



SE5000 DSP + (5/2015)

New, improved professional Digital Stereo Encoder With DSP Filters and Compressor

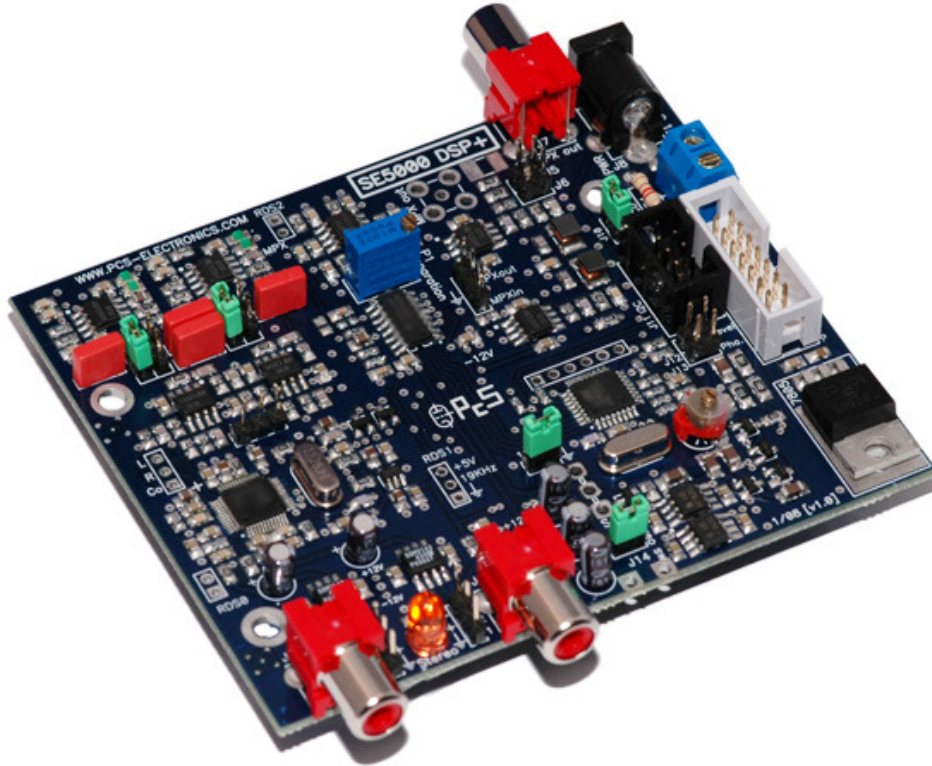


Fig.1: SE5000 DSP+ without the LCD control module

The new SE5000 DSP+ is a high performance stereo encoder with Digital Signal Processor (DSP). It replaces our popular SE4000+ and brings new enhanced performance. Built-in compressor, precise LED limiter and balanced inputs, sharp 19KHz stereo carrier notch filter, pre-emphasis, improved channel separation and sharp filters all help to bring out really crisp sound; all courtesy of our DSP audio processor. SE5000 DSP+ can even be upgraded to RDS functionality simply by plugging-in a RDS daughter board. It is perfect for a demanding, but cost-conscious broadcaster.

SE5000 DSP+ will make sure your signal stays where you want it, providing high quality audio with excellent channel separation without causing interference to nearby channels. High quality components and printed circuit board assure 24/7 operation for years.

Why is SE5000 DSP+ so great?

- Perfect for any mono FM transmitter, several output levels can be selected with jumpers
- DSP technology enables extremely sharp filters and a very deep notch at 19KHz!
- Drop-in replacement for SE3, SE4 and SE4000 DSP+!
- Works with or without LCD control module!
- Balanced or unbalanced audio inputs. This effectively eliminates annoying ground loops and hum.
- LC filtered MPX output signal.
- Built-in limiter, low pass filter and true compressor, all controlled via backlit LCD display and keys.
- You can control the sound parameters from the FM exciter's LCD display unit!

Why is SE5000 DSP+ better than SE4000 DSP+?

