



Micro Reflections Limit on ETM

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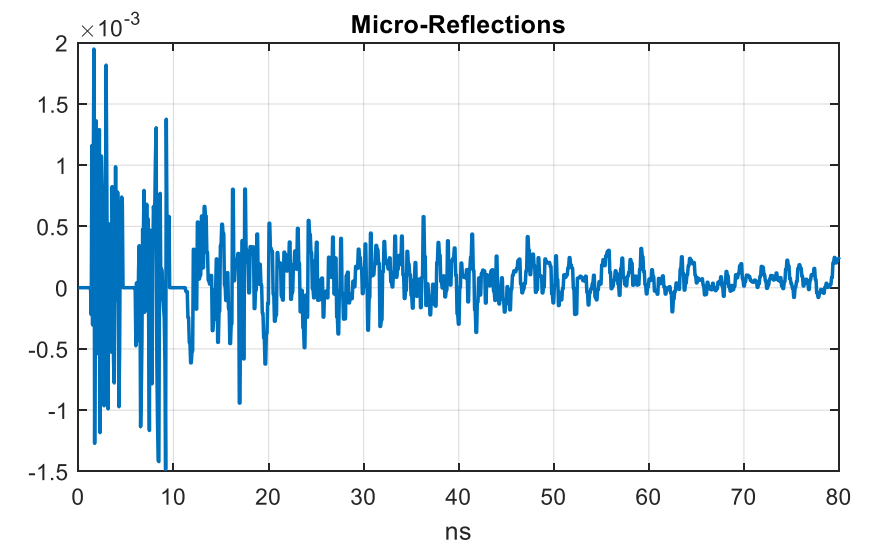
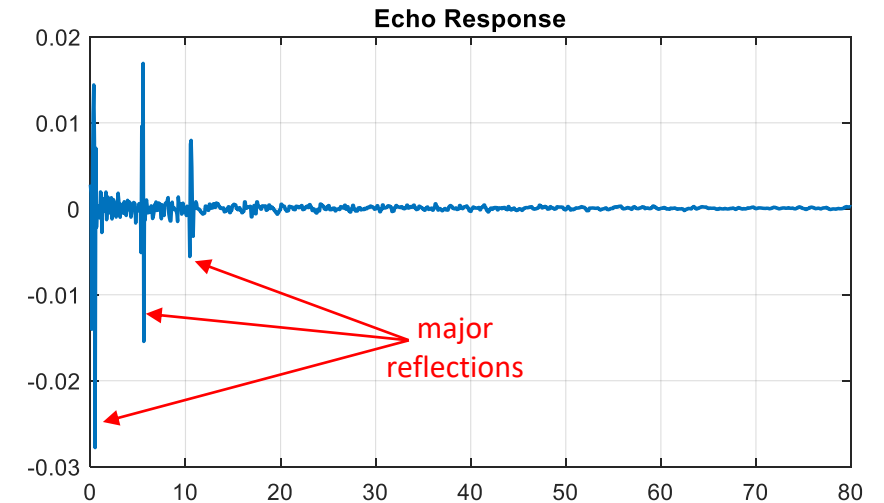
March 15, 2022

Overview

- Draft 0.5 includes time-domain limits on echo channel
- Residual Echo Metric (REM): Limit on the total power of micro-reflections
 - The specification is complete
- Echo-Tail Metric (ETM): Limit on distribution of micro-reflection power over the span of echo response
 - The specification is incomplete
- This presentation is to propose some limits for ETM

