Song Meter SM2BAT

192kHz Stereo or 384kHz Mono Ultrasonic Recorders

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About This Document

This document describes the use of the SM2BAT 192kHz stereo and SM2BAT 384kHz mono daughter cards for the Song Meter SM2 acoustic monitoring and data logging platform.

Refer to the *Song Meter SM2 User Manual* for detailed information on using the Song Meter SM2 platform. This document is intended as a supplement and assumes you are already familiar with the Song Meter's operation.

You will also want to download and install the latest Wac2Wav postprocessing software and Song Meter Configuration Utility software from the downloads section of our website at www.wildlifeacoustics.com.

Overview

The SM2BAT 192kHz stereo or 384kHz mono daughter card is installed on the back of the SM2 motherboard and provides a high-speed 16-bit digital sampling capability.

The audio input to the SM2BAT comes from the output of the two-stage preamplifier on the SM2. Refer to the section on *Amplifier Configuration Jumpers* in the *Song Meter SM2 User Manual* for more information about configuring the analog high-pass filters and gain settings. Note that the SM2BAT audio signal is **not** routed through the third-stage amplifier configured by the left and right gain parameters in the settings menu. Therefore, the gain is configurable only with the SM2 jumpers to +0, +12, +24, +36, +48, or +60dB, and the third stage gain settings will have no effect. For monitoring bats with the SMX-US ultrasonic microphone, the +36dB or +48dB setting is recommended. Use +24dB on the first stage and either +12dB or +24dB on the second stage to get the desired +36dB or +48dB amplification.

The SM2 automatically detects the presence of the SM2BAT daughter card. If present, the 192,000 or 384,000 Hz sample rate choice is added to the list of possible sample rate settings. In addition, the *SET* advanced scheduling command can also configure the 192,000 or 384,000 Hz sample rate as part of an advanced schedule.

When 384,000 Hz sample rate is selected, the SM2BAT 384kHz mono daughter card is used to sample the audio stream from the left channel. When the 192,000 Hz sample rate is selected, the SM2BAT 192kHz stereo daughter card is used to sample the audio stream from the left and right channels. Otherwise, the SM2 uses its on-board codec to sample at audio rates up to 48,000 Hz.

SMX-US Microphone

The SMX-US is an ultrasonic microphone designed for terrestrial monitoring applications, specifically for recording the echolocation calls of bats.

Notes on Weatherproofing

The transducer inside the SMX-US microphone **can be permanently damaged** if it is exposed to water in the event that the weatherproofing fails.

To protect the transducer, there are trade-offs between ultrasonic sensitivity and weatherproofing.

The SMX-US features several layers of protection. First, a porous membrane transparent to ultrasound prevents unpressurized liquid water from entering the microphone. However, the membrane is rated to only 0.07 lbs/in^2 or $5g/cm^2$. This is easily exceeded by wind-blown rain. The foam windscreen provides a critical second layer of protection to absorb the impact of wind-blown rain so that only unpressurized water reaches the membrane effectively protecting the transducer. When dry, the foam windscreen is almost transparent to ultrasound with a loss of only 2dB. However, the loss increases with frequency when wet, and will effectively block ultrasound if it then freezes.

The membrane is also fragile. The foam windscreen adds a layer of protection against insects, rodents and birds who will tend to nibble on the windscreen instead of the membrane.

We strongly recommend operating the SMX-US with the windscreen, and replacing the windscreen if it becomes fully or partially eaten.

