Mars Microphone Instrument Operational Constraints and Considerations

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This is a list of operational constraints for the Mars Microphone (MM) to be used in developing plans and sequences for instrument operations. The instrument is described in the following documents:

"Mars Microphone Instrument"
"Mars Microphone Interface Specification"
"Mars Microphone Instrument Users Manual"

1. Command Timing

Commands should not be sent sooner than one second after power-on, or within one second of power-off. Commands should not be sent closer than one second intervals, or during a MM to LIDAR data transfer, or sooner than one second after a MM to LIDAR data transfer has completed.

1.1. TIME Command Timing

The TIME command should be sent between 1 and 9 seconds after applying power to MM so that data is correctly time stamped. Failure to do so will cause the instrument to report an error, and for data be stamped with time relative to the time of power-on plus 10 seconds. Time is maintained internally by MM, so only the initial TIME command is required.

1.2. MODE Command Timing

The MODE command can be sent any time between power-on plus one second and SHUT DOWN or power off. The new mode will be implemented immediately on receipt of the command. If a MODE command is not received before the first TIME command after turn-on, the instrument will begin operations with the mode setting at the time of the previous power-off on a "Warm Start", or the default mode (00) on a "Cold Start".

1.3. SEND DATA Command Timing

SEND DATA should not be sent before the first TIME command has been sent. The only other constraint on SEND DATA commands is after a "Cold Start", when no sound sample has yet been collected. In this case, there should be a minimum of 45 seconds between the TIME command and the first SEND DATA command when in 2-bit mode, or 30 seconds when in 4-bit mode. If a SEND DATA command is sent before the first sound has been collected and formatted, a diagnostic packet is sent. This diagnostic packet contains a short interval of uncompressed sound data.

1.4. SHUT DOWN Command Timing

The SHUT DOWN command tells the instrument to save its current state, including saved sounds and filter data. This command must be sent between 3 and 9 seconds before power is removed from the instrument for the data to be saved correctly.

No commands should occur between the SHUT DOWN command and power-off. If power is removed without a SHUT DOWN command, the following power-on will be a "Cold Start" – see below.

2. Cold Start and Warm Start

MM Instrument power on may be either a Warm Start or a Cold Start. Cold Start occurs if the previous power-off was not preceded by a SHUT DOWN command, so the instrument status was not saved. In this case the sound sample and filter packets are empty, and the instrument starts off in its default mode (00). If the previous power-off was preceded by a SHUT DOWN command then a Warm Start occurs. In this case sound sample and filter data, plus instrument mode have been saved in Flash memory, and operations pick up right where they were left just before the SHUT DOWN command was received.

2.1. First Martian Sound

The first power-on at Mars should be a Cold Start, so that we don't waste telemetry sending back data collected on Earth. This means the last power-off before Launch should not have a SHUT DOWN command. We may also want to wait a while (maybe an hour or two) after the first MM power-on on Mars for the instrument to listen to Martian sounds before we commit to one by collecting the first packet with the SEND DATA command.

2.2. Timed Sound Collection

If there is a specific sound we want to capture which is planned to occur at a known time (such as a Lander boom operation), the best procedure to Cold Start MM two or three seconds before the sound is scheduled to occur, and then commit the sound to telemetry by collecting the first packet with a SEND DATA 45 seconds later (before another louder sound can over-write the desired sound).

2.3. Timed Sound Avoidance

During a period when we are looking for natural Mars sounds, we may need to temporarily suspend operations to avoid having a spacecraft-generated sound collected. This can be done by powering-off the instrument shortly before the sound is to occur, including a SHUT DOWN command just before power-off. Then power-on just after the sound stops to continue collection.

3. Sound Sample Collection

Sound Samples contain about 10 seconds of sound in Low Frequency mode (5KHz sample rate), or about 2.5 seconds in High Frequency mode (20KHz sample rate). This data typically takes several packets to transmit, depending on the data compression mode. If Silence Compression mode is off, then a sound sample fills 14 packets in 4-bit compression mode, or 9 packets in 2-bit compression mode. If Silence Compression mode is on, then the number of packets per sound sample may be less. Sound Samples may be read out over an extended period of time, and power may be cycled between packet read-outs provided the SHUT DOWN command is sent before power-down.

3.1. Sound Sampling Scheme

MM is constantly monitoring the measured sound level (except when power is off, from power-on to TIME command, from SHUT DOWN to power-off, and while formatting a new sound sample). MM will find the loudest sound during the time it takes to transmit the previous sound. Once a sound sample starts to be transmitted it is locked in, and MM starts to look for a new sound. Note that after a Cold Start, MM has no sound sample, and so the first sound transmitted is the loudest one in the interval between power-on and the first SEND DATA command.

4. Filter Data Collection

Filter data consists of the sum of sound amplitudes in each of 6 frequency bands, sampled at 20KHz, and averaged over an interval selected by the instrument mode (1 second, 10 seconds, 1 minute, or 10 minutes). These samples are taken continuously while the instrument is powered-on so long as there is room in the filter telemetry packets. There are two filter telemetry packets. When both are filled, filter data collection stops until one of the packets is freed by being transmitted by a SEND DATA command. Each packet contains about 340 filter averages. Changes in instrument mode, and periods of instrument power-down are indicated in the packet.

