Application Note AN-14

A High Quality Function Generator System Using the XR-2206

INTRODUCTION

Waveform or function generators capable of producing AM/FM modulated sine wave outputs find a wide range of applications in electrical measurement and laboratory instrumentation. This application note describes the design, construction and the performance of such a complete function generator system suitable for laboratory usage or hobbyist applications. The entire function generator is comprised of a single XR-2206 monolithic IC and a limited number of passive circuit components. It provides the engineer, student, or hobbyist with highly versatile laboratory instrument for waveform generation at a very small fraction of the cost of conventional function generators available today.

GENERAL DESCRIPTION

The basic circuit configuration and the external components necessary for the high-quality function generator system is shown in Figure 1. The circuit shown in the figure is designed to operate with either a 12V single power supply, or with a ±6V split supplies. For most applications, split-supply operation is preferred since it results in an output DC level which is nearly at ground potential.

The circuit configuration of Figure 1 provides three basic waveforms: sine, triangle and square wave. There are four overlapping frequency ranges which give an overall frequency range of 1 Hz to 100 kHz. In each range, the frequency may be varied over a 100:1 tuning range.

The sine or triangle output can be varied from 0 to over 6V (peak to peak) from a 600 ohm source at the output terminal.

A squarewave output is available at the sync output terminal for oscilloscope synchronizing or driving logic circuits.

TYPICAL PERFORMANCE CHARACTERISTICS

The performance characteristics listed below are not guaranteed or warranted by Exar. However, they represent the typical performance characteristics measured by Exar's application engineers during the laboratory evaluation of the function generator system shown in Figure 1. The typical performance specifications listed below apply *only* when all of the recommended assembly instructions and adjustment procedures are followed:

(a) **Frequency Ranges**: The function generator system is designed to operate over four overlapping frequency ranges:

1 Hz to 100 Hz
10 Hz to 1 kHz
100 Hz to 10 kHz
1 kHz to 100 kHz

The range selection is made by switching in different timing capacitors.

(b) **Frequency Setting**: At any range setting, frequency can be varied over a 100:1 tuning range with a potentiometer (see R_{13} of Figure 1).

(c) **Frequency Accuracy**: Frequency accuracy of the XR-2206 is set by the timing resistor R and the timing capacitor C, and is given as:

$$f = 1/RC$$

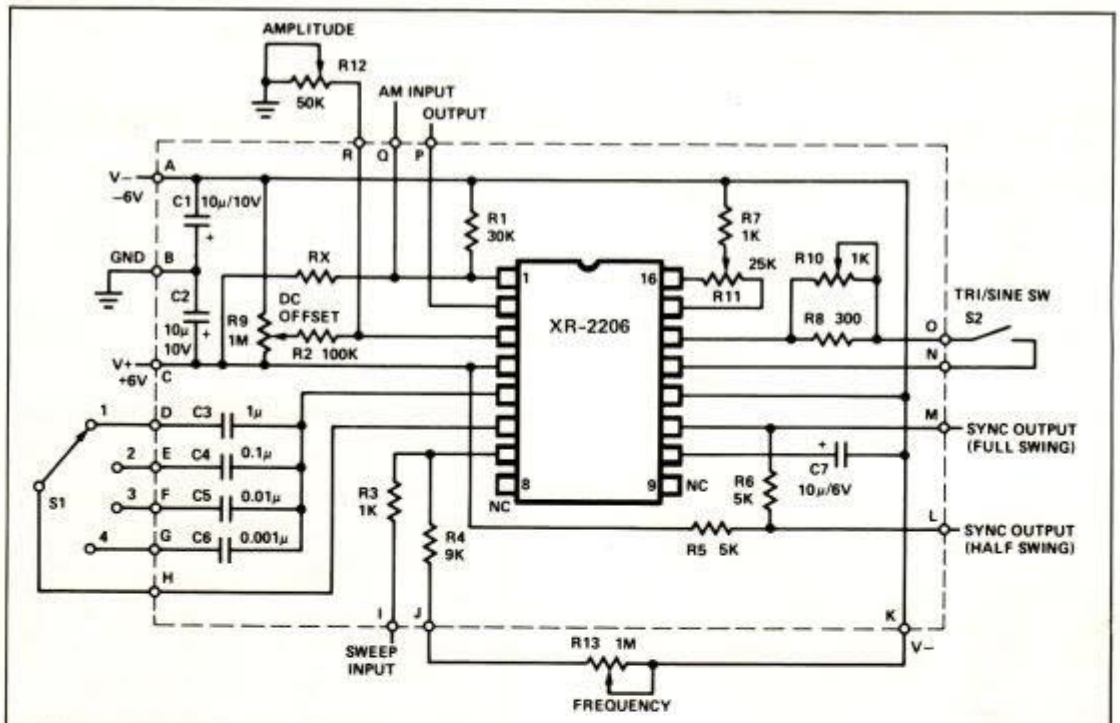
The above expression is accurate to within ±5% at any range setting. The timing resistor R is the series combination of resistors R_4 and R_{13} of Figure 1. The timing capacitor C is any one of the capacitors C_3 through C_6, shown in the figure.

