M-S Stereo: A Powerful Technique for Working in Stereo*

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The practical requirements of broadcast and cinema stereo sound dictate the need for good stereo imaging, as well as full monaural compatibility. Coincident miking fulfills this requirement, and the most versatile of these techniques in the M-S matrixing of a forward-facing directional microphone with a laterally oriented bi-directional microphone. The results offer both good stereo perspective and full (discrete) monaural compatibility. The importance and implementation of this technique to the recording, broadcast, and film media are discussed.

INTRODUCTION

Since the earliest reported experiments in binaural sound reproduction, dating from the Paris Opera in 1881[1], the search has continued for improvements in stereo techniques.

Alan Dower Blumlein applied for a patent in 1931[2] that stands today as a benchmark in the history of stereo technology:

> The fundamental object of the invention is to provide a sound recording, reproducing and/or transmission system whereby there is conveyed to the listener a realistic impression that the intelligence is being communicated to him over two acoustic paths in the same manner as he experiences in listening to everyday acoustic intercourse. This object also embraces the idea of conveying to the listener a true directional impression and thus, in the case in which the sound is associated with picture effects improving the illusion that the sound is coming only from the artist or other sound source presented to the eye.

From 1931 to the present, the techniques developed by Blumlein and others have been expanded, refined, rediscovered, and much discussed. This paper continues in that great tradition, with particular emphasis on the applicability and appropriateness of the M-S technique to the recording, broadcast, and visual media.

1 M-S STEREO: CONCEPT AND THEORY

The mid-side (M-S) stereo technique is one of the two formats of "intensity stereo," that is, stereo in which spatial localization is determined by the differences in the intensity of a sound wave as it arrives in phase at a coincident pair of microphones. Intensity stereo relies completely on the directional characteristics (polar patterns) of the microphone pair to produce this effect, since only intensity differences and not phase differences exist between the channels for any single source arriving at a coincident pair.

The two format variations of intensity stereo are X–Y (left-right) and M–S (mid-side or sum and difference). X–Y stereo is created when a pair of directional microphones of like polare pattern are angled symetrically from the midline (axis of symmetry) of the sound stage.

The M–S technique likewise employs two coincident microphones: one is the mid (M) microphone, which can be of any polar characteristics–from omnidirectional to cardioid to bidirectional–and which is aimed directly at the midline (axis of symmetry) of the sound stage; the other is htre side (S) microphone, which has a bidirectional pattern ($\cos\theta$) that is oriented at right angles horizontally to the centerline axis of the M microphone. The conversion of these two (mid–side or sum and difference) signals into convetional left–right stereo is accomplished via a sum-and-difference matrix network, where typically the left signal is the sum ($L = M + S$) and the right signal is the difference ($R = M - S$).

In-phase intensity stereo provides the listener with a much more accurate and consistent stereo illusion than do spaced microphone techniques. Intensity stereo provides angular position information that is consistent, regardless of the distance of the sound source to the stereo microphone pair.

Spaced microphone techniques provide directional cures which vary radically with the distance of the sound source from the microphones. When the sound source is relatively close to one of the microphones, small changes in position result in dramatic stereo perspective shifts. When the sound source is distant from the spaced micrephones, no directional information is conveyed.

Another disadvantage of the spaced microphone technique is that a sound source can arrive out of phase at one microphone with respect to the other(s) when the air paths from the source to the microphones are unequal. This is a major problem at lower frequencies where the soune source is at either the far left of the far right of the stereo stage. When combined to mono either electrically or acoustically at the listening poistion, considerable low-frequency comb filtering effects can occur. (These can be quite difficult to detect when monitoring via stereo headphones, but become quite obvious via loudspeakers, or when the signal is summed to mono.) During disk mastering this out-of-phase information translates into excessive vertical motion of the cutterhead.

The choice of the polar pattern of the M component, and the relative proportions of the M and S contributions to the whole sound field determine the resultant stereo perspective. As the microphones are essentially coincident with respect to the sound source, the stereo imaging is not phase dependent at any angle of horizontal incidence; it is also independent of time (distance) related phenomena. Furthermore, when microphones of suitably accurate polar frequency response are used, uniform response over the entire sound field is achieved.

Figs. 1 and 2 show some of the "equivalent X–Y" miking patterns and angles resulting from various combinations of M-microphone polar patterns and M0toS ratios. These diagrams illustrate a number of aspects of utilizing M-S stereo to derive X–Y stereo, as well as several more fundamental aspects of the microphones polar patterns.[1]

The 81 diagrams illustrated in Fig. 2 are a representative selection of M–S to X–Y transformations

In theory all basic microphone polar patterns can be described as a ratio of omnidirectional (scalar) to bi-directional (vector or cos 0) components of two perfectly coincident microphones whose outputs have been summed. The polar pattern resultant can be expressed by the equation $P = B + (1 - B) \cos)$, where p is the polar pattern resultant and B is valued between 0 and +1 and expresses the ratio of the omnidirectional to bi-directional components. The typical resultant values and polar patterns for common first-order microphones are shown in Table 1.

graphically presented, where X = M + S (the sum), and Y = M – S (the difference). The diagrams are organized into groups of nine, each group presenting a different M-microphone pattern of the M–S pair.
They are sequenced through nine ratios of M to S, from 0.30M:0.70S to 0.70M:0.30S, stepped in .05 increments. The relative size of the M and S polar plots in each M–S pair graphically presents these ratios. The equivalent X–Y patterns are shown below. The number of degrees printed between each X–Y pair is the included angle between the axes of the microphone of that pair.

The equation given with each diagram describes that particular M-S pair by defining the ratio of M to S and the polar pattern of the M microphone. The output of the S microphone is defined here as a sine function (rather than the more conventional $\cos\theta$) because its principal axis has been rotated 90° to the left of the zero axis.

The general equations used to describe the M and S components are:

$$\mathrm{M} = |\, A\,(B + (1 - B)\cos\theta) \qquad 0 \le \theta \le 2\pi$$

$$\mathrm{S} = |\, (1 - A)\sin\theta) \qquad 0 \le \theta \le 2\pi$$

where A expresses the decimal fraction of the M microphone's contribution to the M–S matrix, and B establishes the pattern of the M microphone by expressing the decimal fraction of the omnidirectional (scalar) to bi-directional (vector) components of its polar pattern. Both A and B are defined as positive numbers valued from 0 to + 1. Where $A = 0$, there is no M microphone contribution to the matrix; where $A = 1$, the M microphone makes the entire contribution to the matrix. Where $B = 0$, the M–microphone polar pattern is bi-directional ($\cos\theta$); where $B = 1$, the M–microphone pattern is omnidirectional (1 or scalar). Where B = 0.5, the M-microphone polar pattern is cardioid ($0.5 + 0.5\cos\theta$). (Note: the M and S values were restricted to positive values for purposes of plotting the polar patterns. In fact, the values can be negative, and these negative values represent the rear lobes (reversed polarity). The right facing lobe of the S microphone, and rear-facing lobe (π rad) of the M microphone, and the rear-facing lobe of any equivalent X–Y pair shown are all such reverse-polarity lobes.)

The equation used to define the extremum (0° axis) of the X = M + S equivalent microphone's θ angle (one-half the included angle of the X–Y pair) is:

$$\theta = \arctan\left(\frac{1 - A}{A(1 - B)}\right)$$

The derivation of this equation as well as the program run on an Apple II computer used to generate the values given are available upon request from the authors.