- Improved stereo separation
- I2C connector was redesigned for standard flat cable, now installation does not require any soldering but merely plugging a 6-pin flat cable into LCD module and stereo encoder.
- A number of small improvements that bring out better sound!
- I2C buffers permit for longer I2C cable and eliminate the notorious I2C error

Technical specifications:

Audio Response: 10Hz-15KHz, DSP filtered (Standards require upper level at 15KHz)

DSP: 24-bit Digital Signal Processor

19KHz notch filter, >-70 dB typ

Precise pre-emphasis, 50uS, 75uS or none

Audio Input Impedance: 10K, balanced or unbalanced

Audio Input Level: 0 dB, level adjustable in 0.5dB steps via LCD display

Distortion: <0.1%

S/N ratio: >80 dB

Separation: >60 dB typ. (more than any radio receiver you can buy on the market, typical figures are 25-35dB)

Pilot Frequency: 19 KHz, DSP generated with 32x oversampling

Output Impedance: 75 Ohms

Power Requirements: 12-15VDC / 160-200mA

PC Board Size: 100x85mm

Audio connectors: all RCA jacks are mounted on the board, 3-pin jumper for XLR balanced input

Power connector: 2.1mm power socket, center is positive, connection terminals (easier for boxed units)

Output level: Ueff 4V, 2V or 1V

What do the jumpers and controls do?

RDS0, RDS1, RDS2: RDS daughter board upgrade socket

J1, J2: Audio input

J3, J4: Pre-emphasis selection

J5, J6: Desired output voltage level setup

-For 1V install both jumpers

-For 2V install only one

-For 4V remove both jumpers

J7: MPX out (Composite stereo signal output)

J8: Power supply socket, 12-15V/100mA (13.8V is perfect), center is positive

J9: Alternative power supply input, wired parallel to J8

J10: Mode selection

- Jumper installed; stand-alone operation, no LCD and no connection to FM exciter

- Jumper NOT installed; operation via LCD module or I2C/MaxLink connection to MAX PRO 2000+/MAX PRO 3000+/MAX PRO 4000+

J11: I2C connector for connection to MAX PRO 3+. Now also carries stereo/mono selection signal

J12: Reduce pilot level; When installed slightly reduces 19KHz pilot level, you can install trimmer here for precise adjustment

J13: Change pilot phase; When installed slightly delays the 19KHz pilot signal, you can install trimmer here for precise adjustment

J14: Stereo/mono selection jumper. Can also be replaced with a switch or controlled via LCD display or MAX PRO 3+

LCD: LCD control module, connect here

LED diode: illuminated in stereo mode.

Trimmer capacitor: If you want to set pilot frequency precisely to 19 KHz, use this trimmer. For advanced demanding users only!

