SAS compliant jitter test pattern T10/02-390r3

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To: T10 Technical Committee
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Subject: SAS compliant jitter test pattern

A jitter test pattern needs to be defined for SAS. The following proposed addition to the SAS specification defines the jitter test pattern and includes guidance on taking into consideration data scrambling so the desired data pattern on the physical link may be achieved.

Rev 1 is editorial clean up. Change bars have been deleted to make the document more readable.
Rev 2 has additional changes editorial changes plus makes the Annex normative to define the CJTPAT desired pattern on the physical link, and informative with an example implementation.
Rev 3 corrects an error in the tables 1, 2, and 3 by changing "4 dword set" to "dword".

5.7.xx Jitter characteristics test pattern (CJTPAT)

The jitter test pattern within a compliant protocol frame (CJTPAT) shall be used for all jitter testing unless otherwise specified. Refer to Annex xx for the required pattern on the physical link and information regarding special considerations for scrambling and running disparity.

Annex xx

XX.1 CJTPAT required pattern on the physical link

The compliant jitter test pattern, CJTPAT, is listed in Table 1 which shows both the 10b test pattern and, in Dxx.y and hexadecimal notation, the corresponding 8b pattern that shall be input into the 8b10b encoder in the transmitter to result in the desired 10b pattern on the physical link for positive running disparity (RD+) at the beginning of the 8b pattern.

The pattern consists of a long run of low-density pattern, followed by a long run of high transition density pattern, followed by another short run of low-density pattern. The transitions between the pattern segments stress the receiver. The test pattern is designed to contain the phase shift in both polarities, from 0 to 1 and from 1 to 0. The critical pattern sections with the phase shifts are underlined in the table.

Table 1 - CJTPAT for RD+

RD+	D30.3(7Eh)			D30.3(7Eh)		D30.3(7Eh)			D30.3(7Eh)		RD+
	1000b	0111b	0001b	1110b	0011b	1000b	0111b	0001b	1110b	0011b	
	The above dword of low density pattern is repeated for a total 41 times										
RD+	D30.3(7Eh)			D30.3(7Eh)		D30.3(7Eh)			D20.3(74h)		RD-
	1000b	0111b	0001b	1110b	0011b	1000b	0111b	0000b	1011b	1100b	
	Phase shift 11100001011										
RD-	D30.3(7Eh)			D11.5(ABh)		D21.5(B5h)			D21.5(B5h)		RD+
	0111b	1000b	1111b	0100b	1010b	1010b	1010b	1010b	1010b	1010b	
	Phase shift 00011110100										
RD+	D21.5(B5h)			D21.5(B5h)		D21.5(B5h)			D21.5(B5h)		RD+
	1010b	1010b	1010b	1010b	1010b	1010b	1010b	1010b	1010b	1010b	
	The above dword of high density pattern is repeated for a total of 12 times										
RD+	D21.5(B5h)			D30.2(5Eh)		D10.2(4Ah)			D30.3(7Eh)		RD+
	1010b	1010b	1010b	0001b	0101b	0101b	0101b	0101b	1110b	0011b	
	Phase shift 01010000b and 10101111b										

If the 8b pattern shown in Table 1 is encoded with negative starting running disparity (RD-), the resulting 10b pattern is different and does not provide the critical phase shifts. To achieve the same phase shift effects with RD-, a different 8b pattern is required, which is shown in Table 2 with the 10b pattern resulting from encoding with RD-. The 8b pattern in Table 2 does not give a proper 10b pattern if it is encoded with RD+.

