CWF-1

Complementary Weighting Filter

Operators Manual

One on One Technical Products, Inc.

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Introducing the CWF-1

Modern acoustic measurement systems employ stimulus which has equal energy per frequency. This is known as "white" weighting. This applies to swept sine, stepped sine, chirp, impulse FFTs and maximum length sequence (MLS) measurement systems. Typically, random environmental noise energy increases as you go down in frequency.

Because the energy distribution of unwanted acoustic noise is weighted toward low frequencies, all acoustic spectrum analyzers will exhibit improved signal-to-noise ratio (SNR) as frequency rises.

Other than increasing the stimulus level, swept sine and stepped sine analyzers have no strategy to deal with this problem. Chirp, impulse FFT and MLS do have effective strategies available, and this is one of the inherent advantages of these systems.

Here are some of the strategies used to improve low frequency signal to noise ratio.

1. Increase the stimulus level: (all analyzers) Increasing the stimulus level has a direct effect on the signal to noise ratio. However, there is a practical limit to how much it can be increased. The device under test (DUT) can be driven into non-linearity and even to the point of destruction.

2. Averaging: (chirp, impulse FFT and MLS analyzers) Every time you double the number of stimulus cycles you will realize a 3dB reduction in noise. Sixteen cycles results in a 12dB improvement over a single cycle. To realize a 24dB improvement would require 256 cycles! This can become quite time consuming.

3. Splicing: (chirp, impulse FFT and MLS analyzers) You can also perform one test at a high sample rate and a second test at a much lower sample rate. The low sample rate test effectively increases the low frequency stimulus level as a consequence of narrowing the measurement bandwidth. The two test results must be spliced together to observe the full spectrum. Like averaging, this method carries a time penalty and it is a multiple step routine requiring excellent operator comprehension.

None of these techniques specifically address the SNR problem without either increasing acquisition time or putting the DUT at risk. Consider that in most environments, residual noise rises with decreasing frequency and the DUT typically has less output with decreasing frequency. In many instances, the residual noise exceeds the output of the DUT.

CWF-1

The One on One Technical Products CWF-1 Complementary Weighting Filter offers an effective, low cost and easy to use solution to signal-to-noise (SNL) problems. The CWF-1 is an analog Encode-Decode filter. Using the "Pink" setting *weights* the stimulus at 3dB per octave from 2Hz to 50kHz. The microphone return is then *un-weighted* with an inverse pink filter, returning the measurement spectrum to flat and preserving time/phase information. Pink weighting very nearly matches the spectral weighting of random noise so this is an excellent all around measurement solution. The combined effect of the pink weighted stimulus and the inverse pink microphone return results in a consistent 35dB SNR improvement with no increase in measurement time.

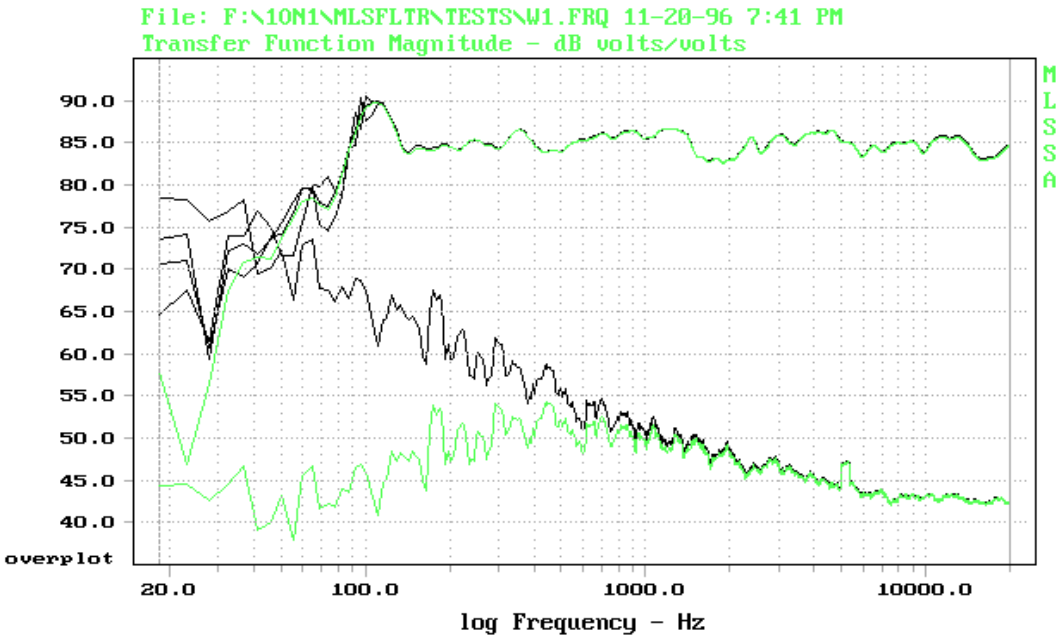
A second weighting "Profile" is provided which has been optimized for anechoic chambers.