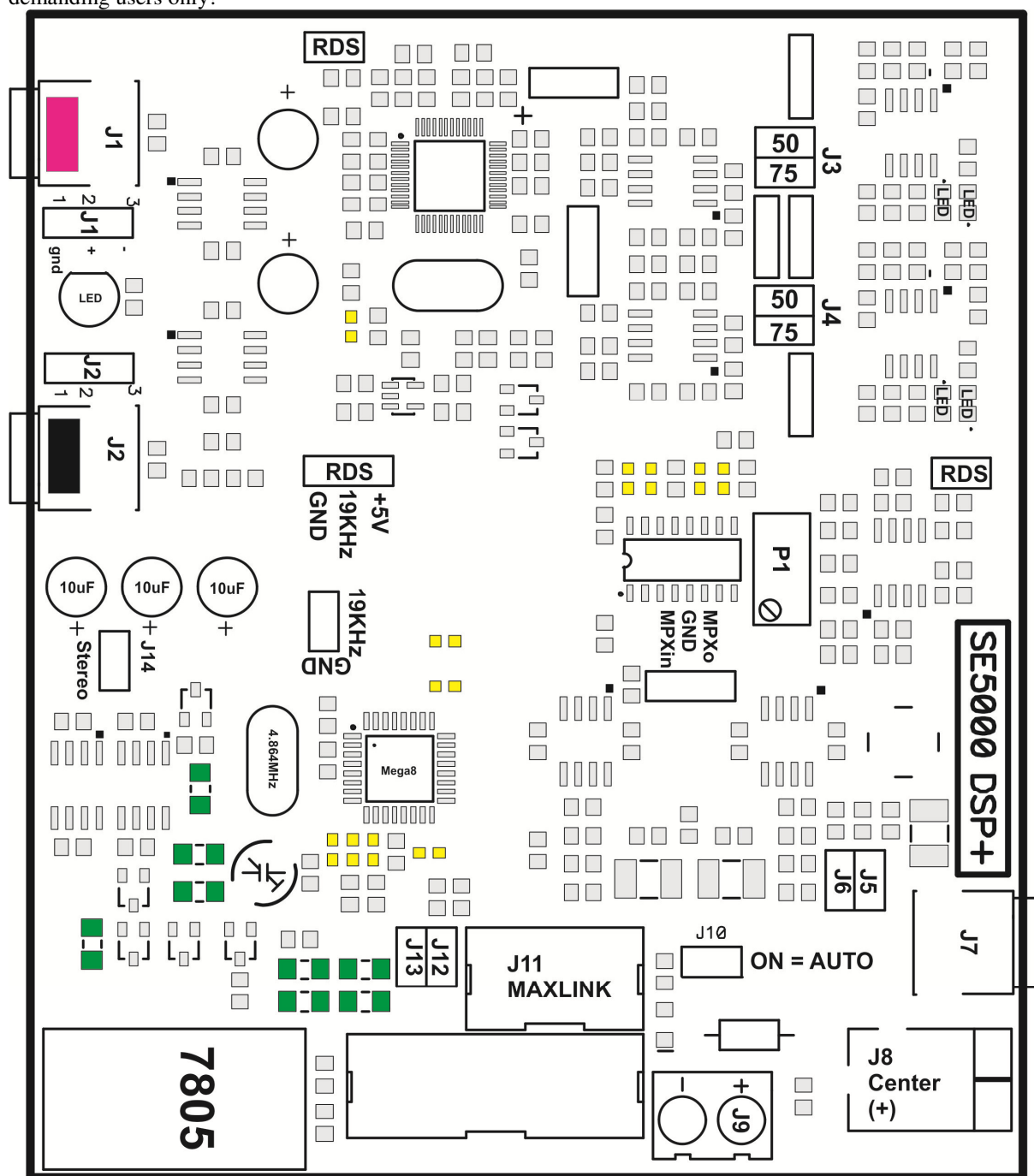


Fig. 2: SE5000 DSP+ board layout

INTRODUCTION - PRINCIPLES OF OPERATION

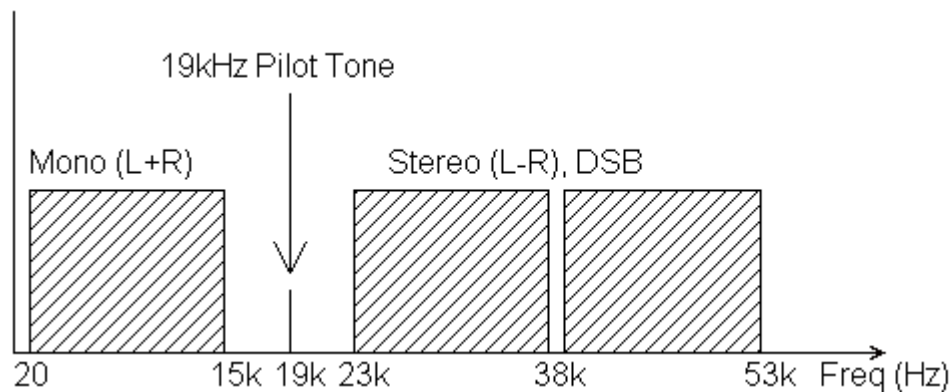


Fig. 3: Theoretical frequency spectrum of the stereo multiplexed signal

Figure 3 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 both 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 19 KHz 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 19 KHz signal is used to demodulate the DSB (Double Side Band Suppressed Carrier) signal stretching from 23 KHz to 53 KHz. 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.

- A.) Add Left and Right signals to get an L+R signal.
- B.) Generate a Pilot Tone of 19 KHz.
- C.) Generate a 38 KHz carrier for the Doubly Balanced Mixer (DBM)
- D.) Generate the L-R (difference of the audio channels) signal for the DBM
- E.) Modulate the 38 KHz carrier with the L-R signal using DBM (DBM suppresses the carrier in the process)
- F.) Add up A, B and C above to get the complete MPX Signal.
- G.) Use the above MPX signal to Frequency Modulate a carrier in the 87.5-108 MHz band.