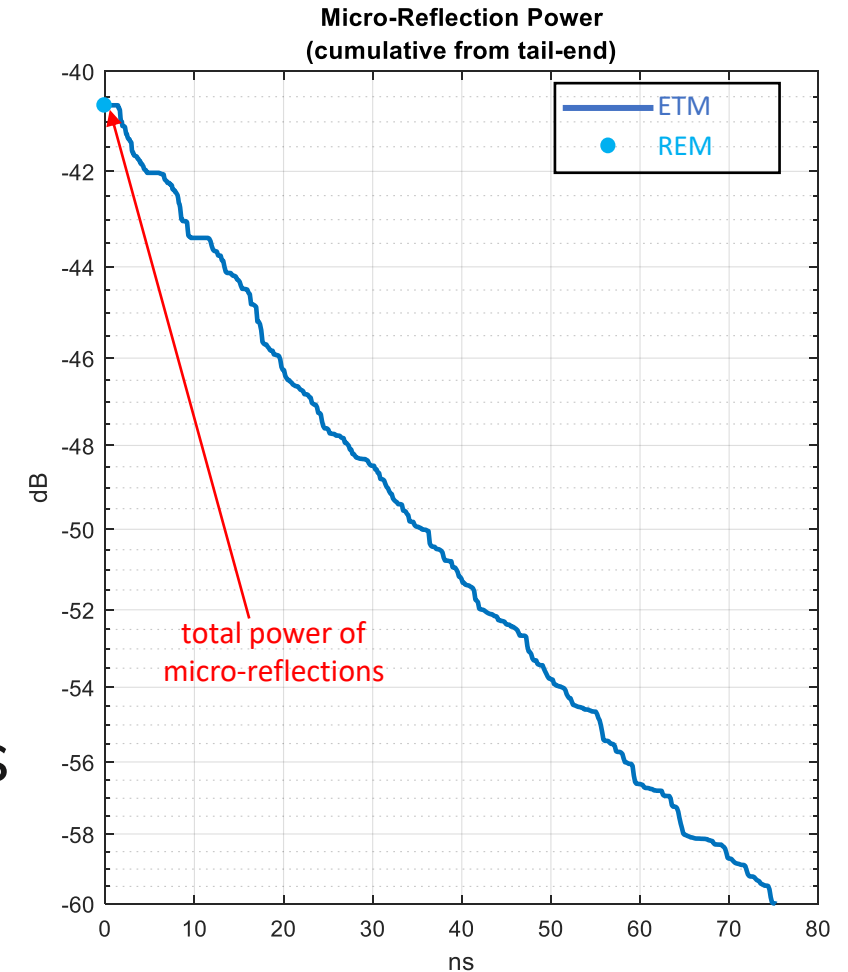
Echo Pulse Response

- Echo response consists of a few major reflection points (due to connectors) and back-ground micro-reflections (due to inhomogeneity of the cable)
- Significant computational power of PHY is dedicated to cancel micro-reflections
- A limit on the power of micro-reflections can help reduce the complexity of the PHY



