



## **APPLICATION NOTE 70**

# **TSA-SMA DIGITAL FILTER COEFFICIENTS**

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STEVE MANION**

**KINEMATICS, INC.  
222 VISTA AVENUE  
PASADENA, CA 91107  
(626) 795-2220**

This note documents the filter coefficients used in the digital filters of the TSA-SMA.

The TSA-SMA incorporates a dedicated sigma-delta analog to digital converter (ADC) for each channel, with each channel sampled simultaneously. As with most seismic digitizers, the final output sampling rate of the system is produced by low pass filtering and decimating the output from this ADC through a series of cascaded linear phase FIR filters. The TSA-SMA always uses two FIR filters after the ADC. The following table documents the output rates of each of the filters within the system:

<b>Final Sampling Rate</b>	<b>Final Filter Decimation Factor</b>	<b>Intermediate Sampling Rate</b>	<b>Intermediate Filter Decimation Factor</b>	<b>Initial Sampling Rate</b>
50	4	200	20	4000
100	4	400	10	4000
200	2	400	10	4000
250	2	500	8	4000
500	2	1000	4	4000

The initial sampling rate refers to the raw output rate from the sigma-delta ADC. This initial sampling rate is produced by the ADC integrated circuit using two filters that are internal to the chip. The first internal filter is a sinc<sup>5</sup> filter with an output rate of 32,000 samples per second. The second is an averaging filter (first order sinc filter) with an output rate of 4,000 samples per second.

The time delay associated with both the internal ADC filters and the external FIR filters are corrected for by the TSA-SMA so all data output by the system is time tagged with a time that has already been corrected for the group delay of all of the filters in the chain.

The final two FIR filters are both linear phase filters with an odd number of coefficients, numbered from 0 to n, and are symmetrical about the central coefficient. The filter data documented below takes advantage of this symmetry by specifying only the first (n+1)/2 unique filter coefficients. The remaining coefficients can be inferred from the symmetry. The data is specified as both a 32 bit hex integer and as a normalized double precision number. Note that the filter coefficients numbering starts from 0.

**Intermediate Sampling Rate Filters**  
**4000 Hz to 1000 Hz Decimation Filter**

This filter has 105 total taps as follows:

0xFFFFFD5C, 000, -0.000000314787  
0xFFFFF4D2, 001, -0.000001332723  
0xFFFFE14A, 002, -0.000003661029  
0xFFFFBF39, 003, -0.000007722061  
0xFFFF912B, 004, -0.000013212208  
0xFFFF6590, 005, -0.000018410385  
0xFFFF5ACF, 006, -0.000019692350  
0xFFFF9D69, 007, -0.000011752825  
0x00005C5A, 008, 0.000011009164  
0x0001B269, 009, 0.000051785726  
0x00038846, 010, 0.000107797794  
0x000579CD, 011, 0.000167107675  
0x0006CDC5, 012, 0.000207635108  
0x00068FD2, 013, 0.000200250186  
0x0003D538, 014, 0.000116970390  
0xFFFE25C5, 015, -0.000056532677  
0xFFF5EE94, 016, -0.000307252631  
0xFFECD22B, 017, -0.000585297588  
0xFFE5A2DE, 018, -0.000804559328  
0xFFE3E0A0, 019, -0.000858232379  
0xFFEAB593, 020, -0.000649741385  
0xFFFFB9F85, 021, -0.000133571681  
0x00152921, 022, 0.000645772088  
0x00323722, 023, 0.001532451250  
0x004A67B2, 024, 0.002270662226  
0x0053C863, 025, 0.002556846943  
0x0045BEBB, 026, 0.002128449734  
0x001C80D2, 027, 0.000869848765  
0xFFDC103D, 028, -0.001096697059  
0xFF917F5C, 029, -0.003372268751  
0xFF518371, 030, -0.005324907135  
0xFF33FC21, 031, -0.006226047408  
0xFF4D0D93, 032, -0.005461028311  
0xFFA56B31, 033, -0.002764321398  
0x00342812, 034, 0.001591690816  
0x00DC7DCA, 035, 0.006728862412  
0x01714D4C, 036, 0.011270200834  
0x01BEB480, 037, 0.013632357121  
0x01983CEB, 038, 0.012458433863

0x00E8673A, 039, 0.007092383690  
0xFFBD3FF0, 040, -0.002037055790  
0xFE4DB1D2, 041, -0.013253948651  
0xFCF4A0E1, 042, -0.023784532677  
0xFC21488F, 043, -0.030234270263  
0xFC3F4D84, 044, -0.029318151996  
0xFD9B9F0C, 045, -0.018688315526  
0x004CD298, 046, 0.002344440669  
0x0425811F, 047, 0.032394542824  
0x08B5385B, 048, 0.068030399736  
0x0D592E40, 049, 0.104284077883  
0x1159EB66, 050, 0.135556626134  
0x140FA339, 051, 0.156727221329  
0x1504ECD7, 052, 0.164212803822

**4000 Hz to 500 Hz Decimation Filter:**

This filter has 211 total taps as follows:

