

## Fibre Channel CRPAT for SAS

This document evaluates the Fibre Channel (FC) Compliant Random Test Pattern (CRPAT) at different starting Running Disparity (RD) to help determine whether this pattern can be directly used for SAS jitter tests.

The CRPAT was specifically designed to contain a broad and relatively flat frequency spectrum for FC jitter tests. The pattern was designed for negative starting RD, which is guaranteed in FC. In SAS, the starting RD of a protocol frame can be positive or negative. The effect of an RD inversion on a pattern depends on the particular pattern. Specifically for the CRPAT, the pattern does not provide the same frequency spectral contents in both RDs. This effect is shown in Figure 1 and Figure 2.

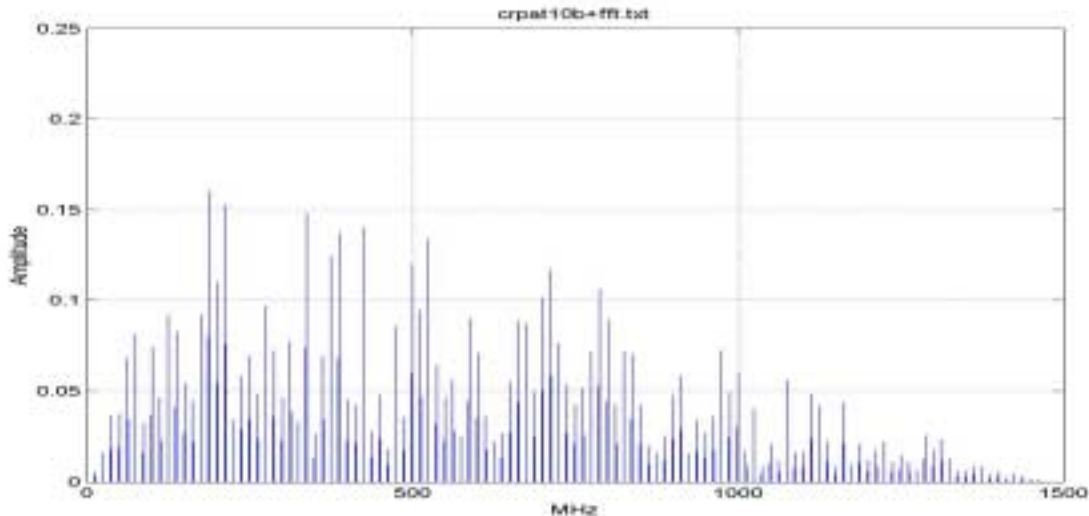
Figure 1 shows the frequency spectrum of the payload component of the original CRPAT (three Dwords repeated 16 times) after 8B/10B encoding with positive starting RD. Table 1 shows this payload.

**Table 1 - CRPAT payload (for positive starting RD)**

+	D30.5 (be)			D23.6 (d7)		D3.1 (23)			D7.2 (47)		+
	1000	0110	1011	1010	0110	1100	0110	0100	0111	0101	
+	D11.3 (6b)			D15.4 (8f)		D19.5 (b3)			D20.0 (14)		-
	1101	0000	1110	1000	1101	1100	1010	1000	1011	0100	
-	D30.2 (5e)			D27.7 (fb)		D21.1 (35)			D25.2 (59)		+
	0111	1001	0100	1001	1110	1010	1010	0110	0110	0101	