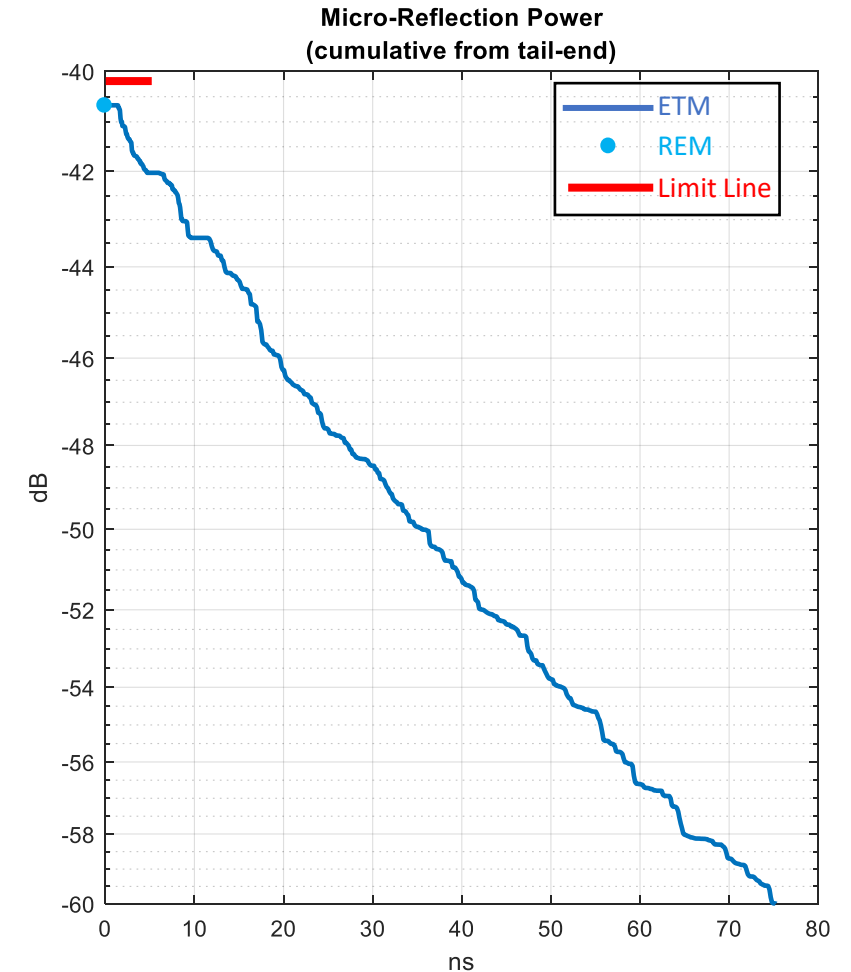
Micro-Reflection: Cumulative Power

- The power of micro-reflections, if not cancelled, contributes to the overall noise and limits the SNR
- ETM is the cumulative power of the micro-reflection from the tail end of the echo pulse response
- REM is the total power of micro-reflections for the entire span of the echo response
 - $REM = ETM$ at time zero



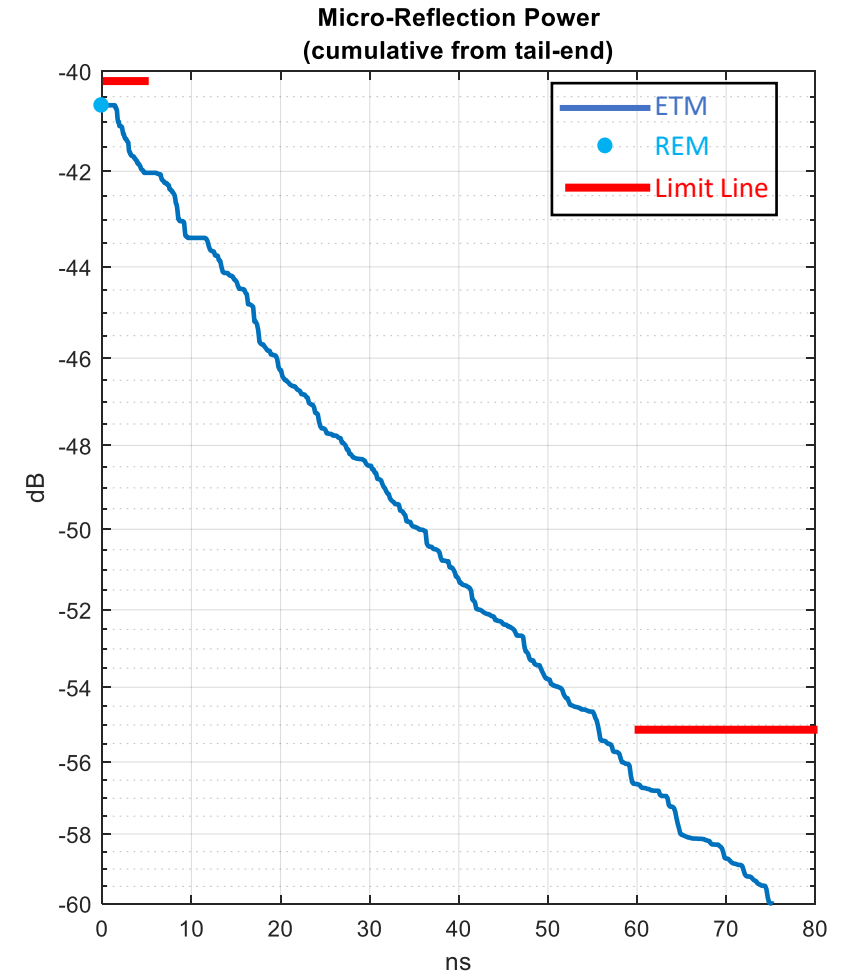
Limits on Micro-Reflection: REM

- The limit on REM: determines the required level of cancellation of micro-reflections to meet a target SNR



