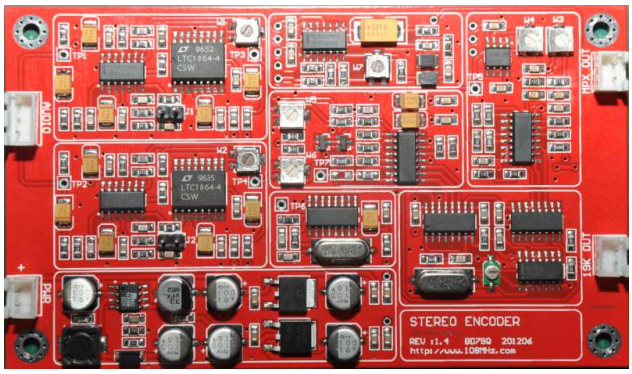


Introduction

Are you still using single-chip FM stereo encoder scheme? One chip integrated audio process, stereo encoder, frequency synthesis, modulation and a series of other functions. It seems is a simple and cheap solution. Though such kind of chip can implement relevant function, its performance can not be guaranteed due to its design orientation and cost control. In principle, it only can be used on mobile phone, PDA and such similar low power portable devices. Such kinds of chips are typically known as ROHM series (BH1415, BH1417, BH1414K, and BU2682 etc.), SI47xx series of SILICON LABS and KT0801 of KT Micro etc.

SE-1201 is a comprehensive scheme based on performances and costs. It is a high specification stereo encoder. Designed for optimum stereo separation and excellent spectral cleanliness this encoder will provide that extra performance for radio stations who want something a little special.

We searched and analyzed such relative encoder product materials that we can find, except those very professional ones (of course, the circuit is also pretty complex), there are only very few schemes.

We do not use matrix code method to design this encoder any more, but use lots of switching mode. However, most of the materials we found are defective even are wrong. Some circuits which claims using microcomputer control circuit, which its chip actually used just to produce the most basic pulse, a CD4060 chips is enough.

Before illustrating how SE1201 FM stereo encoder works, we should make some basic principles clear firstly. We did many experiments and found it is very difficult to make an excellent encoder under normal circumstances. You will need a lot of professional equipments, such as the signal generator, oscilloscope, TRMS voltmeter, frequency counter, receiver, and modulation analyzer, etc. Of course, if you have a FMAB of R&S, it will become easier. In addition, considerable experience and expertise are required if you want to produce such an encoder.

So, we made this encoder and hope you will learn a lot from it and enjoy it.

Specifications

Stereo separation	>55 dB, 50 Hz - 15 kHz (typically 60-70 dB)
Frequency response	±0.5 dB, 20 Hz - 15 kHz
Pilot frequency	19 KHz ±2 Hz
Pilot level	10%
38 KHz rejection	>65 dB
IMD and beats	>60 dB (no clipping)
Input level	0 dBm (775 mVrms/2.2 Vp-p) for ±75 KHz, adjustable
Input impedance	5k Ohms unbalanced
Output level	0 dBm
Output impedance	75 Ohms
Spurious> 100 KHz	< -60 dBc
Spurious> 200 KHz	< -80 dBc
Pre-emphasis	Flat / 50uS (75uS) by jumpering