0xFFFFFFFF3F, 000, -0.000000089873  
0xFFFFFFFFE36, 001, -0.000000213273  
0xFFFFFFFFC3F, 002, -0.000000447500  
0xFFFFFFFF916, 003, -0.000000824220  
0xFFFFFFFF45F, 004, -0.000001386274  
0xFFFFFFFFEDCC, 005, -0.000002169982  
0xFFFFFFFFE52B, 006, -0.000003198627  
0xFFFFFFFFDA7D, 007, -0.000004471745  
0xFFFFFFFFCE11, 008, -0.000005952548  
0xFFFFFFFFC09D, 009, -0.000007556286  
0xFFFFFFFFB355, 010, -0.000009139534  
0xFFFFFFFFA7FA, 011, -0.000010493211  
0xFFFFFFFFA0DA, 012, -0.000011342578  
0xFFFFFFFFA0C3, 013, -0.000011353288  
0xFFFFFFFFAADF, 014, -0.000010148156  
0xFFFFFFFFC276, 015, -0.000007336028  
0xFFFFFFFFEA99, 016, -0.000002551358  
0x000025B5, 017, 0.000004495028  
0x0000751B, 018, 0.000013960060  
0x0000D873, 019, 0.000025802758  
0x00014D43, 020, 0.000039727893  
0x0001CE80, 021, 0.000055134296  
0x0002544A, 022, 0.000071083196  
0x0002D3E1, 023, 0.000086293090  
0x00033FDC, 024, 0.000099165365  
0x000388C3, 025, 0.000107856002  
0x00039DFA, 026, 0.000110385008  
0x00036F12, 027, 0.000104793347  
0x0002ED62, 028, 0.000089333393  
0x00020DE7, 029, 0.000062692445  
0x0000CB33, 030, 0.000024223235  
0xFFFF2756, 031, -0.000025828369  
0xFFFFD2D74, 032, -0.000086134300  
0xFFFFAF2EF, 033, -0.000154145528  
0xFFFF897D1, 034, -0.000226042699  
0xFFFF64658, 035, -0.000296790153  
0xFFFF4316C, 036, -0.000360319391  
0xFFFF29209, 037, -0.000409837347  
0xFFFF1A379, 038, -0.000438276213  
0xFFFF19EA7, 039, -0.000438850839

0xFFFF2B4A9, 040, -0.000405709725  
0xFFFF508ED, 041, -0.000334629323  
0xFFFF8AB79, 042, -0.000223699491  
0xFFFFD93CA, 043, -0.000073934905  
0x00039CDC, 044, 0.000110251829  
0x000A82FB, 045, 0.000320789870  
0x0011E3CA, 046, 0.000545953400  
0x001940FE, 047, 0.000770687126  
0x002005EB, 048, 0.000977267977  
0x00258FF6, 049, 0.001146311872  
0x0029399F, 050, 0.001258089673  
0x002A67A2, 051, 0.001294092275  
0x00289769, 052, 0.001238752622  
0x00236DBA, 053, 0.001081195660  
0x001AC482, 054, 0.000816882588  
0x000EB659, 055, 0.000448983628  
0xFFFFA686, 056, -0.000010666437  
0xFFEE4440, 057, -0.000541180372  
0xFFDB8840, 058, -0.001112908125  
0xFFC8AC02, 059, -0.001688479446  
0xFFB71A83, 060, -0.002224622760  
0xFFA85ADA, 061, -0.002674716525  
0xFF9DF588, 062, -0.002991970628  
0xFF9955EF, 063, -0.003133066464  
0xFF9BA9E3, 064, -0.003062023316  
0xFFA5C1AE, 065, -0.002754011191  
0xFFB7F30E, 066, -0.002198808827  
0xFFD201F0, 067, -0.001403577626  
0xFFFF3115F, 068, -0.000394657720  
0x00199EE4, 069, 0.000781880692  
0x004389EF, 070, 0.002061120700  
0x006E283B, 071, 0.003361729439  
0x00966715, 072, 0.004589925054  
0x00B8F896, 073, 0.005644868128  
0x00D28AC9, 074, 0.006425235886  
0x00E005BB, 075, 0.006836620625  
0x00DECCBC, 076, 0.006799308583  
0x00CCFE5B, 077, 0.006255907472  
0x00A9AE73, 078, 0.005178266671  
0x0075157E, 079, 0.003573118709  
0x0030B0D6, 080, 0.001485924236  
0xFFDF5031, 081, -0.000997520518

0xFF850DA8, 082, -0.003752034158  
0xFF272EF4, 083, -0.006616717204  
0xFECBEFF8, 084, -0.009401325136  
0xFE7A3856, 085, -0.011895139702  
0xFE393F57, 086, -0.013877947349  
0xFE1022EA, 087, -0.015132556669  
0xFE057795, 088, -0.015458156820  
0xFE1ED848, 089, -0.014683689922  
0xFE607D27, 090, -0.012680393178  
0xFECCE089, 091, -0.009372647386  
0xFF6478D3, 092, -0.004746338818  
0x00258CAD, 093, 0.001145920251  
0x010C25C7, 094, 0.008183214348  
0x02122471, 095, 0.016178660560  
0x032F7457, 096, 0.024885694962  
0x045A6077, 097, 0.034008081537  
0x05880274, 098, 0.043213183060  
0x06ACC765, 099, 0.052147793118  
0x07BD02D3, 100, 0.060455658939  
0x08AD876A, 101, 0.067795683630  
0x09743C66, 102, 0.073859739117  
0x0A08A6B9, 103, 0.078389015514  
0x0A645DA5, 104, 0.081187921111  
0x0A836390, 105, 0.082134671509

