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# 1- SST THEORY

## Description

The Small Sample Test (SST) hardware kit is a collection of all items (except base plate, 30dB dummy load and interconnecting cable) needed to setup and perform the multiple SST modes of operation. This proprietary Service tool kit is packaged in a hard case with all items stored within the case's foam inserts. A description of all kit contents and theory of operation follows.

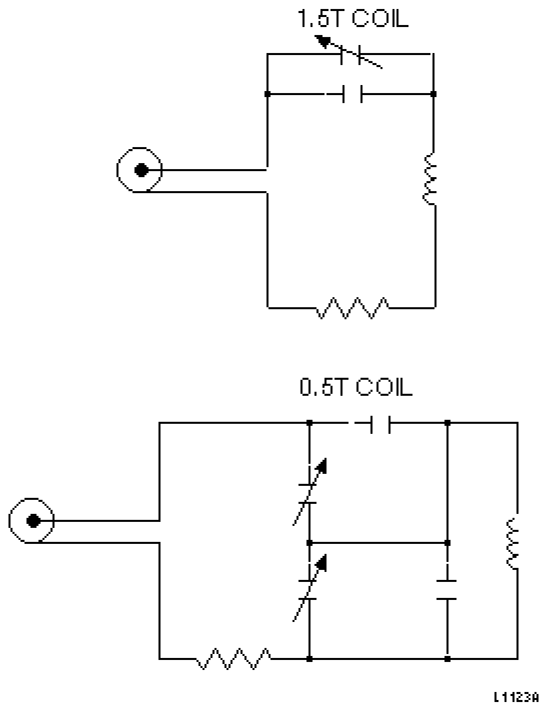
## 1-1 SST RF Coil

### 1-1-1 Universal Coil Design

The Universal Coil is designed to provide greater sensitivity (higher "Q") resulting in higher SNR than the Original SST coil. Thus the Universal Coil allows a wider range of applications with SST and other tests (e.g. High Speed Stability). The original SST coil design included a 50 ohm resistor in series with the coil to reduce the Q, in order to decrease its sensitivity to the Body Coil Shield and other environmental factors.  The Universal Coil does not have a comparable series resistor, thus providing an increase in sensitivity. This increased sensitivity required a shield be added to surround the coil to prevent interaction with the Body Coil Shield.
The coil was designed for use at small RF levels and the average RF input power to the coil should not exceed 1.0W.

### 1-1-2 Original SST Coil Design

The Original SST coil is a transmit and receive coil tuned for use at the resonant frequency of the system (63.86 MHz for the 1.5T coil, 21.28 MHz for the 0.5T coil).  See Illustration L1123A. The original SST coil design included a 50 ohm resistor in series with the coil to reduce the Q, in order to decrease its sensitivity to the Body Coil Shield and other environmental factors. When used with the hermetically sealed glass ampule containing solution, it forms an absolute signal and noise source that is very useful for system troubleshooting.  The coil was designed for use at small RF levels and the average RF input power to the coil should not exceed 1.0W.




**ORIGINAL SST COIL SCHEMATIC**
ILLUSTRATION L1123A

### 1-1-3 Coil Theory of Operation

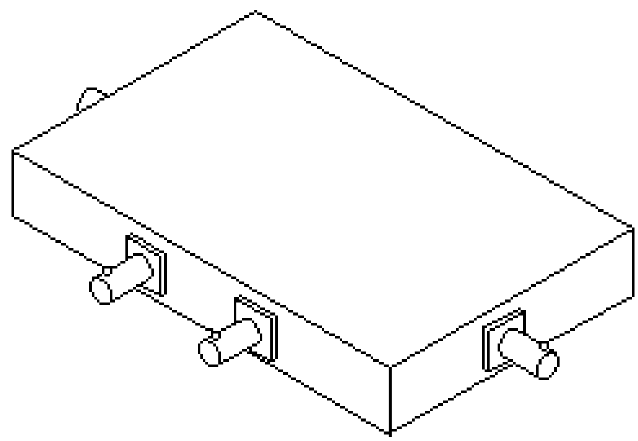
The coil portion, or inductor, is closely coupled to the sample and is dimensionally small to minimize coupling to outer structures such as the body coil and RF shield. The capacitors are series resonant (0.5T SST coil capacitors are also parallel resonant) with the inductor, producing a net zero imaginary component of the input impedance, see Illustration L1123A. A resistor is added to cause the real component of the input impedance to be approximately 50 ohms. This real component establishes the Johnson noise floor, and stabilizes the input of the coil over small variations in tuning. The stabilized input impedance maintains consistent preamplifier noise figure performance.

