signetics

FM DETECTOR AND LIMITER ULN2111

LINEAR INTEGRATED CIRCUITS

DESCRIPTION

A unique method of FM detection by a new technique of linear gating is featured in the ULN2111 monolithic integrated circuit. This linear device comprises a three-stage limiter and a balanced product detector. Applications for the ULN2111 device include TV sound channels, FM receivers, automatic frequency control systems, and communication receivers.

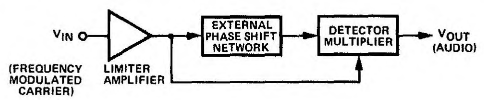
Other applications for the ULN2111 device are in the more sophisticated circuitry in telemetry receivers, automatic control systems, and servo amplifiers.

An outstanding feature of the ULN2111 is that only one, simple, low-cost, single winding coil is required for tuning. Consequently, only one screwdriver adjustment is required to tune a detector employing the ULN2111. The frequency range of the ULN2111 extends from 5 kHz to 50 MHz. Outputs of 0.6V with a total distortion of less than 1% and a limiting threshold voltage of $400\mu V_{rms}$ are typical.

FEATURES

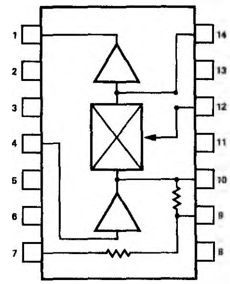
- **HIGH SENSITIVITY – INPUT LIMITING VOLTAGE AT 4.5MHz = 400μV**
- **HIGH IF VOLTAGE GAIN – 60dB**
- **SIMPLIFIED TUNING – ONE RLC PHASE SHIFT NETWORK**
- **HIGH STABILITY**
- **LOW DISTORTION – 1.0%**
- **WIDE FREQUENCY CAPABILITY – 5kHz to 50MHz**

BLOCK DIAGRAM



PIN CONFIGURATION

A PACKAGE
(Top View)



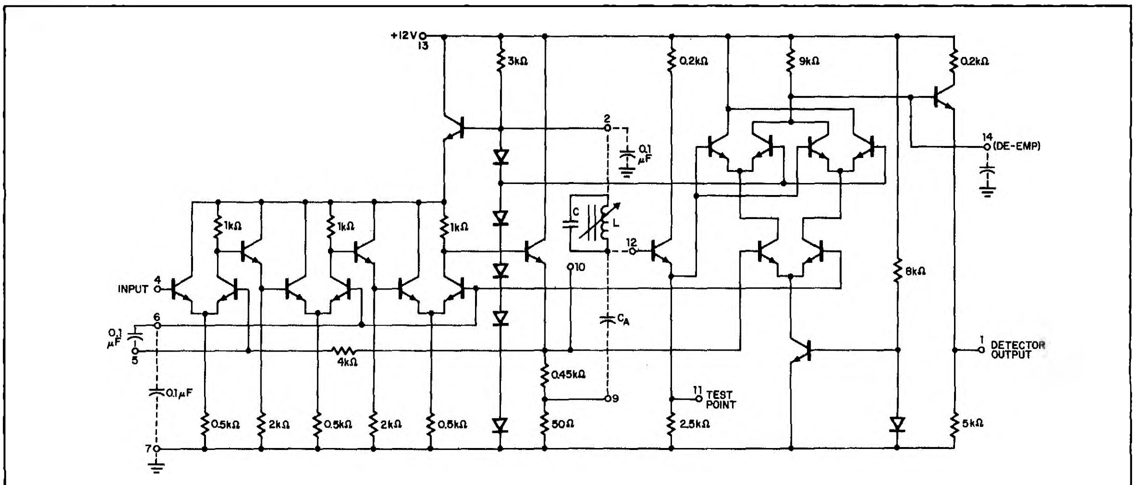
1. Audio Output
2. Detector Input Reference
3. No Connection
4. Input
5. Decoupling
6. Amplifier Input Reference
7. GND
8. No Connection
9. Amplifier Low Output
10. Amplifier High Output
11. Test Point
12. Detector Input
13. V^+
14. De-emphasis

ORDER PART NO. ULN2111A

ABSOLUTE MAXIMUM RATINGS

Input Voltage (Pin 4)	+3.5V
Output Voltage	+15V
Supply Voltage (V+)	+15V
Junction Temperature	+150°C
Storage Temperature	−65°C to +150°C
Operating Temperature	0°C to +85°C
Thermal Resistance $\theta_{J\text{-}A}$, Junction to Ambient	0.15°C/mW
Power Dissipation	300mW