(d) **Sine and Triangle Output**: The sine and triangle output amplitudes are variable from 0V to 6 V_{pp}. The amplitude is set by an external potentiometer, R_{12} of Figure 1. At any given amplitude setting, the triangle output amplitude is approximately twice as high as the sinewave output. The internal impedance of the output is 600Ω.

(e) **Sinewave Distortion**: The total harmonic distortion of sinewave is less than 1% from 10 Hz to 10 kHz and less than 3% over the entire frequency range. The selection of a waveform is made by the triangle/sine selector switch, S_2.

(f) **Sync Output**: The sync output provides a 50% duty cycle pulse output with either full swing or upper half swing of the supply voltage depending on the choice of sync output terminals on the printed circuit board (see Figure 1).

(g) **Frequency Modulation (External Sweep)**: Frequency can be modulated or swept by applying an external control voltage to sweep terminal (Terminal 1 of Figure 1). When not used, this terminal should be left open-circuited. The open circuit voltage at this terminal is approximately 3V above the negative supply voltage and its impedance is approximately 1000 ohms.



NOTE:

1. For single supply operation lift GND connection keeping R12 across terminals R and B intact, and connect terminal A to GND.
2. For maximum output, R_X may be open. R_X = 68 KΩ is recommended for external amplitude modulation.

Figure 1. Circuit Connection Diagram for Function Generator. (See Note 1 for single supply operation.)

(h) Amplitude Modulation (AM): The output amplitude varies linearly with modulation voltage applied to AM input (terminal Q of Figure 1). The output amplitude reaches its minimum as the AM control voltage approaches the half of the total power supply voltage. The phase of the output signal reverses as the amplitude goes through its minimum value. The total dynamic range is approximately 55 dB, with AM control voltage range of 4V referenced to the half of the total supply voltage. When not used, AM terminal should be left open circuited.

(i) Power Source: Split supplies: ±6V, or single supply: +12V. Supply Current: 15 mA (see Figure 3).

EXPLANATION OF CIRCUIT CONTROLS:

Switches

Range Select Switch, S1: Selects the frequency range of operation for the function generator. The frequency is inversely proportional to the timing capacitor connected across Pins 5 and 6 of the XR-2206 circuit. Nominal capacitance values and frequency ranges corresponding to switch positions of S1 are as follows:

Position	Nominal Range	Timing Capacitance
1	1 Hz to 100 Hz	1 μF
2	10 Hz to 1 kHz	0.1 μF
3	100 Hz to 10 kHz	0.01 μF
4	1 kHz to 100 kHz	0.001 μF

If additional frequency ranges are needed, they can be added by introducing additional switch positions.

Triangle/Sine Waveform Switch, S2: Selects the triangle or sine output waveform.

Trimmers and Potentiometers

DC Offset Adjustment, R9: The potentiometer used for adjusting the DC offset level of the triangle or sine output waveform.

Sinewave Distortion Adjustment, R10: Adjusted to minimize the harmonic content of sinewave output.

Sinewave Symmetry Adjustment, R11: Adjusted to optimize the symmetry of the sinewave output.

Amplitude Control, R12: Sets the amplitude of the triangle or sinewave output.

Frequency Adjust, R13: Sets the oscillator frequency for any range setting of S1. Thus, R13 serves as a frequency dial on a conventional waveform generator and varies the frequency of the oscillator over an approximate 100 to 1 range.