The important aspect of an ideal omnidirectional (scalar) microphone is that it possesses no mechanism for reporting the direction of a sound wave; it responds only to the (pressure) magnitude. The fundamental aspect of a bi-directional (vector or cos 0) microphone patterns is that it reports both the magnitude and polarity of a sound wave, based upon the angle of incidence: it has greatest in polarity magnitude at 0 degrees (on-axis) incidence; equal magnitude but opposite polarity at 180 degrees incidence; and minimum magnitude at both 90 degrees and 270 degrees incidence. When coincident omnidirectional and bi-directional microphones are combined equally, the resultant is a cardioid.

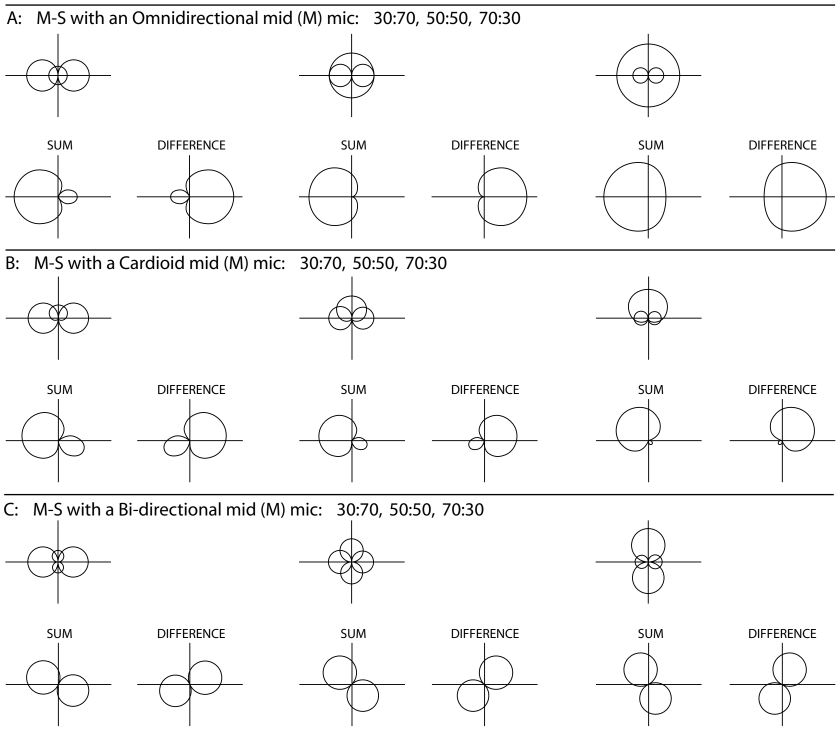


Fig. 1. M-S tp "equivalent X-Y" transformation for M-to-S ratioof 30:70, 50:50, and 70:30. (A) M-S with omni-directional mid (M) microphone, (B) M-S with cardioid mid (M) microphone, and (C) M-S with bidirectional mid (M) microphone.

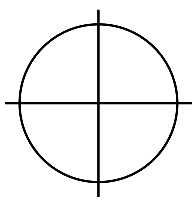
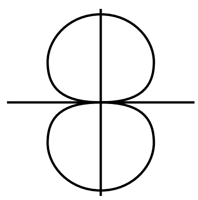
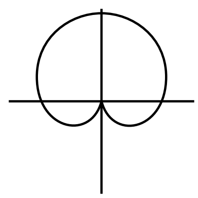
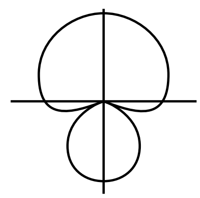
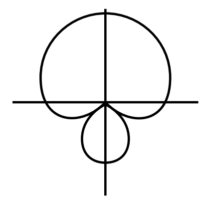
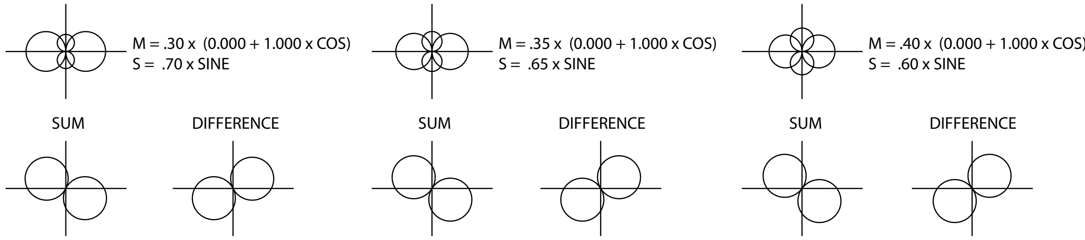
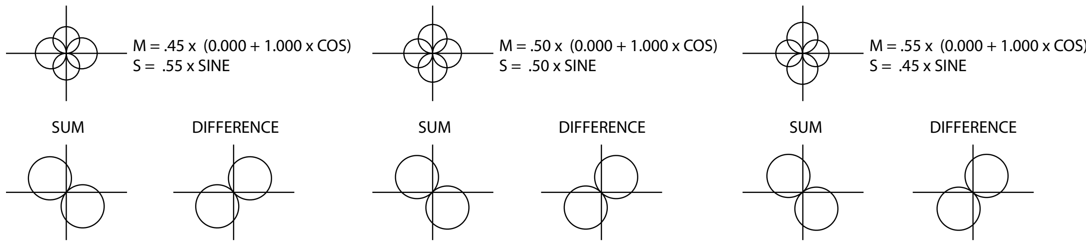
Characteristic	Omnidirectional	Bidirectional	Cardioid	Hypercardioid	Supercardioid
Polar Response Patterns					
Polar Equation If $(\theta) = \infty$	1	Cos θ	1/2(1+Cos θ)	1/4(1+3Cos θ)	.37+.63Cos θ
Pickup Arc 3 dB Down ()	360°	90°	131°	105°	115°
Pickup Arc 6 dB Down	360°	120°	180°	141°	156°
Relative Output at 90° (dB)	0	- ∞	- 6	- 12	- 86
Relative Output at 180° (dB)	0	0	- ∞	- 6	-117
Angle at which Output = 0 (θ)	—	90°	180°	110°	126°
Random Energy Efficient (RE)	1 0 dB	333 - 48 dB	333 - 48 dB	250 - 60 dB	268 - 57 dB
Distance Factor (DSF)	1	17	17	2	19

Table 1. Polar equations a diagrams for first-order microphone patterns [3].

Fig. 2 a through i.   Complete set of diagrams and equations for M-S to X-Y transformations.