Table 2 - CJTPAT for RD-

RD-	D30.3(7Eh)			D30.3(7Eh)		D30.3(7Eh)			D30.3(7Eh)		RD-
	0111b	1000b	1110b	0001b	1100b	0111b	1000b	1110b	0001b	1100b	
	The above dword of low density pattern is repeated for a total of 41 times										
RD-	D30.3(7Eh)			D30.3(7Eh)		D30.3(7Eh)			D11.3(6Bh)		RD+
	0111b	1000b	1110b	0001b	1100b	0111b	1000b	1111b	0100b	0011b	
	Phase shift 00011110100b										
RD+	D30.3(7Eh)			D20.2(54h)		D10.2(4Ah)			D10.2(4Ah)		RD-
	1000b	0111b	0000b	1011b	0101b	0101b	0101b	0101b	0101b	0101b	
	Phase shift 11100001011b										
RD-	D10.2(4Ah)			D10.2(4Ah)		D10.2(4Ah)			D10.2.(4Ah)		RD-
	0101b	0101b	0101b	0101b	0101b	0101b	0101b	0101b	0101b	0101b	
	The above dword of high density pattern is repeated for a total of 12 times										
RD-	D10.2(4Ah)			D30.5(BEh)		D21.5(B5h)			D30.3(7Eh)		RD-
	0101b	0101b	0101b	1110b	1010b	1010b	1010b	1010b	0001b	1100b	
	Phase shift 10101111b and 01010000b										

To use CJTPAT as the payload in a protocol frame, the 8b patterns for both RD+ and RD- shall be included as shown in Table 3. The 10b pattern resulting from encoding the 8b pattern in Table 3 contains the desired bit sequences for the phase shifts in both starting running disparities.

Table 3 - CJTPAT for RD+ and RD-

D30.3(7Eh)	D30.3(7Eh)	D30.3(7Eh)	D30.3(7Eh)	This dword is repeated for a total of 41 times.
"	"	"	"	
D30.3(7Eh)	D30.3(7Eh)	D30.3(7Eh)	D20.3(74h)	
D30.3(7Eh)	D11.5(ABh)	D21.5(B5h)	D21.5(B5h)	
D21.5(B5h)	D21.5(B5h)	D21.5(B5h)	D21.5(B5h)	This dword is repeated for a total of 12 times.
"	"	"	"	
D21.5(B5h)	D30.2(5Eh)	D10.2(4Ah)	D30.3(7Eh)	
D30.3(7Eh)	D30.3(7Eh)	D30.3(7Eh)	D30.3(7Eh)	This dword is repeated for a total of 41 times.
"	"	"	"	
D30.3(7Eh)	D30.3(7Eh)	D30.3(7Eh)	D11.3(6Bh)	
D30.3(7Eh)	D20.2(54h)	D10.2(4Ah)	D10.2(4Ah)	
D10.2(4Ah)	D10.2(4Ah)	D10.2(4Ah)	D10.2.(4Ah)	This dword is repeated for a total of 12 times.
"	"	"	"	
D10.2(4Ah)	D30.5(BEh)	D21.5(B5h)	D30.3(7Eh)	

XX.2 Scrambling considerations for achieving a proper CJTPAT on the physical link

Before the pattern described in Table 3 is encapsulated in a protocol frame, the effect of the scrambling of data in the transmitter before the 8b10b encoding should be compensated for. By scrambling the desired 8b pattern prior to submitting it to the transmitter scrambler, the scrambling in the transmitter scrambler reverses the prior scrambling of the 8b pattern and the desired pattern is presented to the 8b10b encoder.

The 8b data are scrambled by XOR-ing the pattern with the output of the scrambler dword by dword, taking into account the position of the 8b pattern within the protocol frame. Table 4 shows this principle for the pattern from Table 3 embedded in a SSP protocol frame with 24-byte address following the SOF primitive.

The column titled 8b Data lists the desired 8b pattern data that is to be 8b10b encoded.

The column titled Scrambler Output lists the output, in dword format, of the transmitter scrambler.

The column titled Scrambled 8b Data shows the result of XOR-ing the 8b data with the scrambler output. The data in this column, if supplied to the transmitter scrambler, results in the desired 10b test pattern on the physical link.

The scrambler gets initialized (seeded) at the beginning of each frame (SOF) and the scrambler output is independent of the scrambled data. The insertion of ALIGNs within the frame should be avoided because of the possible disruption of the pattern on the physical link.