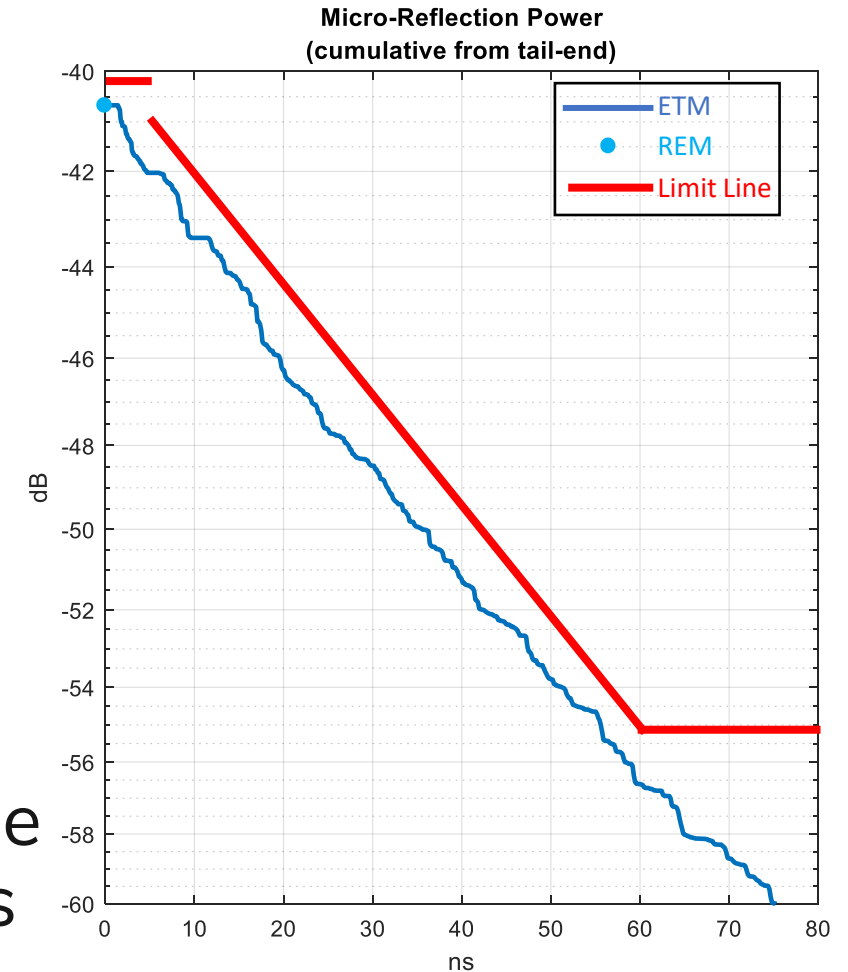
Limits on Micro-Reflection: Tail Power

- The limit on REM: determines the required level of cancellation of micro-reflections to meet a target SNR
- A limit on ETM: determines the span of time beyond which the power of micro-reflections is negligible, hence they can remain uncanceled



