Monolithic Waveform Generator

GENERAL DESCRIPTION

The XR-205 is a highly versatile, monolithic waveform generator designed for diverse applications in communication and telemetry equipment, as well as in systems design and testing. It is a self-contained, totally monolithic signal generator that provides sine, square, triangle, ramp and sawtooth output waveforms, which can be both amplitude and frequency modulated.

The circuit has three separate sections: a voltage-controlled oscillator (VCO) which generates the basic periodic waveforms; a balanced modulator which provides amplitude or phase modulation; a buffer amplifier section which provides a low impedance output with high current drive capability.

FEATURES

High Frequency Operation
AM and FM Capabilities
Sine, Triangle, Square, Sawtooth, Ramp
 and Pulse Waveforms
Wide Supply Range 8V to 26V
Split Supply Capability

## APPLICATIONS

Waveform Generation
   Sinewave   Sawtooth
   Triangle   Ramp
   Square   Pulse
AM Generation Double Sideband Suppressed Carrier
FM Generation
Sweep Generation
Tone Burst Generation
Simultaneous AM/FM
Frequency-Shift Keyed (FSK) Signal Generation
Phase-Shift Keyed (PSK) Signal Generation
On-Off Keyed Oscillation
Clock Generation

ABSOLUTE MAXIMUM RATINGS

Power Supply	26 Volts
Power Dissipation	750mW
Derate above +25°C	6mW/°C
Temperature	
Storage	−65°C to + 150°C

PIN ASSIGNMENT
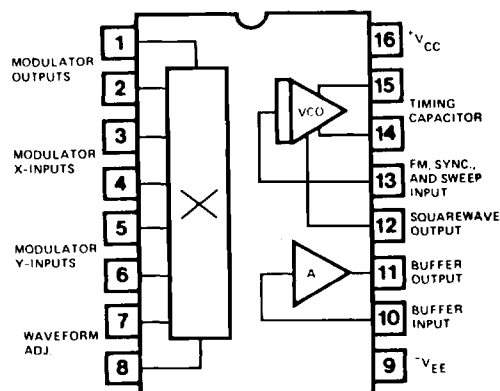
ORDERING INFORMATION

Part Number	Package	Operating Temperature
XR-205	Ceramic	0°C to + 70°C

SYSTEM DESCRIPTION

The XR-205 is a high frequency monolithic function generator capable of sine, square, triangle, ramp, saw-tooth, and pulse waveforms with frequencies ranging to 4MHz. Operating frequency is determined by a single capacitor and may be externally swept over a 10:1 range. Duty cycle is variable from 10% to 90%. Amplitude modulation, up to 100%, is accomplished using the modulator X inputs (Pins 3 and 4). The on board buffer amplifier features 50Ω output resistance and 20mA output capability. The XR-205 operates with either single or split supplies.

ELECTRICAL SPECIFICATIONS

Test Conditions: Supply Voltage = 12V (single supply) $T_A = 25°C$, f = 10kHz, $R_L = 3k\Omega$, unless otherwise specified.

