innovations: the manufacturer's view

Evolution And Grace

GRACE DESIGN MODEL M108

BY MICHAEL GRACE

The Model m108 evolved from the need for a new generation of high-performance microphone preamplifiers with digital conversion for our remote recording and fixed installation customers. The m108's predecessor, the m802, found itself at home in remote trucks, symphony halls, opera companies and broadcasters. This preamplifier was in a 2U rack space chassis with a half-width 1U power external power supply.

While this system was incredibly robust and set a new standard in audio clarity, problems our customers confronted were as follows: A 64-channel system of m802s took 16 rack spaces for just for the preamplifiers and then another eight rack spaces for the power supplies, creating large, heavy racks which were difficult to transport and required adequate ventilation. Additionally, a multi-channel system of 64 channels would cost the user on the order of $60,000.

Our new goal was to design a new preamplifier for the modern recording world: One that could find its home at the front end of large multi-channel systems as well as in simple, purist location recording applications, or in a home studio. We knew we could make something that performed better than anything we have done before *and* expand on the I/O and control capabilities of the m802.

Of course, the best-performing preamp in the world is useless if it is not working, so reliability was at the forefront during the entire design process. The reliability of the m802 has been really good, but we felt we could bring more simplicity to the build of the m108. The m802 with ADC option contained a total of 16 separate PCBs, and our goal was to reduce this to three. Not only would this help with reducing the overall size of the unit, it would greatly reduce the internal wiring along with the associated pin and socket contacts. Connecting those 16 PCBs involved more than 450 pin and socket connections along with their wire crimps or solder joints. The m108 reduces that count to about 150. Not only does this reduce the possibility of failure, it also reduces system cost. In the end, we also chose to add a two-channel DA converter for reference monitoring during recording. Additionally, in a Dante network, the D/A converter can be used as an auxiliary output for cue mixes or talk-back applications.

We found what we needed to do was to re-engineer the system into a smaller, more lightweight package, make it a more cost-effective system, and take advantage of the newer generation of converter, clock technology and digitally controlled preamplifier circuitry. Along with that, we needed to design in modern connectivity and control technology. But also, recognizing a large installed base of m802 preamplifiers, we needed to have traditional RS 422 and MIDI communications for backwards compatibility.

We knew that we needed to start with the foundation that all of our microphone amplifiers have been based on for nearly 25 years. The short list here includes no electrolytic capacitors in the signal path; separate power supplies for each channel; sealed gold contact relays for all signal switching; current feedback input amplifiers; precision metal film signal path resistors; careful attention to signal routing; power supply grounding; and complete EMI/RFI protection.

After establishing a design for the microphone preamplifiers, we proceeded to the ADC. The m108 was conceived to have A/D conversion built in as standard rather than an optional module, which, while being more economical, would also allow for optimal signal and power supply layout for the critical audio path.

The next task was to design a clocking system that could handle all of the sample rates and clock sources that the m108 would need to support. Low intrinsic jitter and high jitter rejection were the two most critical parameters for this design. We chose to base the design on the latest generation of DSPLL (Digitally Synthesized Phase Locked Loop). This type of clock system has very low jitter <100 fs typ (12 kHz–20 MHz). In the audio band, its intrinsic jitter is as low as an ideal VCXO-based clock, but with several advantages. Being that it is digitally synthesized, the clock can be programmed to hold its output frequency in the event of loss of word clock, and when word clock is restored, the clock will re-lock smoothly. Also, for the most external clock jitter rejection, the DSPLL can set its loop bandwidth to 500 mHz, which provides jitter rejection all the way down to 1/2 Hz but with a fast lock time. All of this can be done with an analog PLL, but requires large capacitors, sophisticated switching circuits for dual bandwidths, lots of PCB real estate, lots of money—and, in the end, would require its own 1U chassis!

With the core circuitry of the mic pres, ADC and clock designed, we proceeded to the digital processing, digital IO, control and power supply design. Each of these were significant engineering projects in their own right.

In the digital processing area, we needed multiple output formats: ADAT, AES3, USB, and I2S for the DANTE option module. We also needed an internal low latency digital mixer so that the ADC channels could be mixed to stereo along with a stereo return from a computer (via USB) or Dante. We accomplished this with the XMOS processor.

The main processor in the m108 is responsible for managing all of the internal systems—clock and converter configuration, mic preamp control, thermal management and user interface. In addition to these tasks, the main processor is responsible for communicating with the outside world. Control via RS485/RS422, MIDI and Ethernet are all managed in the main processor. The m108 processor contains a mini web server so the preamplifier can be controlled from a standard web browser or a stand-alone Mac or Windows control application. This was a substantial software task! The main processor also manages the front-panel user interface. Designing this interface so that it would be be simple enough for a new user to get up and running immediately, yet would provide in-depth control of the wide range of settings and parameters was an important goal. As any recording engineer can attest, when you are in the heat of the moment at a recording session, it is vital to be able to find your settings and go.

Housing the power supply in the same chassis as the microphone preamplifier was another challenge. A traditional 60 Hz linear power supply simply radiates too much noise to be in close proximity to the extremely sensitive low-level circuits (which is why the m802 had an external supply). So we decided to use a custom-designed, universal input switch-mode power supply, which is light, efficient and creates no noise in the audio spectrum. However, it does create ultrasonic noise at its switching frequency, so we worked hard to eliminate the radiated and conducted noise from this supply using shielding and filtering.

In the end, we are all very proud of the m108. It represents the biggest single engineering project in our company history. I believe its performance and reliability will help recording engineers achieve their best art.

The m108, as reviewed by *PSN* software editor Rich Tozzoli in 2016.

Electronics Designer Michael Grace is founder and chief designer of Grace Design.