BASIC CIRCUIT SCHEMATIC



ELECTRICAL CHARACTERISTICS: Standard Conditions: V_{CC} = +12V ±10%, T_A = 25°C

CHARACTERISTICS	SYMBOL	LIMITS MIN	TYP	MAX	UNITS	TEST CONDITIONS	Pin	TEST FIGURE	NOTES
Supply Current	I_{CC}	12.0	17	22	mA		13		
Amplifier Input Reference	V_{bias}		1.45		V	Internally derived	6		
Detector Input Reference	V_{bias}		3.65		V	Internally derived	2		
Amplifier High Output Level	V_{oh}		1.45		V		10		
Amplifier Low Output Level	V_{ol}		0.145		V		9		
Detector Output Level	V_o	4.3	5.0	5.7	V		1		
Amplifier Input Resistance	R_{in}		5.0		KΩ		4		
Amplifier Input Capacitance	C_{in}		11		pF		4		
Detector Injection Input Resistance	R_{in}		70		KΩ		12		
Detector Injection Input Capacitance	C_{in}		2.7		pF		12		
Amplifier High Output Resistance	R_{out}		60		Ω		10		
Detector Output Resistance	R_{out}		200		Ω		1		
De-Emphasis Resistance	R_{de}		9		KΩ		14		
FM Detection for Television Applications:						Detector injection voltage = 60mV_{rms}, f_o = 4.5 MHz, F deviation = 25 kHz, Peak separation = 150 kHz, FM modulating frequency = 400 Hz, Amplifier source resistance = 50Ω.			
Amplifier Voltage Gain	V_g	55	58		dB	$V_{in} \leq 0.3mV_{rms}$ V_{cc} = 12V ±5%	10	1	
Amplifier Output Voltage	V_{oa}		1.45		V_{pp}	$V_{in} = 10mV_{rms}$	10	1	
Input Limiting Threshold	V_{th}		400	800	μV_{rms}		4	2	1
Recovered Audio Output	A_{vo}	0.5	0.6		V_{rms}		1	2	
Output Distortion	T_{hd}		1.5		%	100% FM Modulation	1	2	
AM Suppression	AMR	40	46		dB	$V_{in} = 10mV_{rms}$	1	3	2
FM Detection for 10.7 MHz Applications:						Detector injection voltage = 60mV_{rms}, f_o = 10.7 MHz, F deviation = 75 kHz, Peak separation = 550 kHz, FM modulating frequency = 400 Hz, Amplifier source resistance = 50Ω.			
Amplifier Voltage Gain	V_g		53		dB	$V_{in} \leq 0.3mV_{rms}$ V_{cc} = 12V ±5%.	10	1	
Amplifier Output Voltage	V_{oa}		1.45		V_{pp}	$V_{in} = 10mV_{rms}$	10	1	
Input Limiting Threshold	V_{th}		500		μV_{rms}		4	2	1
Recovered Audio Output	A_{vo}		0.45		V_{rms}		1	2	
Output Distortion	T_{hd}		1.0		%	100% FM modulation	1	2	
AM Suppression	AMR		40		dB	$V_{in} = 10mV_{rms}$	1	3	2

NOTES

1. The limiting threshold voltage is the FM input voltage V_i, expressed in rms volts, for a recovered V_{out} which is 3dB less than the recovered V_{out} at a V_i of 200mV_{rms}.

2. The Amplitude Modulation Rejection in decibels, often abbreviated AMR, is given by the following formula:

$$AMR = 20 \log \frac{V_{out} \text{ for 100\% FM modulated } V_i}{V_{out} \text{ for a 30\% AM } V_i}$$

USAGE INFORMATION

1. FM DETECTION.
   a. Tuning. Apply FM modulated signal through DC decoupling network to pin 4, V_{in} = 5mV_{rms}. Tune for maximum recovered audio at pin 1 or maximum RF voltage at pin 11.
   b. General
      (1) A DC path less than 100Ω shall be provided between pins 2 and 12. No other biasing provisions are required.
      (2) A DC path less than 300Ω should be provided between pins 4 and 6. No other biasing provisions are required.
      (3) The maximum AC load current can be increased by adding an external resistor between pins 1 and 7. The minimum value for this resistor is 800Ω, giving a maximum load current of 4mA_{rms}.

2. EXTERNAL DECOUPLING AND MOUNTING CONSIDERATIONS.
   a. All decoupling capacitors should be ceramic type with minimum residual inductance at the operating frequency.
   b. Decoupling capacitor leads at pins 5, 6, and 12 should be as short as possible.
   c. Connections from pin 4 should be as far removed as possible from connections at pins 9, 10, and 12.
   d. The power supply pin 13 should be decoupled with a 0.1μF ceramic capacitor, keeping the leads as short as possible.
   e. When using a large internal impedance power supply (voltage dropping resistor), decouple pin 13 for the lowest audio demodulation frequency.
   f. Keep appropriate distances between the input coil and any other coil in the phase shift network for the voltage gain between these points is high (40 to 60dB).

