



DOCUMENT 705-98

SPECTRUM EFFICIENT MODULATION

WHITE SANDS MISSILE RANGE
KWAJALEIN MISSILE RANGE
YUMA PROVING GROUND
DUGWAY PROVING GROUND
ABERDEEN TEST CENTER
NATIONAL TRAINING CENTER

ATLANTIC FLEET WEAPONS TRAINING FACILITY
NAVAL AIR WARFARE CENTER WEAPONS DIVISION
NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
NAVAL UNDERSEA WARFARE CENTER DIVISION, NEWPORT
PACIFIC MISSILE RANGE FACILITY
NAVAL UNDERSEA WARFARE CENTER DIVISION, KEYPORT

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AIR FORCE FLIGHT TEST CENTER
AIR ARMAMENT CENTER
AIR WARFARE CENTER
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GOLDWATER RANGE
UTAH TEST AND TRAINING RANGE

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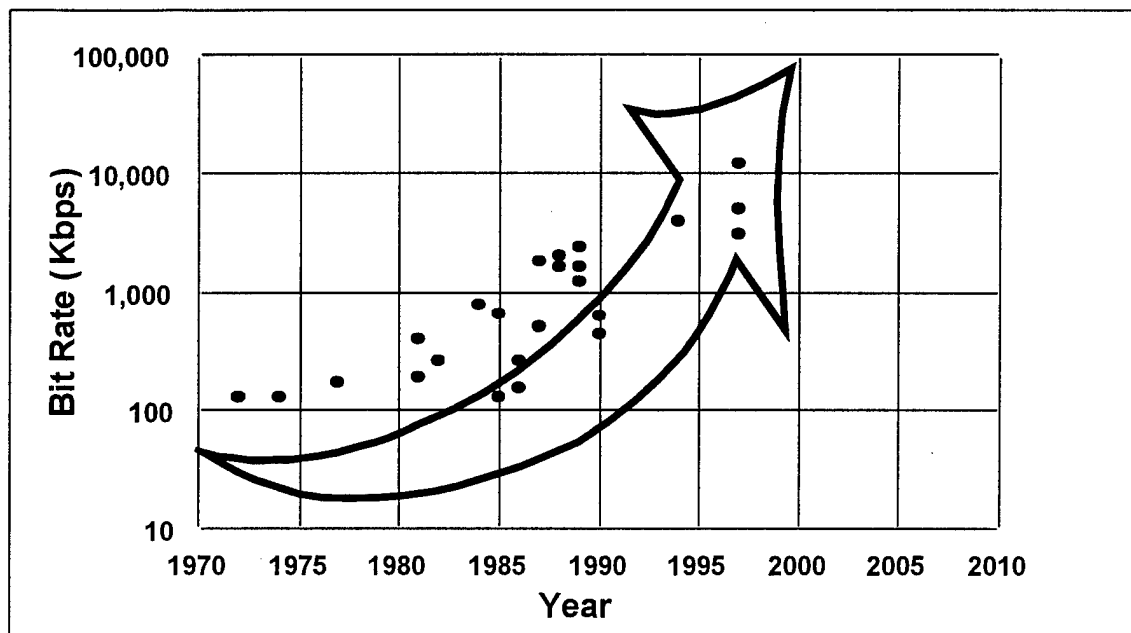
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SPECTRUM EFFICIENT MODULATION

Since 1992 the amount of available aeronautical telemetry spectrum has been decreasing. Efforts by the national and international communities have reallocated 25 MHz of telemetry spectrum and efforts are under way to reallocate even more. This is completely opposite of the requirements of the telemetry community as can be seen from figure 1. The chart clearly shows the data requirements of the test community are increasing at an almost exponential rate. This increase in requirements is being driven by the increasing complexity of the test articles coupled with compressed test schedules. The increasing requirements for data coupled with the reduction in the amount of available spectrum is causing the major test centers to have serious concerns if there will be sufficient spectrum available to support all their programs.



To be spectrally efficient means that data rates must be kept at the absolute minimum, proper transmitter pre-modulation filtering techniques must be used, and efficient modulation schemes must be employed. Currently the most common modulation scheme is PCM/FM; this is a very robust modulation technique that is fairly efficient. To be efficient these systems must have proper pre-modulation filtering and be properly aligned. As can be seen from figure 2, improper selection of pre-modulation filtering, and over deviation of the transmitter can increase the required channel bandwidth by over 50%. Figure 2 shows ideal spectrum with proper modulation filtering of $.7 \times F_b$ (Bit frequency), improper pre-modulation filtering at $1.4 \times F_b$ & $2 \times F_b$, and excessive transmitter deviation of $1.2 \times F_b$ ($.35 \times F_b$ is ideal).