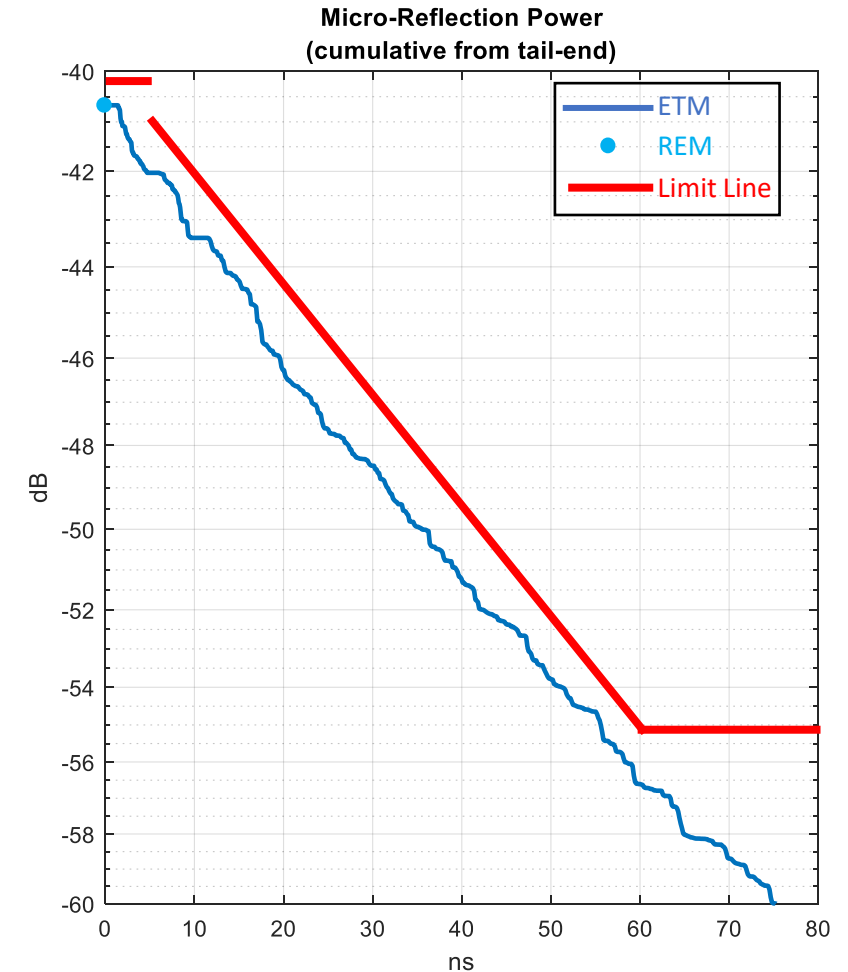
Limits on Micro-Reflection: Slope

- The limit on REM: determines the required level of cancellation of micro-reflections to meet a target SNR
- A limit on ETM: determines the span of time beyond which the power of micro-reflections is negligible, hence they can remain uncanceled
- A limit on ETM slope: a minimum rate of reduction in micro-reflection power which provides a bound on the magnitude and the resolution of the echo canceller coefficients



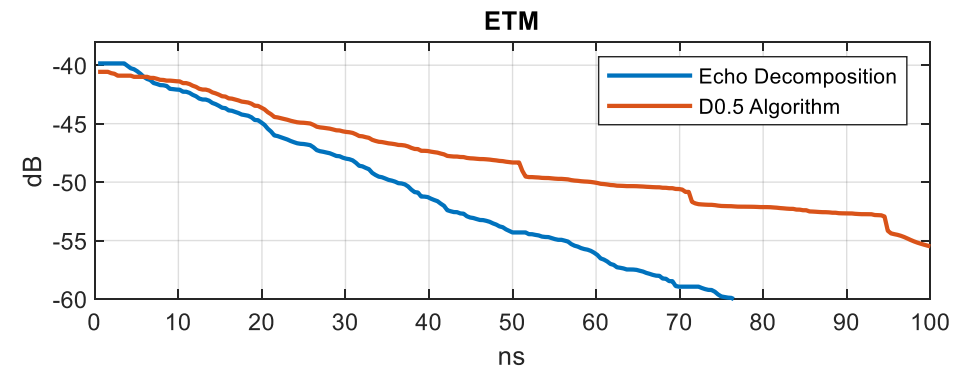
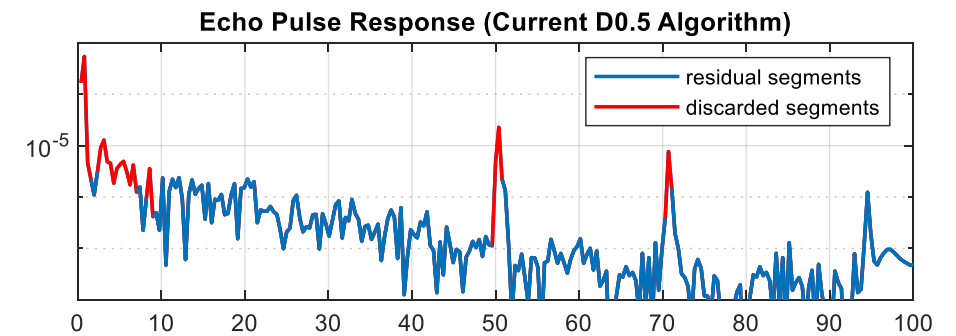
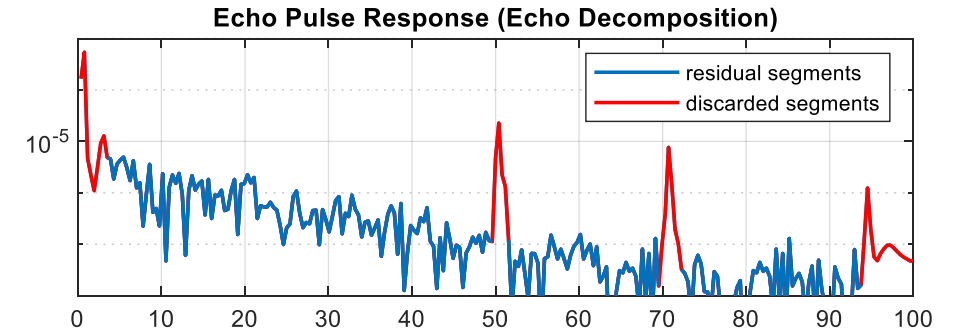
Limits on Micro-Reflection

