from *The Craft of Controlling Sound* by Stephen Solum

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Chapter 7 Excerpt...

Block Diagrams

Mixer signal paths can get too complex to be obvious, or even to perceive, without a great deal of trial-and-error experimentation. Larger mixers not only combine multiple paths, they include bells and whistles inserted in various places, as well as side door exits and secret entrances. Fortunately there are road maps for any commercial mixer; they're printed in the back of the manual, ready to guide us. They save time, and are often the only practical means of understanding what's going where and in what order. These road maps are called **block diagrams**, and they help us practice that first Key to Successful Work in the Analog World: directing the signal path.

Here are some block diagram basics:

- A block diagram is a chart of signal paths as they travel through an audio component from the inputs to the outputs.

- A block diagram shows how signals are split, merged, and routed within the component.

Block diagrams are distinct from *schematic diagrams*, which show the positions of the innards of each circuit: every diode, resistor, integrated circuit, OP amp… things important to those who design or repair the equipment, but which can remain mystery to the rest of us.

Block diagrams—like road maps—have conventions and symbols. A primary convention or tradition rounds out our basic block diagram concepts:

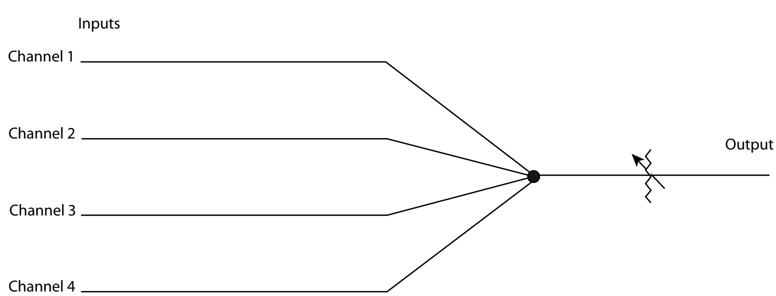
- In a block diagram, the signal generally begins at the left and moves toward the right.

You may assume this to be true unless there are arrows or other markings to lead you, or unless the signal direction is obvious.

> Once in a while the signal direction is obvious only to the person who drew the diagram, but that is the rule-proving exception. It's also a good reason to learn to read simple diagrams first

Learning to read block diagrams has great practical value as a shorthand manual for using complex mixers. It also develops your "analog thinking patterns." Let's look at a few generic diagrams and associated mixers, and learn symbols (and a few more analog concepts) as we go along.

Figure 7-1a



Very Simple Mixer #1
Block Diagram Showing Level Control

Figure 7-1a is a block diagram of Very Simple Mixer #1. Four inputs (left) combine to receive four signal paths, which result in one signal at the output (right). Notice that this diagram shows us nothing about levels: this is because most mixers operate at line level (where most analog business happens), and we can assume this one does too unless there is evidence to the contrary. Again, note the direction—left to right.

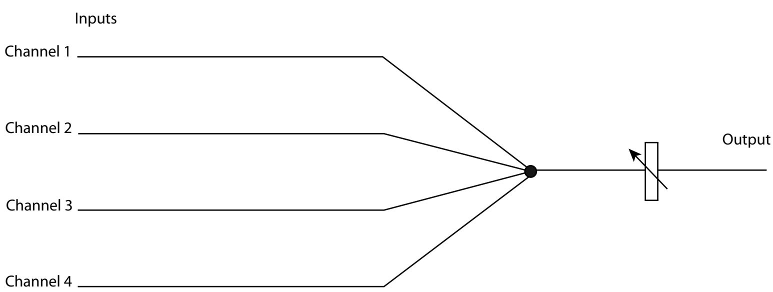
Note also a term that may be familiar to you, but is new to us in this book. Each input path is called a **channel.** By convention, special names are given to particular signal paths. The primary *inputs* of a *mixer* are called channels; the outputs, however, are not. (More labels will be added as we go.) In the diagram, it looks like the wires just connect to each other at that dot in the center. This is functionally true, but electronically, something else has to happen too. The problem with merely fusing signal path wires (as in combining cables with Bomber's Y-cord) is that although the signal path goes in one direction only, the electrons themselves don't know this: they just go wherever they're attracted. So if a bunch of electrons converge on the connection "dot" without any guidance, some of them may head back up a different input channel instead of toward the output—those lazy electrons will go whatever direction that gives least resistance to their travel at a given moment. If they start heading in the wrong direction (for our purposes), they will bump into the electrons (the audio signal) coming down that channel, and get in the way. The result is that if you have two signals with differing amplitudes combined with a Y-cord, they may not mix together in the same amplitude relationships. One may push the others back up the stream. This effect will vary depending upon which signal is the highest level at any given instant. The circuit won't blow up, but the resulting sound may be quite unpredictable and most likely undesirable. Y-cords are not useful for *combining* two signal paths into one. What we need is a traffic cop at the junction to make sure all the signals combine correctly and head toward the right on the diagram, eventually to an output. The mixer provides this electronically; it gets the sum of all the signals down the path, and places "valves" to keep an anything from going back upstream. You may come across terms like "summing circuit" or "summing amplifiers," which refer to this part of a mixer circuit.