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:

THE TRANSMITTER

The first problems usually occur 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 a stereo encoder Do not jump to the conclusion that the stereo sound that you are listening to is the stereo encoder only.

THE RECEIVER

Filter Bandwidth and Stereo Decoder of a 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 35 dB of separation, some even give you only 25 dB. So even with modern day DSP (digital signal processor) stereo encoders which achieve separation of more than 70 dB, you will never hear it because the radio you will be listening to on will only allow 35 db at best. As you see, stereo is not just about a stereo encoder!

CIRCUIT DESCRIPTION

Left and Right audio signals are applied to the connectors J1 and J2. Make sure not to ground the outer shield of the RCA connectors, this will help reject the noise on your audio lines. Alternatively balanced inputs can be used. Connect them to J12/R and J13/L 3-pin jumpers. The audio signals are then fed into the balanced-to-unbalanced converter and passed over to DSP processor circuit. 24-bit DSP processor takes care of signal processing for us. DSP also generates the pilot tone (19 KHz) via the D/A converter. All these signals (DSB and pilot) are summed up and “exported” back into the analog world with the help of a D/A converter, then filtered, limited and filtered again to obtain a close to perfect and crisp sounding MPX signal.

HERE IS WHAT YOU NEED TO USE SE5000 DSP+:

POWER SUPPLY

This unit is designed to work even with a stabilized wall-wart, which must provide 12-15V at approx. 200mA, provided it has a good regulation. You can connect the DC supply by inserting the power jack into provided socket.

ENCLOSURE

If you want to make your own, use aluminum or other metal, ventilation holes are recommended. The 7805 regulator needs to be bolted to the enclosure via metallic spacer as it does get hot. Fix the PCB with all screws tightly. A shield is recommended between the exciter and the encoder, if you have them both in the same enclosure. Attractive and predrilled enclosures of exact size are available, check our site for info.

A 19” rack enclosure for SE5000 DPS+ is available from our website.

SETUP AND TESTING

SE5000 DSP+ is very easy to setup. What we do have to do however is match the output level of the encoder and input level of the transmitter so that the pilot tone (19 kHz) alone (no audio) gives a deviation of the exciter of 6.75 kHz (9 percent). This automatically sets the remaining audio levels. If you’re using our line of FM exciters just connect the stereo encoder to the transmitter, set encoder to Stereo, set audio level on the fm transmitter to zero and keep increasing it until the stereo led on the receiver comes on.

Let’s assume that you don’t own an expensive peak deviation meter or modulation meter/analyzers. If you have or can gain access to these pieces of equipment then you probably also know how to use them; setting of the level is as easy as adjusting the input level of the transmitter for the appropriate deviation.

To set up the encoder, disconnect audio from the input sockets on the encoder. Adjust the modulation level at the exciter so that the LED diode lights on the receiver. The next step in setting up the encoder is to optimize the stereo separation by adjusting the trimmer. The setting for this will vary from tuner to tuner slightly. To set this follow the procedure below:

- 1.) Disconnect one audio input source so that only one channel is connected. Apply audio to this source.
- 2.) Listen to the audio on a high-grade tuner and adjust the input volume pot for that audio channel so that the volume is only half that of a commercial station. The reason we want this is to be sure we are inside the +/- 75 kHz bandwidth. Over deviation will cause degradation of the stereo separation. We now should have the encoder correctly setup with only one channel of audio that is inside the +/-75 kHz bandwidth so separation should be able to be fine tuned without problems such as over deviation affecting our measurements. Turn your amplifiers balance control so that you are listening to only the channel with no audio on.

If everything is good and well then you should have this channel a lot quieter than the other channel. Turn the amplifier up in volume so you can hear the crosstalk between the channels. Now adjust P1 and P2 until the sound in the opposite channel disappears or is at least barely noticeable. You should be able to achieve your maximum separation. You can now reconnect the other channel and apply your audio at the correct level. The encoder is now aligned and ready for operation. **DO NOT FORGET TO DISABLE PREEMPHASIS AT THE TRANSMITTER WHEN YOU CONNECT IT TO THE STEREO ENCODER** (failure to do so results in very poor stereo separation and distortion).