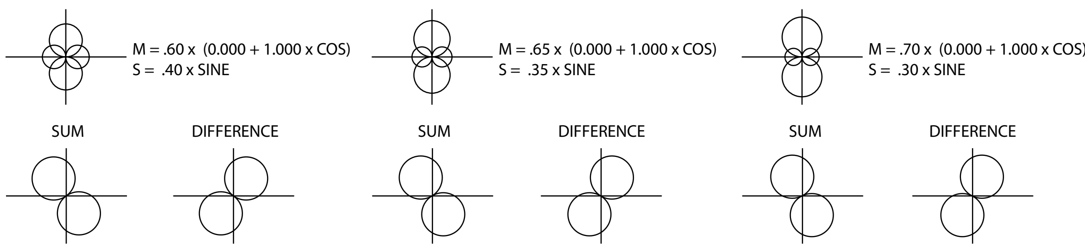
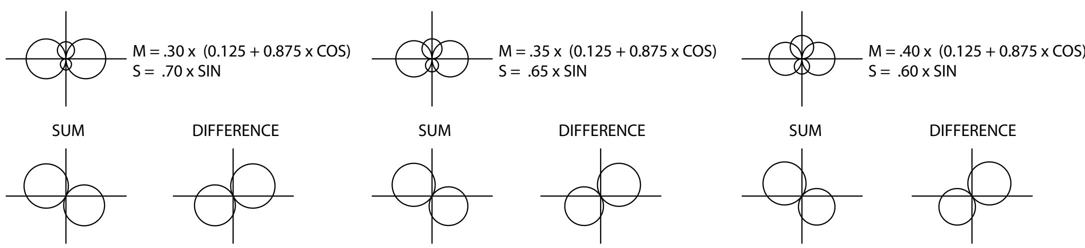
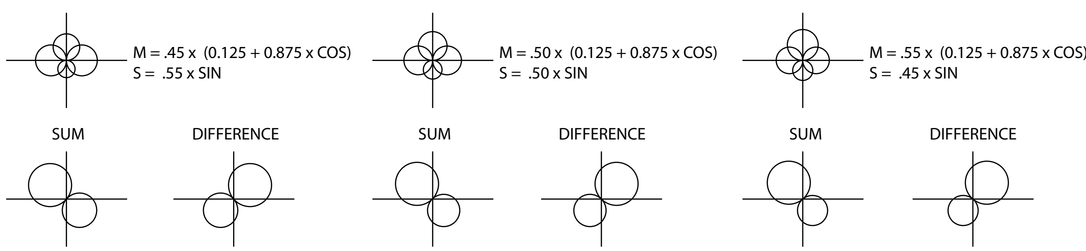


Fig. 2 b.





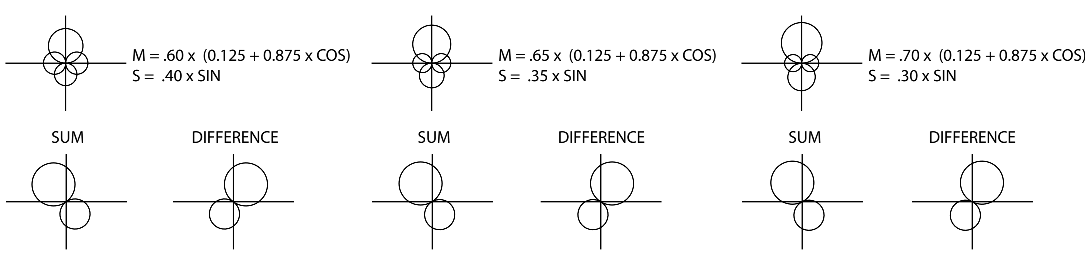


Fig. 2 c.

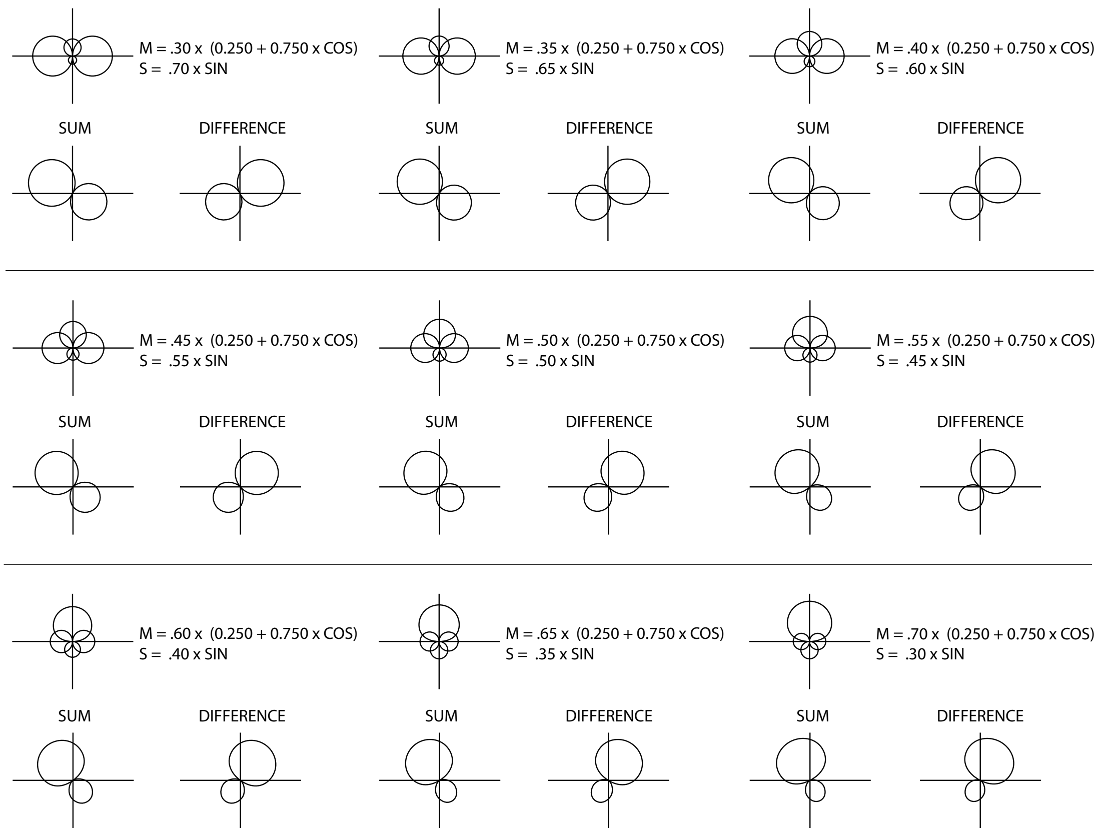

M = .30 x (0.250 + 0.750 x COS)
S = .70 x SIN
M = .35 x (0.250 + 0.750 x COS)
S = .65 x SIN
M = .40 x (0.250 + 0.750 x COS)
S = .60 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .45 x (0.250 + 0.750 x COS)
S = .55 x SIN
M = .50 x (0.250 + 0.750 x COS)
S = .50 x SIN
M = .55 x (0.250 + 0.750 x COS)
S = .45 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .60 x (0.250 + 0.750 x COS)
S = .40 x SIN
M = .65 x (0.250 + 0.750 x COS)
S = .35 x SIN
M = .70 x (0.250 + 0.750 x COS)
S = .30 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE

Fig. 2 d.