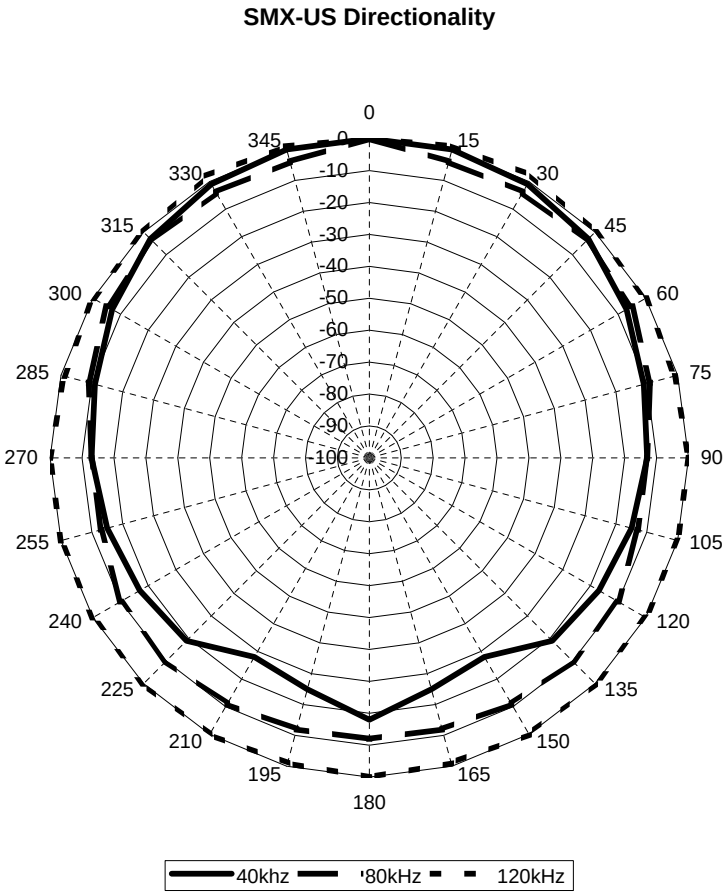
We also recommend positioning the microphones so that they point parallel to the ground, or even slightly downward. In this configuration, even if the windscreen is absent and water penetrates the membrane, the water should not collect in sensitive areas inside the microphone and there is a good chance that the transducer will survive. If you suspect that water may have entered the microphone, you should avoid handling it until it has completely dried out. Otherwise water could change position and come in contact with the transducer resulting in damage.

If you are deploying the SM2 in field conditions expected to remain wet or frozen, you may want to operate the SMX-US microphone without its foam

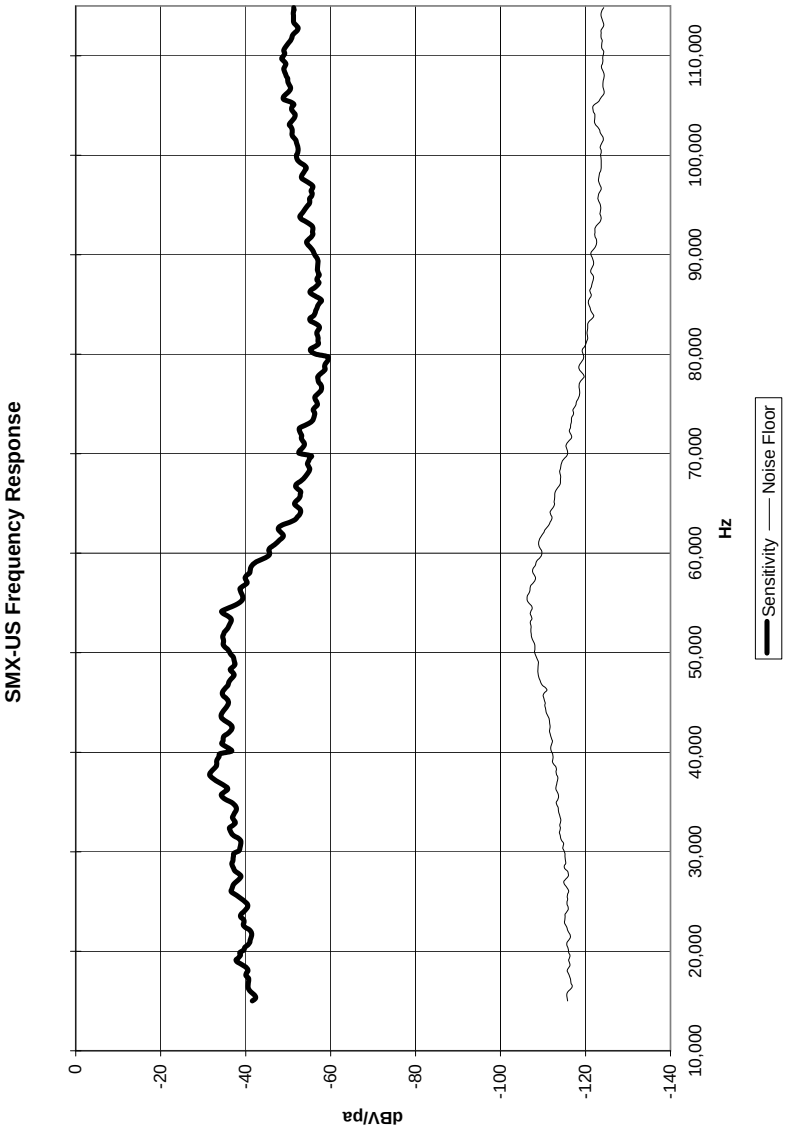
windscreen and instead implement your own weather protection to protect the membrane from wind-blown rain. Again, we recommend that you aim the microphone horizontally or downward (not upward) to reduce the risk of damage should weatherproofing fail.

