

Timing Offset Synchronization using Gardner Timing Error Detector(TED) Algorithm.

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CONTENTS

1. GARDNER TED

A. Transmitter

$$P = \sin\left(2\pi \frac{[0 : T_{sym} - 1]}{2T_{sym}}\right) \quad (1.0.1)$$

Where T_{sym} is the samples per symbol. P is the half sine pulse shaping filter.

$$X = P \otimes C \quad (1.0.2)$$

Where C is upsampled by T_{sym} to the mapped data. And X is the convolution of pulse shaping filter and interpolated data. main equation

B. Receiver

$$Y = X + N \quad (1.0.3)$$

Where Y is the received vector.

$$U_I(r) = Y_I(r - 0.5) [Y_I(r) - Y_I(r - 1)] \quad (1.0.4)$$

$$+ Y_Q(r - 0.5) [Y_Q(r) - Y_Q(r - 1)] \quad (1.0.5)$$

Where r is the symbol index number. $Y_I(r - 0.5)$ is the mid sample between $Y_I(r)$ and $Y_I(r - 1)$.

2. DERIVATION

$$U_I(r) = L(r - 1) - E(r) \quad (2.0.6)$$

$$= Y^2(\tau + (r - 1)T_{sym}) - Y^2(\tau + rT_{sym}) \quad (2.0.7)$$

$$+ 2Y(\tau + (r - 0.5)T_{sym}) \{Y(\tau + rT_{sym}) - Y(\tau + (r - 1)T_{sym})\} \quad (2.0.8)$$

Average over many samples, first two terms are equal.

$$U_I(r) = Y(\tau + (r - 0.5)T_{sym}) \{Y(\tau + rT_{sym}) - Y(\tau + (r - 1)T_{sym})\} \quad (2.0.9)$$

$$= Y(r - 0.5) \{Y(r) - Y(r - 1)\} \quad (2.0.10)$$

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