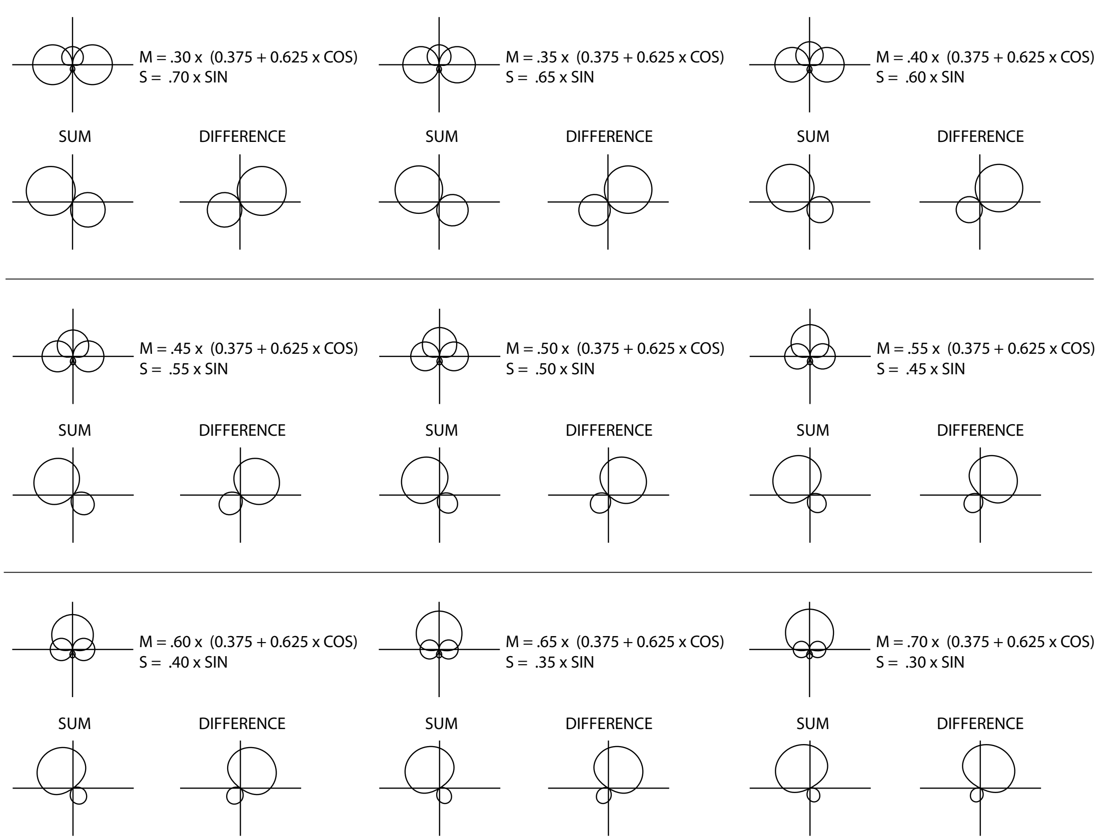

M = .30 x (0.375 + 0.625 x COS)
S = .70 x SIN
M = .35 x (0.375 + 0.625 x COS)
S = .65 x SIN
M = .40 x (0.375 + 0.625 x COS)
S = .60 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .45 x (0.375 + 0.625 x COS)
S = .55 x SIN
M = .50 x (0.375 + 0.625 x COS)
S = .50 x SIN
M = .55 x (0.375 + 0.625 x COS)
S = .45 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .60 x (0.375 + 0.625 x COS)
S = .40 x SIN
M = .65 x (0.375 + 0.625 x COS)
S = .35 x SIN
M = .70 x (0.375 + 0.625 x COS)
S = .30 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE

Fig. 2 e.

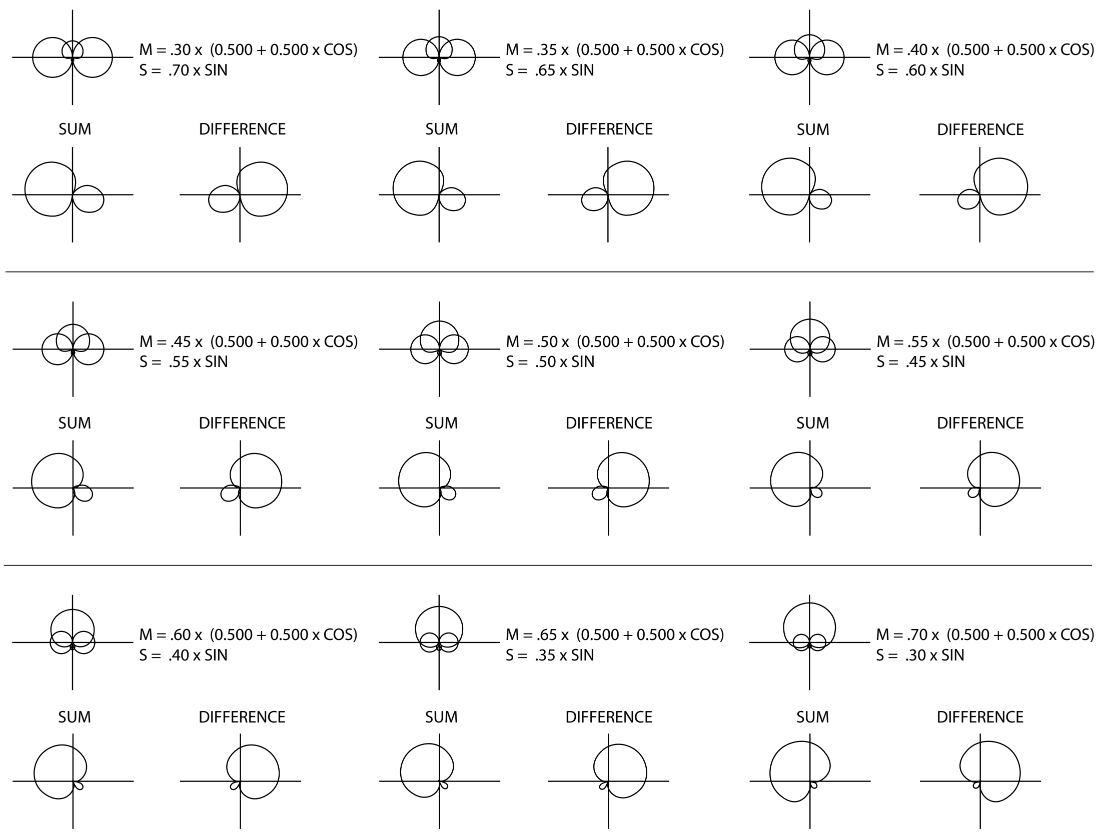

M = .30 x (0.500 + 0.500 x COS)
S = .70 x SIN
M = .35 x (0.500 + 0.500 x COS)
S = .65 x SIN
M = .40 x (0.500 + 0.500 x COS)
S = .60 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .45 x (0.500 + 0.500 x COS)
S = .55 x SIN
M = .50 x (0.500 + 0.500 x COS)
S = .50 x SIN
M = .55 x (0.500 + 0.500 x COS)
S = .45 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .60 x (0.500 + 0.500 x COS)
S = .40 x SIN
M = .65 x (0.500 + 0.500 x COS)
S = .35 x SIN
M = .70 x (0.500 + 0.500 x COS)
S = .30 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE

Fig. 2 f.