A third weighting filter is available. This is the industry standard STI/RASTI (Speech Intelligibility Index/Rapid Speech Transmission Index) low pass filter, used in the assessment of speech intelligibility in noisy environments. No complementary inverse filter is provided, as this would not be appropriate for this type of analysis.

The CWF-1 is simple, and once installed is completely transparent to the user. This is especially important when doing production line testing with technically untrained personnel.

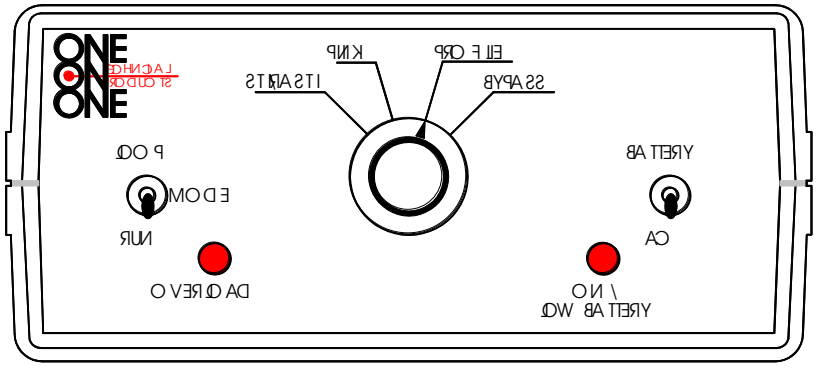
CWF-1 Performance Example

The following test was conducted in a calibrated* 150Hz anechoic chamber. The black traces are tests conducted with the CWF-1 in "BYPASS" mode (no filters). The lowest black trace is the unimproved noise floor of the chamber. Note that the three black test plots exhibit apparent response variations below about 120Hz. This measurement ambiguity is illustrative of the corrupting influence of random environmental noise energy. The green traces are the results of using the CWF-1 "PROFILE" setting. Note the improved noise floor and that the response plot is now un-corrupted to below 30Hz.



* Reference speakers were measured in a free field environment and the tests were repeated in the chamber. The speakers and microphone positions were varied to characterize the low frequency behavior of the chamber. From this information optimum microphone and DUT positions are determined. A correction curve is then stored in the analyzer. This is used to "null out" the low frequency response anomalies normally observed below the cutoff of the test chamber.

Operating Instructions



Function Select:

This four position rotary switch selects one of four response profiles.

1. **STI/RASTI:** An industry standard weighting curve. Appropriate for speech intelligibility measurements. The microphone return is bypassed when STI/RASTI is selected. Response characteristics of this filter are illustrated on page 10.
2. **PINK:** This invokes standard pink weighting (-3dB per octave. Typically this is most appropriate for reverberant field measurements. This setting is also useful for power compression measurements. The microphone return has a complementary inverse pink profile resulting in flat throughput response. Response characteristics of these filters are illustrated on page 8.
3. **PROFILE:** When this is selected, the incoming stimulus will be low frequency enhanced in a manner that is typical for most anechoic chambers. The microphone return has a complementary inverse profile resulting in flat throughput response. Response characteristics of these filters are illustrated on page 9.
4. **BYPASS:** In this position all active circuitry is bypassed, returning the measurement system to its normal state. Be sure the CWF-1 is in bypass mode when calibrating a microphone.