So are Y-cords ever useful? Sometimes: a **Y-cord**, as you may imagine, has one connector (say, an RCA plug) on one end, is split into two cables, each with its own RCA plug. (For this discussion, exclude any Y-cord made with XLR connectors). As we learned above, it's not good to combine two signals (except in an emergency–situation where you don't care about the precise blend of sounds). However, electronic circuits are such that a Y-cord can be a quick and dirty way to split a signal into two clones, heading for two devices. The reason for this is: a) it is assumed that you're going into components that already know not to send signals backward out their own inputs and b) modern circuits have enough extra potential amplitude (voltage) going out the outputs to share. So, if necessary, use a Y-cord to split signals, but not to combine them.

Back at our fig. 7-1a, we now follow the four input channels, summed (combined) to one as they move left to right, where they run into a squiggle. This squiggle is one of several icons for a level control. The design comes from the fact that most level controls offer a variable resistance to the electron flow, lowering or **attenuating** the signal level when the control is turned down. A zig-zag line is the universal electrical symbol for resistance, and the arrow added means we can adjust how much resistance is in the circuit. The arrow/zig-zag icon thus represents a level or volume control in the signal path.

Often, other icons more specific to the actual shape of the control are used

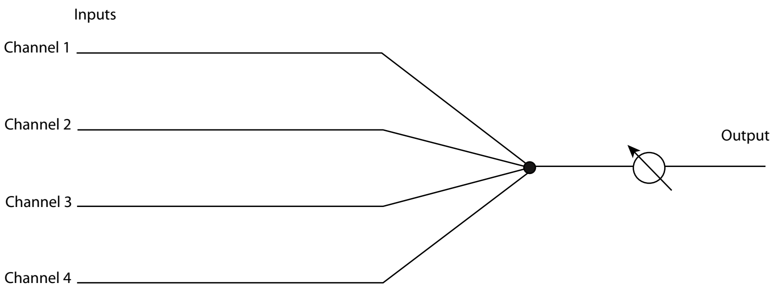
Figure 7-1b



Very Simple Mixer #1
Block Diagram Showing Linear Fader

Figure 7-1b is a block diagram of the same mixer, but now it has a **linear fader**. Many mixers and a few other components use straight-line controls (those devices that slide up and down) for levels. The advantages of linear faders are a) you can know what the level is without looking, only touching; and b) you can manipulate eight signal paths simultaneously with eight fingers. (Incidentally, the term "fader" originated with large levers used to control or "fade out" various lights on theater stages years ago.)

Figure 7-1c



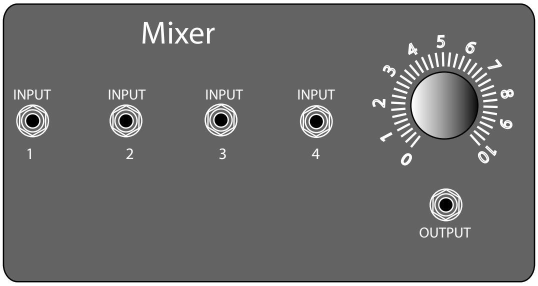
Very Simple Mixer #1
Block Diagram Showing Rotary Potentiometer

A rotary knob may be depicted as in Figure 7-1c. This is called a "**rotary pot**" (level pot, pan pot, etc.), short for "potentiometer" (recall that "potential" is a term related to voltage).