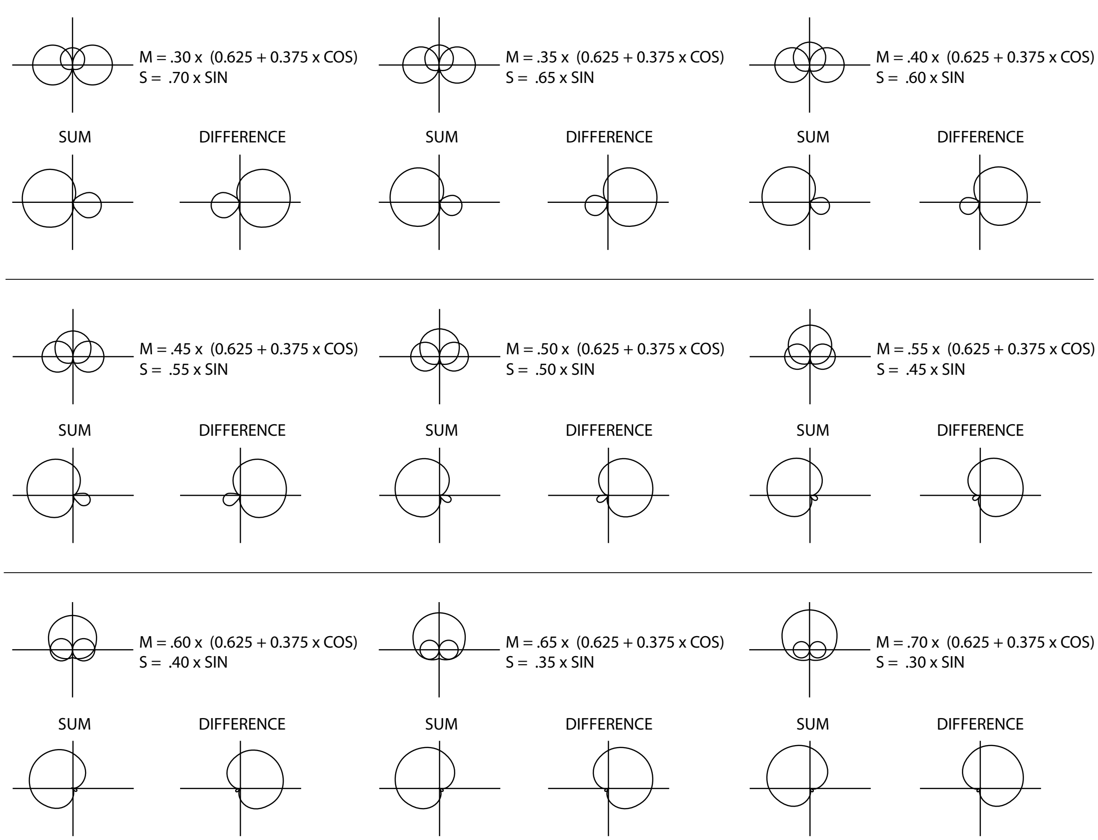
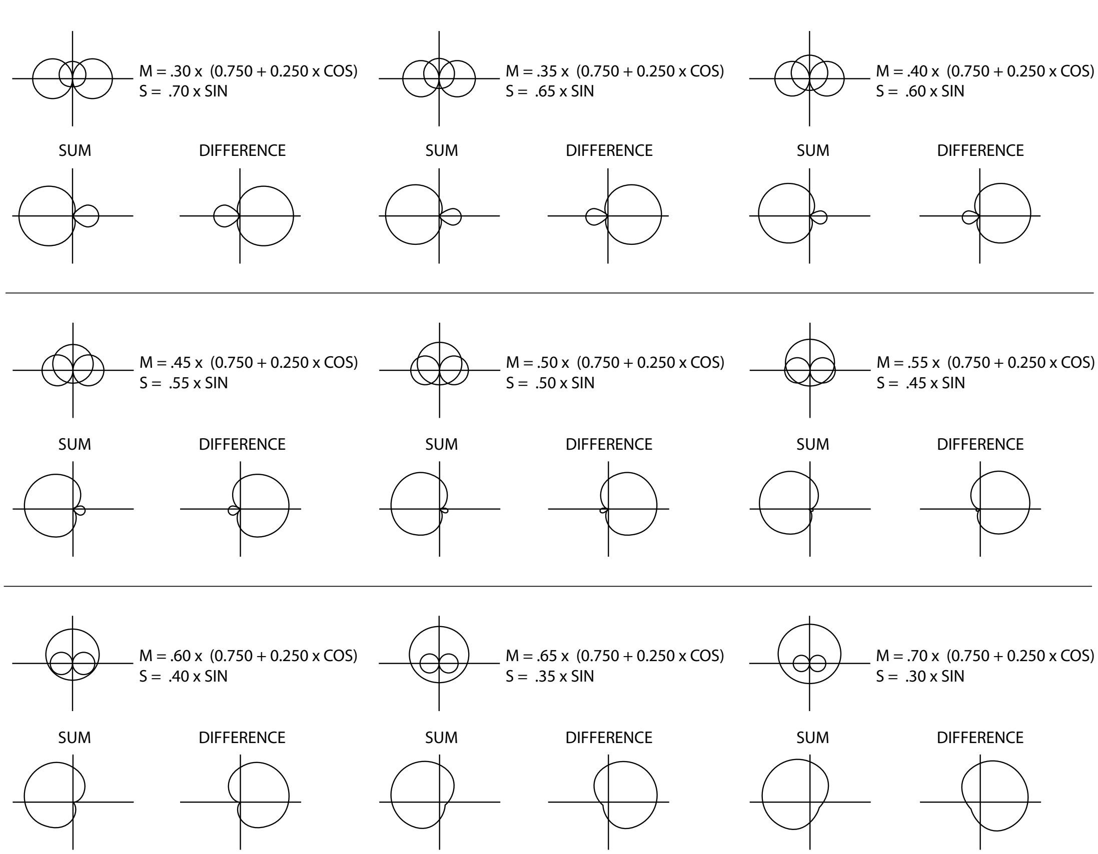
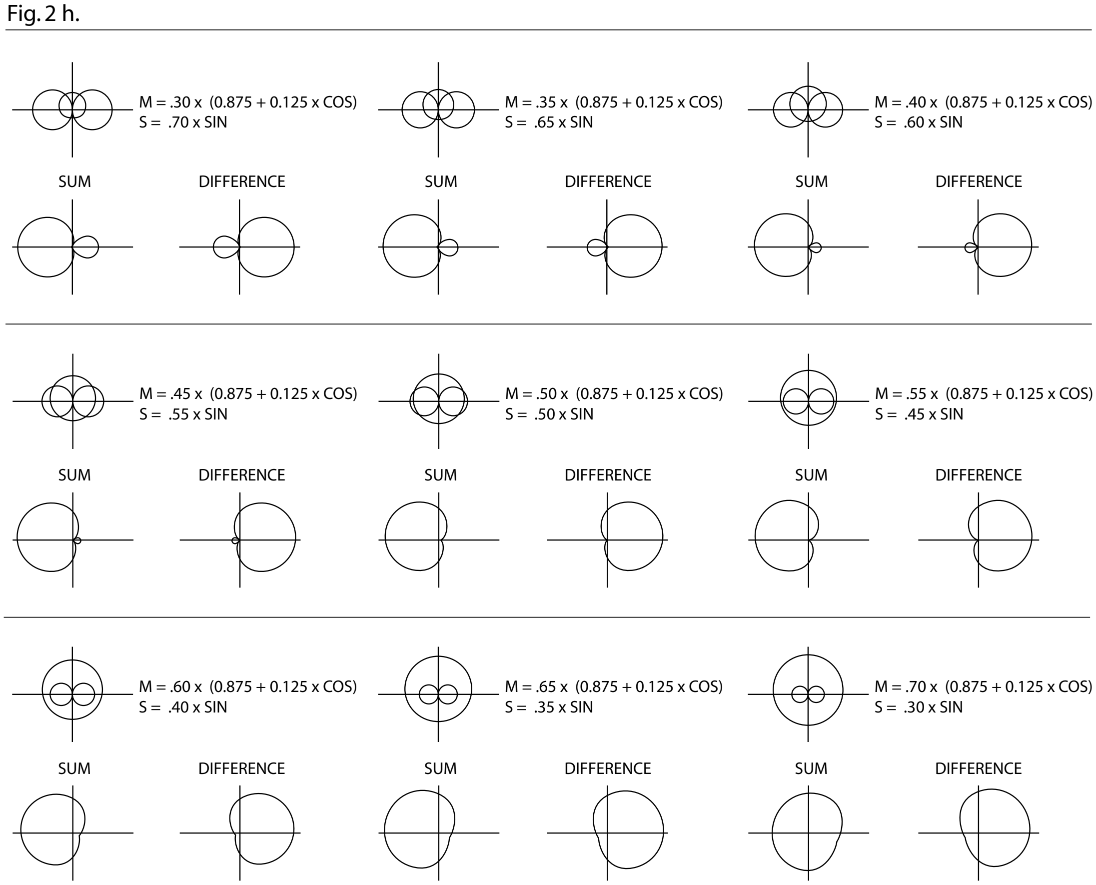