CAUTION: Keep in mind that whenever you turn to the bypass position, the high frequency energy removed by the CWF-1 is restored. If you do not reduce the stimulus level, tweeter damage could result.

DON'T DO THIS! Even in bypass mode, the gain circuits are still connected to the inputs. Do not operate the device when an overload is indicated. Doing so can result in an increase in stimulus signal distortion, which can alter the measurement accuracy. A severe overload can damage the CWF-1 circuits and this would not be covered under warranty.

DON'T DO THIS EITHER! When the CWF-1 is off, the circuits are still connected to the inputs, even in bypass mode. When off, the circuits are intolerant of large signals applied to their input. Doing so will result in very high distortion, if you persist, the circuits can be damaged.

MODE SWITCH:

This two-position toggle switch allows loop testing of the selected profile.

RUN: Use this position while performing tests. In this position the CWF-1 applies the selected weighting to the DUT and "un-weights" the microphone return to the analyzer.

LOOP: In this position the CWF-1 internally bypasses the DUT and microphone, routing the weighted stimulus directly into the inverse weighted microphone circuit and back to the analyzer. This is used when performing a reference loop back test to correct the small phase and amplitude errors generated by each device in the signal chain. This includes not only the CWF-1 but amplifiers, attenuators, preamps, wiring and any other signal processor in use.

POWER SWITCH:

This two-position toggle switch selects between battery and AC operation.

BATTERY: In this position the CWF-1 runs on the internal batteries. If no batteries are installed this becomes the off position.

AC: In this position the CWF-1 operates on AC provided by the external transformer. If the transformer is not connected this becomes the off position. When both AC and batteries are present there is no off position. Leaving the CWF-1 in the AC position will prevent premature battery drain.

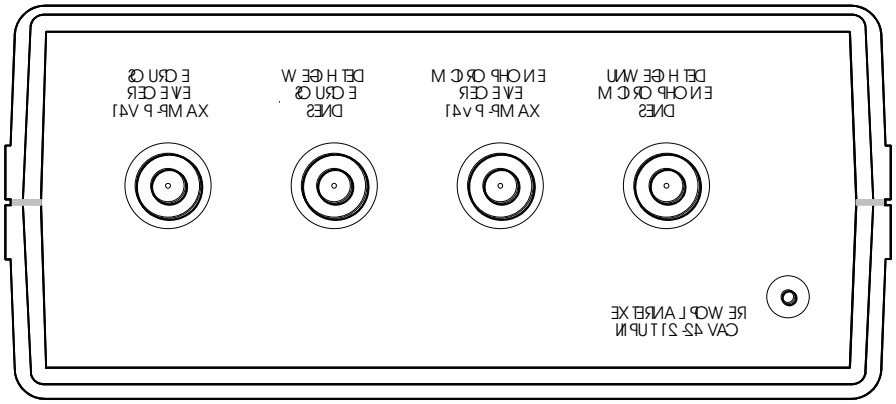
ON/LOW BATTERY LED:

When the CWF-1 is on, this LED will blink every three to five seconds. When the batteries require replacement the blink rate increases to about three per second. The CWF-1 will continue to operate for about an hour without excessive distortion or noise. However, the peak voltage capability may be below specification. If you must keep working, watch the overload LED carefully to be sure signals are not being clipped.

OVERLOAD LED:

When illuminated, this indicates an overload condition in either the source weighting circuit or the microphone return circuit. Depending on the frequency of overload and the circuit that is overloaded, this LED will illuminate somewhere between 0.03% and 0.5% distortion. Never perform tests when this LED is on. Reduce the stimulus level or the microphone pre-amp gain if this occurs. With fresh batteries or on AC power, the CWF-1 circuits can pass up to 16V peak-to-peak without distortion.

Rear Panel:



NOTE: The CWF-1 does not provide phantom power or gain for the microphone. An appropriate microphone-conditioning amplifier must be used and its output connected to the "MICROPHONE RECEIVE" connector.