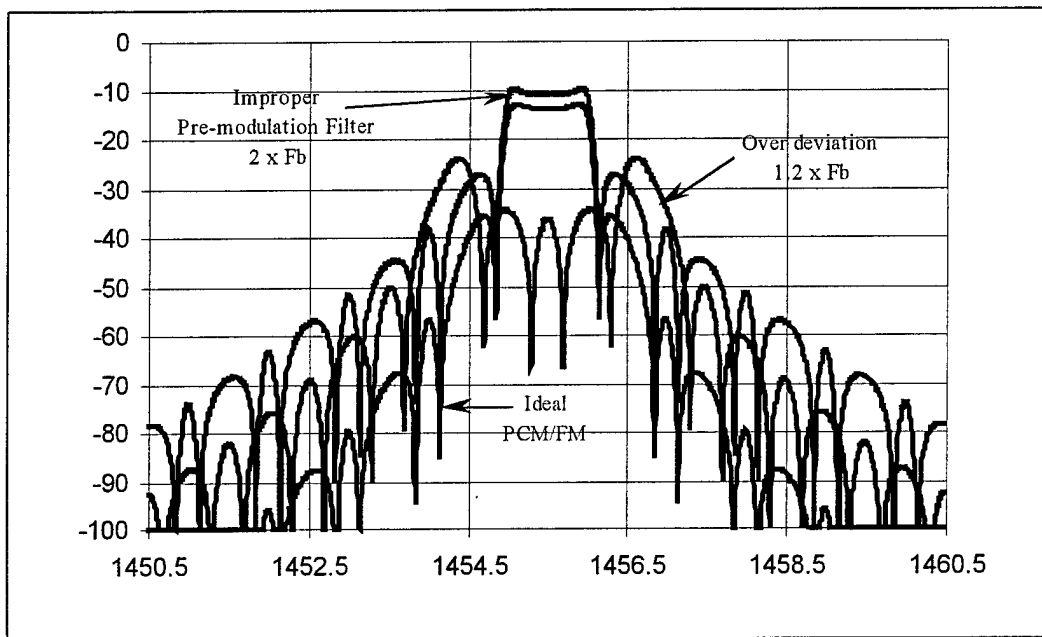


Figure 2. Ideal spectrum with proper modulation filtering of $.7 \times F_b$ (Bit frequency), improper pre-modulation filtering at $1.4 \times F_b$ & $2 \times F_b$, and excessive transmitter deviation of $1.2 \times F_b$ ($.35 \times F_b$ is ideal).

Improvement in pre-modulation filter selection and tighter controls on alignment of systems will provide a great improvement in spectrum efficiency. New modulation techniques such as GMSK and FQPSK have the potential to double spectrum utilization. As can be seen from figure 3, these new modulation techniques are much more efficient than PCM/FM. Once the equipment can be developed, we can expect to see vast improvements in spectrum efficiency. In the meantime efforts should be concentrated on insuring that currently deployed telemetry systems have been properly constructed and aligned.

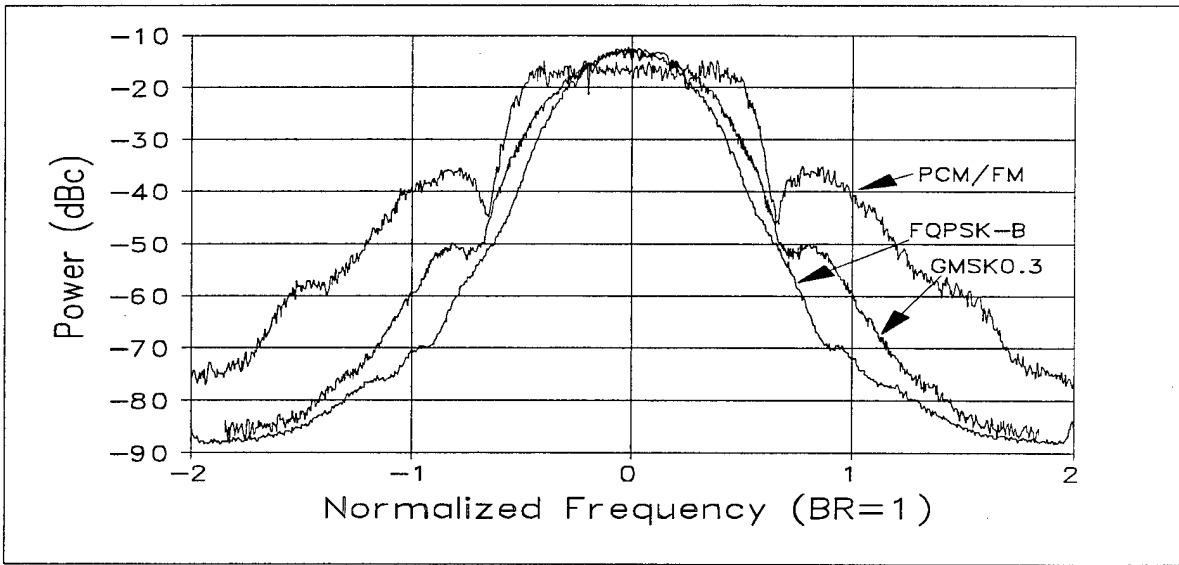


Figure 3. New Modulation Techniques vs PCM/FM.