- The limit on REM: determines the required level of cancellation of micro-reflections to meet a target SNR
- A limit on ETM: determines an efficient distribution of computational resources over the span of the echo-canceller



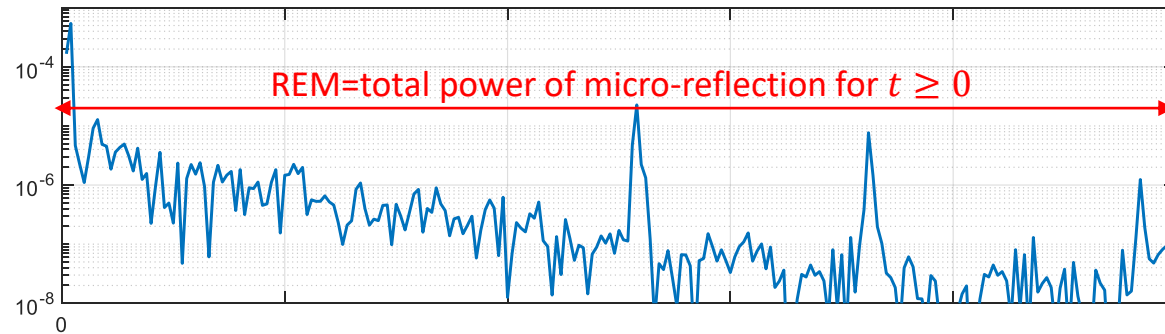
REM/ETM Calculations

- Current adopted algorithm:
 - Breaks echo response into small segments
 - Discards the segments with highest power
 - It does not decompose the echo pulse response into major and micro reflections
- ✓ REM is the overall power of residual segments and is a reasonable estimate of the total power of micro-reflection
- ✗ Calculated ETM includes the effects of major reflections, artificially elevating the accumulated power and reducing the slope of ETM