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| PARAMETERS	LIMITS			UNITS	CONDITIONS
	MIN	TYP	MAX		
I — GENERAL CHARACTERISTICS					
Supply Voltage:					
Single Supply	8		26	Vdc	See Figure 1
Split Supply	±5		±13	Vdc	See Figures 2 and 3
Supply Current	8	10	12	mA	w/o buffer amp
Frequency Stability:					
Power Supply		0.2	0.5	%/V	$|V_{CC}-V_{EE}| > 10V$
Temperature		300	600	ppm/°C	Sweep input open circuit
Frequency Sweep Range	7:1	10:1			See Figure 7
Output Swing:					
Single Ended	2	3		Vpp	Measured at pin 1 or 2
Differential	4	6		Vpp	Measured across 1 and 2
Output Diff. Offset Voltage		0.1	0.4	Vdc	Measured across 1 and 2
Amplitude Control Range		60		dB	Controlled by R_q (see Figure 1)
Buffer Amplifier Output Resistance		50		ohms	$R_L = 750\Omega$
Output Current Swing	±6	±10		mA	
II — Output Waveforms					
Sinusoidal:					
Upper Frequency Limit	2	4		MHz	Measured at Pin 11
Peak Output Swing	2	3		Vpp	S_1, S_3 closed. S_2 open
Distortion (THD)		2.5	4	%	closed S_2 Open
Triangle:					
Peak Swing	2	4		Vpp	Measured at Pin 11
Non-Linearity		±1		%	S_1, S_2 open, S_3 closed
Asymmetry		±1		%	f = 10kHz
Sawtooth:					
Peak Swing	2	3		Vpp	See Figure 1, S_2 closed;
Non-Linearity		1.5		%	S_2 and S_3 Closed
Ramp:					
Peak-Swing	1	1.4		Vpp	See Figure 1, S_2 and S_3 open
Non-Linearity		1		%	pin 10 connected to pin 15
Squarewave (Low Level):					
Output Swing	0.5	0.7		Vpp	See Figure 1, S_2 and S_3 Open,
Duty Cycle Asymmetry		±1	±4	%	pin 10 connected to pin 12
Rise Time		20		ns	10pF connected from pin 11
Fall Time		200		ns	to ground
Squarewave (High Level):					
Peak Swing	2	3		Vpp	See Figure 3, S_2 Open
Duty Cycle Asymmetry		±1	±4	%	
Rise Time		80		ns	10pF connected from pin 11
Fall Time		60		ns	to ground
Pulse Output:					
Peak Swing	2	3		Vpp	See Figure 3, S_2 closed
Peak Swing	2	3		Vpp	See Figure 3, S_2 closed
Rise Time		80		ns	
Fall Time		60		ns	
Duty Cycle Range		20-80		%	Adjustable (see Figure 6)
III — Modulation Characteristics (sine, triangle and squarewave):					
Amplitude Modulation:					
Double Sideband					
Modulation Range		0-100		%	See Figure 2 S_3 dosed
Linearity		0.5		%	for 30% modulation
Sideband Symmetry		1.0		%	
Suppressed Carrier					
Carrier Suppression		52		dB	f < 1MHz after R_q adjustment
Frequency Modulation:					
Distortion		0.3		%	See Figure 2 (±10 frequency deviations)

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TEST CIRCUITS
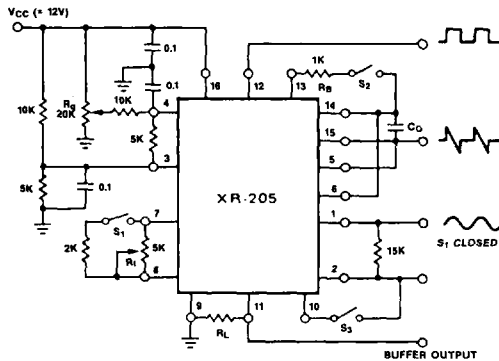
Figure 1. Test Circuit for Single-Supply Operation
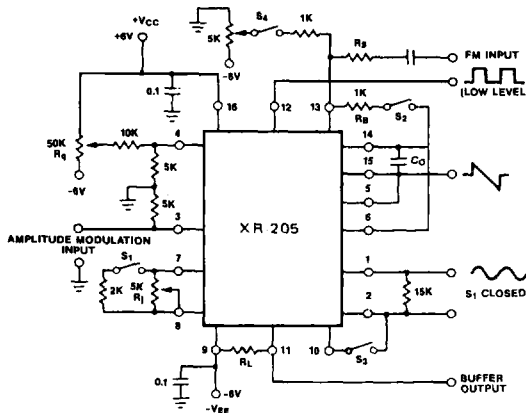

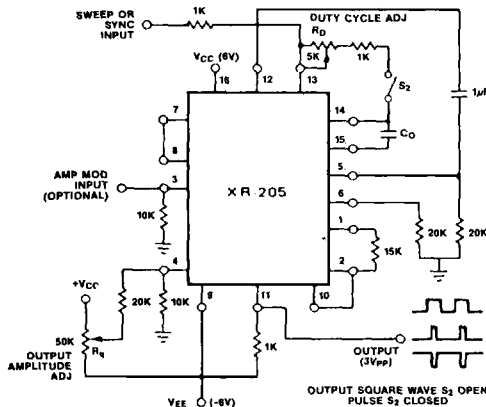**Figure 2. Test Circuit for Split-Supply Operation and AM/FM Modulation**

Figure 3. Test Circuit for High-Level Pulse and Squarewave Output

DESCRIPTION OF CIRCUIT CONTROLS

(Refer to functional block diagram)

TIMING CAPACITOR (PINS 14 AND 15)

The oscillator frequency is inversely proportional to the value of the timing capacitor, C_o, connected between pins 14 and 15. With the sweep input open circuited, frequecy f_o can be approximated as: $f_o = 400/C_o$ where f_o is in Hz and C_o is in microforads. (See Figure 4.)

