

Digital Mixing For The Analog Mind

A look around the Mackie TT24

By John Boudreau & Fraser Warne

Over the past several years we've witnessed a digital revolution at the top end of the live sound arena. Digital consoles have now proven themselves robust and roadworthy, and as a result are now common for both large tours and installations.

We're also seeing digital consoles in smaller applications. However, getting digital benefits like recall, flexible routing,

"super" channel strips with gates and compressors as well as equalization (and don't forget internal effects processors!) can get pretty expensive.

Further, some of the smaller digital boards were originally developed for recording applications, with features and interfaces often better suited to the studio. And, limited input/output (I/O) capacity forces the live user to add card slot expanders just to access the power of the on-board DSP.

Set against this backdrop, Mackie sought to develop a mid-size digital mixer for live sound applications, with the result being the new TT24.

We kicked off the design process for the TT24 by listing all potential features and then eliminating those not inherently related to live mixing. Our team focused on two primary goals: Develop a control surface that would allow instant access to any primary mix function within two hand movements, and provide a "digital edge" to the tools needed for mixing live every day.

We interfaced with live sound companies and installers from around the world; this input was invaluable in terms of tightening up our list of potential applications and desirable features. Further, this group worked with us throughout the development process, helping to keep us on the right track.

INTERNAL PATH

Architecturally, the TT24 is a 24-bit/96 kHz-capable digital mixer with a 32-bit internal data path. A quick look at the rear panel shows connections to all of the mixer's internal



From the top down, the work surface of the new TT24 digital console.

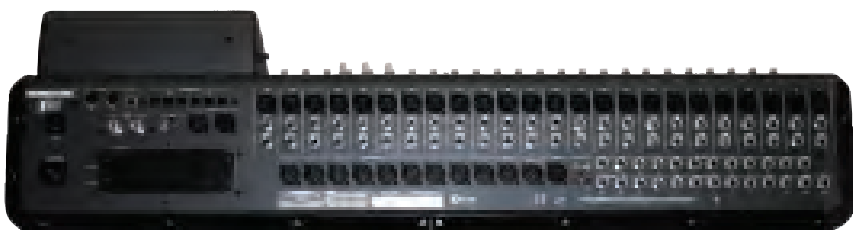


Figure 1: The view from the rear – ample I/O and expandability.

capabilities. (Figure 1) External I/O cards are not needed, although two slots are provided for optional add-on cards that we'll address later.

The TT24 also includes 24 low-noise microphone preamps, similar to those found in both our Digital 8-Bus and new Onyx analog mixers. Each analog input channel offers XLR and 1/4-inch TRS connectors, plus an insert jack (another 1/4-inch TRS). Eight additional line inputs on TRS can be stereo linked and used as four stereo channels, for a total of 32 possible analog inputs. In addition, a dedicated pair of two-track-inputs, plus a separate talkback input, ensure that channel strips will not be used up for these functions.

The TT24's digital inputs include a set of ADAT light pipe ports providing 24 channels of I/O at 48 kHz, or 12 channels at 96 kHz using SMUX format. (An optional expansion card for those who need the full 24 channels of ADAT I/O at 96 kHz is planned.)

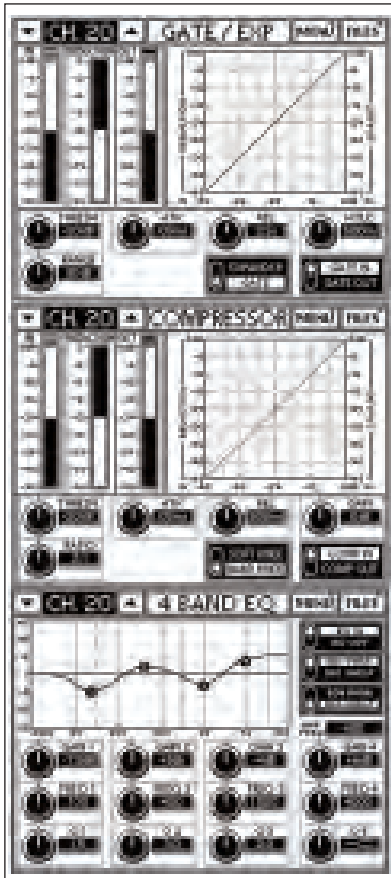


Figure 2: Mic inputs offer four-band EQ, comp/limiter and gate.

