

Table 1: Assumed system parameters for FS and MRS analysed

	Mobile radio	Fixed service
Max. transmitted power	100µW	0.5W
Antenna gain	0dBi	see [3]
Received noise figure		4dB
Clutter factor	-40dB	
Antenna heights	1.5 and 5m	10m
Voice activity	0.5	
Performance requirements	$BER \leq 10^{-3}$	$P_{out} \leq 10^{-9}$
Fade occurrence factor		6.4×10^{-6}
Power control exponent	4	

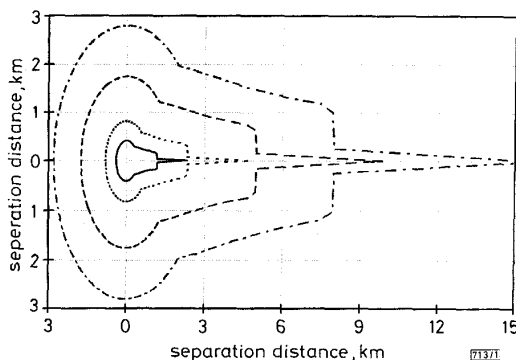


Fig. 1 Required geographical isolation between FS and MRS when standard deviation of interfering signals, $\sigma_I = 4\text{dB}$ and 8dB

Isolation required for FS: — $\sigma_I = 4\text{dB}$; $\sigma_I = 8\text{dB}$
Isolation required for MR: - - - $\sigma_I = 4\text{dB}$; — $\sigma_I = 8\text{dB}$

Contours which indicate the required geographical isolation for the MRS and FS are shown in Fig. 1 for two different shadowing scenarios. For example, from Fig. 1 it can be seen that an MRS with five active users/cells requires a separation distance of between ~1700 and 2800m from an FS, when operating outside the FS boresight region. An FS requires a minimum separation distance (outside the boresight region) of between ~400 and 700m from the same MRS.

Conclusions: General techniques for estimating the performance of a DS-CDMA mobile radio system and an FS simultaneously sharing the same spectrum are outlined. These techniques have been used to analyse a particular spectrum sharing arrangement.

The results demonstrate that spectrum sharing between the two systems considered will be difficult to implement. It is shown that the lognormal shadowing has a significant effect on the required geographical separation between the two systems. It is the sensitivity of the MRS (rather than the FS) to the mutual interference that determines the minimum required geographical isolation.

© IEE 1995
Electronics Letters Online No: 19951380

P.J. Marshall and K.W. Sowerby (Department of Electrical and Electronic Engineering, The University of Auckland, Private Bag 92019, Auckland, New Zealand)

M. Shafi (Telecom Corporation of New Zealand Ltd., PO Box 570, Wellington, New Zealand)

References

- 1 TONGUZ, O.K., and WANG, M.M.: 'Cellular CDMA networks impaired by Rayleigh fading: system performance with power control', *IEEE Trans.*, 1994, VT-43, (3), pp. 515-527
- 2 HALL, M.P.M.: 'The effects of the troposphere on radio communication' (Peter Peregrinus, New York, 1979)
- 3 GARDENIER, P., SHAFI, M., VERNALL, R.B., and MILNER, M.: 'Sharing issues between FPLMTS and fixed services', *IEEE Commun. Mag.*, 1994, 32, (6), pp. 74-78
- 4 MARSHALL, P.J., SOWERBY, K.W., and SHAFI, M.: 'On spectrum sharing between mobile radio systems and fixed services'. APCC'95 Conf. Proc., June 1995, pp. 450-454

- 5 'Interference criterion of microwave systems in private radio services'. EIA 10E/TIA Telecommun. Syst. Bull. TSB 10-E, November 1990

New bandwidth efficient overlapped pulse shape

Chanbun Park and Jae Hong Lee

Indexing terms: Modulation, Communications and signal processing

A new pulse shape of duration twice the symbol interval is proposed for bandwidth efficient modulation. The proposed pulse shape is obtained by convolving a square pulse shape with a sinusoidal frequency shift keying (SFSK) pulse shape. The power spectral density (PSD) of a signal with the proposed pulse shape shows less power in spectral sidelobes than that of a signal with overlapped raised-cosine pulse shape.

Introduction: The objective in pulse/spectrum shaping is to achieve a narrow signal spectrum with power concentrated within a given bandwidth. A narrow signal spectrum will reduce intersymbol interference (ISI) caused by a bandlimited channel. The spectral characteristic of a signal is controlled by pulse shapes [1]. This Letter presents a new pulse shape of which the duration is twice the symbol interval. The signal with the proposed pulse shape shows a better power spectral characteristic than that with an overlapped raised-cosine pulse shape.