CWF-1 MECHANICAL SPECIFICATIONS

Dimensions: 2.25"H x 5.125"W x 6.0"D Weight: 1LB

CWF-1 ELECTRICAL SPECIFICATIONS

INPUT/OUTPUT IMPEDANCE:

Inputs: 470kΩ Outputs: 150Ω

RESIDUAL NOISE:

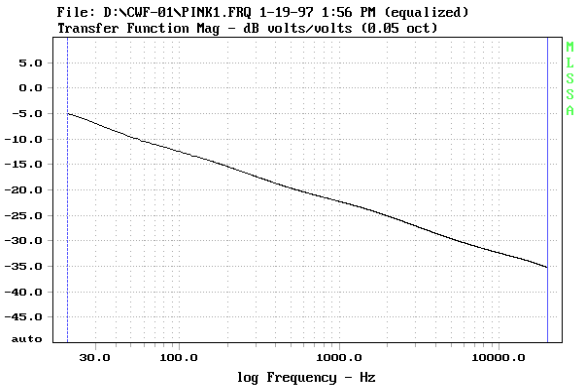
Test Conditions: 30kHz low pass filter on, input shorted

-102dB re; 1VRMS

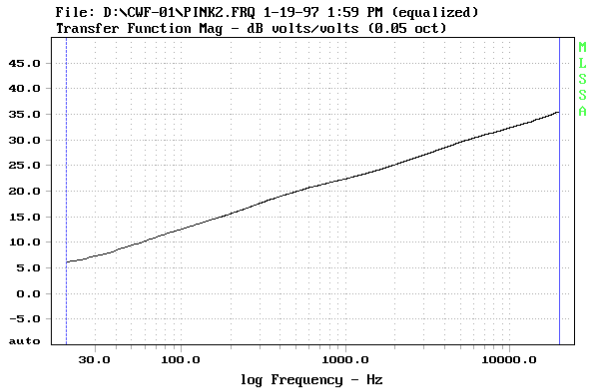
THD:
Test Conditions: 100kHz low pass filter on, 20Hz to 20kHz: -90dB (.003%) re; 1VRMS

INPUT OVERLOAD:
Test conditions: A 1kHz sine wave is applied to the input, the level is increased until 1% distortion is observed. The input level is recorded at this point.
BATTERY: 5.0VRMS (14.0V peak-to-peak)

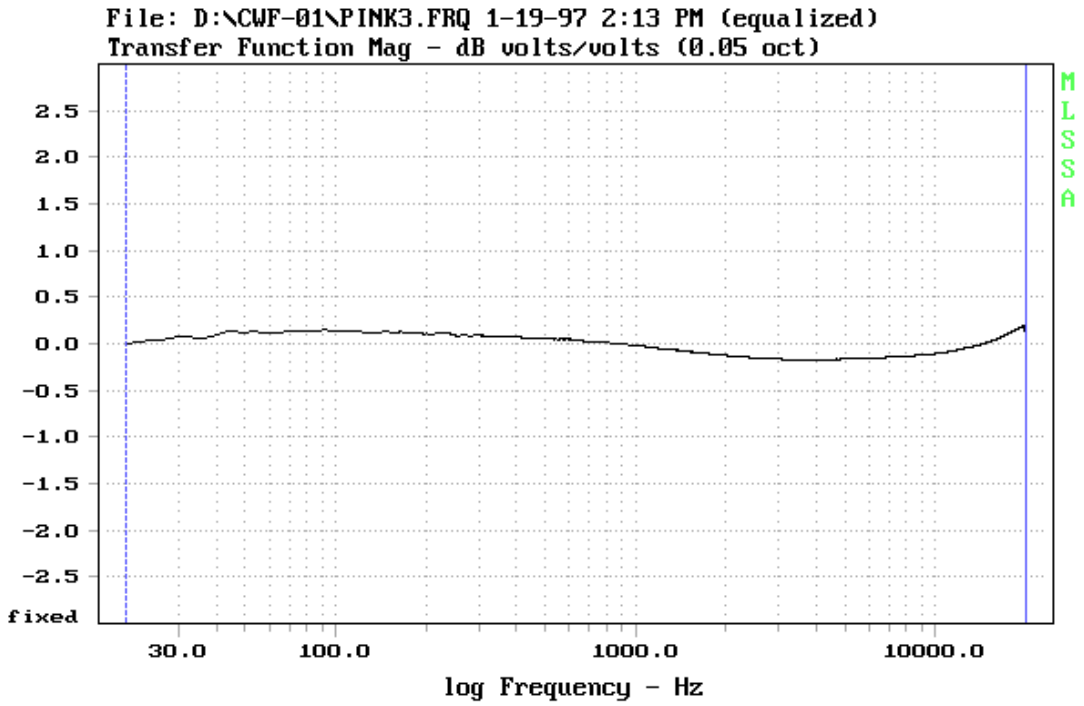
Pre-Emphasis Gain: PINK
(20Hz: -5dB) (20kHz: -35dB)