The built-in digital inputs can be used to connect up to 24 additional analog mic inputs via rack mounted eight-channel mic preamps.

Stereo AES/EBU or S/PDIF digital inputs are also available. Sample rate converters can be inserted into the AES/EBU or S/PDIF input path if required (when connecting a 44.1kHz CD player with S/PDIF output to a TT24 for example).

The TT24's primary outputs (main left, center and right, plus eight group/matrix outputs) are available on balanced XLR connectors. Twelve aux sends are available on 1/4-inch TRS jacks. There's a mono monitor output for monitor mixing applications, a stereo monitor out for control room situations, and headphone out on the front of the mixer. Analog stereo outputs are available as well.

Direct outs for the 24 mic preamps are available on three optical connectors for easy integration into any digital recording system. Finally, there's also a selectable AES/EBU and S/PDIF output for CDR, DAT, etc.

With so many connections, one of our challenges was figuring out the most logical way to access and apply the TT24's digital signal processing in a practical and fast way for live sound applications.

As you'd expect from any digital console, the 24 mic inputs all have four-band EQ, comp/limiter, and gate available, and the eight line inputs have the four-band EQ as well. (Figure 2) This lessens the need for additional out-board dynamics processing.

DSP for the outputs and groups is one area where we focused our efforts in order to get it right for live needs. The main outputs, auxiliaries and groups have a six-band EQ: two bands of high/low shelving EQ, two sweepable mids, plus a pair of "kill filters" – anti-feedback filters with quick manual control. (Figure 3)

Tapping the rotary encoder for one of these kill filters inserts a narrow -6 dB band filter at 1 kHz. Tap again and it's a sharper -12 dB filter. A third tap produces a deep and narrow -18 dB filter. Dial the knob to sweep this notch filter to the feedback frequency. (Comp/limiters to protect amplifier inputs or in-ear wearers are also avail-



Figure 3: Main outputs, auxiliaries have a six-band EQ.

able on all of the main outputs.)

Further, the 12 aux sends can be stereo linked, providing six built-in stereo in-ear mixes with EQ and limiting. The groups have 8 channels of EQ and comp/limiting available. The eight matrix outputs each offer up to 600 milliseconds of delay for typical applications like delayed loudspeaker systems. Last but not least, there are four internal effects processors.

FUNCTION PER BUTTON

One of the biggest challenges in designing digital live mixers is developing an intuitive and live-friendly user interface. The comfort factor built up over years of working with "one knob, one function" analog boards, for example, can be instantly gone. With so many more features available in the digital realm, one function per button makes it difficult to maintain a compact footprint.

As such, some digital desk designers have tended to undervalue the importance of the live user experience, jamming as many features into each button as possible. As a result, we were judicious in applying our experience in the analog realm to make the TT24 as easy as possible to learn while providing quick access to vital live application functions.

For example, the console has 29 100 mm motorized faders, and there are four group faders separate from the 24 channel faders. These group faders control groups 1 through 4, or 5 through 8.

We also considered tactile "feel and

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touch,” a given on analog boards but something that can be lost in the digital domain. New backlit buttons use ultra-bright LEDs for daylight applications and have a rigid – not soft – feel, so the user definitely knows if a button has been pressed. These buttons are multi-functional. In the case of the group faders, there are two rows of buttons above those faders labeled 1 through 4 and 5 through 8. Tapping any one of

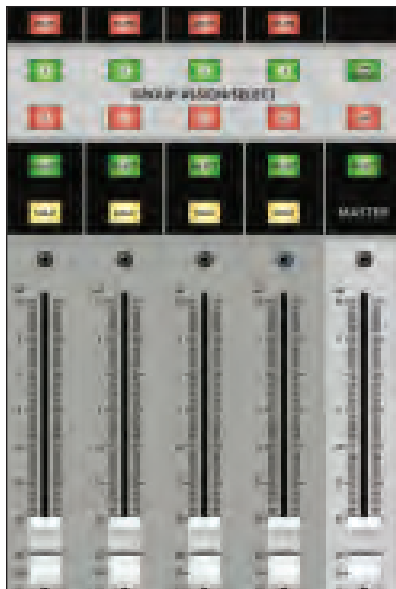


Figure 4: Two rows of buttons. Tapping any one of them will bank between the corresponding faders.