The block diagrams in 7-1a, 7-1b, and 7-1c all depict a simple mixer: the icon in 7-1a is generic for any shaped level control, 7-1b depicts a linear fader, and 7-1c depicts a rotary pot.

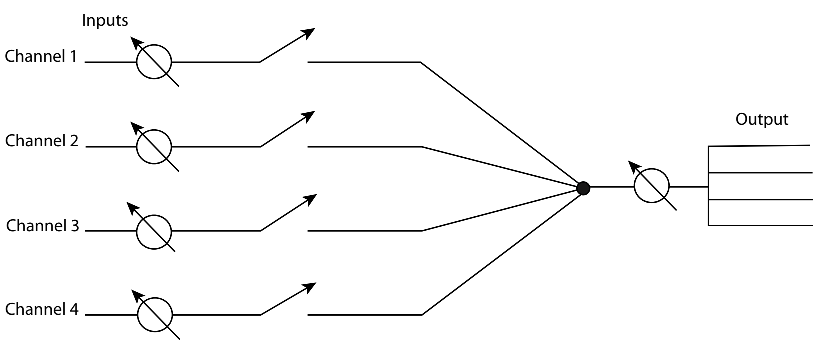
It's obvious with this mixer, but note: the block diagram shows that you can control only the *overall* level of the combined signal paths. There is no control over the blend, i.e., the levels of individual channels. This mixer (with a rotary pot) might actually look something like Figure 7-1d:

Figure 7-1d



Picture of Very Simple Mixer #1

Figure 7-2a



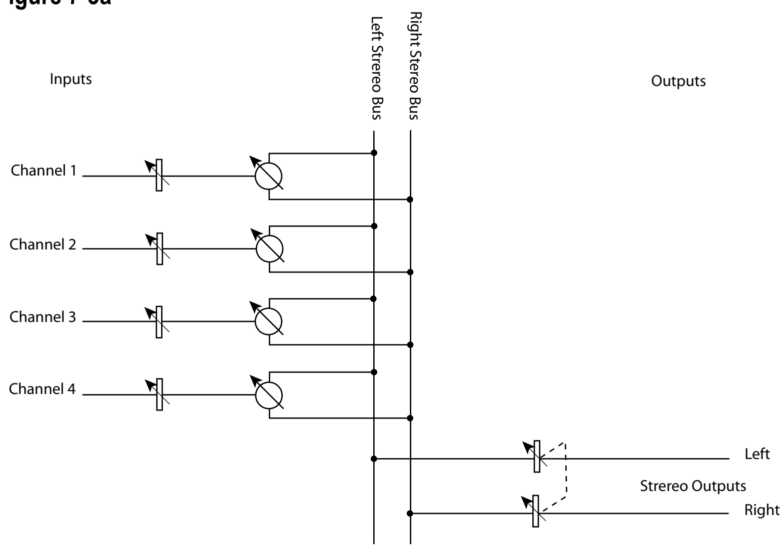
Block Diagram of Mixer #2

Figure 7-2b

Picture of Mixer #2

Figure 7-2a (previous page) is the block diagram of a slightly more complex, but more useful mixer, with its imagined physical layout pictured in Figure 7-2b. This mixer adds a level pot for each input channel, as well an on-off switch, so that any sources may be disconnected easily without unplugging or turning the volume pot fully down. Note the standard icon for an on-off switch: the path ends in an arrow, implying a movable segment that can be straightened (on) or bent (off). Also, look on the far right of the diagram: this mixer has multiple outputs (sort of like internal Y-cords) so that the signal can go to more than one destination. Each of these signal clones will be at the same level, and in all ways identical until you do something else with them.

Figure 7-3a



Block Diagram Showing Stereo Buses

The block diagram in Fig. 7-3a adds a major feature to our mixer repertoire. The left side looks familiar, but the middle of the diagram has sprouted two vertical lines. Just prior to them (that means left—upstream), each channel goes through a pot, where it splits in two. On a block diagram, this split and the icon with it designate a **pan pot**—short for panorama potentiometer. All but the smallest mixers have pan pots; you may be very familiar with them. A pan pot allows you to:

- turn it all the way counterclockwise to send a signal to one output,
- turn it all the way clockwise to send it to the other output, or
- turn it straight up (12 o'clock) to send it to *both* outputs.