Directionality and Frequency Response

The SMX-US is an omnidirectional microphone and is therefore ideally suited to unattended monitoring in which the precise direction of bat activity may not be known in advance. The following graph illustrates the typical pick-up pattern:



The SMX-US is sensitive to frequencies over 150kHz. The graph shows the typical frequency response and noise floor of the SMX-US microphone. Some additional attenuation can be expected if the microphone windscreen is wet, especially in higher frequencies:



Cables

The SMX-US is a powered microphone with low impedance and can drive cables up to 100 meters without a preamplifier and without any noticeable loss at frequencies up to 120kHz.

The SMX-US microphone can be either connected directly to the SM2 enclosure without any cable or extended on one or more lengths of our standard one meter, ten meter and fifty meter cables up to the maximum. For best results, the SMX-US microphone should be mounted on a cable and placed away from the Song Meter enclosure or other hard objects in order to reduce echos.

Power Consumption

The following table illustrates the typical power consumption for different configurations and settings. Note that actual consumption may vary depending on flash cards, variation in electronic components, and other variables:

Rate and Channels	Uncompressed	Compressed	Compressed w/ Trigger
192kHz x 1	115mA	145mA	150mA
192khz x 2	115mA	175mA	195mA
384kHz x 1	90mA	155mA	185mA

High quality Alkaline D cells can deliver about 14,000mAh capacity at 20° C. With compression and triggers, this translates to about 95 hours record time with 192kHz mono, 70 hours record time with 192kHz stereo, and 75 hours record time with 384kHz mono. Longer deployments are possible with larger external batteries using the Song Meter SM2PWR power adapter sold seperately.

When the SM2BAT daughter card is not being used, for example when the Song Meter SM2 is configured for sampling rates at or below 48kHz, it will still consume some additional current when recording compared to an SM2 without the SM2BAT card installed. In the case of the 192kHz stereo card, 25mA of additional current is used. In the case of the 384kHz mono card, 15mA of additional current is used.

When the Song Meter is sleeping between scheduled recording events, the SM2BAT is also powered down and total current consumption is typically less than one milliamp.

Using SM2BAT to monitor Bats

Simple One-Channel Configuration

The configuration described below is available as an example configuration in the Song Meter Configuration Utility distribution, “SM2BAT-192-MONO.SET” for the 192kHz stereo model or “SM2BAT-384-MONO.SET” for the 384kHz model. For the SM2BAT to be able to determine your location's sunrise and sunset times, it is necessary to input your latitude, longitude and timezone. These are found under location settings. You may also want to set a device-specific prefix.

The SM2 Terrestrial Ultrasonic Packages come with one SMX-US ultrasonic microphone. The easiest set-up is to connect the microphone directly to the left microphone connector on the SM2 enclosure and mount the SM2 on a tree or post at the field site. You can also extend the microphone on a cable up to 100 meters away from the enclosure.

With one channel using compression and triggering, you can get about 95 hours of record time at 192kHz or 75 hours at 384kHz out of the internal four “D” alkaline batteries, over one week of night time monitoring. In a typical night with bat activity (and no rain or gusty wind), you will need about 0.5GB per night for a stereo recording. But even with gusty wind causing false triggers, you will probably only need about 2GB per night. Therefore, a single 32GB card should easily last for 2-8 weeks.

For longer deployments, you can use a larger external power source. With 4x32GB flash cards, you should have enough storage to last 50-250 nights depending on conditions.

