased by the voltage divider made of R21,22,25 and 26 (the centre point of which also provides (1/2)Vref for biasing the two OTA's) so that they conduct at different voltages, with the effect of rounding off the trianglewave in a way that produces a reasonably low distortion sinewave at the common connection side of the four diodes. This sinewave appears at the waveform selector switch terminal SW2/2.

The same trianglewave output is also fed via R7, which reduces the amplitude to that of the sinewave, to SW2/1.

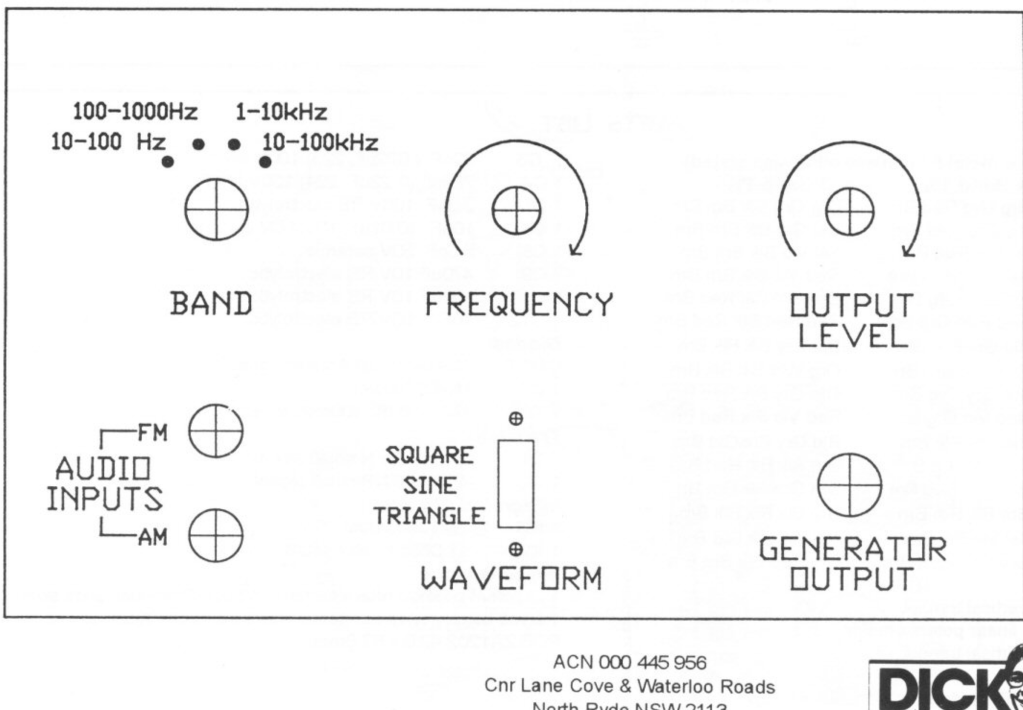
To produce a squarewave, the squarewave output of IC2, which alternates between Vref and 0V, is applied to the resistor network R4-6. The output of this network, which is applied to SW2/3, is a squarewave which is symmetrical about (1/2)Vref (as are the triangle and sine waves) and has the same amplitude as the sine and triangle waves.

Looking now at the amplifier, the selected sine, square or triangle wave from SW2, which has an amplitude of about 0.7Vpk, is applied via attenuator R9,14 to the non inverting input of the amplifier OTA at pin 14. The level that appears at this input has a peak amplitude of about 20mV. It has to be at this low level to minimise distortion without the use of feedback. This particular OTA device actually has inbuilt linearising diodes (shown as part of the OTA circuit symbol) which can be biased to remove this particular nonlinearity, but it was found to reduce the gain too much, and so was not used.

In the absence of any amplitude modulation input, the gain of the amplifier, and hence the output level, is determined by the control current (Iabc) fed into pin 16 via R11 from VR4. R12 raises the voltage at the bottom end of VR4 to about 0.8V because this is about the minimum voltage required to start Iabc flowing (the voltage at pin 16 varies between about 0.8V and 1.4V depending on current and temperature). Amplitude modulation is achieved by applying an ac voltage to the amplitude modulation input causing Iabc, and hence the amplifier gain, to vary in proportion to the modulation signal voltage.

The load for the OTA is formed by R15 and 16 with C8 added to remove overshoot from the square wave. A single resistor to ground could have been used as a load, but the voltage divider was used to raise the quiescent output voltage, compensating for the voltage drop introduced by the darlington buffer, and so increasing the maximum available output voltage. The output amplifier is a common collector stage using the IC1(b) buffer with a 10mA constant current sink in the emitter. This gives a peak output current capability of 10mA. Resistor R20 is added to keep C9 biased in the absence of any other DC load.

Front Panel Template



This template can be photocopied and used as a guide to drilling the lid from a H-2851 case and can also be used for the front panel label.

ACN 000 445 956
Cnr Lane Cove & Waterloo Roads
North Ryde NSW 2113
Ph: (02) (Int 612) 888 3200 Fax: 888 3631