Because the pot is continuously variable instead of being merely a three-way switch, you can also split the signal between the two outputs in any blend or percentage merely by twisting the dial. During the process of mixing signals to two outputs for stereo sound (outside our purpose at the moment), this allows for placing a sound anywhere in the "panorama" from left speaker to right—hence the name 'pan pot'.

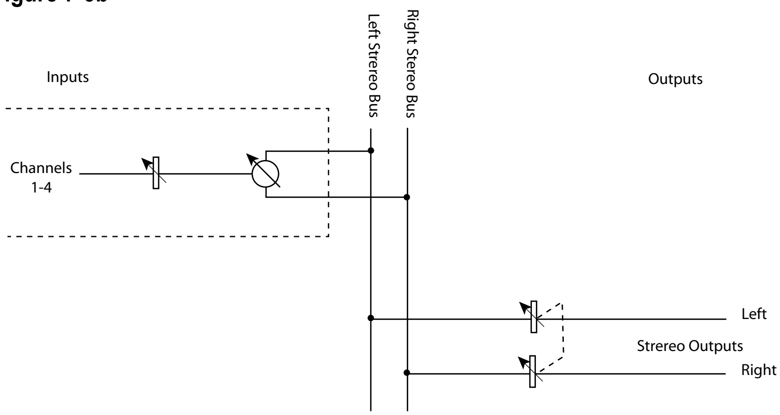
Study Fig. 7-3a and you'll see that each channel's pan pot connects its path to one of the two vertical lines. This is how multiple destinations are depicted in block diagrams, and it essentially follows the actual electronic design. Each vertical line is called a **bus.** The bus is the connecting wire that can combine signals from each channel. The combined output signal then leaves the bus and moves down the path toward the right. Look at the diagram and find the outputs, here labeled "stereo left" and "stereo right." Vertical lines to designate buses are universal in block diagrams. It's easy to imagine many more *channels* filling the page, each connected to the outputs via the vertical buses.

> Years ago a student said she visualized a transit bus line, with various passengers getting on the bus (from different input channels) then getting off the bus at the proper destination (output). This analogy works well as long as you imagine the bus ride happening instantaneously, rather than going from one stop to another over a period of time.

Along with the connecting buses above, the term "bus" sometimes refers to the number of main signal paths out of a mixer. The number of buses is an important indicator of flexibility in the analog world—to the point that mixers and even studios have been designated as such: "Yeah, we just recorded our newest EP over at Billy Bob's Dungeon. It's an 8-bus studio in the basement of a furniture store on Third Street." Note also that the dotted line connecting the left and right stereo output faders designates a "ganged" fader—one slide switch that controls two signal paths identically.

There is no picture of the hypothetical mixer shown in Fig. 7-3a. Using the block diagram, you can picture what it might look like, with its switches, connectors, pots, and faders. Try it.

Figure 7-3b



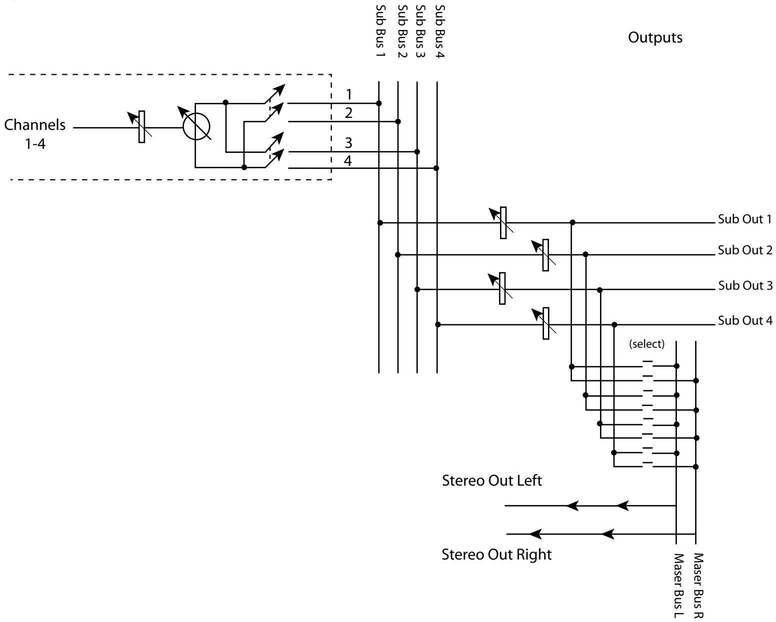
Block Diagram with One Channel Representing Many