Jumper Settings

You should configure the preamplifier jumpers with the analog high-pass filter set to 1kHz and the gain set for +48dB or +36dB. Refer to the *Song Meter SM2 User Manual* for details. The dynamic range can be increased by using +36dB gain to avoid clipping stronger signals without significant impact to quieter signals. +48dB gain will deliver a stronger signal with a slight improvement to high-frequency signal-

to-noise ratio over +36dB gain. (When using +36dB gain, take care to use the recommended jumper settings. Other permutations may not provide as good signal quality).

The SMX-US microphone does not need the 2.5V 2.2K bias, but will work with or without the bias jumper present. Note that the jumper is required for the SMX-II acoustic microphones.

Schedule

You can configure the Song Meter to record only from sunset to sunrise each day in half hour segments as follows:

First, configure your latitude, longitude, and UTC offset in the "Location" settings.

Next, enter the following advanced schedule:

```
   01 AT SSET-00:00:00
   02 DO

   03 RECORD  00:30:00 (recommended for 384kHz)
or 03 RECORD  01:00:00 (recommended for 192khz)

   04 GOTO LINE 03 00X
   05 UNTSRIS+00:00:00
   06 GOTO LINE 01 00X
```

The schedule above will wait for sunset, then record back-to-back one-hour or half-hour segments until sunrise (the last segment will end early at sunrise), and repeat daily. You can modify this example to suit your own needs.

Note that the maximum uncompressed file length is 2GB which works out to 46.6 minutes at 384kHz mono and 192kHz stereo or 93.2 minutes at 192kHz mono. If you use one hour periods instead of half-hour periods for 384kHz mono or 192kHz stereo, recordings would be split into alternating 46.6 and 13.4 minute recordings which may be confusing.

Audio Settings

The audio settings should be set as follows:


```
Sample rate: 192000     (for 192kHz model)
      or    384000      (for 384kHz model)
Channels:   MONO-L      (for left channel)
Compression:WAC0  (lossless compression)
```

Note that the 384kHz model can only be used with the left channel.

With +36dB gain, all 16 bits are needed to resolve fainter signals, and so lossy compression is not recommended. At +48dB gain, WAC1 will offer some improvement in compression without adverse effects. Higher levels of compression with the SMX-US microphone are not recommended.

The advanced settings should be set as follows:

```
Dig HPF Left      fs/12 (16kHz for 192kHz)
            or    fs/24 (16kHz for 384kHz)
Dig LPF Left      Off   (low-pass disabled)
Trg Lvl Left      18SNR (adaptive +18dB)
Trg Win Left      2.0s
```

The digital high-pass filter shown above is set to either 1/12th of the sample rate for 192kHz / 12 = 16kHz or 1/24th of the sample rate for 384kHz / 24 = 16kHz. This will filter out frequencies below 16kHz. Higher or lower settings are available to suit your needs. For example, if you have low frequency bats echolocating near or below 16kHz, you may consider using fs/16 for 192kHz and fs/32 for 384kHz for a 12kHz high pass filter.

Song Meter will measure the rolling-average power spectrum in the frequency band (above 16kHz in the above example) for periods of the trigger window setting 2.0 seconds in the above example), and if an onset of signal is detected that exceeds this threshold by 18dB, a trigger event is started. Recording will continue until no trigger is detected for a 2.0 second period of time. Longer or shorter trigger windows are available. Longer windows will increase card usage, but will allow further detection if a bat is passing and becomes too faint to re-trigger.

You can increase detection rate on fainter signals by reducing the threshold, but this may also increase the false trigger rate, especially in wind and rain.

More information on filters and triggers can be found in the *Song Meter SM2 User Manual*

Stereo Ultrasonic Recording

The 192kHz stereo board allows for stereo ultrasonic recording. The configuration described below is available as an example configuration in the Song Meter Configuration Utility distribution, “SM2BAT-192-STEREO.SET”. For the SM2BAT to be able to determine your location's sunrise and sunset times, it is necessary to input your latitude, longitude and timezone. These are found under location settings. You may also want to set a device-specific prefix.

For stereo ultrasonic recordings, you can configure Song Meter to use both channels and install a second SMX-US microphone.

Refer to the one-channel recording settings above. The Settings->Audio->Channels should be set to “STEREO” to enable both channels, and you will want to set the digital high-pass filter and triggers for the right channel as well.

Stereo recordings with compression and triggering consume about 30% more power and will use twice as much flash storage as single-channel recordings.