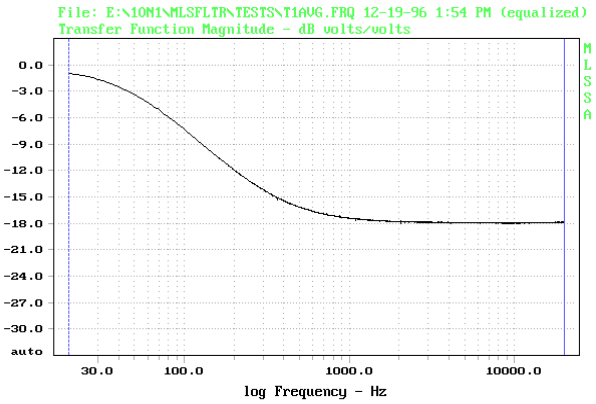
De-Emphasis Gain: PINK
(20Hz: +5dB) (20kHz: +35dB)



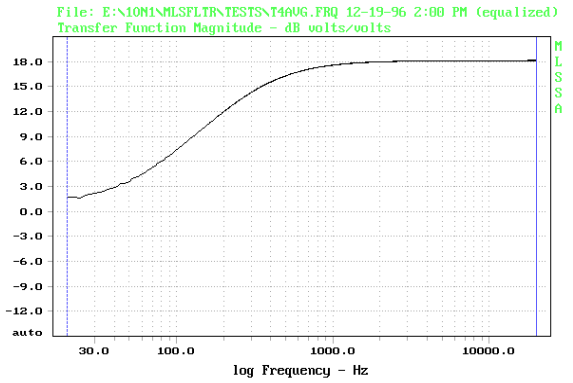
Typical throughput error: Pink ± 0.25dB 20Hz to 20kHz, worst case ± 0.4dB



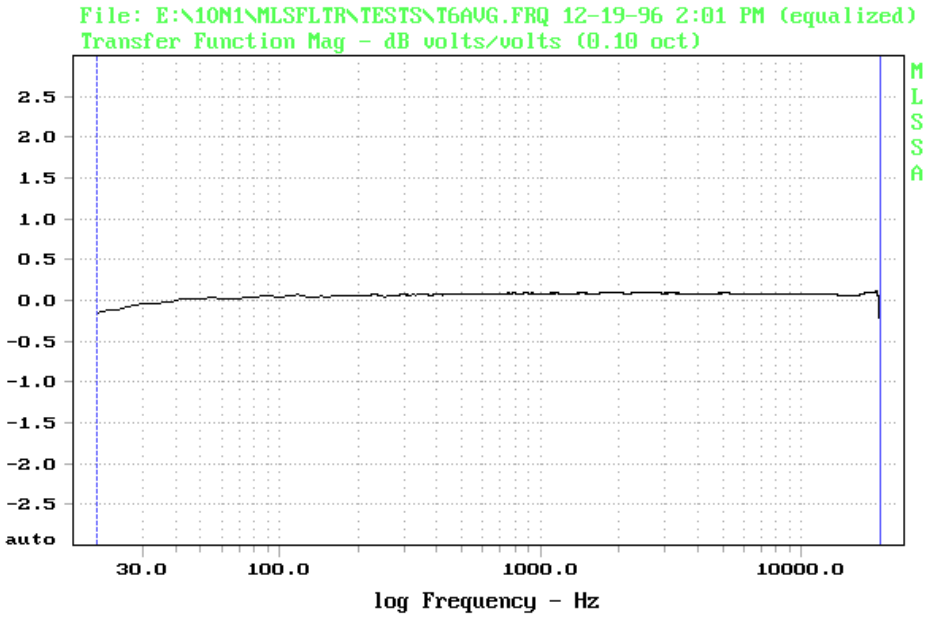
Pre-Emphasis Gain: PROFILE
(20Hz: -0.8dB) (200Hz: -12dB) (2kHz: -18dB)