BALANCED AUDIO AND POWER CONNECTOR

SE5000 DSP+ features balanced audio inputs, just connect XLR connector to L or R 3-pin header (next to rca jacks). Pin 1 is ground, the other two are Audio + and Audio -. They are numbered 1-3 and match the markings on the connector, so just make sure you are connecting 1 to pin 1, 2 to pin 2 etc.

Any hum problems usually magically disappear once the XLR input is used instead of the basic unbalanced RCA input. Note that you will have to purchase XLR connectors as only RCA type is typically included on the PCB.



Fig. 4: *Balanced audio input – Panel mounted XLR connector*

You will also find the usual power socket (center is positive) on board. Use either our 15V mains power supply or another power supply with appropriate ratings. See product specifications for more details. Next to the power socket is the IDC14 connector for optional LCD control unit.

STEREO/MONO MODE SELECTION AND MAXLINK (I2C) BUS

Users of our older unit, the SE4000 DSP+, will notice absence of the stereo/mono switch in the middle between audio inputs. This switch can still be installed, but is not included by default. Mode selection is now possible in 3 different ways:

1. In stand-alone mode without LCD control module or without FM exciter's LCD module you can install or remove jumper J14 or install the switch in its place.
2. When you are using LCD control module you can simply set the mode via the control module/menu system with up/down keys.
3. When used with our FM exciter board you can set the mode via LCD control module/menu system as well, but you need to connect stereo encoder and FM exciter with the MAXLINK cable. This is a 6-wire flat cable that is simply plugged into appropriate IDC connectors on stereo encoder and the LCD module. See fig. 5 below for wiring directions.