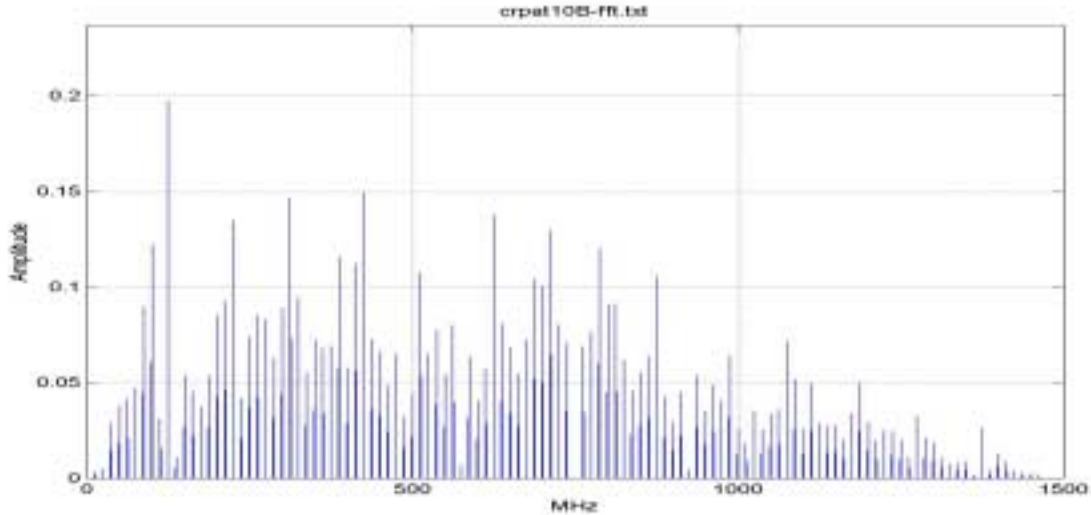
Above 12-byte RPAT is repeated 16 times

Note that the SOF primitive causes an inversion of the RD, which means that for a FC frame starting with negative RD the payload starts with positive RD. The effect of the SOF and EOF primitives and the CRC on the frequency spectrum is relatively minor. The FFT was taken on the 10B pattern as a pure digital (1, 0) data stream; rise/ fall times are not accounted for.



**Figure 1 - FFT of CRPAT payload with positive starting RD**

Figure 2 shows the spectrum of CRPAT payload after 8B/10B encoding with negative starting RD. It is obvious that the spectral composition of the CRPAT changes significantly with the RD.



**Figure 2 - FFT of CRPAT payload with negative starting RD**

The payload definition of the the CRPAT can be changed such that the original spectral composition is maintained when the payload is 8B/10B encoded with the opposite starting RD. Table 2 below shows the modified payload. Note that the 10B code is the bit-wise binary complement of the original CRPAT payload, however this inversion does not affect the spectral contents.

**Table 2 - CRPAT payload modified for negative starting RD**

-	D30.2 (5e)			D23.1 (37)		D28.6 (dc)			D07.5 (a7)		-
	0111	1001	01 00	0101	1001	0011	1001	10 11	1000	1010	
-	D20.3 (74)			D15.4 (8f)		D12.2 (4c)			D11.0 (0b)		+
	0010	1111	00 01	0111	0010	0011	0101	01 11	0100	1011	
+	D30.5 (be)			D27.7 (fb)		D10.6 (ca)			D06.5 (a6)		-
	1000	0110	10 11	0110	0001	0101	0101	10 01	1001	1010	
Above 12-byte RPAT is repeated 16 times											

The modified CRPAT encoded with negative starting RD has the same spectral contents as the original CRPAT encoded with positive starting RD.