Terminals

A. Negative Supply −6V
B. Ground
C. Positive Supply +6V
D. Range 1, timing capacitor terminal
E. Range 2, timing capacitor terminal
F. Range 3, timing capacitor terminal
G. Range 4, timing capacitor terminal
H. Timing capacitor common terminal
I. Sweep Input
J. Frequency adjust potentiometer terminal
K. Frequency adjust potentiometer negative supply terminal
L. Sync output (1/2 swing)
M. Sync output (full swing)
N. Triangle/sine waveform switch terminals
O. Triangle/sine waveform switch terminals
P. Triangle or sinewave output
Q. AM input
R. Amplitude control terminal

PARTS LIST

The following is a list of external circuit components necessary to provide the circuit interconnections shown in Figure 1.

Capacitors:

C1, C2, C7	Electrolytic, 10 μF, 10V
C3	Mylar, 1 μF, nonpolar, 10%
C4	Mylar, 0.1 μF, 10%
C5	Mylar, 0.01 μF, 10%
C6	Mylar, 1000 pF, 10%

Resistors:

R1	30 KΩ, 1/4W, 10%
R2	100 KΩ, 1/4W, 10%
R3, R7	1 KΩ, 1/4W, 10%
R4	9 KΩ, 1/4W, 10%
R5, R6	5 KΩ, 1/4W, 10%
R8	300Ω, 1/4W, 10%
RX	62 KΩ, 1/4 W, 10% (RX can be eliminated for maximum output)

Potentiometers:

R9	Trim, 1 MΩ, 1/4W
R10	Trim, 1 KΩ, 1/4W
R11	Trim, 25 KΩ, 1/4W

The following additional items are recommended to convert the circuit of Figure 1 to a complete laboratory instrument:

Potentiometers:

R12	Amplitude control, linear, 50 KΩ
R13	Frequency control, audio taper, 1 MΩ

Switches:

S1	Rotary switch, 1-pole, 4 pos.
S2	Toggle or slide, SPST

Case:

7" x 4" x 4" (approx.) Metal or Plastic
(See Figures 4(a) and 4(b).)

Power Supply:

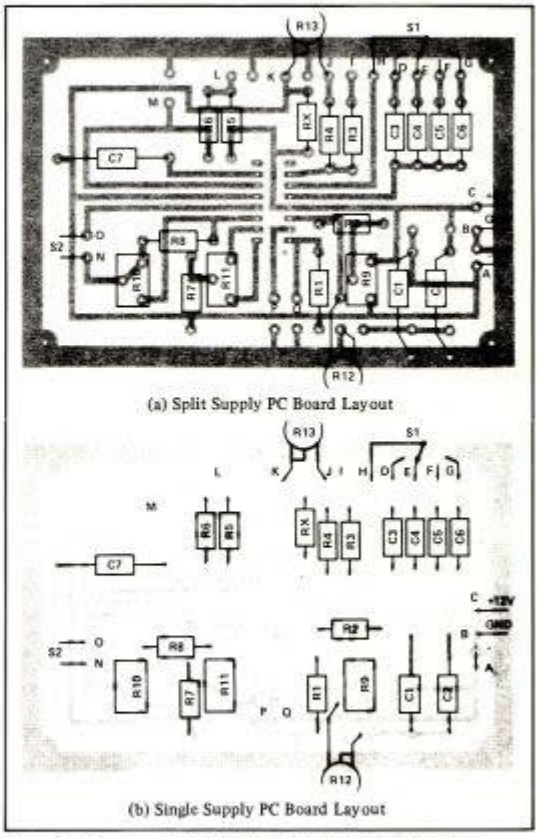
Dual supplies ±6V or single +12V
Batteries or power supply unit
(See Figures 3(a) and 3(b).)

Miscellaneous:

Knobs, solder, wires, terminals, etc.

BOARD LAYOUT

Figures 2(a) and 2(b) show the recommended printed-circuit board layout for the function generator circuit of Figure 1.



(a) Split Supply PC Board Layout

(b) Single Supply PC Board Layout

Figure 2. Recommended PC Board Layout for Function Generator Circuit of Figure 1.

RECOMMENDED ASSEMBLY PROCEDURE

The following instructions and recommendations for the assembly of the function generator assume that the basic PC board layout of Figures 2(a) or 2(b) is used in the circuit assembly.