Introduction

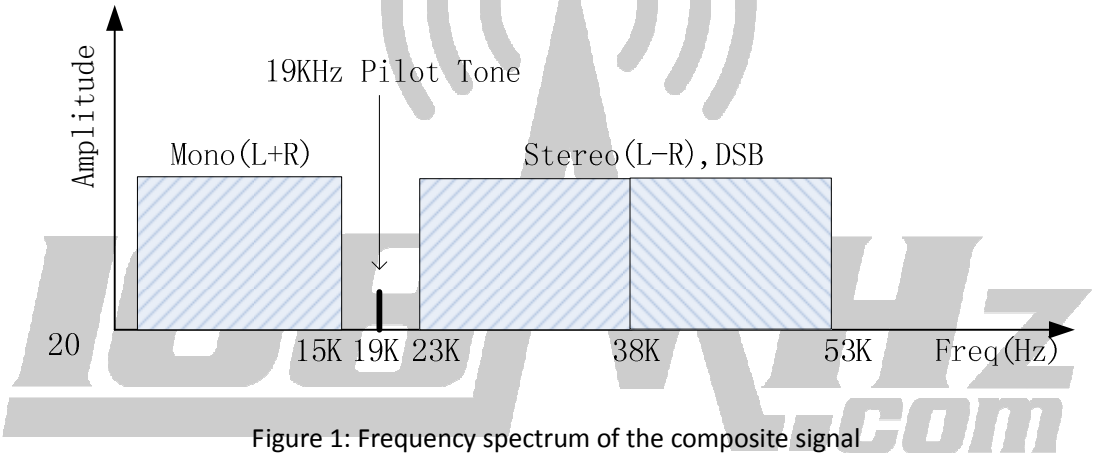


Figure 1: Frequency spectrum of the composite signal

Above shows the theoretical frequency spectrum of the stereo multiplex signal (MPX-signal). The MONO signal on the far left goes from approx 20Hz to 15KHz and is used to transmit the sum of the left and right channel. This assures compatibility with older MONO receivers that only receive this part of the spectrum. Going from left to the right we stumble upon the 19KHz pilot just above the MONO signal. This pilot has a couple of functions.

(1) It signals presence of the stereo signal; by detecting it the receiver switches to stereo.

(2) It enables demodulation of the L/R signal and LEFT/RIGHT channel reconstruction

The 19KHz signal is used to demodulate the DSB(Double Side Suppressed Carrier) signal stretching from 23KHz to 53KHz. This signal contains the L-R information (difference between the left and right audio channel). This is what the stereo encoder does to generate the Stereo Multiplex signal.

SOME FACTS ABOUT STEREO

Even the best stereo encoder is by itself not enough to guarantee good channel separation at the receiving side over the whole audio frequency range. Many factors are involved.

(1) THE TRANSMITTER

The first problem usually occurs at the transmitter. Badly designed audio stages of the modulator will produce low frequency phase shifts, affecting separation. But the main problem is the phase locked loop section of the transmitter. PLL tries to correct the frequency deviations caused by the audio effectively canceling modulation. The frequency correcting signal is passed through a low pass filter (loop filter). This loop filter dampens (smoothes and averages) the correcting pulses from the PLL circuit before passing the corrected voltage to the frequency control part of the modulator. The loop filter is usually the cause of the phase shifts due to not being able to sufficiently dampen and smooth the correcting pulses when the transmitter is fed with low frequencies. Variable frequency oscillators do not suffer from the problem at all due to no frequency correcting circuits (PLL). In short, a badly designed transmitter can be hugely detrimental to the stereo signal created by stereo encoder. Do not jump to the conclusion that the stereo sound that you are listening to is the stereo encoder only.