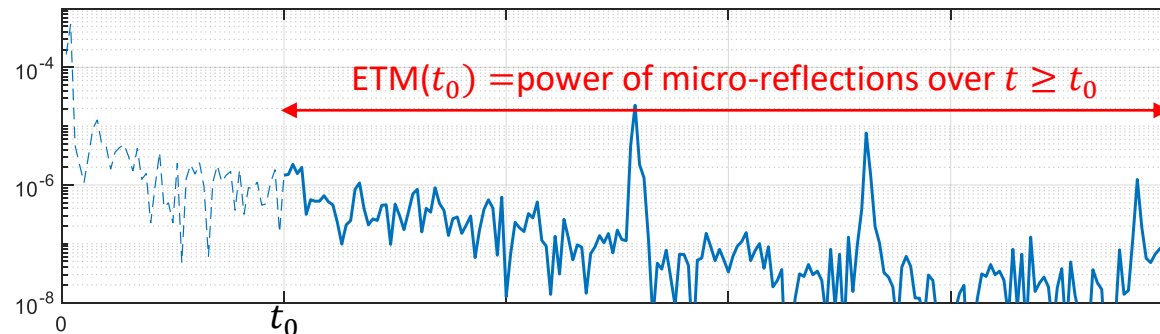


ETM vs REM

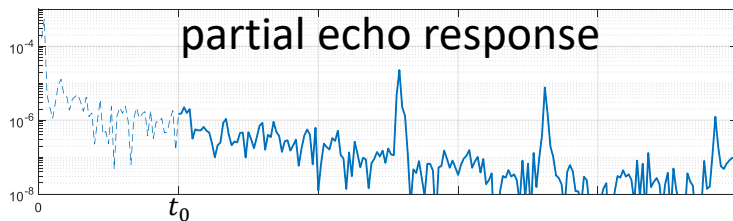
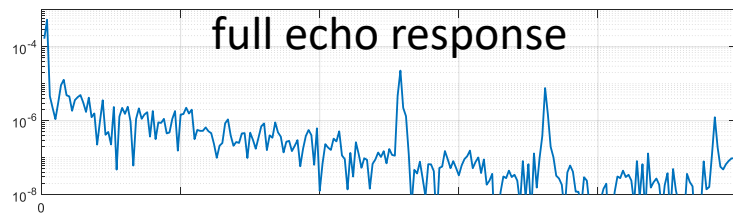
- REM is the power of micro-reflections for the entire echo pulse response ($t \geq 0$)



- $ETM(t_0)$ is the power of micro-reflection for the echo pulse response over $t \geq t_0$



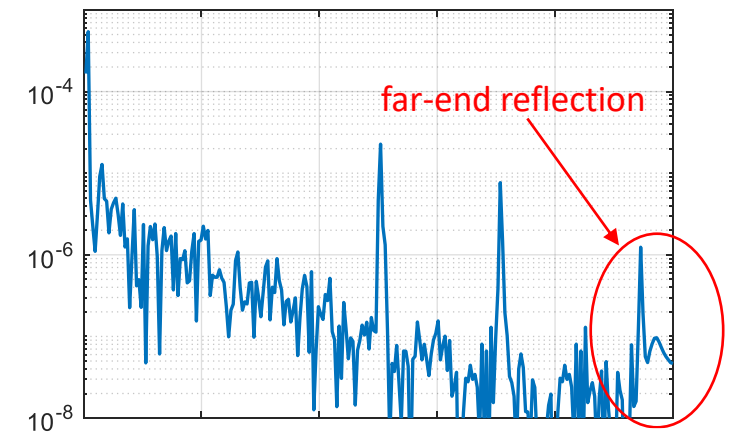
New ETM Algorithm



Proposed new ETM algorithm is the same as REM algorithm with partial echo pulse response as its input

