



Servomotor and Controller Having Large Dynamic Range

A lightweight, compact, mechanically simple system offers high performance.

Marshall Space Flight Center, Alabama

A recently developed micro-commanding rotational-position-control system offers advantages of less mechanical complexity, less susceptibility to mechanical resonances, less power demand, less bulk, less weight, and lower cost, relative to prior rotational-position-control systems based on stepping motors and gear drives. This system includes a digital-signal-processor (DSP)-based electronic controller, plus a shaft-angle resolver and a servomotor mounted on the same shaft. Heretofore, micro-stepping has usually been associated with stepping motors, but in this system, the servomotor is micro-commanded in response to rotational-position feedback from the shaft-angle resolver.

The shaft-angle resolver is of a four-speed type chosen because it affords four times the resolution of a single-speed resolver. A key innovative aspect of this system is its position-feedback signal-conditioning circuits, which condition the resolver output signal for multiple ranges of rotational speed. In the preferred version of the system, two rotational-speed ranges are included, but any number of ranges could be added to expand the speed range or increase resolution in particular ranges. In the preferred version, the resolver output is

conditioned with two resolver-to-digital converters (RDCs). One RDC is used for speeds from 0.00012 to 2.5 rpm; the other RDC is used for speeds of 2.5 to 6,000 rpm. For the lower speed range, the number of discrete steps of RDC output per revolution was set at 262,144 (4 quadrants at 16 bits per quadrant). For the higher speed range, the number of discrete steps per revolution was set at 4,096 (4 quadrants at 10 bits per quadrant).

In the preferred version, there are position-feedback signal-conditioning circuits that generate two separate outputs. The electronic controller is used to select the rotational-speed range along with whichever of the two position-feedback outputs is appropriate to that range. The controller also receives a speed command through an RS232 serial interface. This rate command is converted to a position command updated at a set frequency — that is, the position is commanded at so many steps per unit time to obtain rotation at a desired speed. Finally, the controller takes the position command and the selected position feedback and implements a proportional + integral + derivative (PID) control law with a current-command output. The current-

command output is fed as input to a current amplifier that provides power to the motor. The motor can be a brushless or a standard brush-type DC motor.

The main innovative aspect of this system is the use of the multiple signal-conditioning circuits with the single resolver in generating micro-rotation commands for the motor. The use of the multiple signal-conditioning circuits increases the rotational resolution and the dynamic range for speed control. The speed-control dynamic range of this system is 5×10^7 ; a greater dynamic range could be obtained by adding signal-conditioning circuits for additional speed and position ranges.

This work was done by Dean C. Alhorn, David E. Howard, and Dennis A. Smith of Marshall Space Flight Center, Ken Dutton of Madison Research Corp., and M. Scott Paulson of Mevatech. Further information is contained in a TSP (see page 1).

This invention has been patented by NASA (U.S. Patent No. 7,081,730). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31529-1.

