LM380, LM565

AN-146 FM Remote Speaker System

Literature Number: SNAA087
INTRODUCTION
A high quality, noise free, wireless FM transmitter/receiver may be made using the LM566 VCO and LM565 PLL Detector. The LM566 VCO is used to convert the program material into FM format, which is then transformer coupled to standard power lines. At the receiver end the material is detected from the power lines and demodulated by the LM565.

The important difference between this carrier system and others is its excellent quality and freedom from noise. Whereas the ordinary wireless intercom uses an AM carrier and exhibits a poor signal-to-noise ratio (S/N), the system described here uses an FM carrier for inherent freedom from noise and a PLL detection system for additional noise rejection.

The complete system is suitable for high-quality transmission of speech or music, and will operate from any AC outlet anywhere on a one-acre homesite. Frequency response is 20–20,000 Hz and THD is under 0.66% for speech and music program material.

Transmission distance along a power line is at least adequate to include all outlets in and around a suburban home and yard. Whereas many carrier systems operate satisfactorily only when transmitter and receiver are plugged into the same side of the 120–240V power service line, this system operates equally well with the receiver on either side of the line.

The transmitter is plugged into the AC line at a radio or stereo system source. The signal for the transmitter is ideally taken from the MONITOR or TAPE OUT connectors provided on component system Hi-Fi receivers. If these outputs are not available, the signal could be taken from the main or extra speaker terminals, although the remote volume would then be under control of the local gain control. The carrier system receiver need only be plugged into the AC line at the remote listening location. The design includes a 2.5W power amplifier to drive a speaker directly.

TRANSMITTER
Two input terminals are provided so that both LEFT and RIGHT signals of a stereo set may be combined for mono transmission to a single remote speaker if desired. The input signal level is adjustable by R1 to prevent overmodulation of the carrier. Adding C2 across each input resistor R4 and R6 improves the frequency response to 20 kHz as shown in Figure 5. Although casual listening does not demand such performance, it could be desired in some circumstances.

The VCO free-running frequency, or carrier frequency fC, determined by R6 and C4 is set at 200 kHz which is high enough to be effectively coupled to the AC line. VCO sensitivity under the selected bias conditions with VS ~ 12V is about ±0.66 fC/V. For minimum distortion, the deviation should be limited to ±10%; thus maximum input at pin #5 of the VCO is ±0.15V peak. A reduction due to the summing network brings the required input to about 0.2V rms for ±10% modulation of fC based on nominal output levels from stereo receivers. Input potentiometer R16 is provided to set the required level. The output at pin #3 of the LM566, being a frequency modulated square wave of approximately 6V pk-pk amplitude, is amplified by a single transistor Q1 and coupled to the AC line via the tuned transformer T1. Because T1 is tuned to fC, it appears as a high impedance collector load, so Q1 need not have additional current limiting. The collector signal may be as much as 40–50V pk-pk. Coupling capacitor C9 isolates the transformer from the line at 60 Hz.

A Voltage regulator provides necessary supply rejection for the VCO. The power transformer is sized for peak secondary voltage somewhat below the regulator breakdown voltage (35V) with a 125V line.

RECEIVER
The receiver amplifies, limits, and demodulates the received FM signal in the presence of line transient interference sometimes as high as several hundred volts peak. In addition, it provides audio mute in the absence of carrier and 2.5W output to a speaker.

The carrier signal is capacitively coupled from the line to the tuned transformer T1. Loaded Q of the secondary tank T1C2 is decreased by shunt resistor R1 to enable acceptance of the ±10% modulated carrier, and to prevent excessive tank circuit ringing on noise spikes. The secondary of T1 is tapped to match the base input impedance of Q1A. Recovered carrier at the secondary of T1 may be anywhere from 0.2 to 45V p-p; the base of Q1A may see pk-to-pk signal levels of from 12 mV to 2.6V.

Q1A–Q1D operates as a two-stage limiter amplifier whose output is a symmetrical square wave of about 7V pk-pk with rise and fall times of 100 ns. The output of the limiting amplifier is applied directly to the mute peak detector, but is reduced to 1V pk–pk for driving the PLL detector.

The PLL detector operates as a narrow band tracking filter which tracks the input signal and provides a low-distortion demodulated audio output with high S/N. The oscillator within the PLL is set to free-run at or near the carrier frequency of 200 kHz. The free-run frequency is fC = 1/(3.7 R16C13). Since the PLL will lock to a carrier near its free-run frequency, an adjustment of R16 is not strictly necessary; R16 could be fixed at 4700 or 5100Ω. Actually, the PLL with the indicated value of C11 can lock on a carrier within about ±40 kHz of its center frequency. However, rejection of impulse noise in difficult circumstances can be maximized by carefully adjusting fC to the carrier frequency fC. Adding...
FIGURE 1. Carrier System Transmitter

FIGURE 2. Carrier System Receiver
C_{10} \approx 100 \text{ pF} \text{ will reduce the carrier level fed to the power amplifier. Even though the listener cannot hear the carrier, the audio amplifier could overload due to carrier signal power.}

A mute circuit is included to quiet the receiver in the absence of a carrier. Otherwise, when the transmitter is turned OFF, an excessive noise level would result as the PLL attempts to lock on noise. The mute detector consists of a voltage doubling peak detector D_1Q_2C_7. The peak detector shunts the 1–2 mA bias away from Q_{1E} without loading the limiter amplifier. When no carrier is present, the +4V line biases Q_{1E} ON via R_{10} and R_{11}; and the audio signal is shorts to ground. When a carrier is present, the 7V square wave from the limiter amplifier is peak detected*, and the resultant negative output is integrated by R_{13}C_9, averaged by R_{10} across C_7, and further integrated by R_{11}C_6. The resultant output of about –4V subtracts from the +4V bias supply, thus depriving Q_{1E} of base current. Peak detector integration and averaging prevents noise spikes from deactivating the mute in the absence of a carrier when the limiter amplifier output is a series of narrow 7V spikes.