The triggers act independently so each channel is compressed efficiently.

Mixed Ultrasonic and Acoustic Recording

The 192kHz stereo board permits two channels to simultaneously record conventional audio on one channel and ultrasonic activity on the other by using an SMX-II acoustic microphone on one channel and an SMX-US ultrasonic microphone on the other.

The 384kHz mono board permits the recording of conventional audio on one channel on one schedule and ultrasonic activity on the other channel on a different schedule, but not simultaneously.

Stereo Mixed Recordings

One way to make a mixed recording is to sample both channels with SM2BAT stereo 192kHz board at the same time to make a stereo recording. But you can then use the digital low-pass filters to set a cut-off frequency on the acoustic side to filter out the ultrasonic sounds and improve compression ratios. For example, setting a digital low-pass filter to fs/24 will filter out sounds above 8kHz. An example of this is

available in the Song Meter Configuration Utility distribution "SM2BAT-192-MIXED-STEREO.SET"

Scheduled Mixed Recordings

Another way to make mixed recordings is to use the Song Meter advanced schedule "*SET*" command to make ultrasonic recordings at some times and conventional recordings at other times. An example of this configuration is available in the Song Meter Configuration Utility distribution "SM2BAT-192-MIXED-SCHED.SET"

For example, the following schedule would make ultrasonic recordings on the left channel at 192kHz at night, and then a 24kHz recording on the right channel to record the dawn chorus for an hour after sunrise.

```
01 SET192000xMONO-L
02 AT SSET-00:00:00
03 DO
04 RECORD  01:00:00
05 GOTO LINE 04 00X
06 UNTSRIS+00:00:00
07 SET 24000xMONO-R
08 RECORD  01:00:00
09 GOTO LINE 01 00X
```

A similar example for 384kHz can be found in "SM2BAT-384-MIXED-SCHED.SET":

```
01 SET384000xMONO-L
02 AT SSET-00:00:00
03 DO
04 RECORD  00:30:00
05 GOTO LINE 04 00X
06 UNTSRIS+00:00:00
07 SET 24000xMONO-R
08 RECORD  01:00:00
09 GOTO LINE 01 00X
```

Post Processing

A .WAC file is created for each scheduled recording segment. In the advanced program above, for example, a .WAC file would be created every hour from sunset to sunrise.

The *Song Scope* software can open .WAC files natively. To quickly locate and review potential bat echolocation calls in a long triggered recording, you can set up *Song Scope* band-pass and detector parameters and use the batch scan feature.

The *WAC2WAV* utility (available at no charge on our web site) can convert the .WAC files into standard .WAV files for analysis by other programs. Usually it is best when processing triggered ultrasonic recordings to use the "Split Triggers" feature. This will take a mono or stereo .WAC file containing possibly many individual triggered events (e.g. bat passes), and break them out into many individual .WAV files for analysis.

The max duration and min spacing parameters let you selectively restrict the duration of each created .wav file and to optionally ignore detections to satisfy the desired spacing in order to fit whatever monitoring protocol you may be used to. For example, if you are used to using Time Expansion detectors that only record for 5 seconds and then pause for 50 seconds while the time expansion buffer is recorded, you could select a max duration of 5 seconds and a min spacing of 50 seconds to simulate this behavior. By default, all detections are included in their entirety.

The compensation filter may be selected to digitally alter the signal to compensate for the SMX-US microphone by effectively altering the frequency response to match approximately a 240X. This may be helpful for analysis by automated classification software that relies on the frequency response of the 240X to match known bat recordings.

The "Skip Noise" feature can be used to further analyze each candidate trigger to determine if it contains actual bat echolocation calls (or other biological activity) rather than just noise. The algorithm looks for the presence of narrowband energy in the specified frequency band with at least the minimum specified duration. Files that do not meet this criterion are still split out as .WAV files, but the filename is prepended with the prefix "NOISE_" so they can be set aside.

Finally, if you prefer zero crossing analysis over full spectrum recordings, you can select “Output ZCA” to create zero crossing files instead of .WAV files. In this way, the SM2 is like having a full spectrum recorder and a zero crossing recorder in one device. The division ratio can be specified as well as the sensitivity. The sensitivity is specified in dB relative to a full-scale signal, or can be set to zero for autoleveling