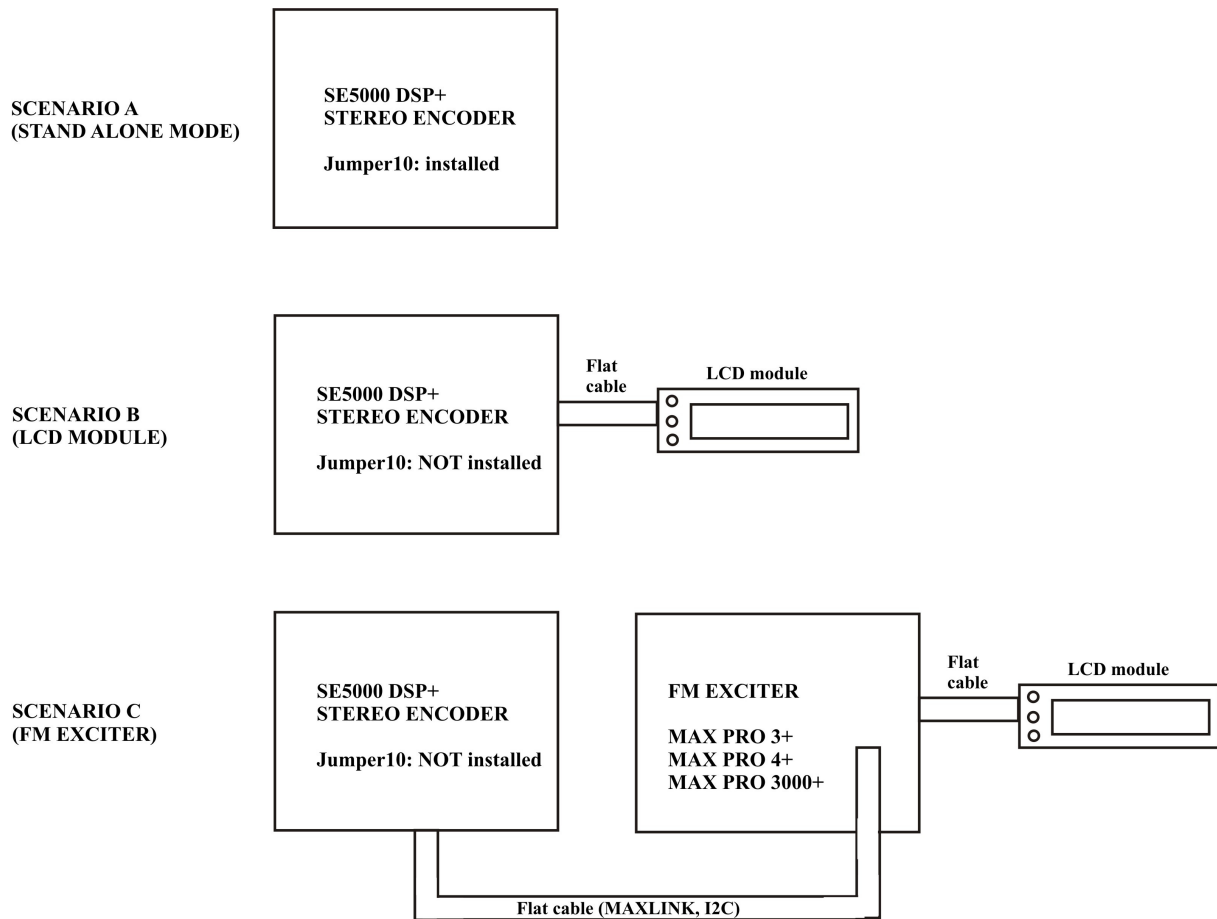


Fig. 5: Connecting stereo encoder to FM exciter or LCD display.

Whatever method you use to set the mode, it is still represented with the LED diode as well; if illuminated, you are in STEREO mode.

NEW LCD CONTROL MODULE AND EXPANDED MENU SYSTEM

LCD module has been upgraded to provide Maxlink (I2C) connector for simplified connectivity. The front of the unit starts with the three keys on the left, followed by the backlit LCD display. LCD control module is equipped with our new menu system. It can be modified on request to include your station name or any other messages you may want displayed on the LCD.

The UP and DOWN keys are used to change parameter value. In normal mode the LCD is simply showing the welcome screen. Menu key can be used to enter the menu mode, repeatedly pressing this key brings up the following menus: TREBLE, BASS, CONTRAST, LEFT CH. GAIN, RIGHT CH. GAIN, FIRMWARE VERSION, COMPRESSION RATIO, COMPRESSION THRESHOLD, ATTACK, DECAY, INTEGRATION INTERVAL and STEREO MODE. Pressing the UP or DOWN key selects the desired parameter and allows you to modify its value. Another tap on the MENU key and you're back to normal mode.

NOTE: Default and recommended values are represented with a (D) behind the parameter value.

WELCOME SCREEN

This is the general appearance of the LCD menu system in idle state, during normal use (Note that this photo is from version 4000, the new version is identical except it says SE5000 DSP+ now). Note stereo mode in the second line and product name in the first line:



Fig. 6: Welcome screen

TREBLE and BASS

This option allows you to set the amount of TREBLE and BASS in your audio. Recommended values are marked with (D).



Fig. 7: Welcome screen

COMPRESSOR SETTINGS

A number of MENU settings control the operation of the compressor. Lets assume that the audio signal enters the transmitter at some low level. Compressor does nothing to the signal until at one point as the input signal increases the signal reaches the compression threshold. Digital signal processor starts compressing the signal beyond that point. The higher the compression ratio the higher the compression. For example, compression ratio of 1:∞ would in effect be a limiter.

