TEXAS SPACE GRANT CONSORTIUM DESIGN CHALLENGE

TOPIC # - TDC - 96 - S24

BONE CONDUCTION HEADSET WITH HEARING PROTECTION DESIGN

BACKGROUND

The new space suit being developed for exploration EVAs on the surface of the Moon and in microgravity environments is referred to as xEMU. A government reference model has been developed and has undergone extensive functional and environmental testing. This suit contains new upgrades from the current EMU on ISS, such as integrated speakers and microphones, eliminating the need for astronauts to wear a Communications Carrier Assembly (CCA) a.k.a "Snoopy Cap" on their heads during spacewalks. However, this design approach results in speaker-to-microphone acoustic coupling, and communications echo and feedback. A proposed solution to this issue is to replace the integrated open speakers with an astronaut-worn bone conduction headset for audio capabilities while on EVA to receive incoming voice communications from Mission Control and other EVA or IVA crew members. This would eliminate the acoustic coupling and echo effect caused by open speakers and microphones. However, the open ear benefit of bone conduction headsets may be negated in acoustic environments with excessive ambient acoustic noise levels such as has been observed in the reference suit design.

PROBLEM DESCRIPTION

The challenge is to develop a custom headset that incorporates bone conduction audio transducers into over-the-ear hearing protection ear cushions with a comfortable low profile head mounting method and design an audio amplifier to drive the transducers. The project will require a multi-disciplinary approach to develop a custom prototype design that optimizes bone conduction audio transducer placement, performance, headset comfort and fit. Research will be required to understand the physics behind bone conduction transducer operation, sound conduction through bone to the inner ear, optimum physical integration of transducers with hearing protection, placement of transducers on the human head, mechanical coupling requirements from the transducer to ear cup housing and from the transducer to bone. Integration of multiple transducers may be considered to ensure optimum transducer head contact and sound transmission for multiple head sizes and bone structures for a one size fits all design. Hearing protection ear cup design must provide attenuation of ambient acoustic noise of at least 10 dB. Analog electrical design will be required for an amplifier optimized to drive the transducers providing a frequency response tuned for maximum speech intelligibility given the mechanical and electrical impedances of the transducer interface. The circuit design should include a voltage regulator or dc-dc converter required for standalone battery-powered operation.

Human factors such as comfort, adjustability, ease of donning, ear cushion design and material selection, etc. are major considerations since the headset will be used for up to 8 hours in a space suit, so a trade between head contact pressure for maximum transducer sound conductance and performance versus crew comfort will have to be considered. The hearing protection ear cup and head mounting method must be physically low profile to avoid hindering astronaut head movement within the suit helmet. Stretch goals include: 1) Assembled prototype headset subjective evaluation using human test subjects. This would include planning and conducting speech intelligibility testing per ANSI standard S3.2 Modified Rhyme Test (MRT). 2) Amplifier circuit board assembly integrated in a small enclosure with the necessary audio interface connectors and including accommodations for a 9 volt battery.

DELIVERABLES: First semester: 1) A project plan and schedule, 2) Requirements document, 3) Preliminary research summary report, 4) CAD files for preliminary conceptual ear cup design including integrated bone conduction transducers, 5) Sketch or CAD design files for conceptual head mount apparatus, 6) Schematic for preliminary analog amplifier circuit design, 7) SPICE simulation of analog circuit, and/or measurement data for breadboard showing frequency response with transducer load. Second semester: 1) Updated research report, 2) Test plan and test procedures, 3) 3D printed prototype left and right earcup with embedded transducers and ear cushions, 4) Measurement of acoustic noise attenuation for earcup (NASA can assist with this), 5) Updated frequency response measurements for amplifier circuit, 6) Assembled prototype headset, 7) Updated CAD and schematic capture files, 8) Final report documenting design approach, prototype characteristics, measurement and performance data and recommendations for follow-on design updates.

DESIGN TEAM PROFILE

NASA MENTOR:	Andrew Romero
LEVEL:	Upper level
MAJOR / DISCIPLINES:	EE, ME,IE (Human factors)
TEAMS:	Mentor is accepting one team
DURATION:	Two-Semester Project