Figure 5: Fat Channel speeds workflow by using the digital control paradigm of “select and adjust.”

the buttons will bank between 1- 4 and 5- 8. Further, the entire row will illuminate accordingly. (Figure 4)

Press and hold the Group 1 button and channels can be added or subtracted from that group using the channel select buttons. Routing inputs to groups and mains is a simple, quick task.

Each channel fader also has a Virtual Potentiometer (V-Pot), which consists of a push-button rotary encoder and a 15-segment LED ring. Angled for easy viewing whether sitting or standing, every V-Pot function (aux sends 1 through 12, trim, pan, high-pass filter, and meters) is available on a set of buttons just to the right of the channel fader. Pressing “meters” turns the V-Pot into a high-resolution meter bridge.

The high-pass filter (HPF) is another example of an old school, analog interface approach. The red LED at the bottom of each V-Pot indicates that the HPF is engaged. Press the encoder to engage the filter, and turn the knob to sweep it between 20 Hz and 400 Hz to the desired frequency.

FAT AND QUICK

The upper right of the console is called the “Fat Channel,” consisting of a 5.7-inch touchscreen, 12 push-button rotary encoders and 10 “Quick Mix” buttons. (Figure 5) The Fat Channel is intended to speed the workflow on the TT24 by using the common digital control paradigm of “select and adjust.” Press “select” on any channel, group or output and the Fat Channel presents that section’s parameters for adjustment. This portion of the interface is flat, as opposed to deep or nested – no “forward” or “back” buttons are necessary.

For example, the four upper-most Quick Mix buttons on the left side of the Fat Channel represent the channel strip. The “FAT” button provides an overview of all elements of the channel, “EQ” accesses the detailed EQ control screen, “DYN” accesses the compressor/gate, and “AUX/GRP” accesses all of the routing for the channel. To adjust the low end on a vocal track, select the vocal channel, press EQ in the Fat Channel, then dial it in using the corresponding rotary encoders.

The 12 rotary encoders always cor-

relate to knobs on the 5.7-inch touchscreen. Go straight from the “FAT” screen to “EQ” by touching and adjusting the EQ on the screen itself.

The four upper-most Quick Mix buttons on the right configure some of the mixer’s deeper functionality. “AUX MSTR” puts all 12 aux master sends on the 12 rotary encoders, another way to avoid banking on the channel faders. The push button provides selection of that aux master for EQ and comp/limiting.

Meanwhile, “SNAP” provides detailed control of the 99 snapshots including naming, locking and filtering. Any or all elements can be filtered out of a snapshot. For example, you can remove the pulpit mic from a snapshot and still retain manual control. The bottom two Quick Mix buttons on either side of the rotary encoders allow easy scrolling through adjacent channels without reaching across the console.

WORKING WITH GROUPS

The “digital edge” begins with the TT24’s eight “Flex-Groups.” Each group can be configured individually as a mono, stereo, or VCA-style group. The TT24 initializes with eight mono groups just like many analog consoles, but any group can be configured instantly by using the touchscreen to select the group type on the group “FAT” screen. (Figure 6)

A stereo group can be designated, with all drum tracks routed to it. The input channel panning remains intact,

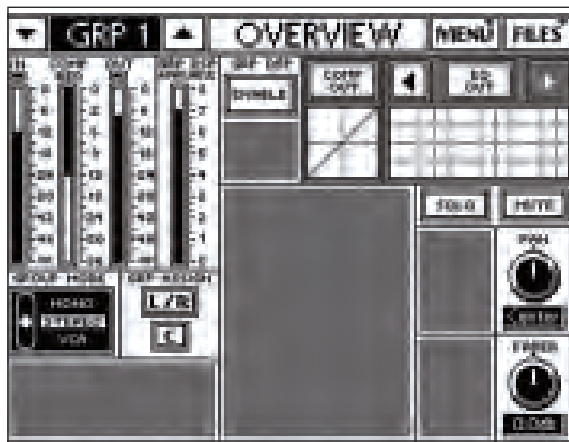


Figure 6: The TT24 initializes with eight mono groups, with any group configured instantly by using the touchscreen.