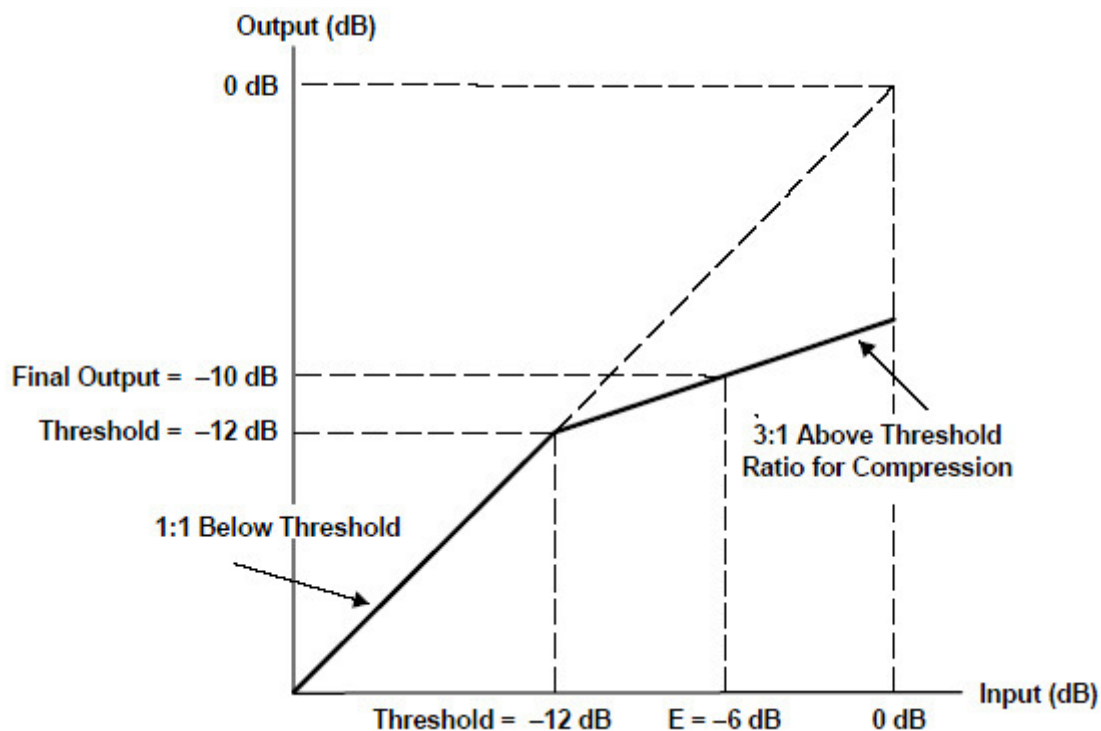


Fig. 8: Explanation of the compressor settings



Fig. 9: Setting the compression level



Fig. 10: Setting the compression threshold



Fig. 11: Setting the attack time, this is the time between the signal rise and the actual response of the compressor

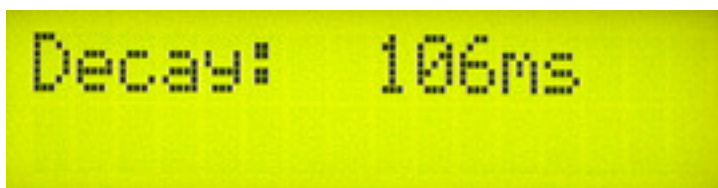


Fig. 12: Setting the decay time, this is the time the compressor needs to respond to a decrease of the signal

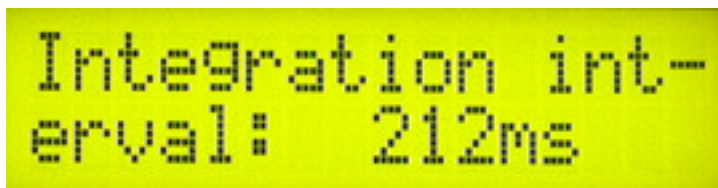


Fig. 13: Setting the integration interval, this is the time the DSP extracts the samples

Integration interval determines the energy needed to trip the compressor. In laymans terms it determines how long the audio needs to be loud for the compressor to respond by reducing the gain. This is not to be confused with attack time. Attack time of 50ms means the compressor will respond in 50ms after the signal spike is detected, regardless of duration of that spike, even if it is just a very short event. With longer integration interval, on the other hand, compressor only responds if a substantial number of spikes is detected (meaning more signal energy).

PRE-EMPHASIS

Pre-emphasis is now selected with a jumper and should be set to either 50uS (standard for EU and most of the world) or 75uS (United states and Canada). There are two jumpers, correct position is marked on the board. This change in operation was done to enable operation without the LCD module.

FIRMWARE

This option allows you to display current LCD module firmware version.



Fig. 14: *Firmware version*

CONTRAST

This option allows you to change LCD display contrast .



Fig. 15: *Changing contrast*

LEFT AND RIGHT CHANNEL GAIN

This option allows you to precisely adjust the input sensitivity of both audio channels. This is very usefull when your audio source has either too high or too low output level.