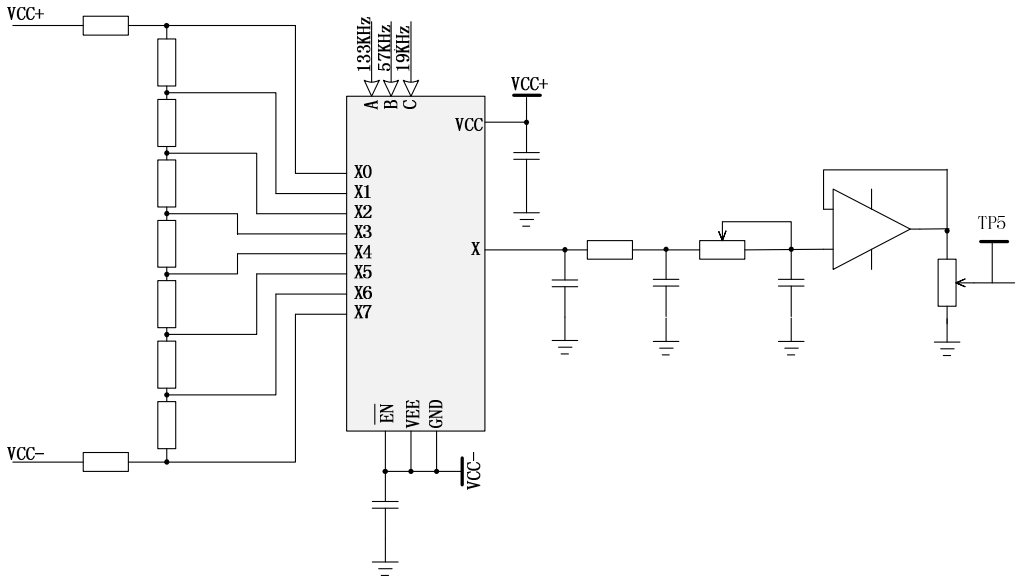
(2) THE RECEIVER

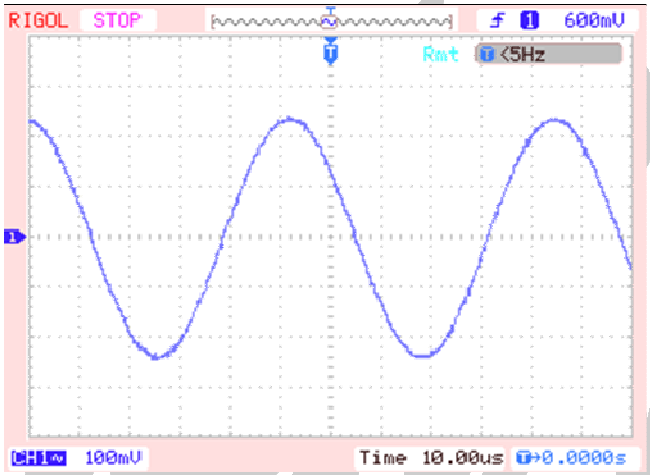
Filter Bandwidth and Stereo Decoder of receiver. Even if the transmitter adds no phase shifts to the multiplex signal transmitted, the receiver (radio) at the listening end can still cause trouble. The filters in the radio can cause phase shifts to the multiplex if too narrow in bandwidth. Many cheaper tuners have less filtering (less manufacturing cost) which although not great for selectivity provides for excellent separation in strong signal environments. The above is only true if the stereo decoder in the radio or tuner is ok. It is very hard to obtain any modern stereo decoder chips that give more than 45 dB of separation, some give only 35 dB. So even with modern day DSP (digital signal processor) stereo encoders that achieve separations of more than 70 dB, you will never hear it because the radio you will be listening to it on may only allow 45 dB at best. As you see, stereo is not just about a stereo encoder!

Circuit Description

(1) 19kHz Pilot Tone Generator Section

The 19KHz pilot tone comprises a baseband signal, and the L+R and L-R signals consist of DSBSC (double-sideband-suppressed-carrier) modulation centered at 38 kHz. For a receiver to correctly demodulate the signal, the transmitted pilot tone and L R signal must synchronize at their respective zero crossings. In addition, any distortion in the pilot tone produces harmonics that can interfere with adjacent sections of the signal.



