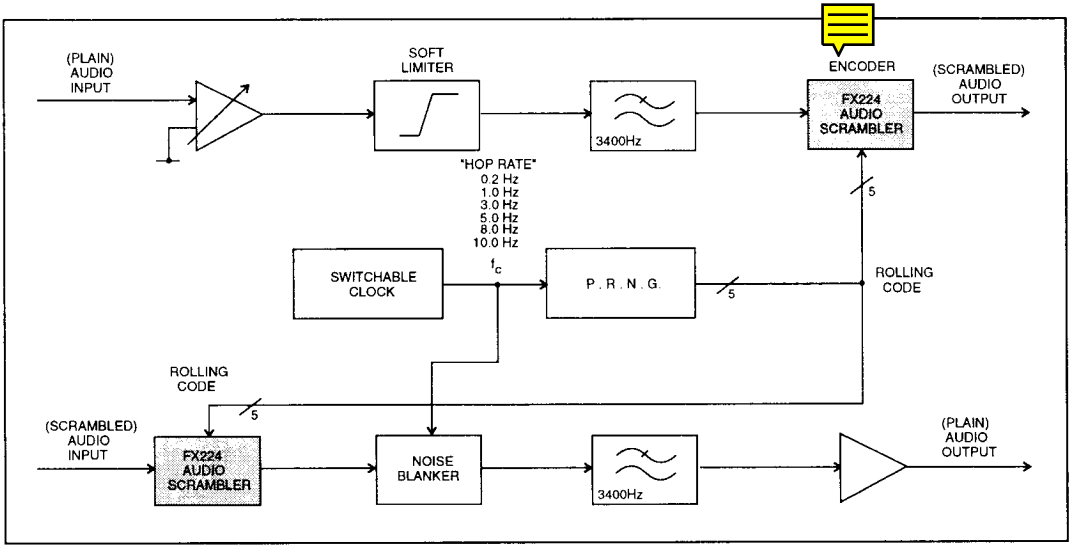
Application Information

A Rolling Code Scrambler using the FX224

- Variable Split Band Operation
- High Quality Received Audio
- 6 Code Hop-Rates
- 32 Different Split-Point/ Carrier (Code) Combinations
- Half-Duplex System
- Pseudo-Random Codes



Introduction

The principle application of the FX224 Variable Split Band Scrambler is that of a frequency domain speech-band inverter

Scrambling is achieved by splitting the input voice frequencies into upper and lower frequency bands using switched capacitor filters, -modulating each band with a separate carrier frequency to "frequency invert" the bands, -then summing the output.

De-scrambling is carried out using the same method, ensuring that the carrier frequencies are the same as those used to scramble the original audio.

Using the FX224, a total of 32 different split-point and carrier frequecny combinations are externally programmable using a 5-bit code which can be fixed or varying (rolling), for greater security.

This application note, used with a current FX224 data sheet, is intended to assist in integrating the device into audio circuitry by giving details of:

(a) The transmission (scramble) circuit.