Table 4 - CJTPAT scrambled in SSP protocol frame

Frame Element	8b Data	Scrambler Output (SCR)	Scrambled 8b Data = 8b XOR SCR
SOF		n/a	n/a
Address	xxxxxxxx	C2D2768Dh	xxxxxxxx
	xxxxxxxx	1F26B368h	xxxxxxxx
	xxxxxxxx	A508436Ch	xxxxxxxx
	xxxxxxxx	3452D354h	xxxxxxxx
	xxxxxxxx	8A559502h	xxxxxxxx
	xxxxxxxx	BB1ABE1Bh	xxxxxxxx
Pattern data	7E7E7E7Eh	FA56B73Dh	8428C943h
	7E7E7E7Eh	53F60B1Bh	2D887565h
	7E7E7E7Eh	F0809C41h	8EFEE23Fh
	7E7E7E7Eh	747FC34Ah	0A01BD34h
	7E7E7E7Eh	BE865291h	C0F82CEFh
	7E7E7E7Eh	7A6FA7B6h	0411D9C8h
	7E7E7E7Eh	3163E6D6h	4F1D98A8h
	7E7E7E7Eh	F036FE0Ch	8E488072h
	7E7E7E7Eh	1EF3EA29h	608D9457h
	7E7E7E7Eh	EB342694h	954A58EAh
	7E7E7E7Eh	53853B17h	2DFB4569h
	7E7E7E7Eh	E94ADC4Dh	9734A233h
	7E7E7E7Eh	5D200E88h	235E70F6h
	7E7E7E7Eh	6901EDD0h	177F93AEh
	7E7E7E7Eh	FA9E38DEh	84E046A0h
	7E7E7E7Eh	68DB4B07h	16A53579h
	7E7E7E7Eh	450A437Bh	3B743D05h
	7E7E7E7Eh	960DD708h	E873A976h
	7E7E7E7Eh	3F35E698h	414B98E6h
	7E7E7E7Eh	FE7698A5h	8008E6DBh
	7E7E7E7Eh	C80EF715h	B670896Bh
	7E7E7E7Eh	666090AFh	181EEED1h
	7E7E7E7Eh	FAF0D5CBh	848EABB5h
	7E7E7E7Eh	2B82009Fh	55FC7EE1h