It's a short step now to Fig. 7-3b, a simplified block diagram depicting the same mixer. Why simplify? Larger mixers might have 56 or more input channels. To keep the block diagrams from being 7 feet tall, they depict only *one* channel to represent them all, because in this mixer they are all identical. This is common practice. Most mixers have no more than two types of input channels, so they only need to show one or two channels in the diagram, each labeled to indicate which actual channels it represents. This reminds us of a very comforting reality: most of those intimidating buttons do the same things—they're just duplicated over and over. So, if you have a 16-channel mixer and can figure out how one channel works… or if you have an 8-bus mixer and can figure out the path through bus 1… etc., etc. Compare 7-3a and 7-3b again, and you'll see that they are functionally identical.

The final mixer in our first tour is depicted in Figure 7-4 (following page). Now there are eight input channels, represented in the block diagram by just one channel on the left side. Each channel can now be assigned to one of four buses, this time with a combination of push-button switches and a pan pot. Activating a switch enables its own pair of signal paths, which you direct using the pan pot in the same manner as in the previous mixer, i.e., pushing button "1-2" *and* turning the pan pot fully to the right (clockwise) assigns (say) channel 1 to bus 2. Pushing both "1-2" and "3-4" down while turning the pan pot to the center assigns the input channel path equally to all four buses.

This method of assigning paths to buses is now essentially universal in the mixing world, and allows for any number of channels and buses, each channel sporting a push button for each pair of buses. The output coming from each bus may be labeled "Group Out (5)" or "Program Out (3)," or maybe "Submaster Out (2)," depending upon the manufacturer. In any case, these are the primary routes out of the mixer, and will usually come out to the patch bay, labeled appropriately.

Figure 7-4



A Mixer with Multiple Buses

Note well: there is no such thing as "*Signal Path* 3" in a sound studio (analog or digital). It's vitally important to know whether you're dealing with *Channel* 3 or *Bus* 3 (or *Track* 3 or *Aux* 3 or whatever other terms pop up later). Some of those 3s may at some point be connected, but most often they will be separate signal paths. By the time a studio is large enough to require a patch bay, it will have several "3s".

Again, it's vital to understand these concepts, but they will become useful only after you have put them in practice (emphasize the word practice), consciously connecting, assigning, and plugging, over and over, mentally labeling and following the directional trail, in a real studio setup, small or large, analog or digital. (Remember, most digital studios have the appearance and apparent function of analog.)

There is one more new wrinkle in the block diagram in Figure 7-4. Look in the lower right of the diagram: besides going directly out of the mixer and to the patch bay, each signal path from the buses splits and takes a scenic route. Note several things:

- In this case, the split occurs *after* the Bus Out (Group Out, etc.) fader.

- Points of connection have a dot on them. Where signal paths cross but do not connect—like ships passing in the night—there is no dot. This is standard practice on most diagrams.

- Unless there is a switch or extra level control of some sort, assume that the signal always goes *both* toward the right (to the Group Out) and down (to the scenic route).

- There are little arrows to help us keep track of the direction of the signal path.

The scenic route in this case leads each of these four paths to a split and a pair of on-off switches ('push-to-select' switches). These in turn potentially send each group bus to yet another one or two vertical lines—the stereo buses, left and right (or master buses; whatever terms are used). The scenic route functions like another mini-mixer within the mixer. Following the stereo buses down, we find that each one "is tapped by" (sends the signal to) an output path leading out of the mixer.

The uses for all these outputs may not as yet be clear, but (hopefully) you now understand their basic arrangements and connections—as represented by the block diagram. Try to sketch a picture of the faceplate of this imaginary mixer, as well as (part of) the patch bay for an imaginary studio. Imagine sending signals and turning buttons; imagine the effect of everything you do. Consult the block diagram. If you have access to a sound arts work area that looks anything like this, transfer what you've learned. The real equipment will probably have more buttons, the real block diagram may seem much more complex than this (look for it in the back of the mixer manual… OK, look for the manual first), but if you temporarily ignore the parts you haven't learned yet (or—better yet—try to figure them out), the multiple signal paths will start to make sense.

and continuing...

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