### 1-1-4 Original SST Coil Functional Check

If, in the unlikely occurrence of suspected coil failure, an input impedance check can be performed on the suspect coil to qualify its functional operation. Place the coil on a non-conductive surface and ensure no conducting items are within three feet. Uncoil the cable and lay it in a straight line to a vector impedance meter. Connect cable to vector impedance meter probe via BNC adapter and BNC barrel. Set meter frequency for 63.86 MHz for **1.5T** SST coil, or 21.29 MHz for **0.5T** SST coil. The Magnitude should measure between 50.8 ohms to 53.8 ohms and Phase between -10 degrees to +10 degrees. The coil is not field repairable or tunable (except for BNC connector replacement) and must be returned to headquarters in Milwaukee for any corrective action. If performing BNC connector replacement, cut minimal cable when removing and replacing connector so as to not alter coil tuning. Recheck coil tuning per above procedure any time BNC connector is replaced or repaired.

## 1-2 SST RF Combiner Assembly

**Description -** The SST RF Combiner Assembly was designed to act as a power splitter/combiner interface between the Body Hybrid Splitter and the SST RF coil, see Illustration L1124A. The RF Combiner Assembly incorporates microstrip hybrid technology with diode switching control. It effectively allows operation of a linear SST RF coil with a quadrature RF drive system by splitting/combining the quadrature signal to correctly drive and receive from a linear RF coil.

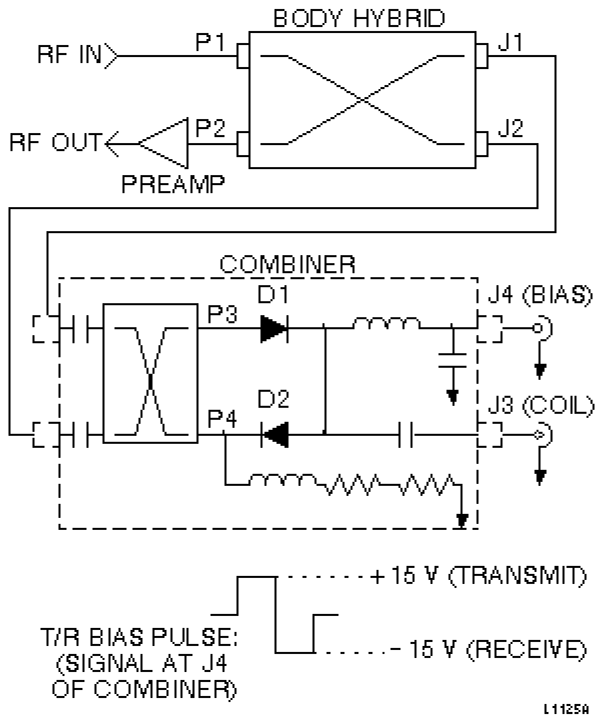


L1124A

**SST RF COMBINER ASSEMBLY**
ILLUSTRATION L1124A

### Operation

The RF Combiner Assembly has two modes of operation as determined by input transmit/receive bias pulse conditions applied at bias connector J4. During transmit, RF power incident at P1 of the Body Hybrid splitter is split and presented in phase quadrature to connectors J1 and J2 of the combiner. The total power is therefore available at port P4 of the Combiner. The positive T/R bias condition enables signal transmission to the SST RF coil via connector J3. During receive, power received from the SST RF coil is routed to P3 via the reconfigured bias pathway. Transversing the combiner, the signal is halved and delivered in phase quadrature to the Body Hybrid. The signal is then recombined and made available to the preamp via P2. See Illustration L1125A.




**SST COMBINER ASSEMBLY SCHEMATIC**
ILLUSTRATION L1125A

### 1-3 RF Attenuators, Adapters And Cables

**Description -** Various RF adapters, connectors and cables are needed to hookup SST kit components to system under test. All these items are included in every SST kit, including two variable attenuators (0-1 and 0-10 dB) needed when running Head and Body Full Power tests.

### 1-4 Gradstress Test

**Description -** This test has been removed from SST.

### 1-5 Stability Test

**Description -** This test checks RF signal stability with no gradients applied, one gradient applied and/or all gradients applied. The test outputs plots (if plotting is selected) of signal stability (%), frequency drift (Hz) and phase drift (degrees) on IP. These results as well as the mean, peak to peak, and standard deviation are displayed on the selected display terminal. All results are relative to the mean values for the no gradient case. The peak signal value and time between applied pulse and peak is displayed for the no gradient case and peak delay time relative to the no gradient case is displayed for all other possible stability test configurations.