MODULATOR Y-INPUTS (PINS 5 AND 6)

These inputs are normally connected to the oscillator outputs. For sinewave or trianglewave outputs, they are dc coupled to pins 14 and 15 (see Figure 1); for high-level squarewave or pulse output, ac coupling is used as shown in Figure 3.

MODULATOR X-INPUTS (PINS 3 AND 4)

Modulator output (at pins 1 or 2) is proportional to a dc voltage applied across these inputs — (see Figure 5). These inputs can be used for amplitude modulation or, as an output amplitude control. The phase of the output voltage is reversed if the polarity of the dc bias across pins 3 and 4 is reversed; therefore these inputs can be used for phase-shift keyed (PSK) modulation.

MODULATOR OUTPUTS (PINS 1 AND 2)

All of the high level output waveforms are obtained at these terminals. The output waveforms appear differentially between pins 1 and 2. The terminals can, therefore, be used for either in-phase or out-of-phase outputs. Normally, a 15KΩ load resistor should be connected between these terminals to prevent the output from saturating or clipping at large output voltage swings. This output has a high output impedance and should be buffered.

LOW LEVEL SQUAREWAVE OUTPUT (PIN 12)

The output at this pin is a symmetrical squarewave with 0.7V amplitude and 20 ns rise time. It can be used directly as an output waveform, or amplified to a 3Vpp signal level using the modulator section of the XR-205 as an amplifier (see Figure 3).

SWEEP OR FM INPUT (PIN 13)

The oscillator frequency increases linearly with an increasing negative voltage, V_s, applied to this terminal. Normally a series resistor, R_s ($R_s \approx$ approx. 1 KΩ) is connected in series with this terminal to provide current limiting and linear voltage-to-frequency transfer characteristics. The frequency deviation (for any given modulation level) is inversely proportional to R_s. Typical sweep characteristics of the circuit are shown in Figure 7. For proper operation of the circuit with R_s = 1KΩ, the sweep voltage, V_s, must be within range: $(V_{so} - 6) < V_s < (V_{so} + 1)$ where V_{so} is the open circuit voltage at pin 13.

WAVEFORM ADJUSTMENT (PINS 7 AND 8)

The shape of the output waveform at pins 1 and 2 is controlled by a potentiometer, R_j, connected between these terminals as shown in Figure 1. For sinewave outputs at pins 1 and 2, the value of R_j is adjusted to minimize the harmonic content of the output waveform. This adjustment is independent of frequency and needs to be done only once. The output can be converted to a symmetrical triangle waveform by increasing the effective resistance across these terminals. This can be done without changing the potentiometer setting, by opening the switch S_2 as shown in Figures 1-3.

BUFFER INPUT AND OUTPUT (PINS 10 AND 11)

The buffer amplifier can be connected to any of the circuit outputs (pins 1, 2, 12, 14 or 15) to provide low output impedance and high current drive capability. For proper operation of the buffer amplifier, pin 11 must be connected to the most negative potential in the circuit, with an external load resistor R_L (0.75KΩ < R_L < 10KΩ). The maximum output current at this pin must not exceed 20mA.

DUTY CYCLE ADJUSTMENT

The duty-cycle of the output waveforms can be adjusted by connecting a resistor RB across pins 13 and 14, as shown in Figures 1-3. With switch S_2 open, the output waveform will be symmetrical. Duty cycle is reduced as R_B is decreased. (See Figure 6.)

ADDITIONAL GAIN CONTROL

For amplitude modulated output signals, the dc level across pins 3 and 4 is fixed by the modulation index required. In this case, the output amplitude can be controlled without effecting the modulation by connecting a potentiometer between pins 1 and 2.