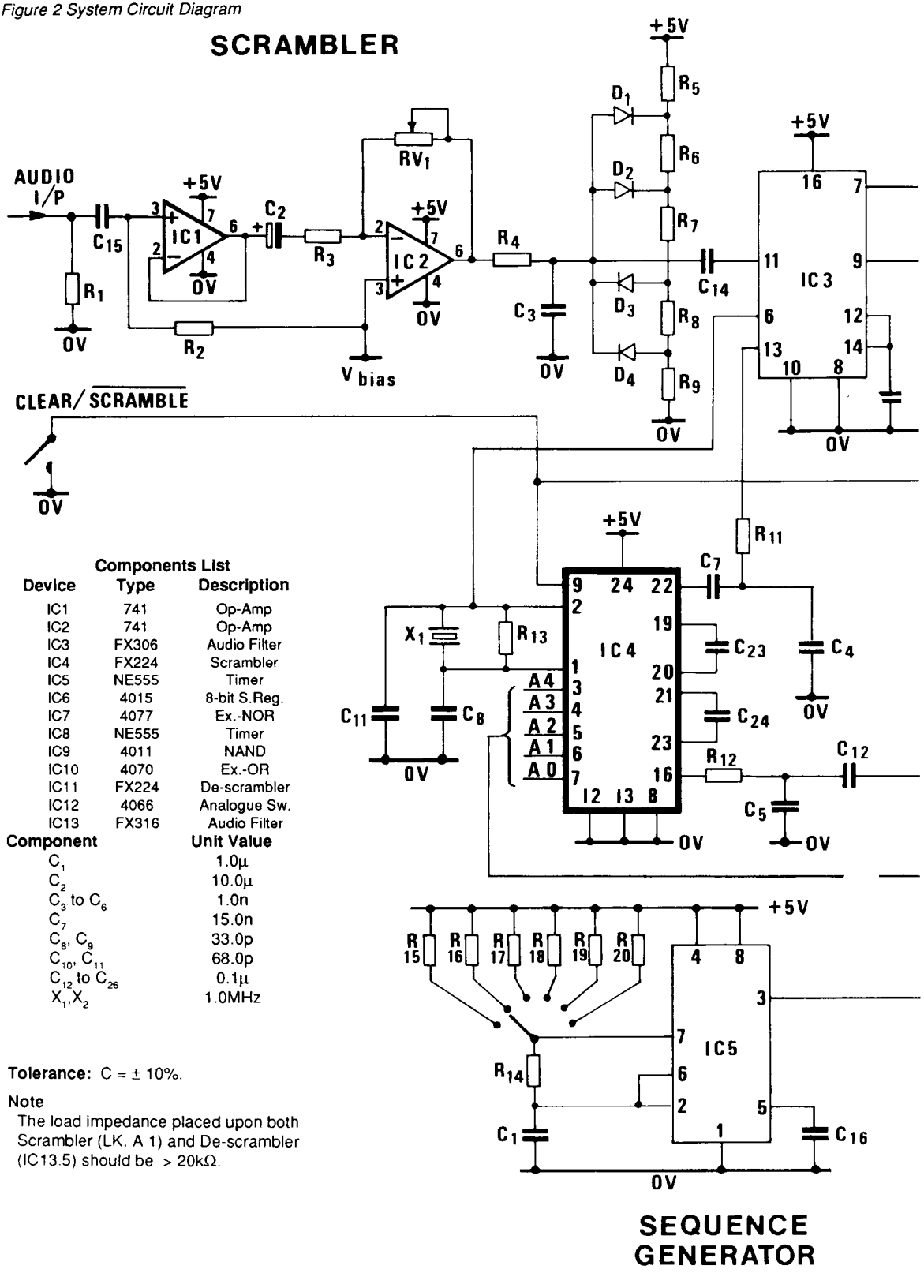
(b) The reception (de-scramble) circuit.

(c) A pseudo-random code generator with switchable clock circuitry controlling the 'rolling' (change) rate of the 5-bit pseudo-random code at the rates of: 0.2Hz, 1.0Hz, 3.0Hz, 5.0Hz, 8.0Hz and 10.0Hz.

Synchronization of the scrambling and de-scrambling devices is important and can be accomplished by using either FSK data bursts or contiuous outband tone signals.

The power requirement of this particular application is between 50mA and 60mA at 5 volts per Rx/Tx pair; i.e. one complete scrambling circuit.

Figure 2 System Circuit Diagram



Components List

Device	Type	Description
IC1	741	Op-Amp
IC2	741	Op-Amp
IC3	FX306	Audio Filter
IC4	FX224	Scrambler
IC5	NE555	Timer
IC6	4015	8-bit S.Reg.
IC7	4077	Ex.-NOR
IC8	NE555	Timer
IC9	4011	NAND
IC10	4070	Ex.-OR
IC11	FX224	De-scrambler
IC12	4066	Analogue Sw.
IC13	FX316	Audio Filter