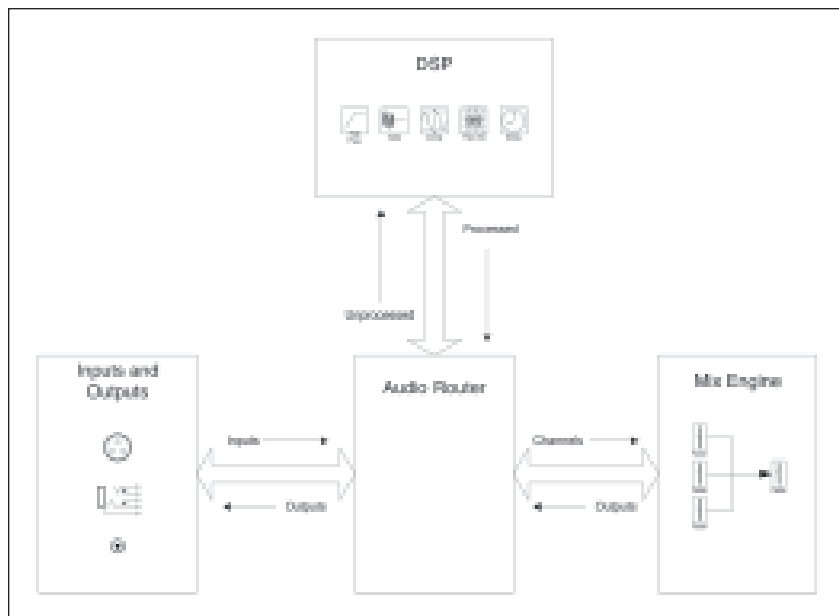


Figure 7: How the audio routing works.

offering single-fader level control of this stereo drum mix, plus group-level EQ and stereo dynamics processing.

Configure another group as a VCA, and the fader will act like a VCA fader, controlling level to all post-fader destinations of the selected channels (this is also a simple way to create a mute group). With eight groups, the TT24 can be set up with two mono groups, a pair of stereo groups, and four VCAs to fit a given application.

“AUX MODE” also helps enhance workflow efficiency. This button, the only blue backlit one on the board, effectively turns the TT24 into a monitor mixer. In this mode, the channel faders effect the selected aux mix and the group faders control aux master sends. Another press of the blue AUX MODE button and it returns the console to standard front-of-house mode.

Matrix Plus, referred to earlier as an 11 by 8 matrix, is really eight 11-line input/mono output mixers, into which the user can plug whatever is wanted. It defaults to the common arrangement. Groups 1

through 8 as well as left, right, and center/mono are the 11 inputs available to each of the eight matrices. For a broadcast feed, replace a subgroup with an announcer’s mic and mix it in at the desired level.

In some cases, Matrix Plus may be an easier way to create a more appropriate mix. Let’s take a vocalist’s monitor mix. Use the drum, bass, back-up vocals, keyboards, and guitar subgroups, which are already feeding the matrix channel. Insert the vocal mic, the vocal reverb and delay returns, and dial in a more accurate monitor mix using far fewer controls than with the typical aux send method.

BUILDING BLOCKS

The TT24 is composed of three primary building blocks: the DSP section, the mix engine and the audio router. Twelve Analog Devices 32-bit, floating-point SHARC DSP chips provide the input and output signal-processing power (EQ, compression, limiting, gating, etc.). They also perform all of the user interface functions: reading screens, running the touch screen, reading and moving the motorized faders, and so on. A dedicated SHARC chip handles effects such as reverbs, chorus and delay.