De-Emphasis Gain: PROFILE
(20Hz: 0.8dB) (200Hz: +12dB) (2kHz: + 18dB)

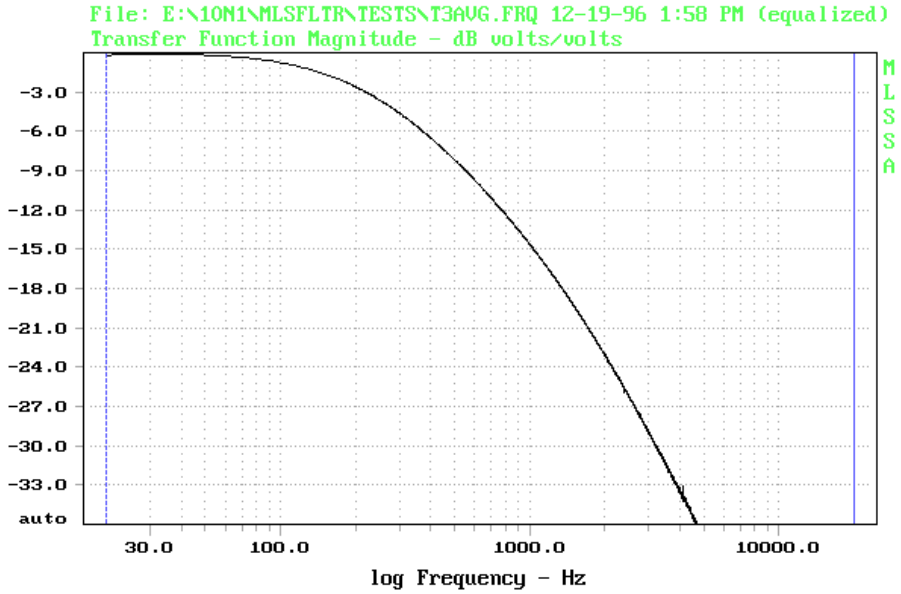


Typical throughput error: Profile ± 0.2dB 20Hz to 20kHz, worst case ±0.3dB



Pre-Emphasis Gain: STI/RASTI

Industry standard 2nd order low-pass, -3dB at 220Hz



Product Support

Warranty: One on One Technical Products Warrants the CWF-1 to be free of manufacturing and component defects for a period of one year. This warranty does not cover any damage that is a result of misuse or operation not in accordance with this manual. This is not a life support device and must not be used in any application that could endanger the operator or anyone in the area.

> **Who Does What:** Before returning the device to One on One for service, please call us at 805.492.0773 and discuss the problem. When it is agreed that the product needs repair, you will be asked to ship the unit in its original packing to One on One Technical Products, 219 Cedar Heights Drive, Thousand Oaks, CA 91360. If you do not have the original packing material, it will be provided for a charge of $5.00. You are responsible for the cost of shipping to One on One and we will assume the cost of return shipment.

