

## SCHOEPS RFI Shield

SCHOEPS uses the term RFI shield in connection with their professional condenser microphones to designate a particularly high standard of measurable immunity from radio-frequency interference ("RFI").

### What is RFI?

In Pro-Audio, protection from RFI Signals start at approximately above 200 kHz. Below that frequency, audible disturbances have to be tackled separately. The topic is common mode rejection which is not discussed in this article.

Radio-frequency interference is caused by electromagnetic waves that are omnipresent in today's world. Every possible range of frequencies is filled with wireless services of various kinds, for example:

- Medium- and short-wave (through 30 MHz): Power-line modems; switching power supplies; AM radio; lighting controls
- VHF (30 MHz through 300 MHz): Digital radio and television; FM radio
- UHF (300 MHz through 3 GHz): Broadband communications, cell phones, digital TV broadcasting

For audio equipment the UHF band is one of the most critical frequency ranges, since several very widely distributed services operate within it. Technological development is trending strongly in the direction of ever more services (cellular / "the Internet of things") sharing the available bandwidth, along with ever-increasing usage of those services.

### Causes

Radio-frequency interference can have many diverse causes, and many kinds of audible disturbances can result (broadband noise, discrete tones, etc.), depending on the frequency, strength and waveform of the interfering signal.

Radio-frequency signals aren't directly audible since their frequency is far too high. They become audible only when demodulated somewhere in the circuitry of a piece of equipment. Thus the circuitry must be protected from these RF signals.

The figure below shows the outline of the output circuit of a condenser microphone. Since it can be a point of entry for RF signals carried by the cable, we must consider this audio-frequency output simultaneously as a potential radio-frequency input.

In the circuit shown here, capacitors at the microphone's output form a filter that shunts any radio-frequency signals directly to ground.

This prevents demodulation from occurring elsewhere in the circuitry.

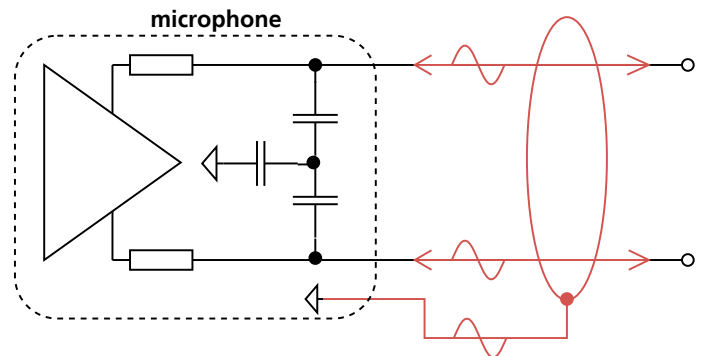


Fig. 1: Principal of RF filtering.

Capacitors at the output shunt RF signals to ground

The connection between the cable shield and microphone housing must be made outside the housing; otherwise, even if the wire that makes this connection is very short, it will function as an antenna that can bring RF signals into the interior of the microphone. This is why Schoeps, in the CMC 6 amplifier, employs a toothed, gold-plated shield just outside the housing to connect pin 1 of the XLR connector, and the cable shield, to the microphone housing (Fig. 2).



Fig. 2: Gold-plated shield plate

### Main features of the RFI Shield

- RF filter at the point of connection with the modulation leads
  - good symmetry at low frequencies < 200 kHz  
-> good common mode rejection
  - high degree of suppression of RF signals  
-> protection from RF signals on the signal leads
- completely sealed housing
  - the housing (CMC 6, CCM) has no switch openings through which RF signals could reach the interior
  - the switches in the CMIT 5U are mounted on a circuit board with an integrated shielding layer, thereby providing a fully-sealed housing for the rest of the circuitry

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- gold contact plate in the exterior XLR connector
  - connects the cable shield and pin 1 directly, outside the housing
  - avoids creating an "antenna" that could bring RF into the interior of the housing
  - RF signals in the cable shield are kept out of the housing
- effective RF protection in the 500 kHz – 6 GHz range
  - fully complies to IEC 60268-4

