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Report CNC Parametric Curve Interpolation and Trajectory Tracking
Part 4 of 5 Snailshell and SnaHyp (x-y) parametric curves

ITEM	DESCRIPTION	SNAILSHELL CURVE					SNAILSHELL + HYPOTROCOID CURVE				
		FC10	FC20	FC25	FC30	FC40	FC10	FC20	FC25	FC30	FC40
1	Run user feedrate command (mm/s)										
2	Total interpolated u-points	15621	9883	8935	8370	7766	38672	20223	16618	11497	8889
3	Parameter completion (reached u-end = 1.00)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.706104	0.703536
	Pushdown epsilon eps(u) algorithm									***	***
4	Count before pushdown, eps(u) is below (1E-6)	12245	5010	3569	2671	1592	37227	18167	14266	0	0
5	Count pushdown points, eps(u) to below (1E-6)	3376	4873	5366	5699	6174	1445	2056	2352	0	0
6	Check Total u-points	15621	9883	8935	8370	7766	38672	20223	16618	0	0
	Epsilon eps(u) chord error										
7	Count eps(u) above (1E-6)	0	0	0	0	0	0	0	0	0	0
8	Count eps(u) in (1E-7, 1E-6)	7893	9323	8935	8370	7766	4106	6971	9900	0	0
9	Count eps(u) in (1E-8, 1E-7)	7728	560	0	0	0	24178	13252	6718	0	0
10	Count eps(u) in (1E-9, 1E-8)	0	0	0	0	0	10388	0	0	0	0
11	Count eps(u) in (1E-10, 1E-9)	0	0	0	0	0	0	0	0	0	0
12	Count eps(u) below (1E-10)	0	0	0	0	0	0	0	0	0	0
13	Check Total eps(u) points	15621	9883	8935	8370	7766	38672	20223	16618	0	0
	Count interpolated u-points										
14	Count_rising_S_curve u-points	2320	1161	929	774	581	3177	1589	1272	0	0
15	Count_frate is_lower than fratelimit	11722	6605	5826	5386	4860	18305	9773	8142	0	0
16	Count_frate is_equal to fratelimit	0	0	0	0	0	0	0	0	0	0
17	Count_frate is_higher than fratelimit	1210	1747	1811	1859	1956	14859	7695	6271	0	0
18	Count_falling_S_curve u-points	369	370	359	369	369	2331	1166	933	0	0
19	Check Total u-points	15621	9883	8925	8388	7766	38672	20223	16618	0	0
	Count u-points histogram (G01 codes)									***	***
20	Count u-points [0.00 <= u < 0.10)	4435	2218	1774	1479	1109	4631	2317	1856	1563	1217
21	Count u-points [0.10 <= u < 0.20)	3237	1619	1296	1080	849	8961	4480	3584	2987	2240
22	Count u-points [0.20 <= u < 0.30)	2054	1028	851	796	793	6140	3074	2470	2072	1586
24	Count u-points [0.30 <= u < 0.40)	1312	714	710	711	711	2960	1526	1257	1086	885
25	Count u-points [0.40 <= u < 0.50)	881	629	629	629	629	4860	2431	1945	1620	1216
26	Count u-points [0.50 <= u < 0.60)	657	628	628	629	628	3973	1987	1589	1325	994
27	Count u-points [0.60 <= u < 0.70)	710	711	711	710	711	1324	841	769	732	710
28	Count u-points [0.70 <= u < 0.80)	794	794	794	794	794	794	794	794	112	41
29	Count u-points [0.80 <= u < 0.90)	791	791	792	792	792	1141	828	798	0	0
30	Count u-points [0.90 <= u <= 1.00]	750	751	750	750	750	3888	1945	1556	0	0
31	Check Total u-points	15621	9883	8935	8370	7766	38672	20223	16618	11497	8889
32	**Total curve error (sum of epsilon(u))**	0.005115	0.00627	0.006558	0.006764	0.007046	0.002847	0.004003	0.004459	0	0
33	**Total dist traversed (sum of chord lengths)**	138.5595	138.5614	138.5607	138.5602	138.5599	478.9871	478.9987	479.0064	0	0

	Notes and remarks										
	Pushdown or reducing eps(u) algorithm means reducing chord length, thus reduces u_next and so results in generation of more interpolated u-points. See row Item(7). None of the eps(u) values exceed (1E-6).	See row Item(17) Count_frate is_higher than fratelimit. This count is about adjusting the current feedrate to follow the calculated feedrate_limit, and stay just below this feedrate limit. The calculated net feedrate limit is the minimum of four(4) feedrate limit constraints which comprise:									
		(C1) Absolute constraint not to exceed the user feedrate command, example FC20 (20 mm/s),									
		(C2) Constrain the feedrate to stay within the velocity range (min, max) allowable for the CNC									
		(C3) Constraint the feedrate to have chord error eps(u) absolutely below tolerance (1E-6) mm, as it tracks the curve trajectory, See row Item(7).									
		(C4) Constraint feedrate such that the normal acceleration (not tangential) stay within the acceleration range (min, max) allowable for the CNC machine.									
		Note that, in order to achieve meeting all 4 (C1, C2, C3, and C4) constraints simultaneously, sometimes the current feedrate at point u maybe higher than fratelimit calculated for the point u. Our runs showed that these feedrate overshoots are typically below 0.001 % of the calculated fratelimit.									