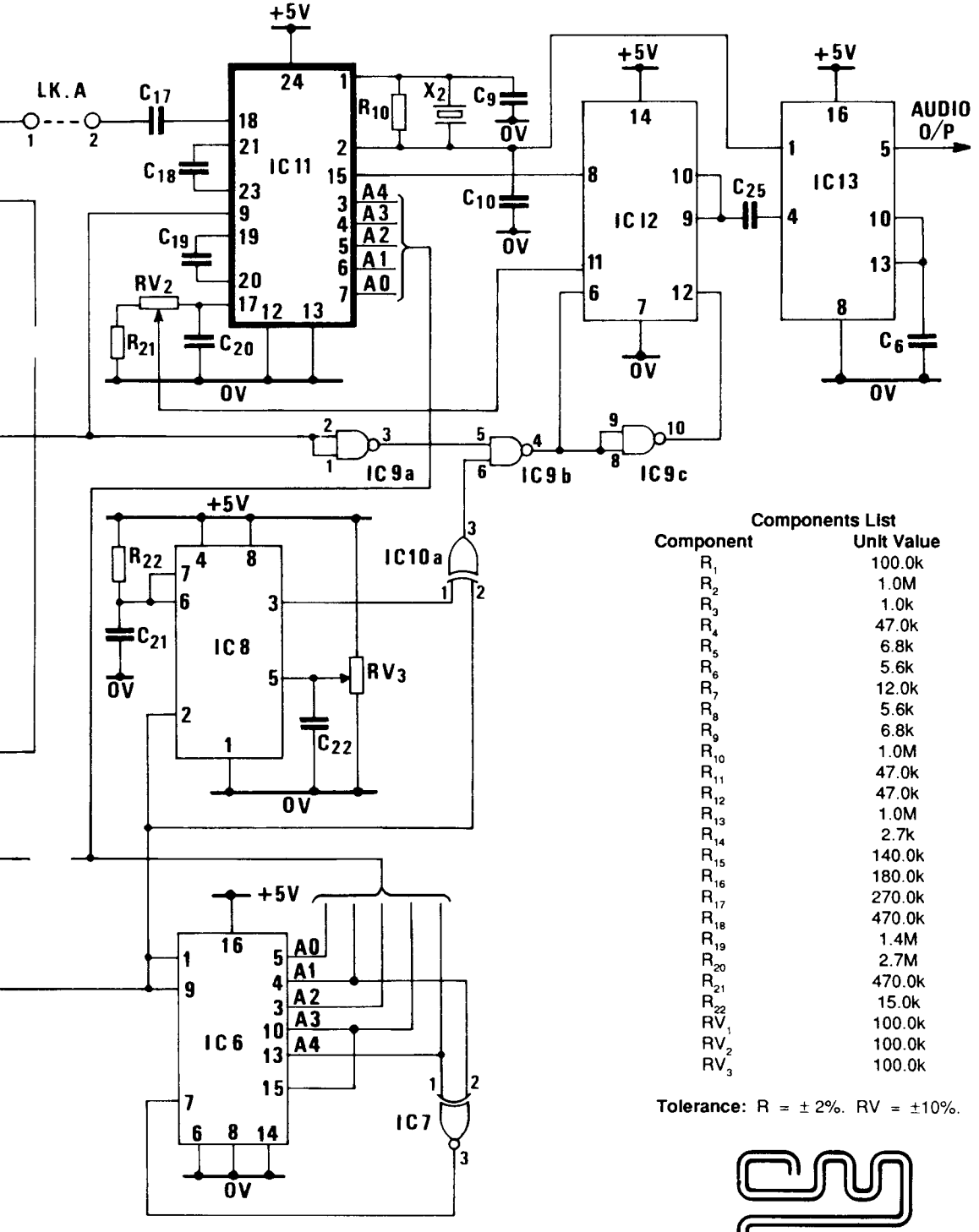
Component	Unit Value
C_1	1.0µ
C_2	10.0µ
C_3 to C_6	1.0n
C_7	15.0n
C_8, C_9	33.0p
C_{10}, C_{11}	68.0p
C_{12} to C_{26}	0.1µ
X_1, X_2	1.0MHz

Tolerance: C = ± 10%.

Note

The load impedance placed upon both Scrambler (LK. A 1) and De-scrambler (IC13.5) should be > 20kΩ.

DE-SCRAMBLER



Components List

Component	Unit Value
R_1	100.0k
R_2	1.0M
R_3	1.0k
R_4	47.0k
R_5	6.8k
R_6	5.6k
R_7	12.0k
R_8	5.6k
R_9	6.8k
R_{10}	1.0M
R_{11}	47.0k
R_{12}	47.0k
R_{13}	1.0M
R_{14}	2.7k
R_{15}	140.0k
R_{16}	180.0k
R_{17}	270.0k
R_{18}	470.0k
R_{19}	1.4M
R_{20}	2.7M
R_{21}	470.0k
R_{22}	15.0k
RV_1	100.0k
RV_2	100.0k
RV_3	100.0k

Tolerance: R = ± 2%. RV = ±10%.