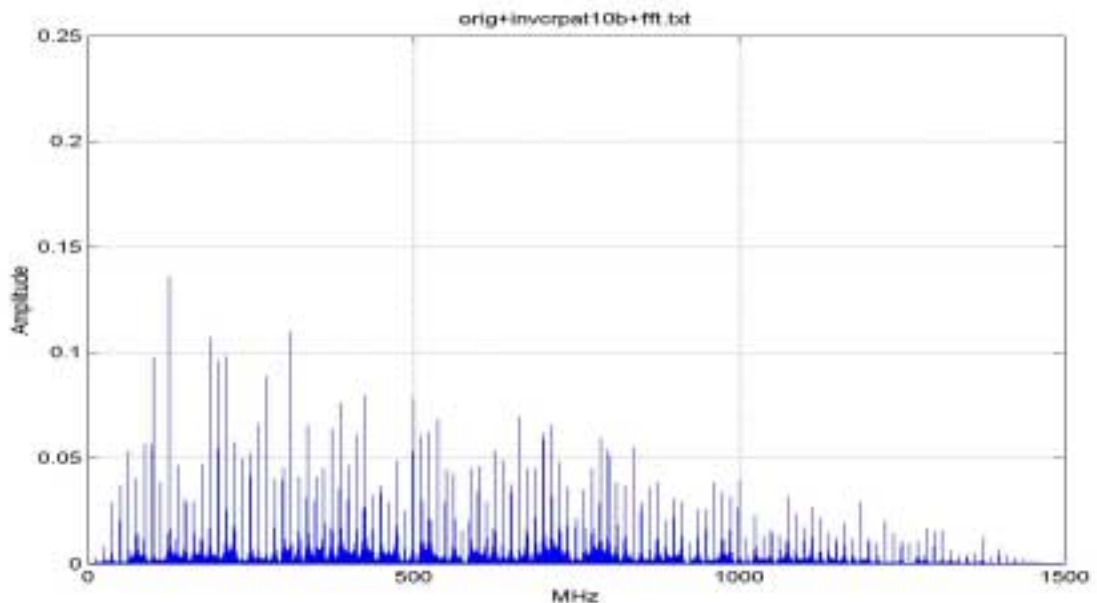
In the following step the original CRPAT payload and the RD-inverse CRPAT payload were combined (concatenated) into a single payload, as shown in Table 3 for positive starting RD.

**Table 3 - CRPAT and modified CRPAT combined**

+	D30.5 (be)			D23.6 (d7)		D3.1 (23)			D7.2 (47)			+
	1000	0110	1011	1010	0110	1100	0110	0100	0111	0101		
+	D11.3 (6b)			D15.4 (8f)		D19.5 (b3)			D20.0 (14)			-
	1101	0000	1110	1000	1101	1100	1010	1000	1011	0100		
-	D30.2 (5e)			D27.7 (fb)		D21.1 (35)			D25.2 (59)			+
	0111	1001	0100	1001	1110	1010	1010	0110	0110	0101		
Above 12-byte RPAT is repeated 16 times												
+	D30.2 (5e)			D23.1 (37)		D28.6 (dc)			D07.5 (a7)			+
	1000	0101	0111	1010	1001	0011	1001	1000	0111	1010		
+	D20.3 (74)			D15.4 (8f)		D12.2 (4c)			D11.0 (0b)			-
	0010	1100	1110	1000	1101	0011	0101	0111	0100	0100		
-	D30.5 (be)			D27.7 (fb)		D10.6 (ca)			D06.5 (a6)			+
	0111	1010	1000	1001	1110	0101	0101	1001	1001	1010		
Above 12-byte RPAT is repeated 16 times												

The purpose of this exercise was to determine whether the spectral composition of this combined pattern is close to that of the original CRPAT, but in both starting RDs.

Figure 3 shows the FFT of the combined payload pattern. As expected, the spectral contents of the combined pattern is the same in both starting RDs. However, the spectral composition is significantly different from that of the original CRPAT, with lower frequencies clearly accentuated.



**Figure 3 - FFT of combined (original + modified) CRPAT payload**

## **Summary**

The FC CRPAT is designed for positive starting RD (negative starting RD of the FC frame) and shows a significantly different spectral contents when 8B/10B encoded with negative starting RD.

A pattern can be defined that, when encoded with negative starting RD, has the same spectral contents as the original CRPAT encoded with positive starting RD (RD-inversed CRPAT). A simple concatenation of the original CRPAT and RD-inversed CRPAT has the same spectral contents in both RDs but the spectral contents is significantly different from that of the original CRPAT.

More effort will be required to define a pattern that has the same spectral contents as the original CRPAT but in both RDs.