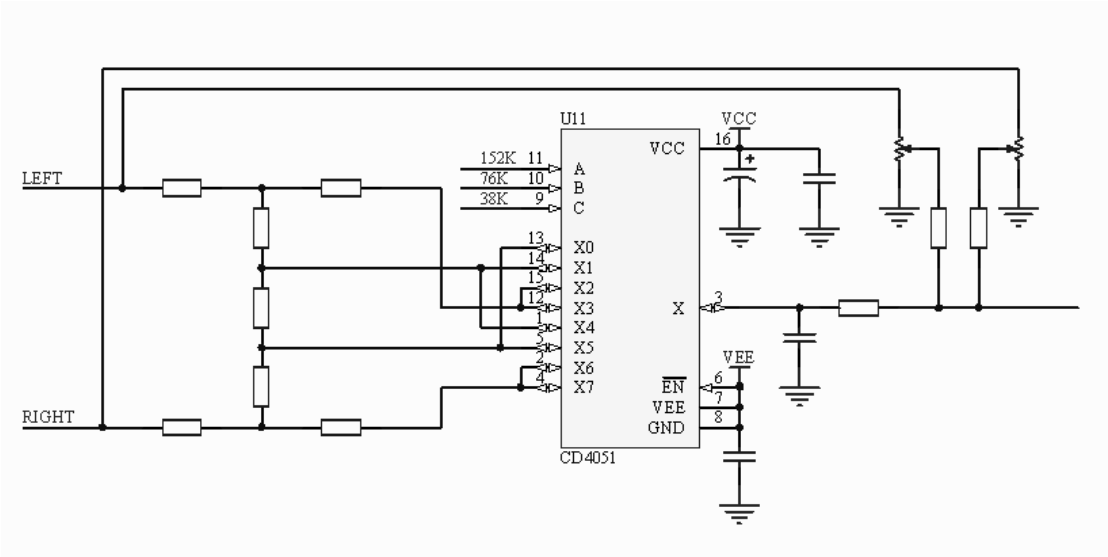


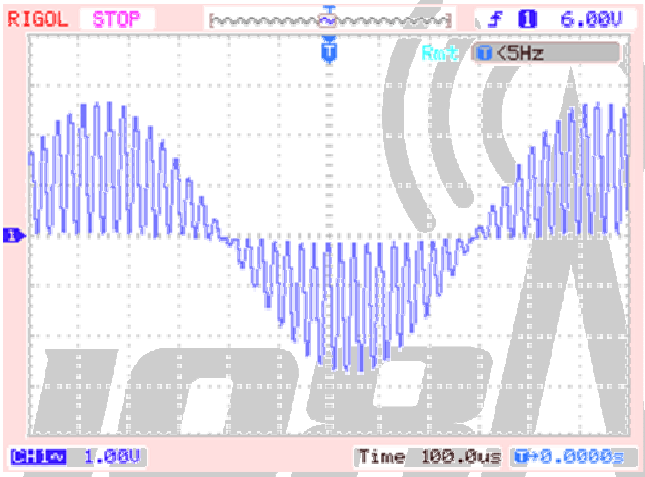
Test Point: TP5

This is the waveform of 19KHz pilot tone. It is precise synthesizing. The phase must synchronizes with sub-carrier (38 kHz)

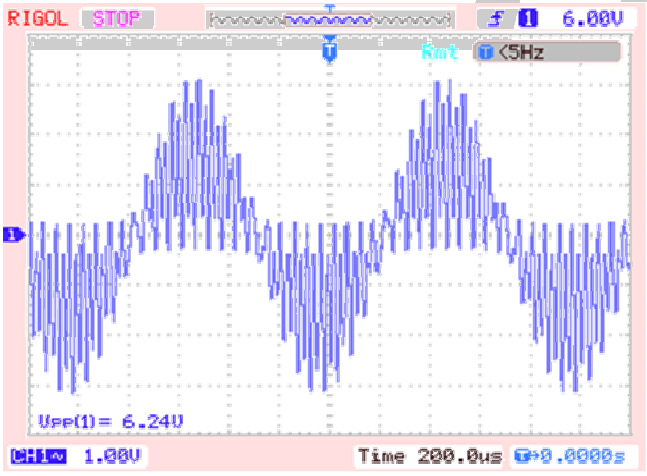
(2) Stereo Generator Section

Switching mode encoder is divided into "hard" and "soft" switch mode. Because subcarrier of hard switching mode outputs rectangular wave, these composite signals contains three times and more harmonic sidebands , still need low frequency filter to eliminate. On 99 KHz has a certain amount of low pass filter attenuation produced by the nonlinear phase shift, to baseband sideband(53 KHz) will still have great influence on, it still needs to add phase compensation circuit, or separating degree index is not high (< 50 dB), even if added phase compensation circuit, also be very difficult, and soft switch mode, subcarrier not rectangle wave but close to cosine wave , does not exist the problems, which can put the separating degree do high (> 60 dB)