Overlapped pulse shape: The overlapped pulses with two symbol interval duration achieve much faster sidelobe drop-off than non-overlapped pulses [1]. It is known that the overlapped raised-cosine pulse shows efficient sidelobe drop-off among the overlapped pulses [2]. When $T_s = 2T_b$ is the symbol duration, the raised-cosine pulse of duration $2T_s$ is obtained by convolving a square pulse with a half-sinusoid pulse. The power spectral density (PSD) of a signal with overlapped raised-cosine pulse shape was shown to take on the form of the product of the PSDs of a signal with square pulse shape (QPSK) and a signal with half-sinusoid pulse shape (MSK) [2].

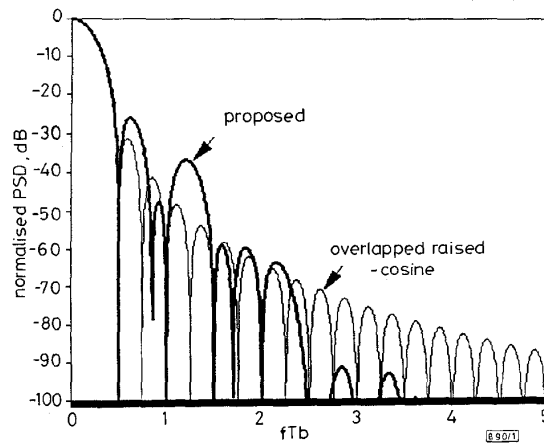


Fig. 1 Comparison of normalised power spectral densities

The overlapped raised-cosine pulse shape is given by

$$p(t) = \begin{cases} \frac{1}{2} \left(1 + \cos \frac{\pi t}{T_s} \right) & |t| \leq T_s \\ 0 & |t| > T_s \end{cases} \quad (1)$$

In this Letter we propose a new overlapped pulse shape of duration $2T_s$ which shows less spectral sidelobes than the overlapped raised-cosine pulse shape. The proposed pulse shape is obtained by convolving a square pulse with a sinusoidal frequency shift keying (SFSK) pulse instead of an MSK pulse (half-sinusoid pulse). This is accomplished by passing the square pulse through the filter which has the impulse response of an SFSK pulse shape.

SFSK is a typical pulse of an MSK-type pulse [3]. The MSK-type pulse is given by

$$p(t) = \begin{cases} \cos \left[\frac{\pi t}{2T_b} - U \sin \frac{2\pi t}{T_b} \right] & |t| \leq T_b \\ 0 & |t| > T_b \end{cases} \quad (2)$$

where $1/T_b$ is the bit rate and U is a real constant. For $U = 0$ the expression reduces to an MSK pulse shape, and for $U = 0.25$ the expression reduces to an SFSK pulse shape. The PSD of SFSK falls below that of MSK for $fT_b > 2$ [3].

Power spectral density: The PSD of a signal with the proposed pulse is the product of PSDs of QPSK and SFSK, since the proposed pulse shape is the convolution of a square pulse with an SFSK pulse. Since QPSK has a narrow mainlobe and SFSK has low power in the sidelobes, the PSD of a signal with the proposed pulse shows narrow mainlobe and low power in the sidelobes.

In Fig. 1 the normalised PSD of a signal with the proposed pulse shape is shown with that with an overlapped raised-cosine pulse shape for comparison purpose. It is shown that the spectrum of a signal with the proposed pulse shape falls below that with an overlapped raised-cosine pulse shape for $fT_b > 2.5$. The proposed pulse shape achieves a normalised PSD of ~ -90 dB for $fT_b > 2.5$.

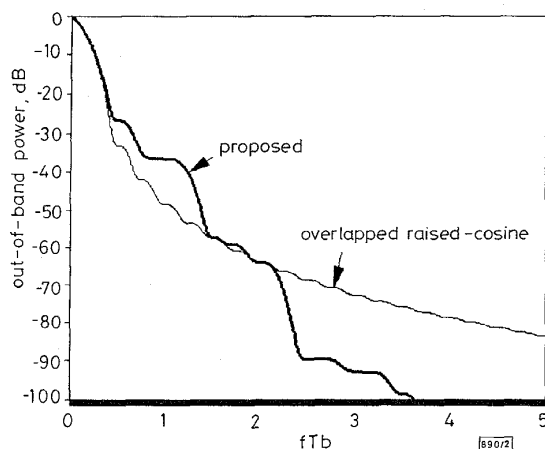


Fig. 2 Comparison of out-of-band powers

In Fig. 2 the out-of-band power of a signal with the proposed pulse shape and that with an overlapped raised-cosine pulse shape are shown. It is shown that the proposed pulse shape achieves lower out-of-band power for the region below -60 dB than the overlapped raised-cosine pulse.