Rolling Code Scrambler – *Circuit Information*

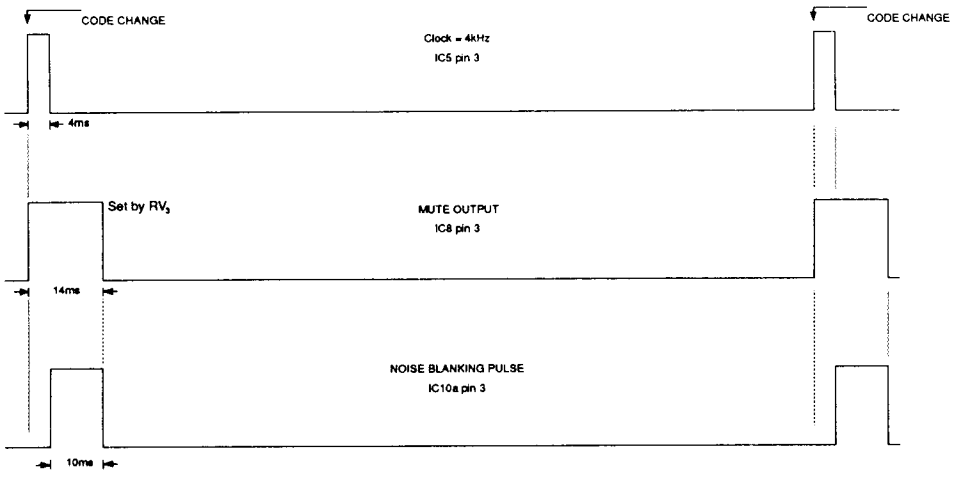


Fig.3 Receiver Timing

Timing

Figure 3 (above) shows the noise blanking pulse generation and its position relative to the code change. The blanking pulse width is variable using RV_2 (Figure 2).

The Circuit Diagram – *Figure 2* – is laid out as a Scramble/De-scramble evaluation circuit with the Scrambled (unintelligable) audio available at LK.A 1. The pseudo-random code is common to both functions.

The Scrambler Circuit

The incoming, plain, audio signal is buffered by IC1 and amplified by IC2. RV_1 sets a level of 300mV rms (this is found to be the optimum level to the FX224 in this application). Prior to the split-band frequency inversion process the signal is 'soft' limited to remove any high frequency spikes, then filtered to 3.4kHz by IC3 to simulate a radio channel voice bandwidth.
Using the 5-bit pseudo-random code generated by ICs 5, 6, & 7, the signal is frequency inverted by the FX224 (IC4). The inverted output of Variable Split-Band Scrambler is once again filtered (300Hz -3400Hz) by IC3, making the resulting scrambled audio compatible with a radio transmission channel. Scrambled (unintelligable) audio is available at LK.A 1.

The De-scrambler Circuit

Frequency inverted audio (LK.A 2) is recovered using the identical pseudo-random code to that used in the scrambling process.
As is the problem with most rolling code frequency inversion systems, unwanted transients are produced in the device, at the code change. In this application, a noise blanking circuit (ICs 8, 9, 10 & 12) is utilized to remove these transients by switching the output of the analogue switch (IC12) between the de-scrambling FX224 (IC11) and a d.c. level, at the code change, for a period determined by RV_3. The d.c. level is approximately 60mV below the FX224 V_{bias} line and is set by RV_2. Whilst the circuit is in the "Clear" mode, the noise blanking is disabled as it is not required.
IC13 completes the audio recovery by removing high frequency noise from the plain audio output.

The Pseudo-Random Code Generator

Produces a random 31-step-sequence 5-bit logic code capable of change rates between 0.2Hz and10Hz. The sequence generator consists of a variable frequency oscillator (IC5) clocking a dual 4-stage shift register (IC6). By selecting a suitable Exclusive-NOR feedback arrangement using IC7, the random sequence length can be extended or modified.
NOTE – The code used at both Scrambler and De-scrambler must be in synchronization.

Power Requirements

This Rolling Code Scrambler operates on a single 5v, 60mA supply.

THIS APPLICATION NOTE MUST BE READ WITH A CURRENT FX224 DATA SHEET

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