5. Sound Sample / Filter Data Interleaving

At the time that a packet completes transmission in response to a SEND DATA command, MM decides what type of data to send next (Filter or Sound Sample). If there is no Filter packet filled and ready to transmit, it will send a Sound Sample packet. If there is a Filter packet ready to transmit, then it decides based on the Telemetry mode bit, which indicate either 10% maximum Filter packets or 50% maximum filter packets. In 50% mode, it will only select a Filter packet to transmit if the previous packet was not a Filter packet. In 10% mode, it will only send a Filter packet if all of the previous nine packets were not Filter packets. The combination of the instrument packet collection rate, the Telemetry mode bit, and the Filter averaging interval mode control the kind of Filter data coverage that is transmitted. Continuous time coverage of Filter data with relatively poor time resolution, or periodic blocks of Filter data at higher time resolution can be selected as desired.

6. Instrument Modes

The MM instrument operation is controlled by an 8-bit mode word included in the MODE command. The mode defaults to 00 on Cold Start, but is remembered from the previous value following a Warm Start. The mode bit definitions are described in the Mars Microphone Instrument Users Manual. The bits control the sample rate (HF or LF), the type of sample compression (Silence Compression, 2-bit and 4-bit), the Filter averaging interval and telemetry allocation, and the microphone preamplifier gain (1x, 4x, 16x, or 64x).

7. Sample Instrument Command Time-Lines

7.1. Typical Mars Day

This day consists of 10 hours of continuous operations with a MM packet collected every 2 hours, followed by 14 hours of "Night Time" operations, where MM is turned on for 10 minutes every 2 hours, with one packet collected each time. The instrument mode selected for this day is 8B hex, which gives 64x gain, 2-bit compression, Silence compression, 1 minute filter averages (about 5-6 hours of operation per packet), up to 50% filter packets, and LF sampling. The actual mode for any given Mars day is TBD. A short interval of Sound Avoidance is included in the middle of the day as an example.

T=0	MM power-on	Start of Mars day
T+1 sec	command MODE 8B	
T+2 sec	command TIME	
T+1 hour	command SEND DATA	
T+3 hours	command SEND DATA	
T+5 hours	command SEND DATA	
T+X	command SHUT DOWN	Sound Avoidance
T+X+3 sec	MM power-off	
T+Y	MM power-on	end of Sound Avoidance
T+Y+1 sec	command MODE 8B	send Mode just in case
T+Y+2 sec	command TIME	
T+7 hours	command SEND DATA	
T+9 hours	command SEND DATA	
T+10 hours	command SHUT DOWN	
T+10 hours+3 sec	MM power-off	Start of night time
TN=T+12 hours	MM power-on	First night-time cycle
TN+1 sec	command MODE 8B	send Mode just in case
TN+2 sec	command TIME	
TN+5 min	command SEND DATA	
TN+10 min	command SHUT DOWN	
TN+10 min+3 sec	MM power off	

Repeat night commands every 2 hours (T=14 hours, T+16 hours, etc.).

7.2. Timed Sample Collection

This sequence causes MM to collect a sound sample at a specified time, perhaps when the Lander is performing some mechanical operation. It starts by powering-on MM and collecting some packets to read out the remainder of what is in the Sound sample (this step can be eliminated if this operation does not follow a period of Mars sound sampling). It then does a cold-start to clear out the sound buffers just before the sound to be sampled. It then reads out the sound immediately to ensure that it is not replaced by some other sound.

T-10 min	MM power-on	Warm start to read-out data
T-10 min+1 sec	command MODE 9B	Long filter average mode

T-10 min+2 sec	command TIME	
T-9 min	command SEND DATA	read out previously collected data
T-9 min+30 sec	command SEND DATA	assume 10 packets is enough
T-8 min	command SEND DATA	
T-8 min+30 sec	command SEND DATA	
T-7 min	command SEND DATA	
T-7 min+30 sec	command SEND DATA	
T-6 min	command SEND DATA	
T-6 min+30 sec	command SEND DATA	
T-5 min	command SEND DATA	
T-5 min+30 sec	command SEND DATA	
T-4 min	MM power-off	No SHUT DOWN
T-3 sec	MM power-up	Cold Start
T-2 sec	command MODE 19	Fast filter average
T-1 sec	command TIME	
T+1 min	command SEND DATA	lock in sound sample
T+1 min+30 sec	command SEND DATA	9 Sample packets + 1 filter packet
T+2 min	command SEND DATA	
T+2 min+30 sec	command SEND DATA	
T+3 min	command SEND DATA	
T+3 min+30 sec	command SEND DATA	
T+4 min	command SEND DATA	
T+4 min+30 sec	command SEND DATA	
T+6 min	command SEND DATA	delay for Filter packet completion
T+6 min+30 sec	command SEND DATA	
T+7 min	command SHUT DOWN	
T+7 min+3 sec	MM power-off	

Note that only the first of the SEND DATA commands after the sound needs to be done immediately to lock in the sound; the rest can be done later.

7.3. No Telemetry Mars day

This is just like the Mars Day shown above except no telemetry is transmitted. This allows the microphone to scan for sounds on days that are otherwise LIDAR days. The only requirement is the additional power of turning MM on.

T=0	MM power-on	Start of Mars day
T+1 sec	command MODE 8B	
T+2 sec	command TIME	
T+X	command SHUT DOWN	Sound Avoidance
T+X+3 sec	MM power-off	
T+Y	MM power-on	end of Sound Avoidance
T+Y+1 sec	command MODE 8B	send Mode just in case
T+Y+2 sec	command TIME	

T+10 hours	command SHUT DOWN	
T+10 hours+3 sec	MM power-off	Start of night time
TN=T+12 hours	MM power-on	First night-time cycle
TN+1 sec	command MODE 8B	send Mode just in case
TN+2 sec	command TIME	
TN+10 min	command SHUT DOWN	
TN+10 min+3 sec	MM power off	

Repeat night commands every 2 hours (T=14 hours, T+16 hours, etc.).