M = .30 x (0.625 + 0.375 x COS)
S = .70 x SIN
M = .35 x (0.625 + 0.375 x COS)
S = .65 x SIN
M = .40 x (0.625 + 0.375 x COS)
S = .60 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .45 x (0.625 + 0.375 x COS)
S = .55 x SIN
M = .50 x (0.625 + 0.375 x COS)
S = .50 x SIN
M = .55 x (0.625 + 0.375 x COS)
S = .45 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .60 x (0.625 + 0.375 x COS)
S = .40 x SIN
M = .65 x (0.625 + 0.375 x COS)
S = .35 x SIN
M = .70 x (0.625 + 0.375 x COS)
S = .30 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE

Fig. 2 g.



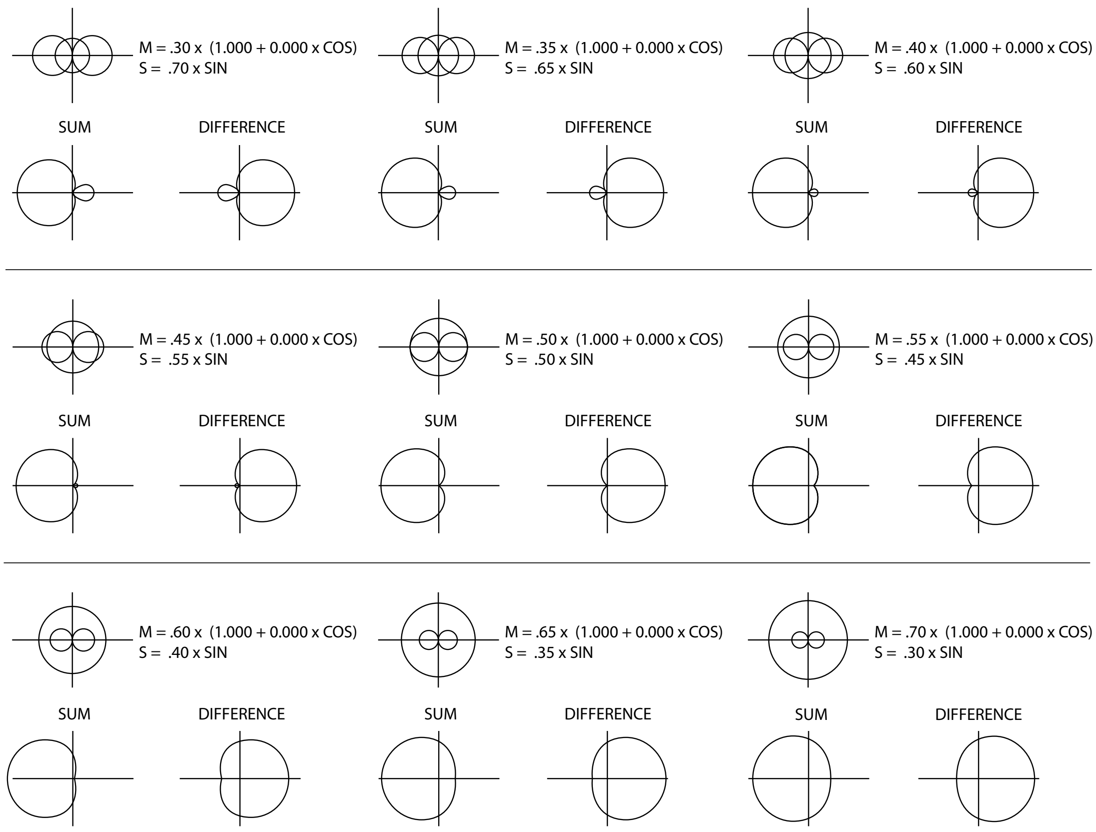
M = .30 x (0.750 + 0.250 x COS)
S = .70 x SIN
M = .35 x (0.750 + 0.250 x COS)
S = .65 x SIN
M = .40 x (0.750 + 0.250 x COS)
S = .60 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .45 x (0.750 + 0.250 x COS)
S = .55 x SIN
M = .50 x (0.750 + 0.250 x COS)
S = .50 x SIN
M = .55 x (0.750 + 0.250 x COS)
S = .45 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .60 x (0.750 + 0.250 x COS)
S = .40 x SIN
M = .65 x (0.750 + 0.250 x COS)
S = .35 x SIN
M = .70 x (0.750 + 0.250 x COS)
S = .30 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE

Fig. 2 h.



M = .30 x (0.875 + 0.125 x COS)
S = .70 x SIN
M = .35 x (0.875 + 0.125 x COS)
S = .65 x SIN
M = .40 x (0.875 + 0.125 x COS)
S = .60 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .45 x (0.875 + 0.125 x COS)
S = .55 x SIN
M = .50 x (0.875 + 0.125 x COS)
S = .50 x SIN
M = .55 x (0.875 + 0.125 x COS)
S = .45 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE
M = .60 x (0.875 + 0.125 x COS)
S = .40 x SIN
M = .65 x (0.875 + 0.125 x COS)
S = .35 x SIN
M = .70 x (0.875 + 0.125 x COS)
S = .30 x SIN
SUM
DIFFERENCE
SUM
DIFFERENCE
SUM
DIFFERENCE

Fig. 2 i.



In an M-S stereo pair comprised of an omnidirectional and a bi-directional microphone, the combination will produce an equivalent X-Y pair of cardioid microphones oriented back to back (180 degrees) if the M and S components of the sum-and-difference matrix are in a ratio of 50:50. From Fig. 1 (a) observe that if the composite ratio favors the bi-directional microphone (the 30:70 ratio) results in a pair of back-to-back subcardioids. Note that in all of these cases, the included angle between the resultant equivalent X-Y microphone pair is always 180 degrees and only the polar patterns vary.