TEST CIRCUITS

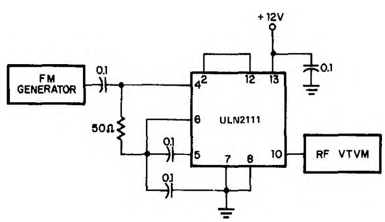


FIGURE 1

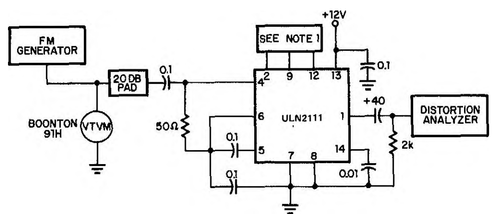


FIGURE 2

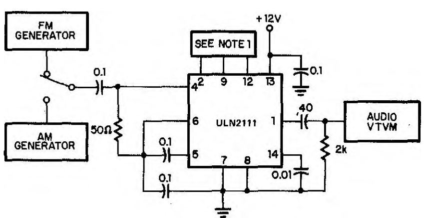


FIGURE 3

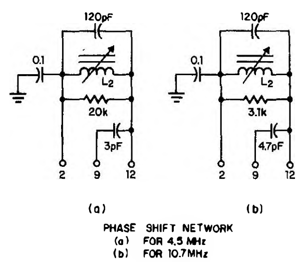
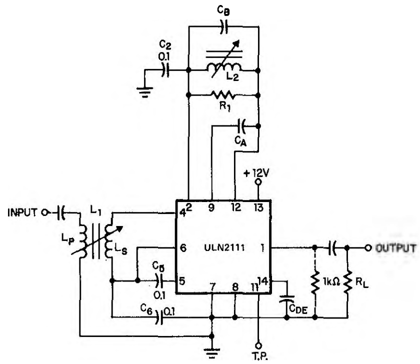


FIGURE 4

NOTES: 1. Phase shift network is specified in Figure 4. 2. All capacitors in microfarads unless otherwise noted.

APPLICATIONS

TYPICAL CIRCUIT REQUIREMENTS FOR FM DETECTION



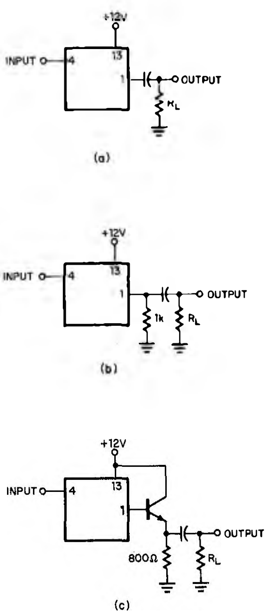
	Component Value		Notes
	TV (4.5 MHz)	FM (10.7 MHz)	
L_2 Inductance	7 - 14μH	1.5 - 3μH	1
L_2 Nom. Unloaded Q	50	50	
L_2 Nom. DC Resistance	50Ω	50Ω	
C_A	3.0pF	4.7pF	
C_B	120pF	120pF	2
R_1	20kΩ	3 1kΩ	
C_5 and C_6	30	20	
C_2	0.1μF	0.1μF	
C_{de}	0.01μF	0.01μF	

NOTES:

1. Suggested coil source: 1.5 - 3μH Miller 9050, 7 - 14μH Miller 9052.
2. Use NPO type capacitor.

Figure 5

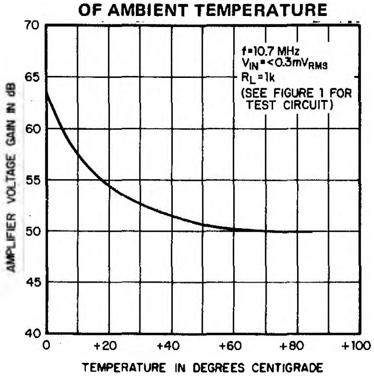
TYPICAL DRIVING CAPABILITIES at f_o = 4.5MHz



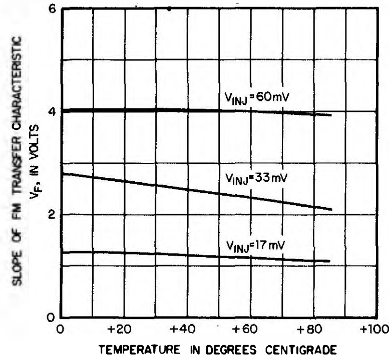
		V_o (mV_{rms})		
Figure	R_L (Ω)	Δf = 7.5 kHz	Δf = 25 kHz	Remarks
A	2000	220	650	No Clipping
B	200	130	400	No Clipping
C	200	220	650	Clipping at V_o=500mV_{rms}