#### 4000 Hz to 400 Hz Decimation Filter

This filter has 265 total taps as follows:

0xFFFFFFFF75, 000, -0.000000064727  
0xFFFFFFFFEEF, 001, -0.000000127126  
0xFFFFFFFFDF2, 002, -0.000000244938  
0xFFFFFFFFC6E, 003, -0.000000425614  
0xFFFFFFFFA3B, 004, -0.000000687782  
0xFFFFFFFF730, 005, -0.000001050532  
0xFFFFFFFF328, 006, -0.000001531094  
0xFFFFFFFFE03, 007, -0.000002144370  
0xFFFFFFFF7AD, 008, -0.000002899673  
0xFFFFFFFFE025, 009, -0.000003797468  
0xFFFFFFFFD788, 010, -0.000004824251  
0xFFFFFFFFCE0F, 011, -0.000005953480  
0xFFFFFFFFC41E, 012, -0.000007138588  
0xFFFFFFFFBA47, 013, -0.000008311588  
0xFFFFFFFFB14D, 014, -0.000009381678  
0xFFFFFFFFAA22, 015, -0.000010236166  
0xFFFFFFFFA5EC, 016, -0.000010738149  
0xFFFFFFFFA5F4, 017, -0.000010734424  
0xFFFFFFFFABA2, 018, -0.000010057352  
0xFFFFFFFFB863, 019, -0.000008536968  
0xFFFFFFFFCD9B, 020, -0.000006007496  
0xFFFFFFFFEC80, 021, -0.000002324581  
0x000015FF, 022, 0.000002622139  
0x00004A98, 023, 0.000008892268  
0x00008A37, 024, 0.000016476493  
0x0000D414, 025, 0.000025281683  
0x0001268F, 026, 0.000035114121  
0x00017F20, 027, 0.000045672059  
0x0001DA3E, 028, 0.000056534074  
0x00023369, 029, 0.000067163724  
0x00028530, 030, 0.000076912344  
0x0002C957, 031, 0.000085036736  
0x0002F90C, 032, 0.000090723857  
0x00030D32, 033, 0.000093125738  
0x0002FEBA, 034, 0.000091400929  
0x0002C717, 035, 0.000084768515  
0x000260B8, 036, 0.000072564930  
0x0001C78D, 037, 0.000054305885  
0x0000F992, 038, 0.000029751100  
0xFFFFFFFF74B, 039, -0.000001037959



0xFFFFEC43B, 040, -0.000037642661  
0xFFFFD673A, 041, -0.000079247169  
0xFFFFBEAAB, 042, -0.000124613289  
0xFFFFA5C8D, 043, -0.000172072556  
0xFFFF8CE4A, 044, -0.000219549052  
0xFFFF7545E, 045, -0.000264600851  
0xFFFF605B2, 046, -0.000304496847  
0xFFFF4FAC0, 047, -0.000336319208  
0xFFFF44C7F, 048, -0.000357091893  
0xFFFF41312, 049, -0.000363937579  
0xFFFF4645D, 050, -0.000354246702  
0xFFFF55272, 051, -0.000325865112  
0xFFFF6EA05, 052, -0.000277278479  
0xFFFF930E5, 053, -0.000207794365  
0xFFFFC24A8, 054, -0.000117700547  
0xFFFFFB98E, 055, -0.000008397736  
0x0003D9C7, 056, 0.000117513817  
0x00086526, 057, 0.000256198458  
0x000D3159, 058, 0.000402611215  
0x00120AB8, 059, 0.000550594181  
0x0016B5B2, 060, 0.000693046488  
0x001AF0D3, 061, 0.000822165515  
0x001E7762, 062, 0.000929758884  
0x00210485, 063, 0.001007618848  
0x002256D1, 064, 0.001047946978  
0x00223418, 065, 0.001043807715  
0x00206D5C, 066, 0.000989599153  
0x001CE2A1, 067, 0.000881508458  
0x00178674, 068, 0.000717932358  
0x001060E9, 069, 0.000499833841  
0x000791D6, 070, 0.000231008045  
0xFFFFD5216, 071, -0.000081767328  
0xFFFF1F3AE, 072, -0.000428714789  
0xFFE5E0A4, 073, -0.000797195360  
0xFFD99883, 074, -0.001172004733  
0xFFCDAC6F, 075, -0.001535840798  
0xFFC2B9F8, 076, -0.001869920641  
0xFFB964A1, 077, -0.002154752146  
0xFFB24E77, 078, -0.002371017355  
0xFFAE0FE2, 079, -0.002500548027  
0xFFAD2F0B, 080, -0.002527351025  
0xFFB0174C, 081, -0.002438629046

0xFFB71100, 082, -0.002225756645  
0xFFC23A36, 083, -0.001885150559  
0xFFD180B9, 084, -0.001418981235  
0xFFE49DD4, 085, -0.000835677609  
0xFFFFB1434, 086, -0.000150179490  
0x00143043, 087, 0.000616104808  
0x002F0B20, 088, 0.001435652375  
0x004A905E, 089, 0.002275510691  
0x0065867D, 090, 0.003098307643  
0x007E9A00, 091, 0.003863573074  
0x00946AC0, 092, 0.004529327154  
0x00A59B2D, 093, 0.005053898785  
0x00B0E0D5, 094, 0.005397895817  
0x00B5159C, 095, 0.005526257679  
0x00B148DE, 096, 0.005410297774  
0x00A4CFB7, 097, 0.005029644351  
0x008F539F, 098, 0.004373982083  
0x0070DE8F, 099, 0.003444499802  
0x0049E3FA, 100, 0.002254960127  
0x001B45EA, 101, 0.000832309015  
0xFFE655D0, 102, -0.000783227384  
0xFFACD09A, 103, -0.002538609318  
0xFF70D5FD, 104, -0.004369021859  
0xFF34DAED, 105, -0.006199487951  
0xFEFB9791, 106, -0.007947019767  
0xFEC7F129, 107, -0.009523253422  
0xFE9CE099, 108, -0.010837483685  
0xFE7D5672, 109, -0.011799997650  
0xFE6C1D87, 110, -0.012325581629  
0xFE6BBD25, 111, -0.012337071355  
0xFE7E5C2A, 112, -0.011768798344  
0FEA5A643, 113, -0.010569779668  
0xFEE2B45C, 114, -0.008706526831  
0xFF35F98D, 115, -0.006165319588  
0xFF9F3557, 116, -0.002953846473  
0x001D6C02, 117, 0.000897885300  
0x00AEE5B6, 118, 0.005337442271  
0x0151347E, 119, 0.010290681385  
0x0201415B, 120, 0.015663308557  
0x02BB5FF7, 121, 0.021343227010  
0x037B6891, 122, 0.027203627396  
0x043CD72E, 123, 0.033106706105

0x04FAEF0A, 124, 0.038907890208  
0x05B0E111, 125, 0.044460423756  
0x0659F3D9, 126, 0.049620133359  
0x06F1ABC0, 127, 0.054250210524  
0x0773F188, 128, 0.058225814253  
0x07DD3606, 129, 0.061438324861  
0x082A9179, 130, 0.063799079973  
0x0859DD4D, 131, 0.065242445562  
0x0869C744, 132, 0.065728100017

#### 4000 Hz to 200 Hz Decimation Filter

This filter has 503 total taps as follows:

0xFFFFFFFFBC, 000, -0.000000031665  
0xFFFFFFFFF0, 001, -0.000000007451  
0xFFFFFFFFF5, 002, -0.000000005122  
0x00000000, 003, 0.000000000000  
0x00000013, 004, 0.000000008848  
0x00000030, 005, 0.000000022352  
0x0000005C, 006, 0.000000042841  
0x00000099, 007, 0.000000071246  
0x000000EB, 008, 0.000000109430  
0x00000157, 009, 0.000000159722  
0x000001E2, 010, 0.000000224449  
0x00000292, 011, 0.000000306405  
0x0000036E, 012, 0.000000408851  
0x0000047C, 013, 0.000000534579  
0x000005C4, 014, 0.000000687316  
0x0000074D, 015, 0.000000870321  
0x00000922, 016, 0.000001088716  
0x00000B49, 017, 0.000001345295  
0x00000DCC, 018, 0.000001644716  
0x000010B5, 019, 0.000001991633  
0x0000140B, 020, 0.000002389308  
0x000017D9, 021, 0.000002842862  
0x00001C27, 022, 0.000003356021  
0x000020FC, 023, 0.000003932044  
0x00002660, 024, 0.000004574656  
0x00002C59, 025, 0.000005286653  
0x000032EA, 026, 0.000006069429  
0x00003A17, 027, 0.000006924849  
0x000041E1, 028, 0.000007853378  
0x00004A47, 029, 0.000008854549  
0x00005344, 030, 0.000009926036  
0x00005CD2, 031, 0.000011065044  
0x000066E7, 032, 0.000012266915  
0x00007175, 033, 0.000013525132  
0x00007C6B, 034, 0.000014831778  
0x000087B3, 035, 0.000016176607  
0x00009335, 036, 0.000017548446  
0x00009ED3, 037, 0.000018933322  
0x0000AA69, 038, 0.000020314474  
0x0000B5D3, 039, 0.000021675136

0x0000C0E3, 040, 0.000022993889  
0x0000CB6B, 041, 0.000024249312  
0x0000D536, 042, 0.000025416724  
0x0000DE0C, 043, 0.000026470050  
0x0000E5B2, 044, 0.000027381815  
0x0000EBE8, 045, 0.000028122216  
0x0000F06D, 046, 0.000028660987  
0x0000F2FC, 047, 0.000028965995  
0x0000F351, 048, 0.000029005576  
0x0000F126, 049, 0.000028747134  
0x0000EC35, 050, 0.000028158072  
0x0000E43B, 051, 0.000027207192  
0x0000D8F6, 052, 0.000025863759  
0x0000CA29, 053, 0.000024099369  
0x0000B79C, 054, 0.000021887943  
0x0000A11C, 055, 0.000019205734  
0x00008680, 056, 0.000016033649  
0x000067A6, 057, 0.000012355857  
0x0000447A, 058, 0.000008163042  
0x00001CEF, 059, 0.000003449153  
0xFFFFF10B, 060, -0.000001783017  
0xFFFFC0DF, 061, -0.000007525552  
0xFFFF8C8D, 062, -0.000013762619  
0xFFFF5449, 063, -0.000020470005  
0xFFFF1858, 064, -0.000027615577  
0xFFFFD913, 065, -0.000035157893  
0xFFFFE96E5, 066, -0.000043047126  
0xFFFFE5250, 067, -0.000051222742  
0xFFFFE0BE8, 068, -0.000059615821  
0xFFFFDC456, 069, -0.000068147667  
0xFFFFD7C55, 070, -0.000076731201  
0xFFFFD34B7, 071, -0.000085268635  
0xFFFFCEE5C, 072, -0.000093655661  
0xFFFFCAA38, 073, -0.000101778656  
0xFFFFC694C, 074, -0.000109517947  
0xFFFFC2CA9, 075, -0.000116746407  
0xFFFFBF566, 076, -0.000123334117  
0xFFFFBC4A6, 077, -0.000129145570  
0xFFFFB9B90, 078, -0.000134043396  
0xFFFFB7B4B, 079, -0.000137890223  
0xFFFFB64FD, 080, -0.000140549149  
0xFFFFB59C5, 081, -0.000141886529

0xFFFFB5AB9, 082, -0.000141772907  
0xFFFFB68DD, 083, -0.000140087213  
0xFFFFB8524, 084, -0.000136716291  
0xFFFFBB068, 085, -0.000131558627  
0xFFFFBEB64, 086, -0.000124527141  
0xFFFFC36B3, 087, -0.000115549657  
0xFFFFC92CA, 088, -0.000104571693  
0xFFFFCFFEF, 089, -0.000091560651  
0xFFFFD7E3C, 090, -0.000076504424  
0xFFFFE0D96, 091, -0.000059415586  
0xFFFFEADAA, 092, -0.000040332787  
0xFFFFF5DEC, 093, -0.000019321218  
0x00001D90, 094, 0.000003524125  
0x0000EB8D, 095, 0.000028079841  
0x0001C697, 096, 0.000054191332  
0x0002AD23, 097, 0.000081674661  
0x00039D61, 098, 0.000110313762  
0x00049543, 099, 0.000139863696  
0x0005927B, 100, 0.000170049723  
0x0006927F, 101, 0.000200569164  
0x0007928C, 102, 0.000231092796  
0x00088FAE, 103, 0.000261268578  
0x000986C1, 104, 0.000290722121  
0x000A747A, 105, 0.000319060870  
0x000B5570, 106, 0.000345878303  
0x000C2622, 107, 0.000370756723  
0x000CE303, 108, 0.000393272843  
0x000D8882, 109, 0.000413001515  
0x000E1317, 110, 0.000429521780  
0x000E7F4E, 111, 0.000442421995  
0x000EC9D3, 112, 0.000451305415  
0x000EEF7E, 113, 0.000455795787  
0x000EED63, 114, 0.000455544796  
0x000EC0DA, 115, 0.000450235792  
0x000E6790, 116, 0.000439591706  
0x000DDF93, 117, 0.000423380639  
0x000D275E, 118, 0.000401421450  
0x000C3DE3, 119, 0.000373588409  
0x000B2299, 120, 0.000339817721  
0x0009D585, 121, 0.000300111715  
0x00085742, 122, 0.000254542567  
0x0006A909, 123, 0.000203256030

0x0004CCBA, 124, 0.000146475621  
0x0002C4DA, 125, 0.000084501691  
0x0000949E, 126, 0.000017716549  
0xFFFFE3FE5, 127, -0.000053418335  
0xFFFFBCB39, 128, -0.000128361862  
0xFFFF93BCD, 129, -0.000206494238  
0xFFFF69775, 130, -0.000287120696  
0xFFFF3E49D, 131, -0.000369475689  
0xFFFF12A43, 132, -0.000452725682  
0xFFEE6FE6, 133, -0.000535977073  
0xFFEBBD77, 134, -0.000618283171  
0xFFE91B4A, 135, -0.000698651187  
0xFFE69202, 136, -0.000776051544  
0xFFE42A77, 137, -0.000849429984  
0xFFE1EDA5, 138, -0.000917715486  
0xFFDFE48E, 139, -0.000979834236  
0xFFDE181F, 140, -0.001034722198  
0xFFDC9117, 141, -0.001081336755  
0xFFDB57E8, 142, -0.001118671149  
0xFFDA749A, 143, -0.001145767979  
0xFFD9EEAA, 144, -0.001161734574  
0xFFD9CCF1, 145, -0.001165754627  
0xFFDA1580, 146, -0.001157104969  
0xFFDACD89, 147, -0.001135166269  
0xFFDBF93E, 148, -0.001099438407  
0xFFDD9BBA, 149, -0.001049551181  
0xFFDFB6E5, 150, -0.000985277351  
0xFFE24B64, 151, -0.000906540081  
0xFFE5587D, 152, -0.000813425984  
0xFFE8DC0C, 153, -0.000706190243  
0xFFECD276, 154, -0.000585262664  
0xFFFF1369D, 155, -0.000451253261  
0xFFFF601DB, 156, -0.000304954592  
0xFFFFB2C03, 157, -0.000147341285  
0x0000AB63, 158, 0.000020430889  
0x000674CA, 159, 0.000197027810  
0x000C7B9B, 160, 0.000380945858  
0x0012B1D7, 161, 0.000570516568  
0x00190839, 162, 0.000763919670  
0x001F6E50, 163, 0.000959195197  
0x0025D29F, 164, 0.001154258382  
0x002C22C2, 165, 0.001346916892

0x00324B9A, 166, 0.001534891315  
0x00383974, 167, 0.001715833321  
0x003DD844, 168, 0.001887353137  
0x004313D2, 169, 0.002047040500  
0x0047D7F4, 170, 0.002192491665  
0x004C10CA, 171, 0.002321337350  
0x004FAAFA, 172, 0.002431270666  
0x005293EC, 173, 0.002520075068  
0x0054BA0B, 174, 0.002585654613  
0x00560D00, 175, 0.002626061440  
0x00567DF5, 176, 0.002639526967  
0x0055FFCC, 177, 0.002624487504  
0x0054875D, 178, 0.002579613123  
0x00520BAF, 179, 0.002503834199  
0x004E8629, 180, 0.002396364231  
0x0049F2C2, 181, 0.002256722189  
0x00445031, 182, 0.002084754873  
0x003DA00E, 183, 0.001880652271  
0x0035E6F2, 184, 0.001644962467  
0x002D2C95, 185, 0.001378605608  
0x00237BD6, 186, 0.001082877629  
0x0018E2CF, 187, 0.000759459566  
0x000D72D1, 188, 0.000410415698  
0x0001405C, 189, 0.000038189813  
0xFFFF46318, 190, -0.000354398042  
0xFFE6F5B1, 191, -0.000764168333  
0xFFD915C2, 192, -0.001187591814  
0xFFCAE3A2, 193, -0.001620813273  
0xFFBC8238, 194, -0.002059672028  
0xFFAE16BC, 195, -0.002499731258  
0xFF9FC878, 196, -0.002936307341  
0xFF91C07B, 197, -0.003364505712  
0xFF842946, 198, -0.003779259510  
0xFF772E7A, 199, -0.004175367765  
0xFF6AFC72, 200, -0.004547542892  
0xFF5FBFE7, 201, -0.004890453536  
0xFF55A584, 202, -0.005198774859  
0xFF4CD97F, 203, -0.005467236508  
0xFF458729, 204, -0.005690674763  
0xFF3FD886, 205, -0.005864080973  
0xFF3BF5D5, 206, -0.005982657429  
0xFF3A052E, 207, -0.006041863002



0xFF3A2A0F, 208, -0.006037466694  
0xFF3C84F7, 209, -0.005965594668  
0xFF413302, 210, -0.005822776817  
0xFF484D89, 211, -0.005605991464  
0xFF51E9CF, 212, -0.005312704016  
0xFF5E18AB, 213, -0.004940907005  
0xFF6CE640, 214, -0.004489153624  
0xFF7E59C4, 215, -0.003956584260  
0xFF927546, 216, -0.003342953511  
0xFFA93584, 217, -0.002648649737  
0xFFC291D0, 218, -0.001874707639  
0xFFDE7BFC, 219, -0.001022817567  
0xFFFFCE053, 220, -0.000095328782  
0x001DA5A3, 221, 0.000904755201  
0x0040AD4C, 222, 0.001973783597  
0x0065D364, 223, 0.003107475117  
0x008CEEE5, 224, 0.004300939385  
0x00B5D1E4, 225, 0.005548702553  
0x00E049DB, 226, 0.006844741758  
0x010C1FF9, 227, 0.008182522375  
0x0139197F, 228, 0.009555041324  
0x0166F82A, 229, 0.010954876430  
0x01957AA3, 230, 0.012374238577  
0x01C45CFA, 231, 0.013805028982  
0x01F35928, 232, 0.015238899738  
0x02222797, 233, 0.016667317133  
0x02507FB0, 234, 0.018081627786  
0x027E186D, 235, 0.019473126624  
0x02AAA8EC, 236, 0.020833125338  
0x02D5E907, 237, 0.022153023165  
0x02FF91EA, 238, 0.023424376734  
0x03275EA5, 239, 0.024638968054  
0x034D0CC0, 240, 0.025788873434  
0x03705CC5, 241, 0.026866527740  
0x039112CD, 242, 0.027864790056  
0x03AEF6FA, 243, 0.028777000494  
0x03C9D5F6, 244, 0.029597039334  
0x03E1815F, 245, 0.030319377314  
0x03F5D02B, 246, 0.030939122196  
0x04069F04, 247, 0.031452061608  
0x0413D096, 248, 0.031854699366  
0x041D4DCB, 249, 0.032144283410

0x04230602, 250, 0.032318831421

0x0424EF33, 251, 0.032377147581

## Final Sampling Rate Filters

### 2x Low Pass Decimation Filter

This filter has 139 total taps as follows:

0x00000B29, 000, 0.000001330394  
0x00004073, 001, 0.000007682946  
0x0000A431, 002, 0.000019573141  
0x0000D8B2, 003, 0.000025832094  
0x000054D9, 004, 0.000010114629  
0xFFFF4E60, 005, -0.000021174550  
0xFFFF0DDB, 006, -0.000028865878  
0x00005C30, 007, 0.000010989606  
0x0001ABCO, 008, 0.000050991774  
0x00008FCF, 009, 0.000017143320  
0xFFFFD94B, 010, -0.000065649394  
0xFFFFD2F2, 011, -0.000066406094  
0x0001D9F9, 012, 0.000056501944  
0x000441AD, 013, 0.000129899476  
0xFFFFC6AB, 014, -0.000006834511  
0xFFFF9D08C, 015, -0.000188762322  
0xFFFFCECDC, 016, -0.000093834475  
0x0006F9BC, 017, 0.000212876126  
0x0007ED96, 018, 0.000241945498  
0xFFFA8FB8, 019, -0.000165972859  
0xFFF2761B, 020, -0.000413166825  
0x00008249, 021, 0.000015531201  
0x0012567E, 022, 0.000559627078  
0x000850D4, 023, 0.000253776088  
0xFFEBE33C, 024, -0.000613780692  
0xFFEB7CCC, 025, -0.000625992194  
0x00106616, 026, 0.000500450842  
0x00223042, 027, 0.001043350436  
0xFFFADE5B, 028, -0.000156598631  
0xFFD1FF07, 029, -0.001403924543  
0xFFF17292, 030, -0.000444105826  
0x00337C85, 031, 0.001571240369  
0x002985FB, 032, 0.001267192420  
0xFFD23517, 033, -0.001397479791  
0xFFB7E3CA, 034, -0.002200628631  
0x0018DC4B, 035, 0.000758682843  
0x006404CE, 036, 0.003052330576  
0x000D36E5, 037, 0.000403272454  
0xFF8B1C60, 038, -0.003567174077

0xFFBD2475, 039, -0.002040331718  
0x00718CA7, 040, 0.003465253394  
0x00821465, 041, 0.003969716374  
0xFFAE2195, 042, -0.002498438116  
0xFF3FC0D5, 043, -0.005866905209  
0x0010F49E, 044, 0.000517441891  
0x00EEC8AB, 045, 0.007287105080  
0x0050AFC9, 046, 0.002462361474  
0xFF031FEE, 047, -0.007717140950  
0xFF348269, 048, -0.006210039835  
0x00D9FF85, 049, 0.006652774755  
0x015004A6, 050, 0.010254460387  
0xFF870B35, 051, -0.003691290971  
0xFE38BAEA, 052, -0.013893733732  
0xFFD2DAFB, 053, -0.001377704088  
0x02140157, 054, 0.016235511284  
0x01168ACF, 055, 0.008500433993  
0xFDEB6BFF, 056, -0.016252995003  
0xFDC85C55, 057, -0.017322977539  
0x01A4081C, 058, 0.012818349525  
0x037B5E6B, 059, 0.027202417608  
0xFF686AAC, 060, -0.004625955597  
0xFB3ACB37, 061, -0.037268255372  
0xFEB07301, 062, -0.010240196716  
0x05F49E3C, 063, 0.046527652070  
0x049D7747, 064, 0.036055478733  
0xF9168DE3, 065, -0.053999199066  
0xF4AC46A6, 066, -0.088492554612  
0x07888303, 067, 0.058853508439  
0x27F80FC1, 068, 0.312257737387  
0x38405717, 069, 0.439463506918

#### 4x Low Pass Decimation Filter

This filter has 277 total taps as follows:

0x000001A9, 000, 0.000000197906  
0x000005B3, 001, 0.000000679400  
0x00000D3B, 002, 0.000001577195  
0x000017AD, 003, 0.000002822373  
0x00002200, 004, 0.000004053116  
0x0000267B, 005, 0.000004587229  
0x00001DFB, 006, 0.000003573950  
0x000002F4, 007, 0.000000352040  
0xFFFFD54A, 008, -0.000005091541  
0xFFFF9D56, 009, -0.000011761673  
0xFFFF6BFE, 010, -0.000017643906  
0xFFFF566A, 011, -0.000020216219  
0xFFFF6DC0, 012, -0.000017434359  
0xFFFFB58B, 013, -0.000008875970  
0x00001D4A, 014, 0.000003491528  
0x00008194, 015, 0.000015446916  
0x0000B6DB, 016, 0.000021798071  
0x00009B8E, 017, 0.000018543564  
0x00002AC3, 018, 0.000005097594  
0xFFFF863D, 019, -0.000014515128  
0xFFFEF04C, 020, -0.000032389536  
0xFFFE841F, 021, -0.000039563049  
0xFFFF039A, 022, -0.000030088238  
0xFFFFD912, 023, -0.000004640780  
0x0000ECF5, 024, 0.000028247479  
0x0001C968, 025, 0.000054527074  
0x0001F94E, 026, 0.000060237013  
0x00014198, 027, 0.000038336962  
0xFFFFCAC3, 028, -0.000006346498  
0xFFFE2241, 029, -0.000056951772  
0xFFFFD0A75, 030, -0.000090306159  
0xFFFFD268C, 031, -0.000086957589  
0xFFFEA470, 032, -0.000041432679  
0x00010F38, 033, 0.000032331795  
0x000368C6, 034, 0.000104042701  
0x00048BE4, 035, 0.000138746575  
0x0003B43B, 036, 0.000113037881  
0x0000F014, 037, 0.000028619543  
0xFFFFD3F58, 038, -0.000084001571  
0xFFFA417B, 039, -0.000175299589

0xFFFF98676, 040, -0.000197594054  
0xFFFFBC8E4, 041, -0.000128639862  
0x00006EE7, 042, 0.000013220590  
0x00059C99, 043, 0.000171255786  
0x0008E774, 044, 0.000271731988  
0x00086CDD, 045, 0.000257118139  
0x0003D2F0, 046, 0.000116698444  
0xFFFFCB1B9, 047, -0.000100884121  
0xFFFF61931, 048, -0.000302172732  
0xFFFF34C9F, 049, -0.000387594569  
0xFFFF633C4, 050, -0.000299004838  
0xFFFE3A34, 051, -0.000054096803  
0x00083AF2, 052, 0.000251167454  
0x000FA98C, 053, 0.000477975234  
0x00109525, 054, 0.000506060664  
0x0009A85C, 055, 0.000294728205  
0xFFFFD2B2A, 056, -0.000086407177  
0xFFFF06552, 057, -0.000476202928  
0xFFE97585, 058, -0.000687894877  
0xFFEC75CD, 059, -0.000596308615  
0xFFFF93A97, 060, -0.000206638593  
0x000ADA42, 061, 0.000331194140  
0x00197366, 062, 0.000776696019  
0x001D9E33, 063, 0.000903868582  
0x001411C8, 064, 0.000612471253  
0xFFFFBD81, 065, -0.000007926952  
0xFFE91F96, 066, -0.000698138960  
0xFFDAD4E0, 067, -0.001134291291  
0xFFDCB798, 068, -0.001076746732  
0xFFEFC010, 069, -0.000495903194  
0x000CBEFD, 070, 0.000388978515  
0x0026E4F2, 071, 0.001186960377  
0x00314DAE, 072, 0.001504621468  
0x00253740, 073, 0.001135736704  
0x0005F502, 074, 0.000181795098  
0xFFE07343, 075, -0.000962822232  
0xFFC6097C, 076, -0.001768888906  
0xFFC498AA, 077, -0.001812855713  
0xFFDF7ACC, 078, -0.000992441550  
0x000CC512, 079, 0.000389703549  
0x0038A6BA, 080, 0.001728859730  
0x004DE9CE, 081, 0.002377725206

0x00400470, 082, 0.001953653991  
0x001207E9, 083, 0.000550259370  
0xFFD6C16B, 084, -0.001258681063  
0xFFA9497F, 085, -0.002646267880  
0xFFA0D304, 086, -0.002904532477  
0xFFC51EFC, 087, -0.001796843484  
0x00093682, 088, 0.000281156041  
0x004F95D5, 089, 0.002428750042  
0x0076B71D, 090, 0.003622903023  
0x0068C7A6, 091, 0.003197628073  
0x002748A5, 092, 0.001198845450  
0xFFCC9DD9, 093, -0.001568097156  
0xFF81CF23, 094, -0.003851039801  
0xFF6C43A4, 095, -0.004508538172  
0xFF9B75B6, 096, -0.003068243153  
0xFFFF677A, 097, -0.000018182211  
0x006D4419, 098, 0.003334533889  
0x00B151EA, 099, 0.005411376245  
0x00A6E277, 100, 0.005092914682  
0x004B5B67, 101, 0.002299714368  
0xFFC2C263, 102, -0.001868917141  
0xFF4A3AC2, 103, -0.005547194742  
0xFF1D2EAE, 104, -0.006921925582  
0xFF58AFBF, 105, -0.005106002558  
0xFFEA8FD0, 106, -0.000654242933  
0x009567B7, 107, 0.004559482913  
0x0109AB2E, 108, 0.008107564412  
0x0109E60E, 109, 0.008114582859  
0x0089F992, 110, 0.004210659303  
0xFFB9FAD4, 111, -0.002136847004  
0xFE57A35, 112, -0.008133625146  
0xFE9C566F, 113, -0.010853954125  
0xFEE56293, 114, -0.008624723647  
0xFFBFB855, 115, -0.001961668488  
0x00D2C93A, 116, 0.006432679482  
0x01A075BD, 117, 0.012709347997  
0x01BCD11B, 118, 0.013574732002  
0x0103C065, 119, 0.007926987950  
0xFFB30C27, 120, -0.002348404843  
0xFE597C75, 121, -0.012894099113  
0xFD9DBEE3, 122, -0.018623484764  
0xFDF2AC0C, 123, -0.016031736508

0xFF598B59, 124, -0.005079824012  
0x01507132, 125, 0.010267400183  
0x02FA8E82, 126, 0.023271382786  
0x037820F1, 127, 0.027103536297  
0x024D8683, 128, 0.017990888562  
0xFFAE9A67, 129, -0.002484035213  
0xFC8A7AFA, 130, -0.027023914270  
0xFA4AAEC8, 131, -0.044595863670  
0xFA56FB4E, 132, -0.044220530428  
0xFD890F81, 133, -0.019254743587  
0x03C5700C, 134, 0.029462819919  
0x0BE4AA75, 135, 0.092915827874  
0x13FBBA65, 136, 0.156119632069  
0x19EF1924, 137, 0.202609198168  
0x1C1ED986, 138, 0.219691458158