Fig. 16: *Changing right input channel gain*

MONO/STEREO MODE SELECTION

This option allows you to change MONO/STEREO mode.

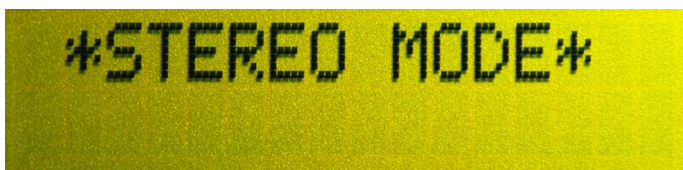


Fig. 17: *Changing mode of operation*

THANK YOU FOR PURCHASING SE5000 DSP+!

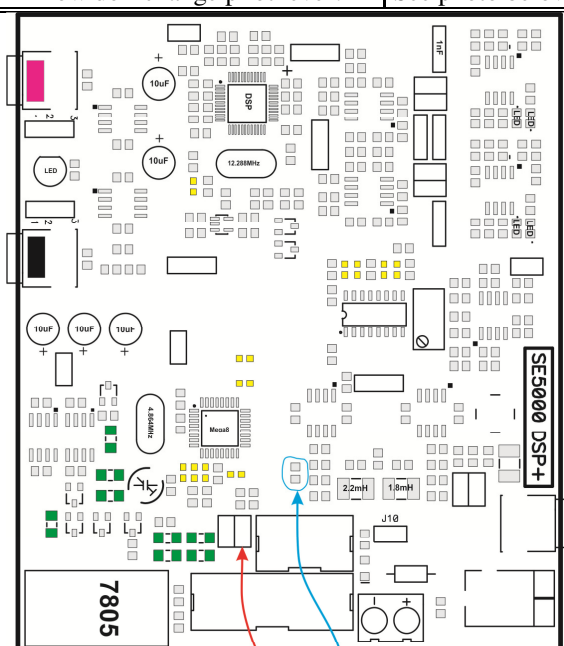
We hope you will enjoy it as much as we do and remember to tell your friends about it. Please feel free to leave your comments at our website or post your experience in our forum.

From all of us we wish you happy broadcasting!

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TROUBLESHOOTING TABLE

PROBLEM DESCRIPTION	POSSIBLE SOLUTIONS
STEREO indicator LED is off in stereo and mono mode	1. Check supply power and voltage 2. Did you connect Maxlink to LCD and set operation to mono with your LCD module? You can only use one method to select stereo/mono mode
Very poor stereo separation, strange audio	1. Make sure you disable pre-emphasis in your FM EXCITER. Check supply voltage 2. Rotate P1 precision trimmer to maximize separation
Audio without any treble	Set pre-emphasis on the stereo encoder board (either 50uS or 75uS).
Audio too quiet	Increase level on your audio source a little bit, make sure modulation on your FM exciter board is opened sufficiently. If you're unable to increase modulation in your exciter set the output voltage level with jumpers.
Audio distortion on high peaks, for example on "s" sound.	Your input level is slightly too big, reduce input audio level slightly at your audio source.
There is HUM in audio	<ul style="list-style-type: none"> - Move antenna as far away from the transmitter and audio gear as possible - Use XLR audio connectors, if possible - Make sure SWR is low - Keep audio cables short and away from antenna and RF coaxial cable - Form a coil from coaxial cable going to the antenna, make a few turns. This stops RF currents that might be flowing on the outer braid of the coaxial cable. This usually happens when you connect unbalanced cable to balanced antenna without proper BALUN (balanced-unbalanced convertor) resulting in coaxial cable becoming part of the antenna and radiating RF energy as well...causing hum.
I2C error message on the LCD display	<p>Make sure to set the J10 jumper correctly. When using FM exciter or LCD module to control stereo encoder, please remove the jumper. When using stereo encoder in stand-alone mode, install this jumper.</p> <p>This error can also be caused by using two units to control stereo encoder, for example when you connect LCD module and FM exciter at the same time.</p>
How do I change pilot level?	See photo below



Pilot, 273(27K change to reduce/increase pilot level)

Install jumper to reduce level (3K resistor to ground)

Fig. 18: Pilot level change

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CHANGE LOG

10/2010 - Document

5/2015 – Added jumper names to board layout, added pilot change data