In the next situation, when the M microphone of the M-S pair is a cardioid (Fig. 1 (b)) and the ratio is 50:50, the resultant equivalent X-Y is a pair of hypercardioid microphones at an included angle of 126.9 degrees. As the M microphone becomes the dominant component (the 70:30 ratio), the included angle of the equivalent X-Y pair becomes narrower (81.2 degrees), and the patterns become more nearly cardioid (the rear lobes are reduced). When the S component is dominant (the 30:70 ratio), the included angle of the equivalent X-Y pair broadens (155.8 degrees), and the patterns become more bi-directional (larger rear lobes). Note that in these cases, both the included angle and the polar patterns of the resultant equivalent X-Y pair are varied.

Finally, when the M microphone of the M-S pair is a bi-directional, the resultant equivalent X-Y patterns are always bi-directional. Note here (Fig 1 (b)) that the only aspect that changes with the M-to-S ratio is the included angle between the bi-directional pair. At the condition where the ratio of M to S is 50:50, the included angle of the equivalent X-Y will be 90 degrees - the same as with the original M-S pair. The axis of the polar patterns, however, is rotated 45 degrees with respect to the center axis of the sound source. 2 When the S component dominates (the 30:70 ratio), the included angle becomes quite large (133.6); when the M component dominates (the 70:30 ratio), the angle narrows (46.4 degrees).

A complete set of cases showing the resultant equivalent X-Y pair resulting from a variety of M microphone polar patterns and M-to-S ratios is diagrammed in Fig. 2. It can be seen that the M-S technique is a transformation of the more conventional X-Y technique.

M-S stereo is not a panacea, but it does afford the diligent producer and/or mixer with the best set of options available. Properly trimmed, the position of the sound source across the stereo stage can be accurately recreated. Alternately, the stereo image can be altered to achieve a particular effect. The stereo image can be compressed toward the center by increasing the M microphone's contribution to the M-to-S ratio. It can also be expanded toward the extremes by increasing the S microphone's contribution. Finally, the center can be expanded by broadening the M microphone's polar pattern toward omni-directional.

2 THE PRACTICAL APPLICATION OF M-S

The use of the M-S technique offers many advantages over other miking techniques, for it provides a discrete on-axis monaural pickup, together with a very versatile and potentially accurate stereophonic image. Monaural compatibility is, by definition, absolute, since when the two stereo channels are summed, only the signal from the M microphone remains: (M + S) + (M - S) = 2M. Thus the summed monaural signal is the discrete output of the M microphone. Proper choice of the polar pattern and placement of the M microphone will result in monaural quality that cannot be equaled by any other stereophonic technique. By listening carefully to the M signal during microphone placement, this monaural compatibility can be optimized. Another related benefit is that with the M microphone aimed directly at the centerline of the sound source and substantially on axis to it, the midsection of the source is not subjected to the off-axis coloration of image ambiguity common to many other stereo techniques (assuming of course, good frequency and polar characteristics of the M microphone).

Similarly, since the reverberant sound field is largely on axis to the S microphone, the coloration of the reverberant field is also reduced. In terms of the monaural/stereo compatibility, this has the pleasant result that M-S stereo often provides for a smaller reverberation component in the summed monaural signal than in the described left-right stereophonic signal. Since the ear is less tolerant of reverberation in a monaural signal than in stereo, this reduction of the reverberant sound field when summing to mono is beneficial for stereo radio, television, and film production, where a large segment of the audience listens in mono. Another advantage of the M-S system is that each component (M and S) is available to be treated separately, prior to matrixing. This allows for selective correction of some problems encountered on location such as out-of-phase low-frequency noise from the environment. Here the S component, which contains the majority of this information, can be passed through a high-pass filter to reduce this unwanted low-frequency component, and this can be accomplished without any alteration of the M component, as long as the matrixed left-right image remains acceptable.

The flexibility of the M-S technique is a great advantage to the sound engineer/producer both during and after the recording session. In real-time situations, using a microphone with remote pattern selection (such as the single-point stereo microphones available from AKG, Milab, Neumann, and others) the M component pattern can be varied to optimize the pickup for any changes in the performing group or setup. Similarly, given a fixed setup, the M component pattern can be varied to optimize the pickup for any changes in the performing group or setup. Similarly, given a fixed setup, the M component pattern can be varied to optimize the pickup for any changes in the performing group or setup. Similarly, given a fixed setup, the M component can be optimized by selection of a particular capsule with a fixed pattern. Some of the newer generation of smaller diameter capsules that possess a more uniform frequency response off axis can be used. These improved polar pattern capsules (such as the Schoeps MK-41 hypercardioid, which is widely used in film and television productions where a tight pattern with good off-axis response is desired) permit a more predictable congruence between the real and the ideal. Given a matrix network with control over the ratio of M-to-S components in the output, the resultant stereo image width and the reverberation component can also be manipulated. This ability to vary or select the pattern of the M component and the image width allows the balancing engineer much latitude in control from the console during real-time production.

Manipulation of the stereo image perspective can also be exercised during postproduction if the M and S signals are recorded directly (as M and S) rather than via the matrix (as left and right). In this way, the stereo image can be chosen or varied to suit the requisites of the moment (e.g., the visual perspective in film or television). Stereo/mono compatibility still remains completely predictable, because the discrete monaural signal is directly available.

Sum-and-difference matrixing of the M-S signal to its equivalent X-Y outputs can be accomplished in a variety of ways. The first published method utilized two transformers with single primary and dual secondary windings (a current example is shown in Fig. 3), where one of the secondary windings from each of the transformers is connected in series and in polarity for the sum output. The other set of secondary windings is connected in series but out of polarity for the difference output. If attenuators are inserted prior to the transformers to adjust the incoming M and S signals, the ratio of M to S can then be varied (Fig. 4). A difficulty with this approach is the increased distortion and noise introduced by the added transformers and pads in the signal path. (If constant-impedance pads are not used, the frequency and phase response suffer from the varying load and source impedances introduced.)

An alternate method involves using three inputs on the mixing console; the M microphone is assigned to both the left and the right channels equally, and the S microphone is split via a “Y adapter” to two inputs, one assigned to the left channel and the other, with the polarity reversed, to the right channel. Thus the left channel receives the sum of M and S, while the right channel receives the difference. By adjusting the relative levels of M and +S signals, the matrixing of the signals is accomplished, with fewer of the problems encountered with the microphone-level transformer matrix described above. The major problem with this arrangement, however, is that the S microphone is now driving two loads and is seeing one-half its normal terminating impedance. This can result in increased noise and/or distortion, depending on the microphone and preamplifier inputs involved. This is also an awkward technique to use when making real-time decisions and varying M-to-S ratios.

Best results are achieved when the M and S microphones are brought directly to high-quality microphone preamplifiers, and then are subsequently matrixed at line level. Again, this can be accomplished by transformers and attenuators, but better results are achieved by using active components which provide a well-balanced matrix and a means of control to vary the M-to-S ratio without compromising the signal-to-noise, frequency, or phase response of the system. Console modules have been available in the past from European manufacturers, such as Telefunken, E.M.T., and Calrec (5), (6). Most recently an outboard active matrix control unit has become available in the United States (Fig. 5). This convenient self-powered unit operates at line level, with a single-knob control to the M-to-S ratio (7).