Discussions: A new overlapped pulse shape is proposed in this Letter. The proposed pulse shape is useful in circumstances requiring normalised PSD levels down -60 dB or less and out-of-band power levels down -90 dB or less.

© IEE 1995

18 September 1995

Electronics Letters Online No: 19951390

Chanbum Park and Jae Hong Lee (Department of Electronics Engineering, Seoul National University, San 56-1, Shillim-dong, Gwanak-gu, Seoul 151-742, Korea)

References

- PROAKIS, J.G.: 'Digital communications' (McGraw-Hill, 1989), 2/e
- AUSTIN, M.C., and CHANG, M.H.: 'Quadrature overlapped raised-cosine modulation', *IEEE Trans.*, 1981, **COM-29**, pp. 237-249
- AMOROSO, F.: 'Pulse and spectrum manipulation in the minimum (frequency) shift keying (MSK) format', *IEEE Trans.*, 1976, **COM-24**, pp. 381-384

New pseudoternary line code for high-speed twisted pair data links

A.N. Coles

Indexing terms: Twisted pair cables, Local area networks

Regulated mark inversion (RMI) is a new pseudoternary line code which minimises high-frequency spectral components in a similar way to the FDDI TP-PMD MLT3 code, and yet also has a bounded running digital sum. The code has significantly lower DC content than standard MLT3, and a lower high-frequency content than run-length-limited MLT3 codes.

As the speed of data transmission on a twisted pair cable has moved beyond 100Mbit/s in several local area network (LAN) applications, much effort has been concentrated on reducing the levels of transmitted signal energy at higher frequencies in order to avoid infringement of the various radiated emissions regulations, all of which are stringent at frequencies >30 MHz. For example, the IEEE 802.12 Demand Priority 100Mbit/s LAN standard has specified a scheme for transmission on four parallel twisted pairs in a single sheath, so that the data rate on each pair is only 25 Mbit/s [1]. Another approach to this problem has been the use of pseudoternary line codes such as MLT3 [2] which, when combined with rectangular pulse amplitude modulation, redistributes signal energy to lower frequencies.

The MLT3 coding scheme is described in [2, 3]. MLT3 suffers from two drawbacks: both the running digital sum (RDS) and the maximum run length of coded data are unbounded. The code therefore has relatively large power spectral density (PSD) at low frequencies ($f < 0.01 \times B$, where B is the symbol rate), making it less than ideal for transmission over transformer coupled twisted pair channels. In [3] a 5B6T block code was described with a high frequency spectrum similar to MLT3 but having the advantage of a bounded RDS. The disadvantage of this block code is the 20% increase in the symbol rate.

More recently, Cook [4] has proposed a modified line code, called MLT3_m, which ensures that the RDS may only take values in a range with peak to peak value m . For small m , the PSD of MLT3_m is significantly less than that of standard MLT3 at frequencies less than $0.01 \times B$. However, we note two penalties for this improvement. First, the PSD increases at higher frequencies, which, for B of the order of 100 MBaud, includes the range above 30 MHz covered by radiated emissions regulations. Secondly, the code introduces transitions between the outer symbol levels, which cause increased timing jitter in the transmitted waveform.

We describe a new pseudoternary line code which, like MLT3_m, has bounded RDS but improves upon the spectrum of MLT3_m at frequencies >30 MHz. This code is similar to alternate mark inversion in that a zero is transmitted as 0V and a 1 is transmitted as either +1 or -1. The polarity of the 1 symbol is regulated as follows:

- The peak to peak RDS variation is bounded by x , and if the RDS equals [Note 1] either $\lceil x/2 \rceil$ or $\lceil -x/2 \rceil$ the next 1 is transmitted as either -1 or +1, respectively.
- If the RDS is positive (negative) and at least two 0s have been transmitted since the last $+/-1$, then the next 1 is transmitted as -1 (+1).
- If the RDS is positive (negative) and at least two 1s follow any number of 0s, then those 1s are transmitted as -1 (+1).
- Otherwise, the polarity of 1s is reversed each time a run of at least one 0 occurs.

We shall refer to this code as regulated mark inversion (RMI) with RDS bounded by x , or RMI_x. The state diagram description of the code is shown in Fig. 1. The coding rules described above control the RDS in two ways. First, the RDS is bounded to a range with peak to peak value x , in a similar way to the MLT3_m code. In addition, the polarity of 1s is chosen such that the RDS is always forced towards zero, unless this would result in the transmitted patterns +1, 0, +1, 0 or -1, 0, -1, 0. In this respect, RMI_x

Note 1: The $\lceil y \rceil$ notation denotes the smallest integer value that is not less than y .