The LM380 supplies 2.5W of audio power to an 8Ω load. Although this is adequate for casual listening in the kitchen or garage, for hi-fi listening, a larger amplifier may be direct.

CONSTRUCTION

PC board layout and stuffing diagrams are shown in Figures 3 & 4. After the receiver board has been loaded and checked, the power transformer is mounted to the foil side of the board with a piece of fish-paper or electrical insulating cloth between board and transformer. Insulating washers of \( \frac{1}{4} \)–\( \frac{1}{2} \) inch thickness can be used to advantage in holding the transformer away from the foil. The board is laid out so that the volume control potentiometer may be mounted on either side of the board depending on the desired mounting to a panel.

The line coupling coils are available in production quantities from TOKO AMERICA, INC, 1250 Feehanville Drive, Mount Prospect, IL 60056. TEL: (312) 297-0070

---

*The peak detector circuit is not shown.
ADJUSTMENT

Adjustments are few and extremely simple. Transmitter carrier frequency $f_c$ is fixed near 200 kHz by $R_4$ and $C_4$; the exact frequency is unimportant. $T_1$ for both transmitter and receiver are tuned for maximum coupling to and from the AC line. Plug in both receiver and transmitter; no carrier modulation is necessary. Insure that both units are operative. Observe or measure with an AC VTVM the waveform at $T_1$ secondary in the receiver. Tune $T_1$ of the transmitter for maximum observed signal amplitude. Then tune $T_1$ of the receiver for a further maximum. Repeat on the transmitter, then the receiver. Tuning is now complete for the line coupling transformers and should not have to be repeated for either. If the receiver is located some distance from the transmitter in use, or on the opposite side of the 110–220V service line, a re-adjustment of the receiver $T_1$ may be made to maximize rejection of SCR dimmer noise. The receiver PLL free-running frequency is adjusted by $R_{16}$. Set $R_{16}$ near the center of its range. Rotate slowly in either direction until the PLL loses lock (evidenced by a sharp increase in noise and a distorted output). Note the position and then repeat, rotating in the other direction. Note the new position and then center $R_{16}$ between the two noted positions. A fine adjustment may be made for minimum noise with an SCR dimmer in operation. The final adjustment is for modulation amplitude at the transmitter. Connect the audio signal to the transmitter input and adjust the input potentiometer $R_1$ for a signal maximum of about 0.1V rms at the audio signal to the transmitter input and adjust the input to the LM566. Adjustment is now complete for both transmitter and receiver and need not be repeated.

A STEREO SYSTEM

If full stereo or the two rear channels of a quadraphonic system are to be transmitted, both transmitter and receiver must be duplicated with differing carriers. Omit $R_6$ and include $R_7$ and $C_2$ on the transmitter if desired. Carriers could be set to 100 and 200 kHz for the two channels. Actually, they need only be set a distance of 40 kHz apart.

PERFORMANCE

Overall S/N is about 65 dB. Distortion is below about 0.01% at low frequencies, and in actual program material it should not exceed 0.1% as very little signal power occurs in music above about 1 kHz.

LIFE SUPPORT POLICY

NATIONAL’S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.

2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.
IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal and regulatory requirements concerning such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are specifically designated by TI as automotive-grade or "enhanced plastic.” Only products designated by TI as automotive-grade meet automotive specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as automotive-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the specific TI products are designated by TI as military-grade or "enhanced plastic.” Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal and regulatory requirements concerning such use.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

<table>
<thead>
<tr>
<th>Products</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio</td>
<td>Communications and Telecom</td>
</tr>
<tr>
<td>Amplifiers</td>
<td>Computers and Peripherals</td>
</tr>
<tr>
<td>Data Converters</td>
<td>Consumer Electronics</td>
</tr>
<tr>
<td>DLP® Products</td>
<td>Energy and Lighting</td>
</tr>
<tr>
<td>DSP</td>
<td>Industrial</td>
</tr>
<tr>
<td>Clocks and Timers</td>
<td>Medical</td>
</tr>
<tr>
<td>Interface</td>
<td>Security</td>
</tr>
<tr>
<td>Logic</td>
<td>Space, Avionics and Defense</td>
</tr>
<tr>
<td>Power Mgmt</td>
<td>Transportation and Automotive</td>
</tr>
<tr>
<td>Microcontrollers</td>
<td>Video and Imaging</td>
</tr>
<tr>
<td>RFID</td>
<td></td>
</tr>
<tr>
<td>OMAP Mobile Processors</td>
<td></td>
</tr>
<tr>
<td>Wireless Connectivity</td>
<td></td>
</tr>
</tbody>
</table>

TI E2E Community Home Page e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated