



Instrument Science Report  
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# New IR Detector Sample Times

L. Petro and T. Wheeler  
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## ABSTRACT

*Exposure sequences for scientific operations of the WFC3 IR detector are presented. These are new sequences that will replace those previously in use. In these new sequences, no settling time is used before reading each line, whereas previously a 3-msec settling time at the start of each line was used. The intervals between readouts for all full-frame sequences are approximately maintained, which causes the sub-array sample times to be increased.*

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## Introduction

Until recently, the scientific operation of the WFC3 IR detector was planned to include a 3.003-msec delay before reading the signal from the pixels in each line (Baggett 2003), the purpose of which was to provide a stable signal from the first-read pixels. However, tests of candidate flight detectors at GSFC's Detector Characterization Laboratory demonstrate that stable signals may be obtained without a "settling" delay. Therefore, in order to reduce the minimum exposure time and thereby to extend the detector's dynamic range, the WFC3 IR detector will be operated without a settling delay before reading each line. Additional changes, in order to maintain the previously determined intervals between readouts in sample sequences, are presented in this report.

## New Sample Sequence Times

The IR detector pixels collect signals at all times between resets of the detector, including during the non-destructive readouts of those pixels. As many as 16 non-destructive readouts of the pixel signals may be made between detector resets, with the time of those readouts controlled by the Timing State Machine (TSM; Baggett 2003). The readout sequences are of four kinds according to the intervals between readouts. Following the

naming convention of the *Phase 2 Proposal Instructions*, the four kinds are: **RAPID** (minimum time between readouts), **SPARS** (equal intervals between readouts), **STEP** (logarithmically increasing intervals), and **MIF** (Fowler-sample readout intervals). All readout sequences begin with two resets of the detector, a readout, a minimum duration exposure (20.48 msec), and a readout. The particular sequence of timed readouts of the array then follows. The time exposing the pixels to a target (the *exposure time*) is the interval of time between a reset of the detector and the final readout. That interval is comprised of two kinds of activities of the TSM: reading the detector (including setup time for reading) and a variable delay time between readouts,  $TSM\_exp$  (Baggett 2003).

The time to readout full-frame and sub-array images is presented in Table 1. The “Former” values are with the 3.003-msec settling delay per line, and the “New” values are without the settling delay, except for the 64×64 sub-array which formerly was a special case without the 3.003-msec delay per line. The time to readout the array, or a sub-array, is reduced by  $n_{line} \times 3.003$  msec (except for the 64×64 sub-array). Because one amplifier is dedicated to each quadrant of the detector,  $n_{line}$  is one-half the length of the detector for full-frame images. For sub-arrays  $n_{line}$  is increased by 5 additional reference pixel lines.

Table 1. **Time to readout WFC3 IR detector.**

Array	$n_{line}$	Readout Time[sec]	
		Former	New
Full (1024×1024)	512	4.449347	2.911811
512×512	261	1.616330	0.832547
256×256	133	0.656734	0.257335
128×128	69	0.299432	0.092225
64×64	37	0.040294	0.040294

If only the readout time were reduced, by removing the unnecessary settling time as indicated in Table 1, then the *exposure time* would be reduced in proportion to the number of samples per exposure. For example, the *exposure time* of a **SPARS10** (a 10-sec linearly spaced, up-the-ramp sample sequence), full-frame image with 15 samples (the maximum value) would be reduced by  $512 \times (15+1) \times (273 \times 11 \times 10^{-6}) = 24.6$  sec. The time between readouts for this sample sequence would be reduced from 10 sec to 9.85 sec. Instead, we have chosen to adjust the values of  $TSM\_exp$  stored in the flight software tables in order to maintain consistency of the *exposure time* and the *sample time* with their previously established values, as useful. These adjustments can be set with a precision of one TSM time tick, 1.024 msec, which permits in principle to achieve substantial agreement of the new values of *exposure time* and *sample time* with their former values. This equality cannot be achieved for all images. Both full-frame and sub-array images use the same set of  $TSM\_exp$  for the various sample sequences (the

Phase 2 Proposal Instructions optional parameter **SAMPSEQ** = **RAPID**, **SPARS**, **STEP**, and **MIF**). As shown in Table 1, the change in *exposure time* will be different for each array due to the difference in readout time. Therefore, because the same value of *TSM\_exp* is used for a full-frame image as a sub-array image, a single adjustment of the value of *TSM\_exp* cannot correct the *exposure time* to its former value for both full-frame and sub-array images.

We will adjust (generally increase) the values of *TSM\_exp* to bring the time between readouts into essential agreement with the former values for full-frame images. Consequently, the sub-array *exposure time* and *sample time* also will be generally increased. The **RAPID** sequences were already at minimum *exposure time* and *sample time*, and the *TSM\_exp* therefore does not require adjustment. Furthermore, in some sequences, some readouts are separated by the minimum value of *TSM\_exp* (20.48 msec) and thus are not adjusted in the new patterns.

The change of *exposure time* is illustrated in Table 2 for the sample sequence times that we developed. Note that the exposure time for **RAPID** 64×64 sub-array images is unchanged, as intended. The other **RAPID** *exposure times* are less than the previous values because the readout time is reduced, while *TSM\_exp* is maintained at its minimum value (20.48 msec). The full-frame *exposure time* is generally less for the new timing patterns because some sample intervals were at the minimum value, as discussed above, which is maintained in the new timing patterns. The full tables of sample times and *TSM\_exp* for all sample sequences and sub-arrays are presented in Appendix A.

Table 2. **Exposure time**<sup>†</sup>.

Seq.	Full		512×512		256×256		128×128		64×64	
	Former	New	Former	New	Former	New	Former	New	Former	New
<b>RAPID</b>	67.05	43.98	24.55	12.80	10.16	4.17	4.80	1.69	0.92	0.92
<b>SPARS10</b>	144.88	142.95	102.38	111.76	87.99	103.13	82.63	100.65	78.74	99.88
<b>SPARS25</b>	354.87	352.94	312.38	321.75	297.98	313.12	292.62	310.65	288.74	309.87
<b>SPARS50</b>	704.87	702.94	662.38	671.75	647.98	663.12	642.62	660.65	638.73	659.87
<b>SPARS100</b>	1404.87	1402.94	1362.37	1371.75	1347.98	1363.12	1342.62	1360.64	1338.73	1359.86
<b>SPARS200</b>	2804.88	2802.93	2762.38	2771.74	2747.99	2763.12	2742.63	2760.63	2738.74	2759.86
<b>STEP25</b>	279.93	274.23	237.44	243.05	223.05	234.42	217.69	231.94	213.80	231.16
<b>STEP50</b>	504.93	499.23	462.44	468.04	448.05	459.42	442.69	456.94	438.80	456.16
<b>STEP100</b>	904.93	899.23	862.44	868.04	848.04	859.42	842.68	856.94	838.80	856.16
<b>STEP200</b>	1604.94	1599.23	1562.44	1568.04	1548.05	1559.41	1542.69	1556.94	1538.80	1556.16
<b>STEP400</b>	2804.94	2799.23	2762.44	2768.05	2748.05	2759.42	2742.69	2756.94	2738.80	2756.16
<b>MIF600</b>	600.42	600.00	557.93	568.82	543.53	560.19	538.17	557.71	534.28	556.93
<b>MIF900</b>	900.50	900.00	858.01	868.81	843.61	860.19	838.25	857.71	834.37	856.93
<b>MIF1200</b>	1200.43	1200.00	1157.93	1168.81	1143.54	1160.19	1138.18	1157.71	1134.29	1156.93
<b>MIF1500</b>	1500.42	1500.00	1457.92	1468.81	1443.53	1460.18	1438.17	1457.71	1434.28	1456.93

<sup>†</sup> Last readout of 15-sample sequence [sec].

## **Summary**

Our adjustment of the values of *TSM\_exp* in the various sample sequences (**RAPID**, **SPARS**, **STEP**, and **MIF**) is the only change to the exposure sequences, in addition to the removal of the 3-msec settling time proposed elsewhere. We will adjust the *TSM\_exp* times such that the time between samples for full-frame images will be close to the same value as before the 3.003-msec settling time was removed, except for the minimum *TSM\_exp* intervals in **RAPID** sample sequences, which are left at their intended minimal value. Only **RAPID** 64×64 sub-array images are unaffected because that sample sequence already did not use the 3.003-msec settling time. As before, the same set of flight software *TSM\_exp* times for each sample sequence (*e.g.*, **MIF1500**) will be the basis of full array readouts and sub-array readouts.

## **References**

Baggett, W. (2003). *WFC3 Detector Readout Details*, WFC3-ISR-2003-08

## Appendix A Sample Times

### RAPID

Readout	TSM Clock Ticks	TSM Expose (millisec)	1024x1024 Sample Times (sec)	64x64 Sample Times (sec)	128x128 Sample Times (sec)	256x256 Sample Times (sec)	512x512 Sample Times (sec)	EngTest Sample Times (sec)	1024x1024 Delta Sample Times (sec)
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	20	20.480	5.864582	0.121548	0.225410	0.555630	1.706054	5.842052	2.932291
3	20	20.480	8.796873	0.182322	0.338115	0.833445	2.559081	8.763078	2.932291
4	20	20.480	11.729164	0.243096	0.450820	1.111260	3.412108	11.684104	2.932291
5	20	20.480	14.661455	0.303870	0.563525	1.389075	4.265135	14.605130	2.932291
6	20	20.480	17.593746	0.364644	0.676230	1.666890	5.118162	17.526156	2.932291
7	20	20.480	20.526037	0.425418	0.788935	1.944705	5.971189	20.447182	2.932291
8	20	20.480	23.458328	0.486192	0.901640	2.222520	6.824216	23.368208	2.932291
9	20	20.480	26.390619	0.546966	1.014345	2.500335	7.677243	26.289234	2.932291
10	20	20.480	29.322910	0.607740	1.127050	2.778150	8.530270	29.210260	2.932291
11	20	20.480	32.255201	0.668514	1.239755	3.055965	9.383297	32.131286	2.932291
12	20	20.480	35.187492	0.729288	1.352460	3.333780	10.236324	35.052312	2.932291
13	20	20.480	38.119783	0.790062	1.465165	3.611595	11.089351	37.973338	2.932291
14	20	20.480	41.052074	0.850836	1.577870	3.889410	11.942378	40.894364	2.932291
15	20	20.480	43.984365	0.911610	1.690575	4.167225	12.795405	43.815390	2.932291

**SPARS10**

Readout	TSM Clock Ticks	TSM Expose (millisec)	1024x1024 Sample Times (sec)	64x64 Sample Times (sec)	128x128 Sample Times (sec)	256x256 Sample Times (sec)	512x512 Sample Times (sec)	EngTest Sample Times (sec)	1024x1024 Delta Sample Times (sec)
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	6923	7089.152	12.933254	7.190220	7.294082	7.624302	8.774726	12.910724	10.000963
3	6923	7089.152	22.934217	14.319666	14.475459	14.970789	16.696425	22.900422	10.000963
4	6923	7089.152	32.935180	21.449112	21.656836	22.317276	24.618124	32.890120	10.000963
5	6923	7089.152	42.936143	28.578558	28.838213	29.663763	32.539823	42.879818	10.000963
6	6923	7089.152	52.937106	35.708004	36.019590	37.010250	40.461522	52.869516	10.000963
7	6923	7089.152	62.938069	42.837450	43.200967	44.356737	48.383221	62.859214	10.000963
8	6923	7089.152	72.939032	49.966896	50.382344	51.703224	56.304920	72.848912	10.000963
9	6923	7089.152	82.939995	57.096342	57.563721	59.049711	64.226619	82.838610	10.000963
10	6923	7089.152	92.940958	64.225788	64.745098	66.396198	72.148318	92.828308	10.000963
11	6923	7089.152	102.941921	71.355234	71.926475	73.742685	80.070017	102.818006	10.000963
12	6923	7089.152	112.942884	78.484680	79.107852	81.089172	87.991716	112.807704	10.000963
13	6923	7089.152	122.943847	85.614126	86.289229	88.435659	95.913415	122.797402	10.000963
14	6923	7089.152	132.944810	92.743572	93.470606	95.782146	103.835114	132.787100	10.000963
15	6923	7089.152	142.945773	99.873018	100.651983	103.128633	111.756813	142.776798	10.000963

**SPARS25**

Readout	TSM Clock Ticks	TSM Expose (millisec)	1024x1024 Sample Times (sec)	64x64 Sample Times (sec)	128x128 Sample Times (sec)	256x256 Sample Times (sec)	512x512 Sample Times (sec)	EngTest Sample Times (sec)	1024x1024 Delta Sample Times (sec)
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	21571	22088.704	27.932806	22.189772	22.293634	22.623854	23.774278	27.910276	25.000515
3	21571	22088.704	52.933321	44.318770	44.474563	44.969893	46.695529	52.899526	25.000515
4	21571	22088.704	77.933836	66.447768	66.655492	67.315932	69.616780	77.888776	25.000515
5	21571	22088.704	102.934351	88.576766	88.836421	89.661971	92.538031	102.878026	25.000515
6	21571	22088.704	127.934866	110.705764	111.017350	112.008010	115.459282	127.867276	25.000515
7	21571	22088.704	152.935381	132.834762	133.198279	134.354049	138.380533	152.856526	25.000515
8	21571	22088.704	177.935896	154.963760	155.379208	156.700088	161.301784	177.845776	25.000515
9	21571	22088.704	202.936411	177.092758	177.560137	179.046127	184.223035	202.835026	25.000515
10	21571	22088.704	227.936926	199.221756	199.741066	201.392166	207.144286	227.824276	25.000515
11	21571	22088.704	252.937441	221.350754	221.921995	223.738205	230.065537	252.813526	25.000515
12	21571	22088.704	277.937956	243.479752	244.102924	246.084244	252.986788	277.802776	25.000515
13	21571	22088.704	302.938471	265.608750	266.283853	268.430283	275.908039	302.792026	25.000515
14	21571	22088.704	327.938986	287.737748	288.464782	290.776322	298.829290	327.781276	25.000515
15	21571	22088.704	352.939501	309.866746	310.645711	313.122361	321.750541	352.770526	25.000515

**SPARS50**

Readout	TSM Clock Ticks	TSM Expose (millisec)	1024x1024 Sample Times (sec)	64x64 Sample Times (sec)	128x128 Sample Times (sec)	256x256 Sample Times (sec)	512x512 Sample Times (sec)	EngTest Sample Times (sec)	1024x1024 Delta Sample Times (sec)
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	45985	47088.640	52.932742	47.189708	47.293570	47.623790	48.774214	52.910212	50.000451
3	45985	47088.640	102.933193	94.318642	94.474435	94.969765	96.695401	102.899398	50.000451
4	45985	47088.640	152.933644	141.447576	141.655300	142.315740	144.616588	152.888584	50.000451
5	45985	47088.640	202.934095	188.576510	188.836165	189.661715	192.537775	202.877770	50.000451
6	45985	47088.640	252.934546	235.705444	236.017030	237.007690	240.458962	252.866956	50.000451
7	45985	47088.640	302.934997	282.834378	283.197895	284.353665	288.380149	302.856142	50.000451
8	45985	47088.640	352.935448	329.963312	330.378760	331.699640	336.301336	352.845328	50.000451
9	45985	47088.640	402.935899	377.092246	377.559625	379.045615	384.222523	402.834514	50.000451
10	45985	47088.640	452.936350	424.221180	424.740490	426.391590	432.143710	452.823700	50.000451
11	45985	47088.640	502.936801	471.350114	471.921355	473.737565	480.064897	502.812886	50.000451
12	45985	47088.640	552.937252	518.479048	519.102220	521.083540	527.986084	552.802072	50.000451
13	45985	47088.640	602.937703	565.607982	566.283085	568.429515	575.907271	602.791258	50.000451
14	45985	47088.640	652.938154	612.736916	613.463950	615.775490	623.828458	652.780444	50.000451
15	45985	47088.640	702.938605	659.865850	660.644815	663.121465	671.749645	702.769630	50.000451



**SPARS100**

Readout	TSM Clock Ticks	TSM Expose (millisec)	1024x1024 Sample Times (sec)	64x64 Sample Times (sec)	128x128 Sample Times (sec)	256x256 Sample Times (sec)	512x512 Sample Times (sec)	EngTest Sample Times (sec)	1024x1024 Delta Sample Times (sec)
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	94813	97088.512	102.932614	97.189580	97.293442	97.623662	98.774086	102.910084	100.000323
3	94813	97088.512	202.932937	194.318386	194.474179	194.969509	196.695145	202.899142	100.000323
4	94813	97088.512	302.933260	291.447192	291.654916	292.315356	294.616204	302.888200	100.000323
5	94813	97088.512	402.933583	388.575998	388.835653	389.661203	392.537263	402.877258	100.000323
6	94813	97088.512	502.933906	485.704804	486.016390	487.007050	490.458322	502.866316	100.000323
7	94813	97088.512	602.934229	582.833610	583.197127	584.352897	588.379381	602.855374	100.000323
8	94813	97088.512	702.934552	679.962416	680.377864	681.698744	686.300440	702.844432	100.000323
9	94813	97088.512	802.934875	777.091222	777.558601	779.044591	784.221499	802.833490	100.000323
10	94813	97088.512	902.935198	874.220028	874.739338	876.390438	882.142558	902.822548	100.000323
11	94813	97088.512	1002.935521	971.348834	971.920075	973.736285	980.063617	1002.811606	100.000323
12	94813	97088.512	1102.935844	1068.477640	1069.100812	1071.082132	1077.984676	1102.800664	100.000323
13	94813	97088.512	1202.936167	1165.606446	1166.281549	1168.427979	1175.905735	1202.789722	100.000323
14	94813	97088.512	1302.936490	1262.735252	1263.462286	1265.773826	1273.826794	1302.778780	100.000323
15	94813	97088.512	1402.936813	1359.864058	1360.643023	1363.119673	1371.747853	1402.767838	100.000323

**SPARS200**

Readout	TSM Clock Ticks	TSM Expose (millisec)	1024x1024 Sample Times (sec)	64x64 Sample Times (sec)	128x128 Sample Times (sec)	256x256 Sample Times (sec)	512x512 Sample Times (sec)	EngTest Sample Times (sec)	1024x1024 Delta Sample Times (sec)
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	192469	197088.256	202.932358	197.189324	197.293186	197.623406	198.773830	202.909828	200.000067
3	192469	197088.256	402.932425	394.317874	394.473667	394.968997	396.694633	402.898630	200.000067
4	192469	197088.256	602.932492	591.446424	591.654148	592.314588	594.615436	602.887432	200.000067
5	192469	197088.256	802.932559	788.574974	788.834629	789.660179	792.536239	802.876234	200.000067
6	192469	197088.256	1002.932626	985.703524	986.015110	987.005770	990.457042	1002.865036	200.000067
7	192469	197088.256	1202.932693	1182.832074	1183.195591	1184.351361	1188.377845	1202.853838	200.000067
8	192469	197088.256	1402.932760	1379.960624	1380.376072	1381.696952	1386.298648	1402.842640	200.000067
9	192469	197088.256	1602.932827	1577.089174	1577.556553	1579.042543	1584.219451	1602.831442	200.000067
10	192469	197088.256	1802.932894	1774.217724	1774.737034	1776.388134	1782.140254	1802.820244	200.000067
11	192469	197088.256	2002.932961	1971.346274	1971.917515	1973.733725	1980.061057	2002.809046	200.000067
12	192469	197088.256	2202.933028	2168.474824	2169.097996	2171.079316	2177.981860	2202.797848	200.000067
13	192469	197088.256	2402.933095	2365.603374	2366.278477	2368.424907	2375.902663	2402.786650	200.000067
14	192469	197088.256	2602.933162	2562.731924	2563.458958	2565.770498	2573.823466	2602.775452	200.000067
15	192469	197088.256	2802.933229	2759.860474	2760.639439	2763.116089	2771.744269	2802.764254	200.000067

**STEP25**

Readout	TSM Clock Ticks	TSM Expose (millisec)	1024x1024 Sample Times (sec)	64x64 Sample Times (sec)	128x128 Sample Times (sec)	256x256 Sample Times (sec)	512x512 Sample Times (sec)	EngTest Sample Times (sec)	1024x1024 Delta Sample Times (sec)
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	20	20.480	5.864582	0.121548	0.225410	0.555630	1.706054	5.842052	2.932291
3	20	20.480	8.796873	0.182322	0.338115	0.833445	2.559081	8.763078	2.932291
4	20	20.480	11.729164	0.243096	0.450820	1.111260	3.412108	11.684104	2.932291
5	9364	9588.736	24.229711	9.872126	10.131781	10.957331	13.833391	24.173386	12.500547
6	21571	22088.704	49.230226	32.001124	32.312710	33.303370	36.754642	49.162636	25.000515
7	21571	22088.704	74.230741	54.130122	54.493639	55.649409	59.675893	74.151886	25.000515
8	21571	22088.704	99.231256	76.259120	76.674568	77.995448	82.597144	99.141136	25.000515
9	21571	22088.704	124.231771	98.388118	98.855497	100.341487	105.518395	124.130386	25.000515
10	21571	22088.704	149.232286	120.517116	121.036426	122.687526	128.439646	149.119636	25.000515
11	21571	22088.704	174.232801	142.646114	143.217355	145.033565	151.360897	174.108886	25.000515
12	21571	22088.704	199.233316	164.775112	165.398284	167.379604	174.282148	199.098136	25.000515
13	21571	22088.704	224.233831	186.904110	187.579213	189.725643	197.203399	224.087386	25.000515
14	21571	22088.704	249.234346	209.033108	209.760142	212.071682	220.124650	249.076636	25.000515
15	21571	22088.704	274.234861	231.162106	231.941071	234.417721	243.045901	274.065886	25.000515

**STEP50**

Readout	TSM Clock Ticks	TSM Expose (millisec)	1024x1024 Sample Times (sec)	64x64 Sample Times (sec)	128x128 Sample Times (sec)	256x256 Sample Times (sec)	512x512 Sample Times (sec)	EngTest Sample Times (sec)	1024x1024 Delta Sample Times (sec)
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	20	20.480	5.864582	0.121548	0.225410	0.555630	1.706054	5.842052	2.932291
3	20	20.480	8.796873	0.182322	0.338115	0.833445	2.559081	8.763078	2.932291
4	20	20.480	11.729164	0.243096	0.450820	1.111260	3.412108	11.684104	2.932291
5	9364	9588.736	24.229711	9.872126	10.131781	10.957331	13.833391	24.173386	12.500547
6	21571	22088.704	49.230226	32.001124	32.312710	33.303370	36.754642	49.162636	25.000515
7	45985	47088.640	99.230677	79.130058	79.493575	80.649345	84.675829	99.151822	50.000451
8	45985	47088.640	149.231128	126.258992	126.674440	127.995320	132.597016	149.141008	50.000451
9	45985	47088.640	199.231579	173.387926	173.855305	175.341295	180.518203	199.130194	50.000451
10	45985	47088.640	249.232030	220.516860	221.036170	222.687270	228.439390	249.119380	50.000451
11	45985	47088.640	299.232481	267.645794	268.217035	270.033245	276.360577	299.108566	50.000451
12	45985	47088.640	349.232932	314.774728	315.397900	317.379220	324.281764	349.097752	50.000451
13	45985	47088.640	399.233383	361.903662	362.578765	364.725195	372.202951	399.086938	50.000451
14	45985	47088.640	449.233834	409.032596	409.759630	412.071170	420.124138	449.076124	50.000451
15	45985	47088.640	499.234285	456.161530	456.940495	459.417145	468.045325	499.065310	50.000451

**STEP100**

Readout	TSM Clock Ticks	TSM Expose (millisec)	1024x1024 Sample Times (sec)	64x64 Sample Times (sec)	128x128 Sample Times (sec)	256x256 Sample Times (sec)	512x512 Sample Times (sec)	EngTest Sample Times (sec)	1024x1024 Delta Sample Times (sec)
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	20	20.480	5.864582	0.121548	0.225410	0.555630	1.706054	5.842052	2.932291
3	20	20.480	8.796873	0.182322	0.338115	0.833445	2.559081	8.763078	2.932291
4	20	20.480	11.729164	0.243096	0.450820	1.111260	3.412108	11.684104	2.932291
5	9364	9588.736	24.229711	9.872126	10.131781	10.957331	13.833391	24.173386	12.500547
6	21571	22088.704	49.230226	32.001124	32.312710	33.303370	36.754642	49.162636	25.000515
7	45985	47088.640	99.230677	79.130058	79.493575	80.649345	84.675829	99.151822	50.000451
8	94813	97088.512	199.231000	176.258864	176.674312	177.995192	182.596888	199.140880	100.000323
9	94813	97088.512	299.231323	273.387670	273.855049	275.341039	280.517947	299.129938	100.000323
10	94813	97088.512	399.231646	370.516476	371.035786	372.686886	378.439006	399.118996	100.000323
11	94813	97088.512	499.231969	467.645282	468.216523	470.032733	476.360065	499.108054	100.000323
12	94813	97088.512	599.232292	564.774088	565.397260	567.378580	574.281124	599.097112	100.000323
13	94813	97088.512	699.232615	661.902894	662.577997	664.724427	672.202183	699.086170	100.000323
14	94813	97088.512	799.232938	759.031700	759.758734	762.070274	770.123242	799.075228	100.000323
15	94813	97088.512	899.233261	856.160506	856.939471	859.416121	868.044301	899.064286	100.000323

**STEP200**

Readout	TSM Clock Ticks	TSM Expose (millisec)	1024x1024 Sample Times (sec)	64x64 Sample Times (sec)	128x128 Sample Times (sec)	256x256 Sample Times (sec)	512x512 Sample Times (sec)	EngTest Sample Times (sec)	1024x1024 Delta Sample Times (sec)
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	20	20.480	5.864582	0.121548	0.225410	0.555630	1.706054	5.842052	2.932291
3	20	20.480	8.796873	0.182322	0.338115	0.833445	2.559081	8.763078	2.932291
4	20	20.480	11.729164	0.243096	0.450820	1.111260	3.412108	11.684104	2.932291
5	9364	9588.736	24.229711	9.872126	10.131781	10.957331	13.833391	24.173386	12.500547
6	21571	22088.704	49.230226	32.001124	32.312710	33.303370	36.754642	49.162636	25.000515
7	45985	47088.640	99.230677	79.130058	79.493575	80.649345	84.675829	99.151822	50.000451
8	94813	97088.512	199.231000	176.258864	176.674312	177.995192	182.596888	199.140880	100.000323
9	192469	197088.256	399.231067	373.387414	373.854793	375.340783	380.517691	399.129682	200.000067
10	192469	197088.256	599.231134	570.515964	571.035274	572.686374	578.438494	599.118484	200.000067
11	192469	197088.256	799.231201	767.644514	768.215755	770.031965	776.359297	799.107286	200.000067
12	192469	197088.256	999.231268	964.773064	965.396236	967.377556	974.280100	999.096088	200.000067
13	192469	197088.256	1199.231335	1161.901614	1162.576717	1164.723147	1172.200903	1199.084890	200.000067
14	192469	197088.256	1399.231402	1359.030164	1359.757198	1362.068738	1370.121706	1399.073692	200.000067
15	192469	197088.256	1599.231469	1556.158714	1556.937679	1559.414329	1568.042509	1599.062494	200.000067

**STEP400**

Readout	TSM Clock Ticks	TSM Expose (millisec)	1024x1024 Sample Times (sec)	64x64 Sample Times (sec)	128x128 Sample Times (sec)	256x256 Sample Times (sec)	512x512 Sample Times (sec)	EngTest Sample Times (sec)	1024x1024 Delta Sample Times (sec)
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	20	20.480	5.864582	0.121548	0.225410	0.555630	1.706054	5.842052	2.932291
3	20	20.480	8.796873	0.182322	0.338115	0.833445	2.559081	8.763078	2.932291
4	20	20.480	11.729164	0.243096	0.450820	1.111260	3.412108	11.684104	2.932291
5	9364	9588.736	24.229711	9.872126	10.131781	10.957331	13.833391	24.173386	12.500547
6	21571	22088.704	49.230226	32.001124	32.312710	33.303370	36.754642	49.162636	25.000515
7	45985	47088.640	99.230677	79.130058	79.493575	80.649345	84.675829	99.151822	50.000451
8	94813	97088.512	199.231000	176.258864	176.674312	177.995192	182.596888	199.140880	100.000323
9	192469	197088.256	399.231067	373.387414	373.854793	375.340783	380.517691	399.129682	200.000067
10	387782	397088.768	799.231646	770.516476	771.035786	772.686886	778.439006	799.118996	400.000579
11	387782	397088.768	1199.232225	1167.645538	1168.216779	1170.032989	1176.360321	1199.108310	400.000579
12	387782	397088.768	1599.232804	1564.774600	1565.397772	1567.379092	1574.281636	1599.097624	400.000579
13	387782	397088.768	1999.233383	1961.903662	1962.578765	1964.725195	1972.202951	1999.086938	400.000579
14	387782	397088.768	2399.233962	2359.032724	2359.759758	2362.071298	2370.124266	2399.076252	400.000579
15	387782	397088.768	2799.234541	2756.161786	2756.940751	2759.417401	2768.045581	2799.065566	400.000579

**MIF600**

<b>Readout</b>	<b>TSM Clock Ticks</b>	<b>TSM Expose (millisec)</b>	<b>1024x1024 Sample Times (sec)</b>	<b>64x64 Sample Times (sec)</b>	<b>128x128 Sample Times (sec)</b>	<b>256x256 Sample Times (sec)</b>	<b>512x512 Sample Times (sec)</b>	<b>EngTest Sample Times (sec)</b>	<b>1024x1024 Delta Sample Times (sec)</b>
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	20	20.480	5.864582	0.121548	0.225410	0.555630	1.706054	5.842052	2.932291
3	20	20.480	8.796873	0.182322	0.338115	0.833445	2.559081	8.763078	2.932291
4	20	20.480	11.729164	0.243096	0.450820	1.111260	3.412108	11.684104	2.932291
5	20	20.480	14.661455	0.303870	0.563525	1.389075	4.265135	14.605130	2.932291
6	20	20.480	17.593746	0.364644	0.676230	1.666890	5.118162	17.526156	2.932291
7	135767	139025.408	159.530965	139.430346	139.793863	140.949633	144.976117	159.452110	141.937219
8	135767	139025.408	301.468184	278.496048	278.911496	280.232376	284.834072	301.378064	141.937219
9	135767	139025.408	443.405403	417.561750	418.029129	419.515119	424.692027	443.304018	141.937219
10	135767	139025.408	585.342622	556.627452	557.146762	558.797862	564.549982	585.229972	141.937219
11	20	20.480	588.274913	556.688226	557.259467	559.075677	565.403009	588.150998	2.932291
12	20	20.480	591.207204	556.749000	557.372172	559.353492	566.256036	591.072024	2.932291
13	20	20.480	594.139495	556.809774	557.484877	559.631307	567.109063	593.993050	2.932291
14	20	20.480	597.071786	556.870548	557.597582	559.909122	567.962090	596.914076	2.932291
15	20	20.480	600.004077	556.931322	557.710287	560.186937	568.815117	599.835102	2.932291



**MIF900**

<b>Readout</b>	<b>TSM Clock Ticks</b>	<b>TSM Expose (millisec)</b>	<b>1024x1024 Sample Times (sec)</b>	<b>64x64 Sample Times (sec)</b>	<b>128x128 Sample Times (sec)</b>	<b>256x256 Sample Times (sec)</b>	<b>512x512 Sample Times (sec)</b>	<b>EngTest Sample Times (sec)</b>	<b>1024x1024 Delta Sample Times (sec)</b>
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	20	20.480	5.864582	0.121548	0.225410	0.555630	1.706054	5.842052	2.932291
3	20	20.480	8.796873	0.182322	0.338115	0.833445	2.559081	8.763078	2.932291
4	20	20.480	11.729164	0.243096	0.450820	1.111260	3.412108	11.684104	2.932291
5	20	20.480	14.661455	0.303870	0.563525	1.389075	4.265135	14.605130	2.932291
6	20	20.480	17.593746	0.364644	0.676230	1.666890	5.118162	17.526156	2.932291
7	209009	214025.216	234.530773	214.430154	214.793671	215.949441	219.975925	234.451918	216.937027
8	209009	214025.216	451.467800	428.495664	428.911112	430.231992	434.833688	451.377680	216.937027
9	209009	214025.216	668.404827	642.561174	643.028553	644.514543	649.691451	668.303442	216.937027
10	209009	214025.216	885.341854	856.626684	857.145994	858.797094	864.549214	885.229204	216.937027
11	20	20.480	888.274145	856.687458	857.258699	859.074909	865.402241	888.150230	2.932291
12	20	20.480	891.206436	856.748232	857.371404	859.352724	866.255268	891.071256	2.932291
13	20	20.480	894.138727	856.809006	857.484109	859.630539	867.108295	893.992282	2.932291
14	20	20.480	897.071018	856.869780	857.596814	859.908354	867.961322	896.913308	2.932291
15	20	20.480	900.003309	856.930554	857.709519	860.186169	868.814349	899.834334	2.932291

**MIF1200**

<b>Readout</b>	<b>TSM Clock Ticks</b>	<b>TSM Expose (millisec)</b>	<b>1024x1024 Sample Times (sec)</b>	<b>64x64 Sample Times (sec)</b>	<b>128x128 Sample Times (sec)</b>	<b>256x256 Sample Times (sec)</b>	<b>512x512 Sample Times (sec)</b>	<b>EngTest Sample Times (sec)</b>	<b>1024x1024 Delta Sample Times (sec)</b>
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	20	20.480	5.864582	0.121548	0.225410	0.555630	1.706054	5.842052	2.932291
3	20	20.480	8.796873	0.182322	0.338115	0.833445	2.559081	8.763078	2.932291
4	20	20.480	11.729164	0.243096	0.450820	1.111260	3.412108	11.684104	2.932291
5	20	20.480	14.661455	0.303870	0.563525	1.389075	4.265135	14.605130	2.932291
6	20	20.480	17.593746	0.364644	0.676230	1.666890	5.118162	17.526156	2.932291
7	282251	289025.024	309.530581	289.429962	289.793479	290.949249	294.975733	309.451726	291.936835
8	282251	289025.024	601.467416	578.495280	578.910728	580.231608	584.833304	601.377296	291.936835
9	282251	289025.024	893.404251	867.560598	868.027977	869.513967	874.690875	893.302866	291.936835
10	282251	289025.024	1185.341086	1156.625916	1157.145226	1158.796326	1164.548446	1185.228436	291.936835
11	20	20.480	1188.273377	1156.686690	1157.257931	1159.074141	1165.401473	1188.149462	2.932291
12	20	20.480	1191.205668	1156.747464	1157.370636	1159.351956	1166.254500	1191.070488	2.932291
13	20	20.480	1194.137959	1156.808238	1157.483341	1159.629771	1167.107527	1193.991514	2.932291
14	20	20.480	1197.070250	1156.869012	1157.596046	1159.907586	1167.960554	1196.912540	2.932291
15	20	20.480	1200.002541	1156.929786	1157.708751	1160.185401	1168.813581	1199.833566	2.932291

**MIF1500**

<b>Readout</b>	<b>TSM Clock Ticks</b>	<b>TSM Expose (millisec)</b>	<b>1024x1024 Sample Times (sec)</b>	<b>64x64 Sample Times (sec)</b>	<b>128x128 Sample Times (sec)</b>	<b>256x256 Sample Times (sec)</b>	<b>512x512 Sample Times (sec)</b>	<b>EngTest Sample Times (sec)</b>	<b>1024x1024 Delta Sample Times (sec)</b>
0	----	----	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	20.480	2.932291	0.060774	0.112705	0.277815	0.853027	2.921026	2.932291
2	20	20.480	5.864582	0.121548	0.225410	0.555630	1.706054	5.842052	2.932291
3	20	20.480	8.796873	0.182322	0.338115	0.833445	2.559081	8.763078	2.932291
4	20	20.480	11.729164	0.243096	0.450820	1.111260	3.412108	11.684104	2.932291
5	20	20.480	14.661455	0.303870	0.563525	1.389075	4.265135	14.605130	2.932291
6	20	20.480	17.593746	0.364644	0.676230	1.666890	5.118162	17.526156	2.932291
7	355493	364024.832	384.530389	364.429770	364.793287	365.949057	369.975541	384.451534	366.936643
8	355493	364024.832	751.467032	728.494896	728.910344	730.231224	734.832920	751.376912	366.936643
9	355493	364024.832	1118.403675	1092.560022	1093.027401	1094.513391	1099.690299	1118.302290	366.936643
10	355493	364024.832	1485.340318	1456.625148	1457.144458	1458.795558	1464.547678	1485.227668	366.936643
11	20	20.480	1488.272609	1456.685922	1457.257163	1459.073373	1465.400705	1488.148694	2.932291
12	20	20.480	1491.204900	1456.746696	1457.369868	1459.351188	1466.253732	1491.069720	2.932291
13	20	20.480	1494.137191	1456.807470	1457.482573	1459.629003	1467.106759	1493.990746	2.932291
14	20	20.480	1497.069482	1456.868244	1457.595278	1459.906818	1467.959786	1496.911772	2.932291
15	20	20.480	1500.001773	1456.929018	1457.707983	1460.184633	1468.812813	1499.832798	2.932291