### Testing the filter quality

For each model of Schoeps microphone, a suitable RF filter is developed to provide optimal protection for the given geometry and construction. The quality of the filter is tested during development by using the measurement apparatus shown in Fig. 3

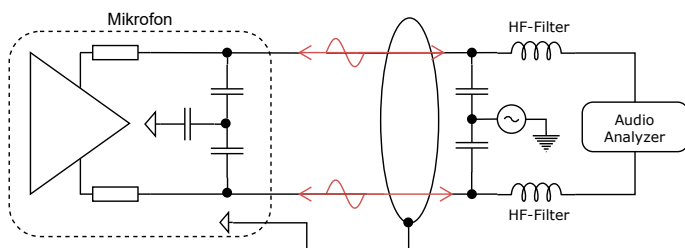


Fig. 3: Measurement setup for the RF injection test

Signal injection measurement allows the investigation of cases in which RF signals appear directly on the modulation leads. For example, this could occur as a result of inadequate or defective shielding. Signal injection measurement is also proposed in IRT technical guidelines 3/1 und 8/2.

An RF signal is generated and coupled to the modulation leads. This simulates a "worst case" situation in which either there is a gap in the cable shield or a defective piece of equipment puts out RF signals directly into the cable. The RF signal is amplitude modulated (1 kHz, 80% modulation), and the carrier frequency is swept throughout the measurement range.

An audio analyzer is also placed across the microphone output in parallel with the RF signal generator. Using steep bandpass filtering, the RMS level of the 1 kHz modulation frequency is measured; this level will depend on how strongly the microphone demodulates the carrier. If the carrier has been strongly suppressed, no demodulation will occur, and the RF filtering can be deemed effective. As the carrier frequency sweeps across the chosen range, the effectiveness of the RF filtering can be determined as a function of the interfering signal's frequency.

During the measurement process the microphone is kept in an acoustically insulated enclosure, so that in the ideal case, all that will be measured at its output is the self-noise of the microphone.

Fig. 4 shows measurements of this kind for small diaphragm condenser microphones of different vendors. All microphones have active output stages and no transformers. It's also important to mention that only one exemplar of every microphone was measured.

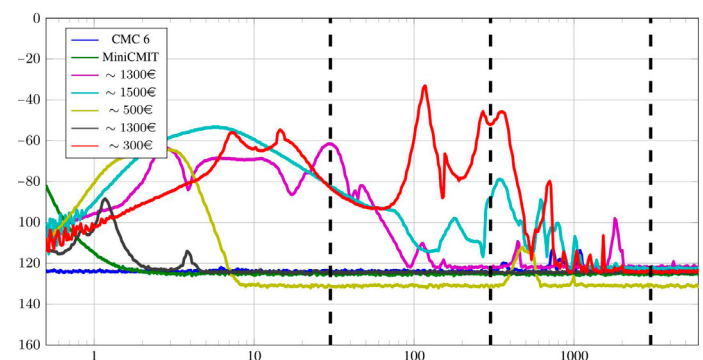


Fig. 4: RF injection measurement from 500 kHz to 6 GHz. The black dashed lines mark the VHF band. Below 500 kHz the RF filtering is not so important anymore because at low frequencies common mode rejection is more important to reduce audible disturbances.

As mentioned above, if no demodulation occurs you only measure the self-noise of the microphone. The optimal result would be a flat curve over the complete frequency range but this is nearly impossible to achieve. Every candidate has a few areas in which it is not working optimal. Normally, a level of selfnoise below -100 dBV is deemed as good.

You can see that there are huge differences between the microphones in resistance to injected RF signals. Even expensive microphones like the violet and cyan candidates have a lot of problems over the whole frequency range. Also the red candidate has no effective RF filtering at the output. The yellow candidate has only some problems below 10MHz. The black candidate and the CMC 6 and MiniCMIT achieve the best results in this measurement and show a reliable RF protection over a wide frequency range.

As a final test, further measurements are carried out in a certified EMV laboratory that is capable of compliance with IEC standards 61000-4. RMS