Digital Multicasting of Multiple Audio Streams

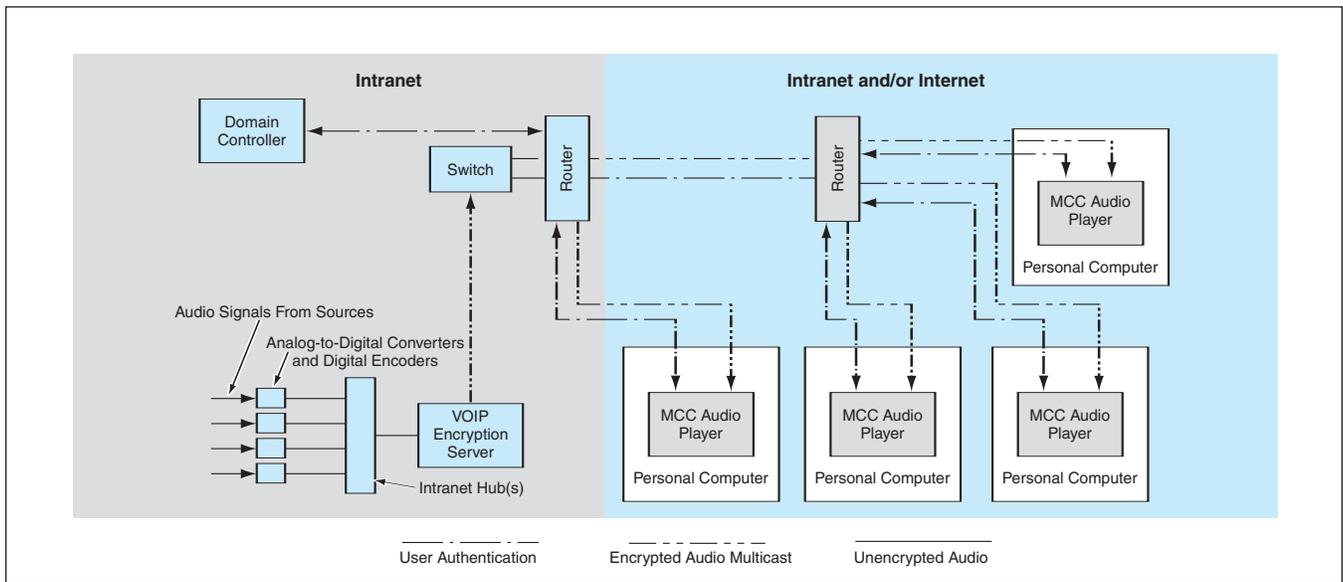
Authorized listeners can hear any or all streams in nearly real time.

Lyndon B. Johnson Space Center, Houston, Texas

The Mission Control Center Voice Over Internet Protocol (MCC VOIP) system (see figure) comprises hardware and software that effect simultaneous, nearly real-time transmission of as many as 14 different audio streams to authorized listeners via the MCC intranet and/or the Internet. The original version of the MCC VOIP system was conceived to enable flight-support personnel located in offices outside a spacecraft mission control center to monitor audio

loops within the mission control center. Different versions of the MCC VOIP system could be used for a variety of public and commercial purposes — for example, to enable members of the general public to monitor one or more NASA audio streams through their home computers, to enable air-traffic supervisors to monitor communication between airline pilots and air-traffic controllers in training, and to monitor conferences among brokers in a stock exchange.

At the transmitting end, the audio-distribution process begins with feeding the audio signals to analog-to-digital converters. The resulting digital streams are sent through the MCC intranet, using a user datagram protocol (UDP), to a server that converts them to encrypted data packets. The encrypted data packets are then routed to the personal computers of authorized users by use of multicasting techniques. The total data-processing load on the portion of the system up-



The MCC VOIP System distributes audio streams, in the form of encrypted data packets, to the personal computers of authorized listeners.

stream of and including the encryption server is the total load imposed by all of the audio streams being encoded, regardless of the number of the listeners or the number of streams being monitored concurrently by the listeners.

The personal computer of a user authorized to listen is equipped with special-purpose MCC audio-player software. When the user launches the program, the user is prompted to provide identification and a password. In one of two access-control provisions, the program is hard-coded to validate the user's identity and password against a list maintained on a domain-controller computer at the MCC. In the other access-control provision, the program verifies that the user is authorized to have access to the audio streams.

Once both access-control checks are completed, the audio software presents a graphical display that includes audio-stream-selection buttons and volume-control sliders. The user can select all or any subset of the available audio streams and can adjust the volume of each stream independently of that of the other streams. The audio-player program spawns a "read" process for the selected stream(s). The spawned process sends, to the router(s), a "multicast-join" request for the selected streams.

The router(s) responds to the request by sending the encrypted multicast packets to the spawned process. The spawned process receives the encrypted multicast packets and sends a decryption packet to audio-driver software. As the volume or muting features are changed by the user,

interrupts are sent to the spawned process to change the corresponding attributes sent to the audio-driver software. The total latency of this system — that is, the total time from the origination of the audio signals to generation of sound at a listener's computer — lies between four and six seconds.

This work was done by Mitchell Macha of Johnson Space Center and John Bullock of LiCom. For further information, contact the Johnson Technology Transfer Office at (281) 483-3809.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23349.