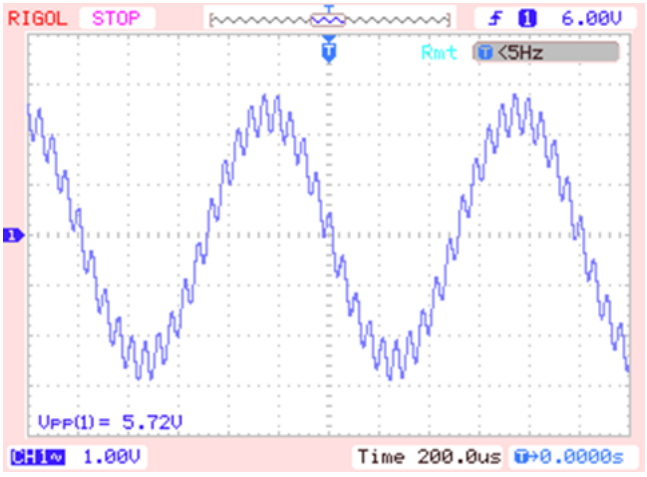


Test Point: MPX OUT
LEFT: 1KHz
RIGHT: None
Pilot: Off

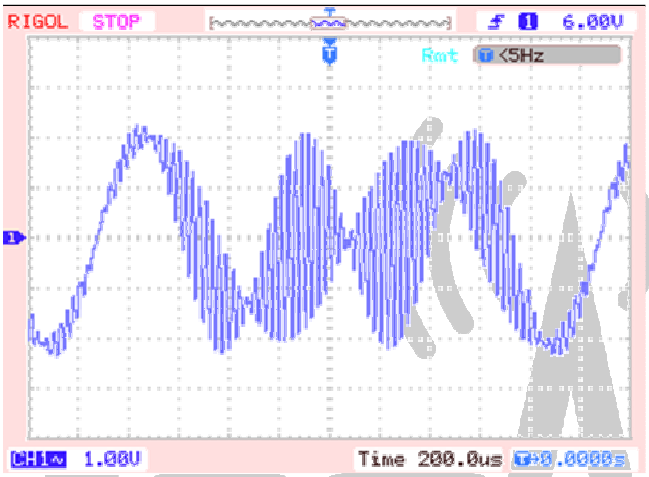


Test Point: MPX OUT
LEFT: 1KHz
RIGHT: None
Pilot: On

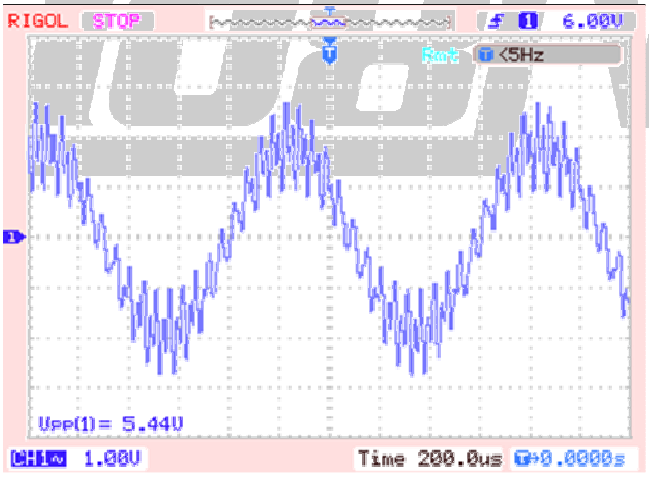
The waveform near the middle axis is the 19KHz Pilot ,Its amplitude could be adjust by W4.