3 PRACTICAL APPLICATION NOTES

The use of the M-S technique in no way replaces the need for careful judgment in microphone placement. Proper balance between the direct and the reflected sound components of the M signal must be made. When choosing the M microphone pattern, the engineer confronts the dichotomic requirements between monaural and stereophonic perspectives: the M pickup can be too narrow for a good overall monaural sound, but still provide an excellent stereophonic image due to the contribution of the S pickup. Conversely, the M pickup can also be too wide, allowing too much reverberant information into the monaural signal. If the on-site engineer pays particular attention to the aural quality of the M signal, maximizing clarity and balance of direct-to-reflected sound, the derived stereophonic image will, in all likelihood, give pleasing and reasonable accurate results. As stated earlier, separate (discrete) recording the M and S signals will allow for postproduction control of both of these signals, as well as long-term archival retrieval and/or enhancement.

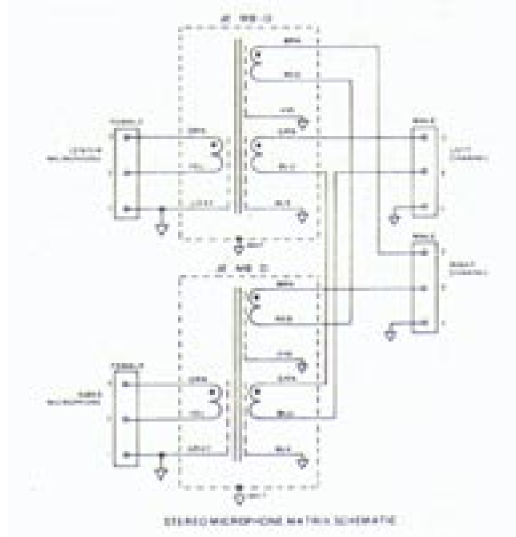


Fig. 3. M-S transformer matrix using Jensen JE-MB-D [4].

Fig. 4. M-S transformer matrix with attenuators. (From [2, Fig. 6].)

It should here be mentioned that the M microphone pattern responds primarily to that part of the sound field where the S microphone is most responsive (except in the case where the M pattern is omnidirectional). Thus the M-S technique is ideal in the horizontal plane. However, as the microphones are not absolutely coincident in the vertical plane, minor anomalies do occur with respect to the vertical sound field. As the ear is less capable of localization in the vertical direction, however, and as these differences are minimal if the two microphone elements are kept very close together, these anomalies are functionally insignificant.

Since the 0 degrees axis of the M microphone is aimed at the midpoint of the sound source, best frequency response will be exhibited on axis, in the horizontal plane. This is another reason why the M-S technique offers better monaural compatibility than its equivalent X-Y counterpart. The M microphone is primarily on axis to the subject as a whole, as contrasted with the X-Y technique, where the principal axes of the microphones are always off axis to the centerfield of the subject, with the consequent coloration and instability of center image inherent in may “real-world” microphones.

Directional microphones generally exhibit best frequency response when the sound source is directly on axis and far enough away to avoid bass boost due to proximity effect. When a microphone is rotated so that the sound arrives from progressively further off axis, high-frequency response typically decreases correspondingly. Anomalies will also be observed which are caused by the acoustical effects of the microphones all of these effects will be more pronounced with larger diameter capsule designs as compared with smaller capsules.

Examining polar diagrams plotted over a range of frequencies for several widely used condenser microphones (of both large and small capsule design) can be very enlightening. For a hypercardioid pattern, the response at 45 degrees off axis is important, because a 90-degree X-Y pair of hypercardioid microphones is a popular configuration. For a cardioid pattern, the response at 55 degrees off axis is of interest, because a 110 degrees included angle pair is frequently configured with these microphones. The off axis response at these angles represents the midline frequency response of the X-Y pairs so configured, and illustrates why the center imaging and the monaural summation can be less than satisfactory, while the sound from the extremes can be more distinct.

M-S stereo offers best frequency response at the center stage where the M microphone is on axis and the extremes where the S microphone is on axis. As a solo pickup, the M-S technique is especially useful not only because of the on-axis pickup of the M microphone, but also because the solo sound source is located primarily in the null of the S microphone. The S component is therefore primarily reverberant information, and thus the M-to-S ratio can be used as a direct-to-reverberant ratio control.

4 SUMMARY

The M-S technique, when used with a stereo microphone having remote pattern control capability and an adjustable matrixing network, offers great flexibility and versatility in stereo and possesses the additional advantage of superior (discrete) monaural compatibility. This perspective selection is one of the virtues of the M-S technique and can be of great advantage in both real-time and postproduction situations.
All miking involves some sets of compromises. Currently used as a recording technique for records, stereo FM broadcast, and multichannel cinema productions (and in the future for stereo AM and television), the M-S stereo technique requires fewer compromises to be made, and extends to the creative balancing engineer and producer more useful options than any other stereo technique.

5 ACKNOWLEDGMENT

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6 REFERENCES

(1) “The Telephone at the Paris Opera,” Sci. Am. (1881 Dec. 31)
(2) A.D. Blumlein, “British Patent Specification 394, 325,” 1931 Dec. 14; reprinted in J. Audio Eng. Soc., vol. 6, p. 91 (1958 Apr.).
(3) J. Eargle, Sound Recording. (Van Nostrand Reinhold, New York, 1976), pp. 53 ff., p. 125.
(4) D. Jensen, “Data sheet for the JE-MB-D Transformer,” Jensen Transformers/Reichenbach Engineering, North Hollywood, CA.
(5) A. Nisbett, The Technique of the Sound Studio (Hastings House, 1962), pp. 68 ff., pp. 162 ff.
(6) J. Mosely, “Eliminating the stereo seat,” J. Audio Eng. Soc., vol. 8, p. 46 (1960 Jan.).
(7) “Data Sheet for the MS-38 Active M-S Matrix Decoder,” Audio Engineering Assoc., Pasadena, CA.
(8) H.A.M. Clark, G.F. Dutton, and P.B. Vanderlyn, “The ‘stereosonic’ Recording and Reproducing System - A Two-channel System for Domestic Tape Recorders,” Proc. IEEE (1957 Sept.); reprinted in J. Audio Eng. Soc.,vol. 6,p. 102 (1958 Apr.).
(9) T. Faulkner, “M-S: Another Purist Technique,” Hi-Fi News and Record Rev., pp. 55 ff. (1980 Aug.).

7 BACKGROUND READING

(10) I.B. Weingartner, “M-S Stereo Recording Techniques,” H. Safransky, Trasl./Ed. (North American Philips Corp.).
(11) “Application Notes, “ db, p.47 (1980 Dec.).
(12) R. Streicher, “Principles of M-S Recording,” Audio Engineering Assoc., Pasadena, CA.

APPENDIX

For those who want to do additional reading in M-S stereo, the following references are recommended. References (1), (2), (6)-(9) are of particular interest. (Note that (2) is the original paper in the field and proposes most of the relevant theory on the subject, (8) is an extensive recapitulation, and (9) is a very concise summary.) The authors would be interested in obtaining copies of any oter related reference materials or research work that may have been overlooked. If you have any such materials, please contact us.

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