Storage of user snapshots is in 32 MB of Flash memory attached to one

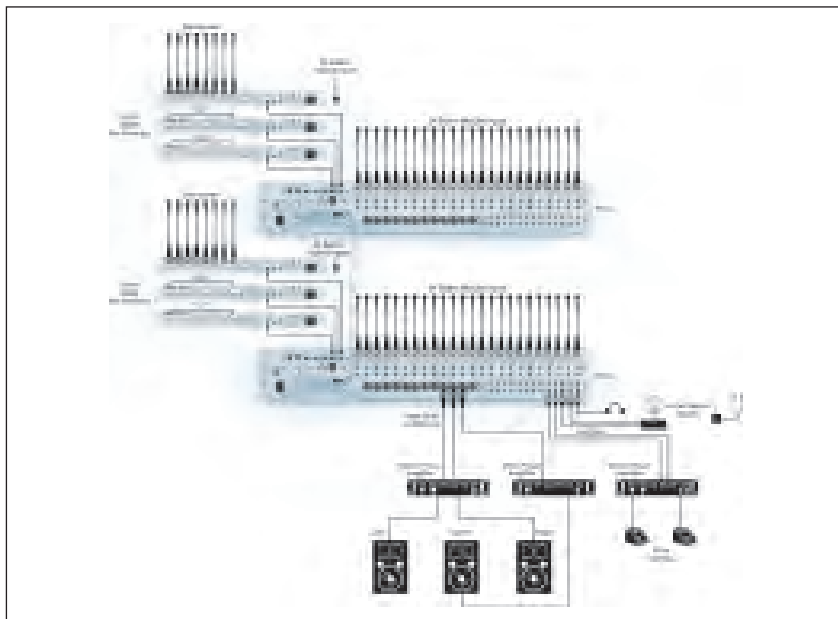


Figure 8: A look at the configuration of a 96-channel dual console LCR system.

of the SHARC DSPs. The TT24's system state is stored in a Ferro-electric memory (FRAM), a non-volatile storage device that is very similar to a standard static RAM (SRAM) device.

Unlike SRAM, however, FRAM does not require battery power. Battery-backed SRAM is guaranteed to fail sooner or later (that battery is going to go flat eventually) but the TT24 will always be able to recall its configuration after power down.

Further, the unit can boot up and be ready to go in less than five seconds. This was one of the key design requirements the TT24 engineering team incorporated in order to make it suitable for live applications. If a circuit breaker trips, or someone trips over a power cable, there should be no need to delay performance while the console reboots.

The TT24 mixes 88 channel inputs to 33 output buses, including eight main mix buses, 12 aux sends, the L/C/R mixes, the solos, etc. The heart of the Mix Engine is a Field Programmable Gate Array (FPGA) that performs almost 279 million (88 by 33 by 96) multiple/accumulate operations per second at a 96 kHz sample rate. The data path of the mix engine is 32 bits at its narrowest, and 56 bits at its widest.

All audio channels pass through an audio router, a fully non-blocking

switch that provides connection of any of 480 32-bit input channels to any of 640 32-bit output channels. (Figure 7, previous page) For example, it lets the expansion network card insert its received signals into the audio path. The audio router has more outputs than inputs because several audio channels are connected to more than one destination (what we refer to as a multicast).

The console, which ships with control software, connects to an external computer via USB and provides a full-color, large view of the touchscreen. In addition to a large view, the outboard PC-based graphic user interface (GUI) offers high contrast graphics with daylight usage in mind.

Black lines on white backgrounds or bright yellow text on black background is used for this very reason and tested extensively in the Seattle summer (believe it or not, there's plenty of sun up here that time of the year!). The same screens designed for the LCD are implemented in the GUI.

In addition, the GUI is unique in that it is an integrated mixing interface. The default setup is for the computer GUI to mimic the LCD screen, but it can also be set up to operate independently if a second engineer is working. The PC software also allows for file saving and firmware upgrades.

EXPANDING OPTIONS

As noted earlier, there are two expansion slots on the rear of the TT24 chassis. These accommodate optional expansion cards that offer additional functionality.

The U-100 console-linking card links two TT24 for applications that require a larger channel count. This link translates to 48 mic pres and 16 line inputs. If the 24 channels of ADAT light pipe were used with rack-mounted mic pres, the complete system would have up to 96 mic pres. (Figure 8)

The second expansion option is a UFXII card, which provides additional DSP (EQ, gate, comp/limiter) for those TOS-Link inputs, as well as 31-band graphic EQ and additional effects processing. For users that chose to expand a single console to 48 mic channels by using outboard mic pre-amps with optical outputs, the UFXII supplies horsepower for the additional channels' DSP requirements. (The UFXII card is also an open platform and in the future will allow for third party plug-ins.)

The third expansion option available is the LP48 loudspeaker processor card designed by Lake Technology, the company behind the Contour processor. The LP48 facilitates Lake's "Ideal Graphic" EQ and parametric "MESA" EQ.

Further, the db25 connector on the card adds eight fully balanced outputs from the 4 by 8 loudspeaker processor, facilitating the driving of a stereo four-way system from the TT24 without going through an extra set of D/A and A/D converters. And, the Lake GUI integrates with that of the TT24.

One more TT24 expansion option is an ADAT I/O card that allows all channels to be available when operating the board at 96kHz internally.

With this combination of features and functionality at a price we worked hard to make very competitive with comparable analog boards, it's our hope that this new console causes even loyal analog users to consider making the move to digital technology. ■

John Boudreau is the TT24 product manager and Fraser Warne is hardware manager for the new console.