Test Point: MPX OUT
LEFT: 1KHz 1.5Vp-p
RIGHT: 1KHz 1.5Vp-p
Pilot: On

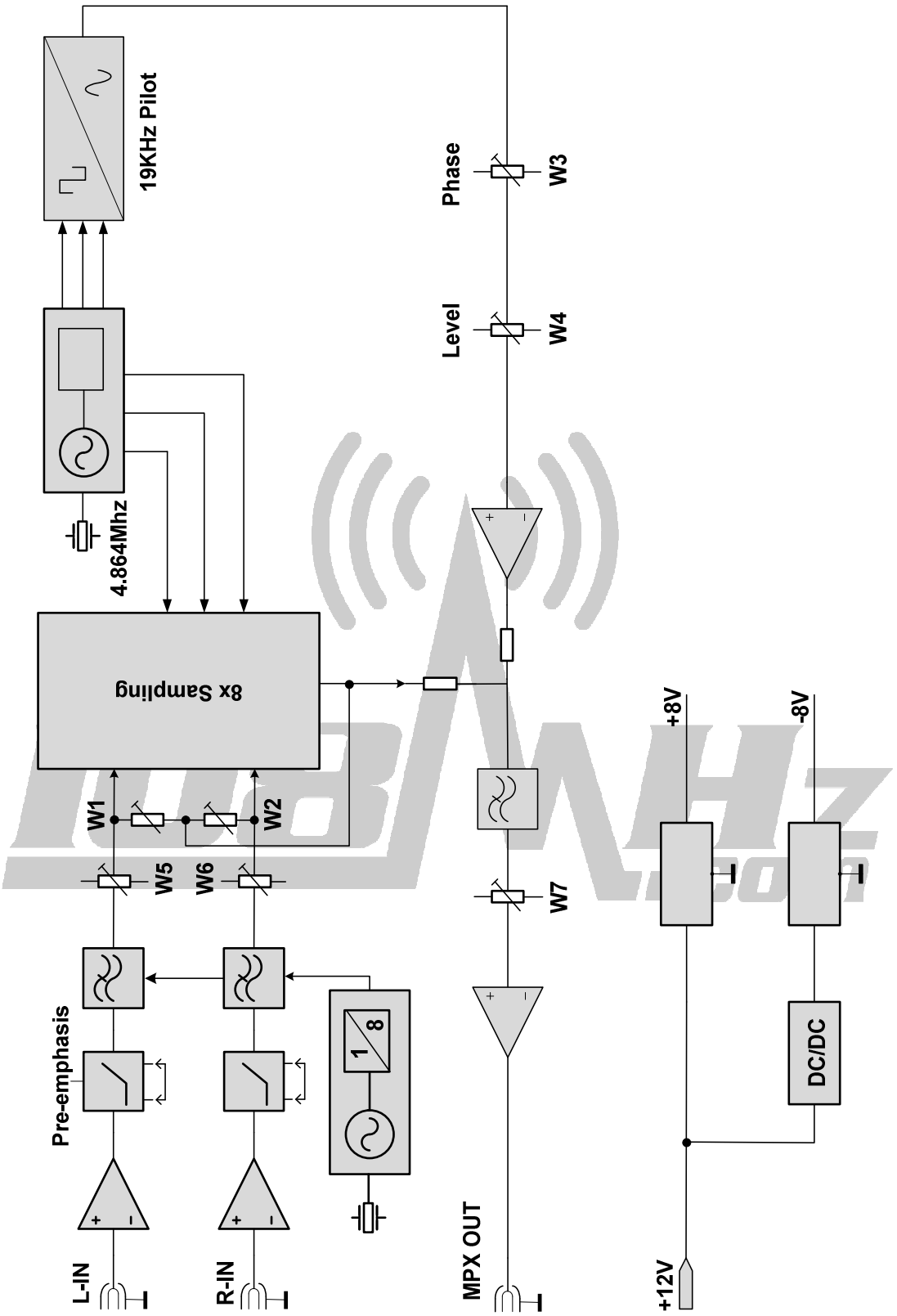


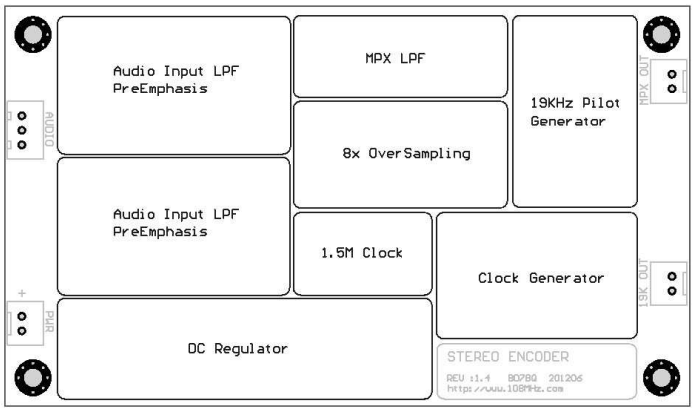
Test Point: MPX OUT
LEFT: 1KHz
RIGHT: 1.5KHz
Pilot: Off