ON-OFF KEYING

The oscillator can be keyed off by applying a positive voltage pulse to the sweep input terminal. With R_s = 1KΩ, oscillations will stop if the applied potential at pin 13 is raised 3 volts above its open-circuit value.

OUTPUT WAVEFORMS

TRIANGLE OUTPUT

The circuit is connected as shown in Figures 1 or 2, with switches S_1 and S_2 open.

SINEWAVE OUTPUT

The circuit is connected as shown in Figures 1 or 2, with switch S_2 open and S_1 closed. The output waveform is adjusted for minimum harmonic distortion using trimmer resistor R_j connected across pins 7 and 8. Sinusoidal output is obtained from pins 1 or 2 (or pin 11 if the buffer amplifier is used). The amplitude of the output waveform is controlled by the differential dc voltage appearing between pins 3 and 4. This bias can be controlled by potentiometer R_q. for a differential bias between these terminals of 12 volts or greater, the output amplitude is maximum and equal to approximately 3Vp-p.

SAWTOOTH OUTPUT

The circuit is connected as shown in Figures 1 or 2, with switch S_1 open and S_2 closed. Closing S_2 places resistor R_B across pins 13 and 14. This changes the duty cycle of the triangle output and converts it to a saw-tooth waveform. The polarity of the sawtooth can be changed by reversing the polarity of the dc bias across pins 3 and 4. If S_1 is closed, the linear sawtooth waveform is converted to the sinusoidal sawtooth waveform of Figure 9.

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Ramp Output (Figure 9B)

For ramp outputs, switch S_3 of Figure 1 or 2 is opened, and pin 10 is shorted to pin 14. This results in a 1.4Vp-p ramp output at pin 11. The duty cycle of this ramp can be controlled by connecting R_B across pins (13-14) or (13-15).

Squarewave and Pulse Outputs

For squarewave outputs, the circuit is connected as shown in Figure 3, with S_2 open. The output can be converted to a pulse by closing S_2. The duty cycle of the pulse output is controlled by potentiometer R_D. The amplitude and polarity of either the pulse or squarewave output can be controlled by potentiometer R_q.
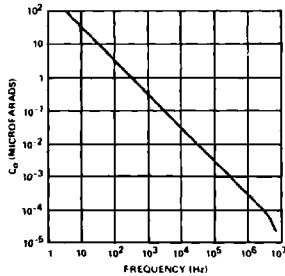
Figure 4. Frequency as a Function of C_o across Pins 14 and 15
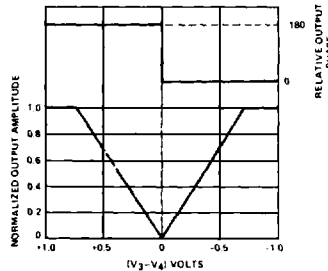
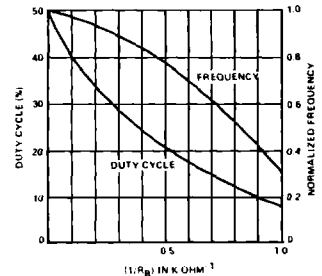**Figure 5. Modular Section Phase and Amplitude Transfer Characteristics**

Figure 6. Duty-Cycle and Frequency Variation as a Function of Resistor R_B Connected Across Pins 13 and 14
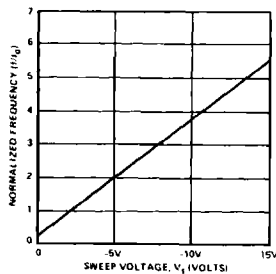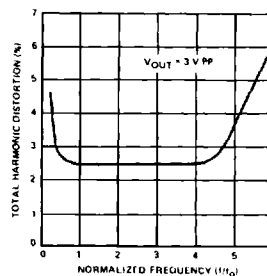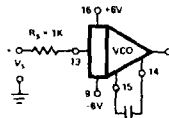
Figure 7. Normalized Frequency vs. Sweep Voltage

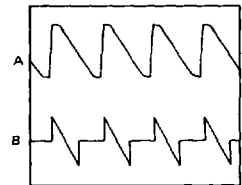**Figure 8. Sinusoidal Output Distortion as a Function of Frequency Sweep**

Figure 9. Sinusoidal Sawtooth and Linear Ramp Outputs

EQUIVALENT SCHEMATIC DIAGRAM