Figure 6

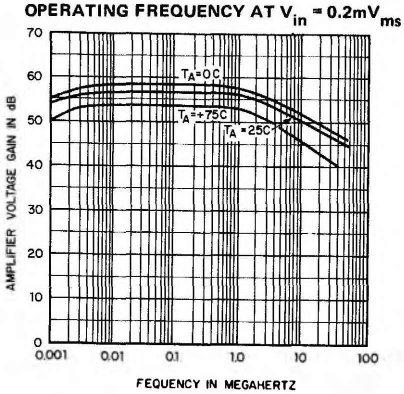
AMPLIFIER GAIN AS A FUNCTION OF AMBIENT TEMPERATURE

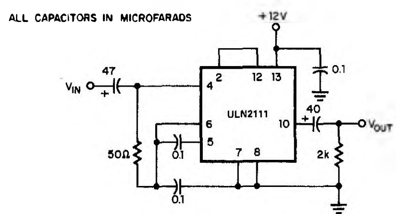


SLOPE OF FM TRANSFER CHARACTERISTICS AS A FUNCTION OF AMBIENT TEMPERATURE

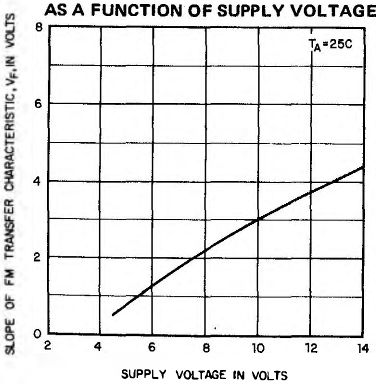


AMPLIFIER VOLTAGE GAIN AS A FUNCTION OF OPERATING FREQUENCY AT V_{in} = 0.2mV_{ms}

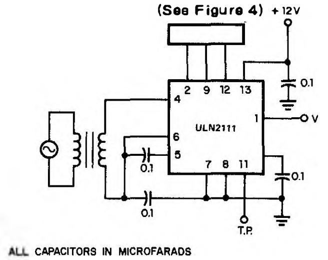




SLOPE OF FM TRANSFER CHARACTERISTIC AS A FUNCTION OF SUPPLY VOLTAGE

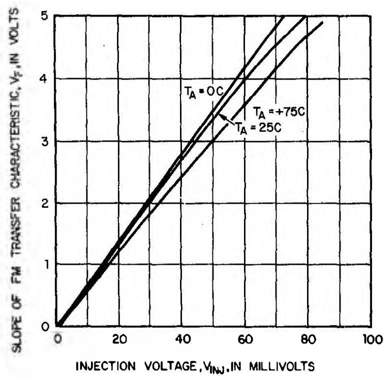


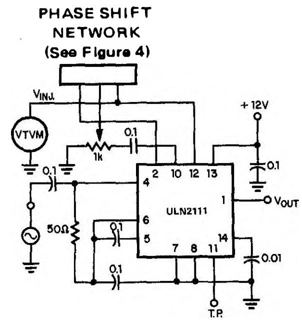
PHASE SHIFT NETWORK (See Figure 4)



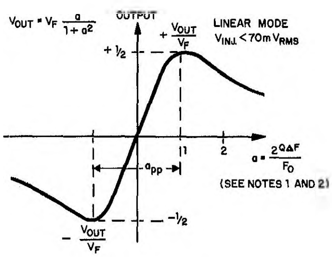
TYPICAL CHARACTERISTIC CURVES (Cont'd.)

SLOPE OF FM TRANSFER CHARACTERISTICS AS A FUNCTION OF INJECTION VOLTAGE





TRANSFER CHARACTERISTICS FOR A SIMPLE LC NETWORK



OUTPUT = ƒ (NORMALIZED DEVIATION)
(The units along the vertical axis are arbitrary units.)
Linear mode: **Operation of the FM detector with no limiting after the phase shift network.**

NOTES:

1. V_F defines the slope of the FM transfer characteristic, at orgin:

$$V_f = \frac{dV_{out}}{da} \qquad a = 0$$

V_F is primarily a function of bias current in the detector and injection voltage.

V_F will decrease with decreasing V_{CC} or V_{INJ}.

2. a = normalized frequency deviation:

$$a = \frac{2Q\Delta F}{F_O}$$