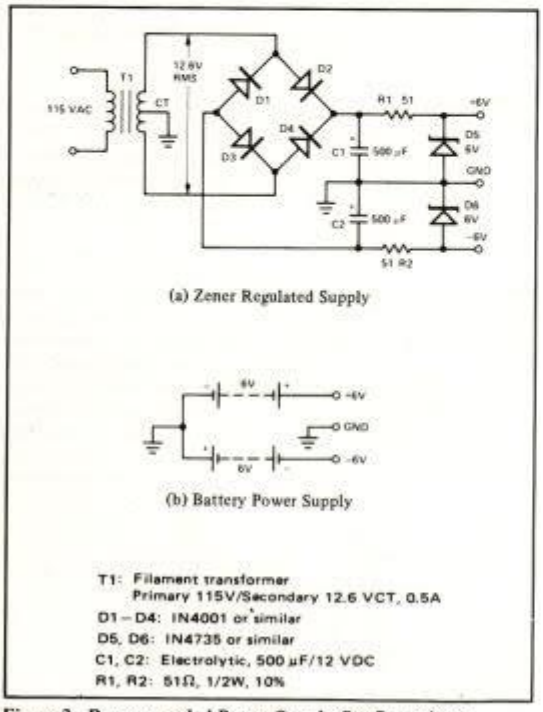
All the parts of the generator, with the exception of frequency adjust potentiometer, amplitude control potentiometer, triangle/sine switch and frequency range select switch, are mounted on the circuit board.

Install and solder all resistors, capacitors and trimmer resistors on the PC board first. Be sure to observe the polarity of capacitors C1, C2 and C7. The timing capacitors C3, C4, C5 and C6 must be non-polar type. Now install IC1 on the board. We recommend the use of an IC socket to prevent possible damage to the IC during soldering and to provide for easy replacement in case of a malfunction.

The entire generator board along with power supply or batteries and several switches and potentiometers will fit into a case of the type readily available at electronic hobby shops. It will be necessary to obtain either output jacks or terminals for the outputs and AM and frequency sweep inputs.

Install the frequency adjust pot, the frequency range select switch, the output amplitude control pot, the power switch, and the triangle/swine switch on the case. Next, install the PC board in the case, along with a power supply.

Any simple power supply having reasonable regulation may be used. Figure 3 gives some recommended power supply configuration.



(a) Zener Regulated Supply

(b) Battery Power Supply

T1: Filament transformer
Primary 115V/Secondary 12.6 VCT, 0.5A
D1 – D4: IN4001 or similar
D5, D6: IN4735 or similar
C1, C2: Electrolytic, 500 µF/12 VDC
R1, R2: 51Ω, 1/2W, 10%

Figure 3. Recommended Power Supply Configurations.

Precaution: Keep the lead lengths small for the range selector switch.

Figure 4 gives an example of the fully assembled version of the function generator system described above.

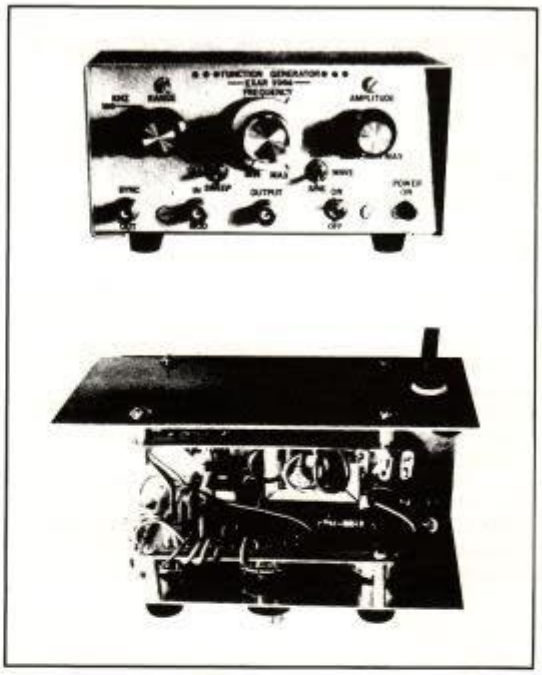


Figure 4. Typical Example of a Fully Assembled Function Generator.

ADJUSTMENT PROCEDURE

When assembly is completed and you are ready to put the function generator into operation, make sure that the polarity of power supply and the orientation of the IC unit are correct. Then apply the DC power to the unit.

To adjust for minimum distortion, connect the scope probe to the triangle/sine output. Close S2 and adjust the amplitude control to give non-clipping maximum swing. Then adjust R10 and R11 alternately for minimum distortion by observing the sinusoidal waveform. If a distortion meter is available, you may use it as a final check on the setting of sine-shaping trimmers. The minimum distortion obtained in this manner is typically less than 1% from 1 Hz to 10 kHz and less than 3% over the entire frequency range.