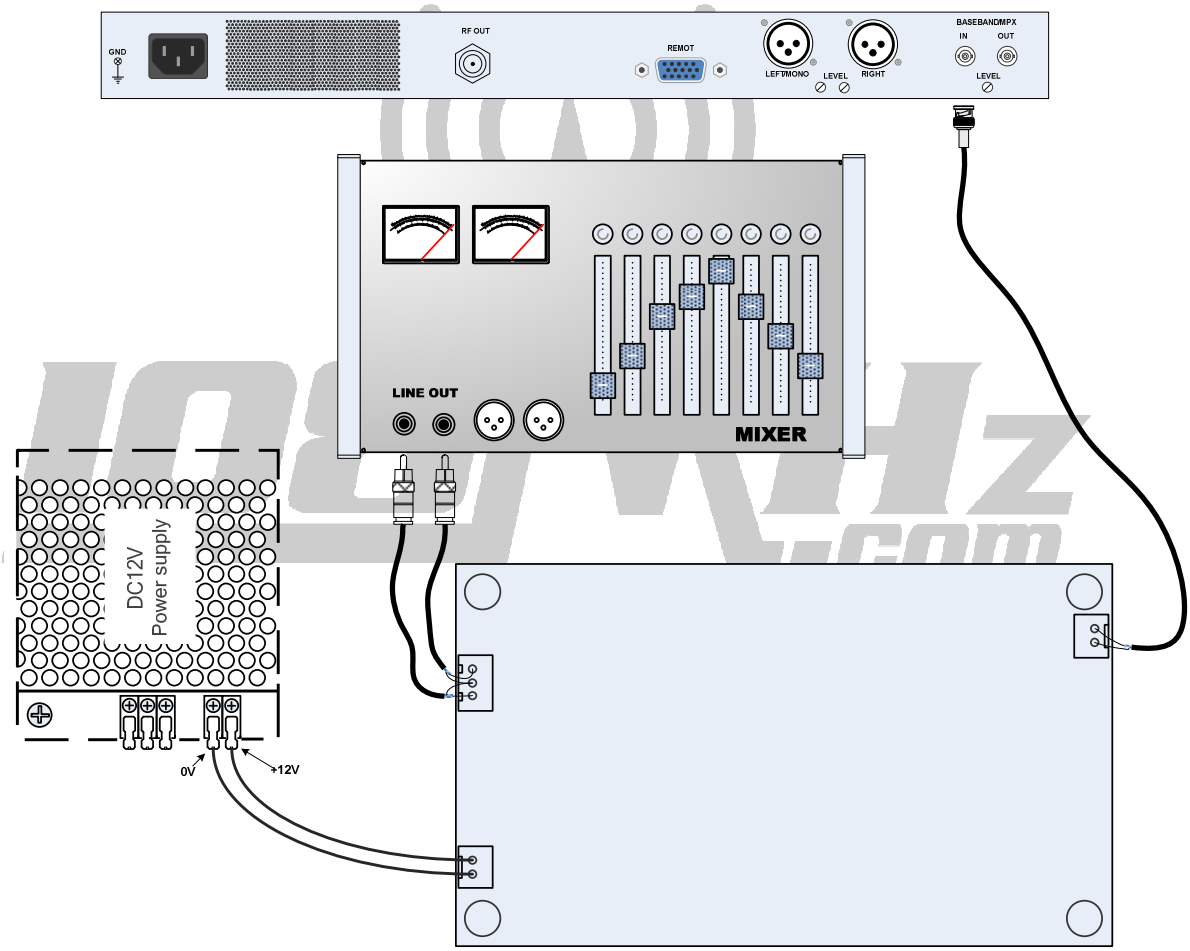
Test Point: MPX OUT
LEFT: 1KHz 1.5Vp-p
RIGHT: 1KHz 0.7Vp-p
Pilot: On

Functional Diagrams





Installation



Reminders

1. Heat will be produced during operation. Pay attention to keep ventilation cooling.
2. Connection wires should be as short as possible.
3. good shielding measures should be adopted to avoid interference