Far-end Reflection Elimination

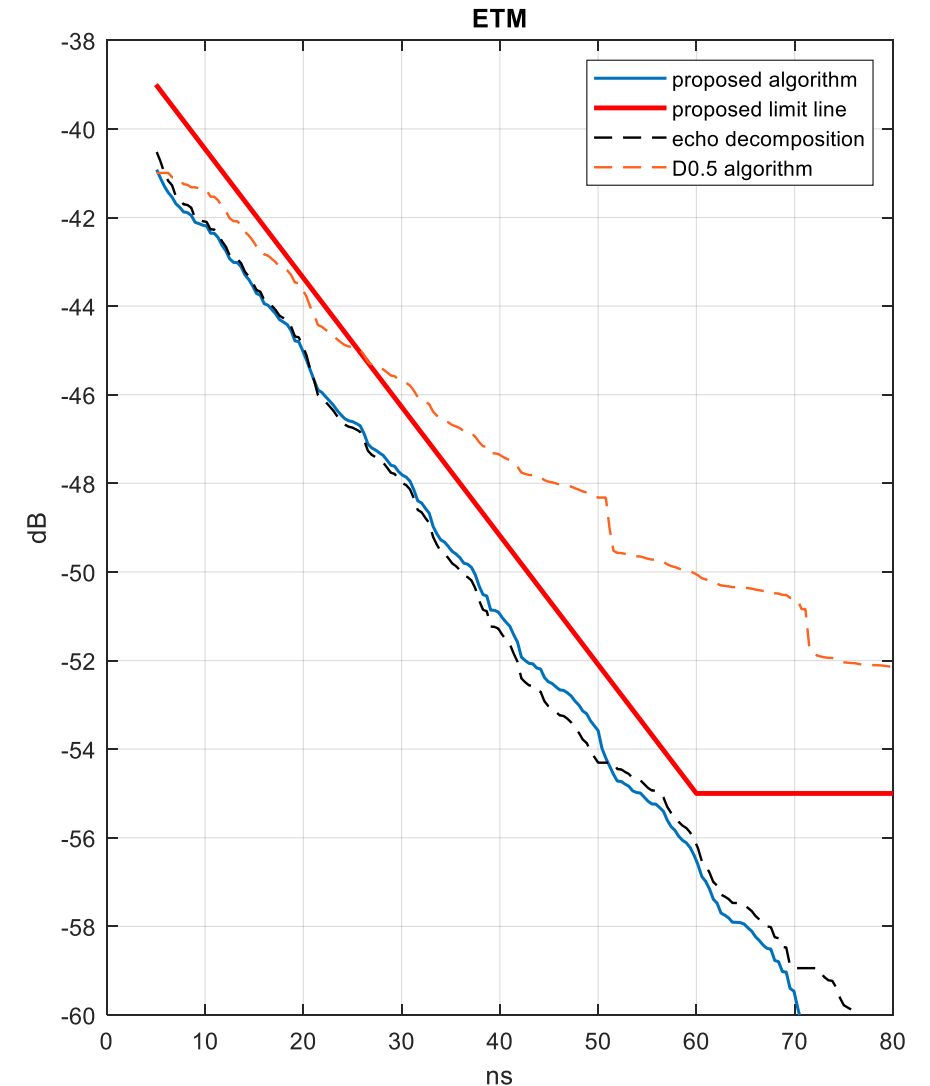
- The reflection from the far-end of the cable is due to discontinuity at the remote MDI
 - Cable measurements do not provide a good representation of this reflection point in a live link
 - This reflection is not due to inhomogeneity of the cable and should not contribute to the power of micro-reflections
 - This reflection may be explicitly eliminated from echo pulse response before ETM calculation
- The position of this major reflection is easily determined by estimating the propagation delay of the cable from S_{12} , S_{21}



Proposed Limit on ETM

- Using $N_discard=6$ and all other parameters as adopted for REM, the calculated ETM follows the cumulative power of micro-reflections closely
- A limit for ETM may be tied to the limit of REM as:

$$\begin{aligned} ETM(t) &\leq REM_{limit} - 16*(t-5)/55 & 5 \text{ ns} \leq t < 60 \text{ ns} \\ ETM(t) &\leq REM_{limit} - 16 & 60 \text{ ns} \leq t \end{aligned}$$



Matlab Code for ETM Calculation

- sedarat_3cy_01_0315.m: slightly modified version of [jonsson_092821](#)
- Changes are limited to
 - Estimation of propagation delay
 - Calculation of ETM

ETM Calculation

```
134 % MODIFIED !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
135 % Calculate the span of the echo up to the major reflection
136 % point at the far-end of the cable
137 - eLen = dly*2*N*df; % delay in terms of samples
138 - eLen = floor(eLen/N_seg); % delay in terms of number of
139 - eLen = eLen*2 - 1; % round-trip delay
140 % Calculate ETM
141 - ETM = zeros(size(ETM));
142 - for i = 1 : (eLen - N_discard_etm)
143     % REM Calculation for echo response that starts from
144     x = sort( P_k(i : eLen) );
145     x = cumsum(x);
146     ETM(i) = x(end - N_discard_etm);
147 - end
148 - ETM = 10*log10(ETM);
149 % MODIFIED !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

Propagation Delay

```
61 % MODIFIED !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
62 % Calculate propagation delay
63 - i = find((f > 100e6) & (f < 5625*2.5e6));
64 - x = s12(i);
65 - dly = [ones(length(x), 1) -2*pi*f(i)']\unwrap(angle(x(:)));
66 - dly = dly(2);
67 % MODIFIED !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

Summary

- A limit on ETM helps with efficient distribution of computational resources within echo canceller
- The current ETM algorithm does not provide a good estimate of cumulative power of micro-reflections
- A new algorithm is proposed which calculates the $ETM(t_0)$ as the REM of the echo pulse response for $t \geq t_0$
- A limit line for ETM is proposed
- No change to REM calculation