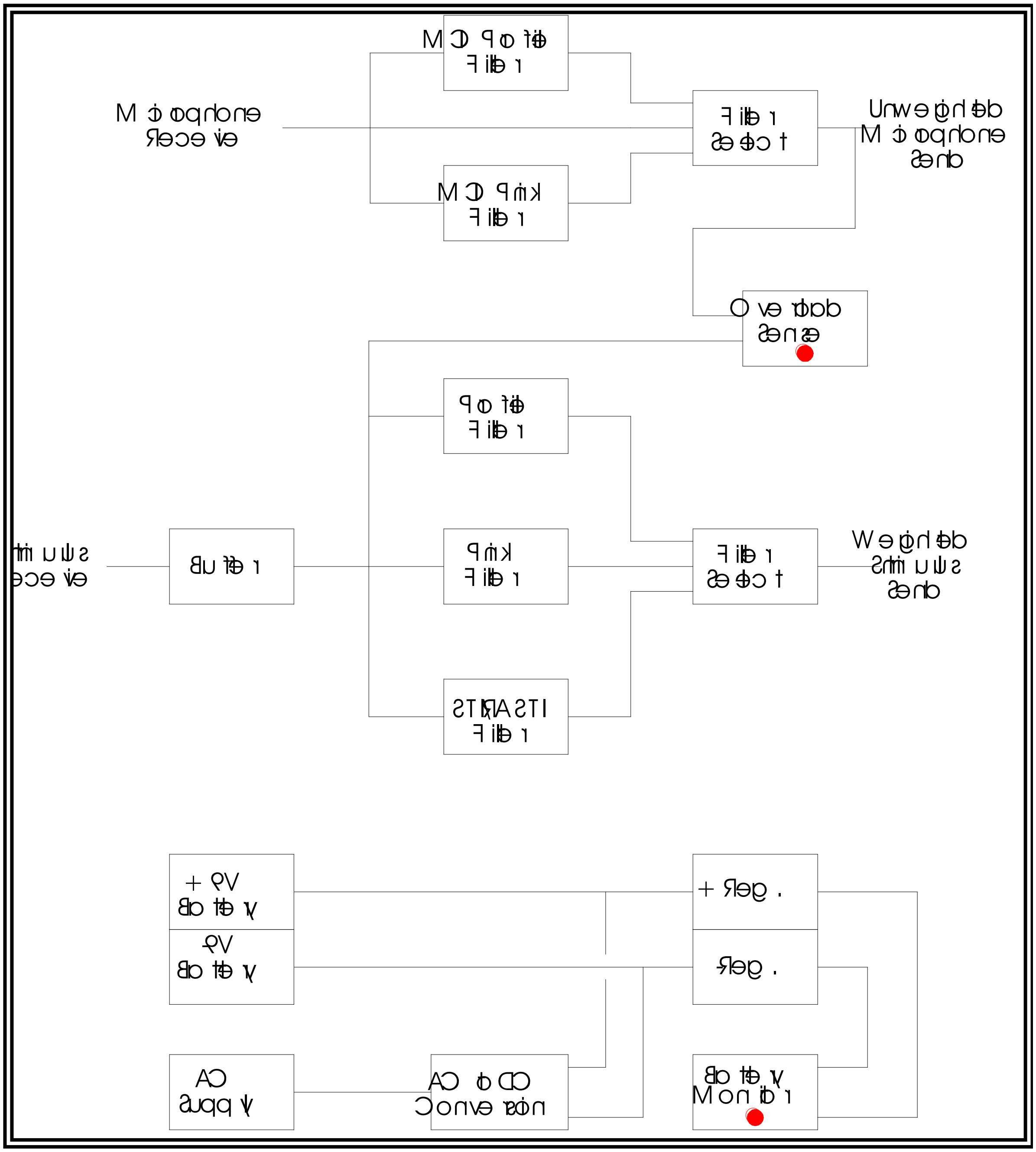
Service after Warranty Expiration: The condition of the unit will be assessed and the cost of repair will be estimated before the work is done. The decision to proceed is yours. All charged repairs are warranted for 90 days.

> **Who Does What:** Shipping charges and cost of all repairs are your responsibility. One on One Technical Products will perform the repair within 10 working days. Unless otherwise instructed, the device will be returned by the most economical shipping method.

☺ **Other Services:** Custom test equipment is our business! The chamber "profile" provided is a best fit to average of a number of different anechoic chambers. If you have surveyed the ambient noise characteristics of your measurement chamber, the "profile" of the CWF-1 can be modified for a better fit. Return the CWF-1 with the measurement data and One on One will perform the modification within 10 working days. The charge for this service is $100.00 prepaid. The cost of packing and shipping is your responsibility.

All of the filters within the CWF-1 can usually be modified to suit your specific needs. The cost of these modifications will be determined on a case by case basis.

CWF-1 Block Diagram



NOTES: