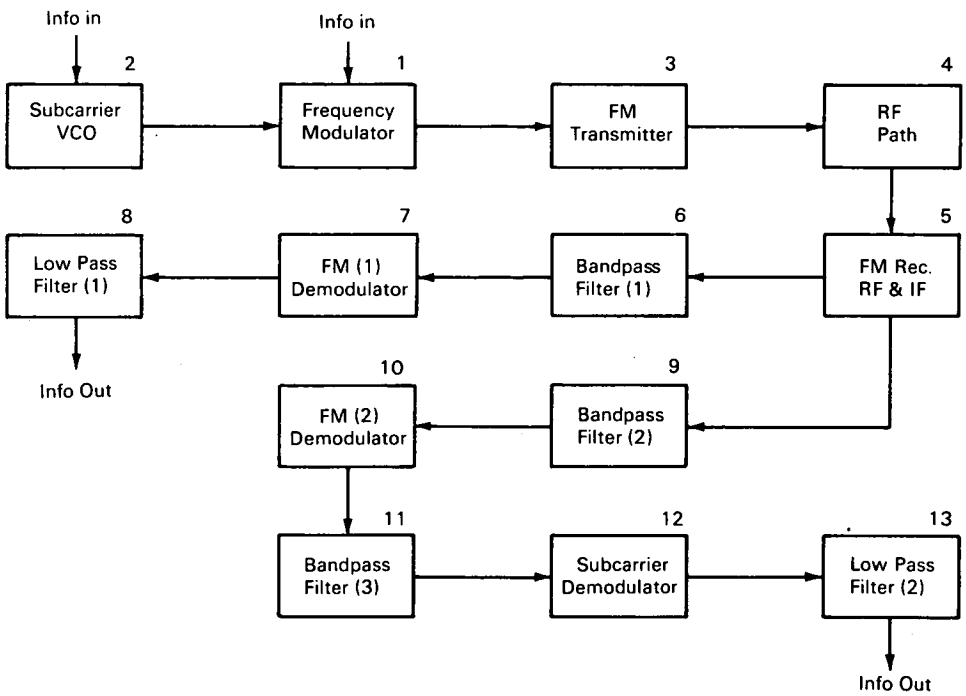
NASA TECH BRIEF

Deep Space FM System, A Concept



In the diagram, item 1 is a frequency modulator which is modulated by a baseband information signal. It is also modulated by a subcarrier from the subcarrier's voltage controlled oscillator (VCO), shown as item 2. This VCO is also modulated by an information signal. The frequency modulated signal from item 1 is transmitted by the fm transmitter, item 3. The rf path, item 4, consists of the transmitting antenna cable, transmitting antenna, free space, receiving antenna, and receiving antenna cable. This portion of the system is quite conventional. However, the information bandwidth and subcarrier frequency must be selected so as to provide frequency separation at the receiving terminal.

Item 5 is a portion of the fm receiver consisting of the rf and i.f. sections. The rf and i.f. bandwidth must be sufficiently wide to pass the normal spectrum for the signal transmitted. The fm demodulators are not included in item 5. Item 6 is a bandpass filter, #1.

The predetection bandwidth for most systems is taken to be equal to twice the sum of the deviation and the highest modulating frequency. For some systems, the predetection bandwidth may be reduced to equal twice the highest modulating frequency or twice the frequency deviation whichever is larger. In this system the bandpass filter #1, is made substantially less. It is less than twice the modulating frequency and is also less than twice the deviation. For

(continued overleaf)

example, a 1 MHz signal may be used for the subcarrier frequency and the total deviation may also be as high as 1 MHz. While the bandpass filter #1, item 6, may be only 1 MHz wide, conventional design practice would require the filter to be 4 MHz. With a bandwidth only 1/4 normal bandwidth, the fm threshold will be 6 db lower, compared to conventional equipment. This will double the range and permit the operation with a signal 6 db weaker than normal.

Since the signal is deviated beyond the passband and also has frequency components well outside the bandlimits, this filter, item 6, will cause a loss in signal components. Specifically, the subcarrier components will be lost. The amount of energy outside the passband will be dependent upon the deviation of this subcarrier. If the deviation is ±600 kHz for example, there is only about 1 db energy outside of the passband as the deviation ratio is 0.6. To maintain the 6 db improvement in threshold, the noise bandwidth of the bandpass filter #1, item 6, must be reduced to 800 kHz. FM demodulator #1, item 7, is used to demodulate the baseband signal. The spectrum of the transmitted signal produced by the baseband modulation, with the subcarrier off, must be confined to the 800 kHz bandwidth. For the conditions specified in this example, the baseband signal will be demodulated by fm demodulator #1, item 7. The low pass filter #1, is used to limit the post detection bandwidth to that necessary for the information baseband being transmitted.

Since the information carried by the subcarrier is lost in the bandpass filter #1, it is necessary to provide another channel for this information. Bandpass filter #2 should be 4 MHz using conventional design practice but may be reduced some. The flat portion of the passband is required to be at least 2 MHz (for the example) so that the first order sidebands of the subcarrier are not suppressed. It also must be wider to pass the modulation components of the subcarrier.

When fm demodulator #1 is operated at the fm threshold, fm demodulator #2, item 10, will be operating below threshold. Consequently, noise spikes will be generated at fm demodulator #2, item 10. The output of fm demodulator #2 is fed to bandpass filter #3, item 11. Bandpass filter #3 is centered at the subcarrier frequency components of the modulated subcarrier. Therefore, it is considerably narrower than bandpass filter #2. Bandwidth reduction improves the signal-to-noise ratio so that the signal from bandpass filter #3, item 11, is above the threshold for the subcarrier demodulator, item 12. As long as the signal-to-noise ratio is adequate at the subcarrier demodulator, the information carried by the subcarrier can be satisfactorily recovered. The low pass filter #2, item 13, limits the output bandwidth to that required for the information transmitted using the subcarrier.

Notes:

1. This system would permit transmission of data where the deviation is greater than 1/2 the predetection bandwidth. It would provide satisfactory performance at greater distances or with lower signal levels than present systems.
2. This development is in conceptual stage only, and, as of date of publication of this Tech Brief, neither a model nor prototype has been constructed.

Patent status:

No patent action is contemplated by NASA.

Source: G. D. Doland
of Lockheed Electronics Company
under contract to
Manned Spacecraft Center
(MSC-11825)