	7E7E7E7Eh	0E317491h	704F0AEFh
	7E7E7E7Eh	76F46A1Eh	088A1460h
	7E7E7E7Eh	F46D6948h	8A131736h
	7E7E7E7Eh	7BCD8A93h	05B3F4Edh
	7E7E7E7Eh	1513AD7Eh	6B6DD300h
	7E7E7E7Eh	1E72FEEEh	600C8090h
	7E7E7E7Eh	A014AA3Bh	DE6AD445h
	7E7E7E7Eh	23AAD4E7h	5DD4AA99h
	7E7E7E7Eh	B0DC9E67h	CEA2E019h
	7E7E7E7Eh	E0A573FBh	9EDB0D85h
	7E7E7E7Eh	06CA944Fh	78B4EA31h
	7E7E7E7Eh	63E29212h	1D9CEC6Ch
	7E7E7E7Eh	4578626Dh	3B061C13h
	7E7E7E7Eh	53260C93h	2D5872EDh
	7E7E7E7Eh	3E592202h	40275C7Ch
	7E7E7E7Eh	2B6ECA63h	5510B41Dh
	7E7E7E7Eh	636A1F1Fh	1D146161h
	7E7E7E74h	35B5A9Edh	4BCBD799h
	7EABB5B5h	4AA2A0FDh	34091548h
	B5B5B5B5h	71AFE196h	C41A5423h
	B5B5B5B5h	E1D57B62h	5460CED7h
	B5B5B5B5h	55A0568Ah	E015E33Fh
	B5B5B5B5h	82D18968h	37643CDDh
	B5B5B5B5h	234CB4FFh	96F9014Ah
	B5B5B5B5h	83481E7Fh	36FDABCAh
	B5B5B5B5h	B21AE87Fh	07AF5DCAh
	B5B5B5B5h	A9C5EACDh	1C705F78h
	B5B5B5B5h	6201ACC3h	D7B41976h
	B5B5B5B5h	F60939CEh	43BC8C7Bh
	B5B5B5B5h	395F767Dh	8CEAC3C8h
	B5B5B5B5h	2FA55841h	9A10EDF4h
	B55E4A7Eh	836D4A7Ah	36330004h
	7E7E7E7Eh	388D587Ah	46F32604h
	7E7E7E7Eh	773DFF5Ch	09438122h
	7E7E7E7Eh	3C239CB3h	425DE2CDh
	7E7E7E7Eh	564D91A0h	2833EFDEh
	7E7E7E7Eh	43ED0BE1h	3D93759Fh
	7E7E7E7Eh	987429A7h	E60A57D9h
	7E7E7E7Eh	E52DDBA2h	9B53A5DCh
	7E7E7E7Eh	E78DC87Fh	99F3B601h
	7E7E7E7Eh	0AB8C669h	74C6B817h
	7E7E7E7Eh	64D083C9h	1AAEFDB7h
	7E7E7E7Eh	053DF93Ah	7B438744h
	7E7E7E7Eh	EEE9D9Eah	9097A794h
	7E7E7E7Eh	44BD3B97h	3AC345E9h
	7E7E7E7Eh	0FE24B8Ch	719C35F2h
	7E7E7E7Eh	F28D5694h	8CF328Eah
	7E7E7E7Eh	6310B6D9h	1D6EC8A7h
	7E7E7E7Eh	1792AECEh	69ECD0B0h
	7E7E7E7Eh	0A562EA1h	742850DFh
	7E7E7E7Eh	B048DF69h	CE36A117h
	7E7E7E7Eh	161A2878h	68645606h
	7E7E7E7Eh	5519CB51h	2B67B52Fh
	7E7E7E7Eh	19F5BE56h	678BC028h
	7E7E7E7Eh	EFFFB4B6h	9181CAC8h
	7E7E7E7Eh	B3826E72h	CDFC100Ch
	7E7E7E7Eh	E4722DDAh	9A0C53A4h
	7E7E7E7Eh	60BF5129h	1EC12F57h
	7E7E7E7Eh	248D90F5h	5AF3EE8Bh
	7E7E7E7Eh	4D06D21Ch	3378AC62h
	7E7E7E7Eh	7E96166Ch	00E86812h
	7E7E7E7Eh	5FAFE3B4h	21D19DCAh

	7E7E7E7Eh	506CB855h	2E12C62Bh
	7E7E7E7Eh	5BF03098h	258E4EE6h
	7E7E7E7Eh	46D4B6B3h	38AAC8CDh
	7E7E7E7Eh	051B9E11h	7B65E06Fh
	7E7E7E7Eh	015CC556h	7F22BB28h
	7E7E7E7Eh	E21035Efh	9C6E4B91h
	7E7E7E7Eh	56604D75h	281E330Bh
	7E7E7E7Eh	2E76675Ch	50081922h
	7E7E7E7Eh	071476F0h	796A088Eh
	7E7E7E7Eh	AFF087Ebh	D18EF995h
	7E7E7E7Eh	1B62DB01h	651CA57Fh
	7E7E7E6Bh	23661F6Ch	5D186107h
	7E544A4Ah	F877B027h	8623FA6Dh
	4A4A4A4Ah	F5E389A2h	BFA9C3E8h
	4A4A4A4Ah	EEC73611h	A48D7C5Bh
	4A4A4A4Ah	4C04FB93h	064EB1D9h
	4A4A4A4Ah	E8D70F32h	A29D4578h
	4A4A4A4Ah	BFF03C54h	F5BA761Eh
	4A4A4A4Ah	E3403C01h	A90A764Bh
	4A4A4A4Ah	20FACA7Eh	6AB08034h
	4A4A4A4Ah	9942458Ch	D3080FC6h
	4A4A4A4Ah	37E2CB89h	7DA881C3h
	4A4A4A4Ah	5A1A9783h	1050DDC9h
	4A4A4A4Ah	CE48AA3Fh	8402E075h
	4A4A4A4Ah	06C9A761h	4C83ED2Bh
	4ABEB57Eh	06C03EABh	4C7E8BD5h
CRC	xxxxxxxx	xxxxxxxx	xxxxxxxx
EOF		N/A	N/A