There have been instances where a defective gradient amplifier can cause a stability failure on another axis even when the defective amplifier is not driven. To troubleshoot these types of failures, the unused gradient amplifiers can be placed into StandBy mode during testing. The sst PSD controls the state of the gradient amplifiers during the scan for the gradient control modes.

**CAUTION**

**Some MR Signa systems have experienced damage to the transistors when running the Stability Tests. It is possible to decrease the power of the gradient waveforms (heater pulses) by manipulating Control Variables (CV's). The CV's for reducing the amplitude of the heater pulses during Stability Tests are:**

**a_gs_ghx for the x axis**
**a_gs_ghy for the y axis**
**a_gs_ghz for the z axis**

**Multiply the default value of the**
**CV by 0.5. This will reduce the power of the gradient pulses by a little more than half which should solve any problems you have been seeing with transistor failures and circuit breaker trips while maintaining a reasonable stress level to test the amplifiers.**

**The heater pulses can be disabled by setting the CV, gs_t4, equal to 600000 (600 ms).**

### 1-6 Signal-to-noise Ratio (SNR) Test

**Description -** This test compares the signal, to the signal expected, with a minimum-gain-spec preamplifier and measures the noise (signal with no RF applied) with the transmitter blanked and unblanked while also monitoring drift in the baseline level. The output plots (if plotting is selected) of I and Q baseline drift (I and Q plotted separately) are the mean and peak unblanked signal values over time. Results also displayed on the selected display terminal are signal level, gain (relative to the minimum-gain-spec preamplifier), time to peak signal (center of echo) , RMS noise values for the blanked amplifier (I and Q separately and combined), SNR value, average and peak unblanked signal and peak to peak and standard deviation values for I and Q baseline.
A Noise Only option of this test is available. The PSD will play out the same sequence as the normal SNR test, however, during the analysis, only noise data will be analyzed and reported. Signal and SNR numbers will all be masked with zero.

## 1-7 RF Linearity Test

**Description -** The RF linearity pulse will ramp up gently to a flat top with center frequency set sufficiently below magnet frequency that no excitation is imparted to the protons in the sample. After the flat top of the pulse has had time to settle, center frequency is changed to magnet frequency and held there until the end of the pulse. So the linearity test is performed with the NMR equivalent of a rectangular RF pulse. Width of the portion of the pulse that is played out at magnet frequency is set to that at full scale modulation the flip angle will be 120 degree. Amplitude is incremented linearly through 128 steps from 1/128 of full scale to full scale (PSGFULL=32767). The process is repeated with RHO modulation polarity inverted. By collecting data twice with opposite modulation polarity, the analysis tool is able to compensate for the adverse effects that carrier leakage would otherwise have on the linearity measurement.

## 1-8 Gradient Bit Test

**Description -** For Signa Advantage systems, this test checks for 16 bits of the three master gradient amplifiers. The three lowest bits are checked by turning on an offset in the echo of the bit being checked and comparing it against assumed values. For checking the remaining bits, the RF pulse is adjusted so that the spin echo is centered in the acquisition window if the bit is correct. A table is output indicating the pass/fail status of each bit for each axis.

For Signa Horizon systems, this test checks the 16 most significant bits, leaving the 4 least significant bits untested.

## 1-9 Rho Modulator Bits Test

**Description -** The flip angle produced by sequentially turning on each bit of the Rho Modulator is measured and compared against expected values. This test is dependent on bits 6 and 12 for testing remaining bits. The test output is a table indicating the pass/fail status of each bit.

## 1-10 Transceiver Quadrature Test

**Description -** The transmitter is tested by sweeping the phase from 0 to 360 degrees and mapping the I and Q response. Output is plots of transmitter amplitude and phase error versus angle. Test frequency (frequency of main component of signal), response of I and Q for selected flip angles, gain (RFQ/RFI) and phase error are displayed. Sideband suppression is calculated from the magnitude and phase error. The more negative the sideband suppression, the lower the intensity of the receive or transmit ghost.

## 1-11 Receiver Bit Test

**Description -** This test checks that all bits of the I and Q channel have experienced both 0 and 1 at one time or another during the tests. The test is performed when reading in the raw data files, and is only executed until all bits have been verified, which usually happens within the first frame of data. A table is output indicating the pass/fail status of each bit.

# REVISION HISTORY

| REV | DATE | AUTHOR | PRIMARY REASONS FOR CHANGE |
|---|---|---|---|
| 0 | | M. Waller | Initial Release |
| 1 | 9/29/96 | M. Waller | Updated for Signa Advantage Hardware and for Signa Horizon Hardware. Updated RF Linearity Test, and Took out Grad Stress Test. Took out all reference to Release 5.3. |
| 2 | 10/17/97 | K. L-P | Updated to Word for Lx2 |
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