Indian Institute of Technology Kanpur
EE-301A Digital Signal Processing 2017-18-a

Assignment Number: 2
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QUESTION
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1 Solving for Optimal Finite-Length Equalizer($\tilde{g}_{opt,FL}$) Coefficients

1.1 Equation for computation of $\tilde{g}_{opt,FL}$ coefficients

The scalar equations for calculation of $\tilde{g}_{opt,FL}$ coefficients are as given below:-

$$\sum_{k=1}^{L} \tilde{\mathbf{g}}_{opt,FL}\mathbf{R}_{vv,j-k} = \sum_{k=1}^{9} \tilde{\mathbf{h}}^*_{d-j+2}$$
$$\forall \mathbf{j},\ 1 \le \mathbf{j} \le L$$

where,

$$\begin{aligned}
\mathbf{d} &= 25, \quad \mathbf{L} = 50 \\
\tilde{\mathbf{g}}_{opt,FL} &= \text{Optimal Finite-Length Equalizer Coefficients} \\
\mathbf{R}_{vv} &= \text{Auto-Correlation Matrix of Input to Equalizer}(\mathbf{v}_n) \\
\tilde{\mathbf{h}}_k &= \text{Finite-Length Channel Coefficients}
\end{aligned}$$

The scalar equations for $1 \le \mathbf{j} \le L$ can be compressed into the following vector equation:-

$$\tilde{\mathbf{g}}_{opt,FL} = \mathbf{R}_{vv}^{-1}\mathbf{H} \tag{1}$$

where,

$$\tilde{\mathbf{g}}_{opt,FL} = [\tilde{\mathbf{g}}_{opt,1}\ \tilde{\mathbf{g}}_{opt,2}\ \tilde{\mathbf{g}}_{opt,3} \cdots \tilde{\mathbf{g}}_{opt,L}]^T$$

$$\mathbf{R}_{vv} = \begin{bmatrix} R_{vv,0} & R_{vv,-1} & R_{vv,-2} & \dots & R_{vv,-(L-1)} \\ R_{vv,1} & R_{vv,0} & R_{vv,-1} & \dots & R_{vv,-(L-2)} \\ R_{vv,2} & R_{vv,1} & R_{vv,0} & \dots & R_{vv,-(L-3)} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ R_{vv,(L-1)} & R_{vv,(L-2)} & R_{vv,(L-3)} & \dots & R_{vv,0} \end{bmatrix}$$

$$\mathbf{H} = [0\ 0\ 0\ \ \dots \tilde{\mathrm{h}}^*_9\ \tilde{h}^*_8 \dots\ \tilde{h}^*_1 \dots\ 0\ 0\ 0]^T$$

Here, range of index of $[\tilde{h}^*_9 : \tilde{h}^*_1]$ in $\mathbf{H}$ is $[18 : 26]$

1.2 Optimum Finite-Length Equalizer Coefficients obtained from Equation(1)

Here, $\mathbf{SNR}_{av,b} = \mathbf{30}db$ and the channel is given below by equation(3) :-

$$\tilde{\mathbf{h}}_n = (1+j)n \;, \qquad \forall \mathbf{n}, \quad 1 \leq \mathbf{n} \leq 9 \tag{3}$$

Figure 1: Optimal Finite-Length Equalizer Coefficients obtained from Equation(1)

	A	B	C	D
1	1	0.00126040311883987 + 1.67987474011042e-08i	26	0.0500194883964206 - 0.0553017518516810i
2	2	0.000129821623783254 + 1.89276070253566e-08i	27	-0.0439741537798440 + 0.0491377326991924i
3	3	0.000133970770720335 + 1.72953471881226e-08i	28	0.000792524278185938 - 0.000607407779732461i
4	4	0.000143382390498972 + 1.57020957118560e-08i	29	0.000930949362639270 - 0.000762066972259307i
5	5	0.000156078716492374 + 1.44728654542754e-08i	30	0.00100583362057892 - 0.000846899330875777i
6	6	0.000171948682285670 + 9.96117107576093e-09i	31	0.00108819580930797 - 0.000941002292865179i
7	7	0.000193272080470173 - 8.52212215750911e-07i	32	0.00118971842138550 - 0.00104511167502240i
8	8	0.000708761589478317 + 9.60466620139491e-07i	33	0.00129786245690564 - 0.00116107543441372i
9	9	0.000145866938974897 + 4.05912724629363e-09i	34	0.00141454320596604 - 0.00129021815034220i
10	10	0.000191894275620273 + 1.83270487333223e-09i	35	0.00152435362569293 - 0.00141468057822270i
11	11	0.000101102750869299 + 1.16053926001560e-09i	36	-0.00384302349089413 + 0.00454440580187945i
12	12	0.000121158432358710 - 1.15922253336709e-09i	37	0.000585983606807941 - 0.000383478338750390i
13	13	0.000139621995058562 - 4.68632926030593e-09i	38	0.000564225985560652 - 0.000367130300309270i
14	14	0.000156090302681767 - 4.99329287065222e-09i	39	0.000516545341991660 - 0.000323115677145837i
15	15	0.000170448053157294 - 2.81190016254013e-08i	40	0.000455562955537987 - 0.000264780409886489i
16	16	0.000198008377330810 - 8.67953299463339e-06i	41	0.000485063559450863 - 0.000185153614966442i
17	17	0.00515135772852167 + 1.74361043340275e-05i	42	0.000369563890080849 - 9.20022370666012e-05i
18	18	-0.00526922775435582 - 8.67599848206903e-06i	43	0.000236831617929932 + 2.35961628609733e-05i
19	19	0.000240630735411094 - 2.50546447623078e-08i	44	8.19800004763016e-05 + 0.000166965341012278i
20	20	0.000241254664449154 - 9.07048134301744e-09i	45	-9.80136037096980e-05 + 0.000341149198952798i
21	21	0.000243610321235075 - 2.26379115748215e-08i	46	0.000296695506881710 - 0.000120646468013362i
22	22	0.000245093732536875 - 3.67427652578529e-08i	47	0.000250892365050887 - 9.06363327095580e-05i
23	23	0.000246685147831527 - 6.94864696944991e-09i	48	0.000205879578067049 - 5.94242896806387e-05i
24	24	0.000248096425378127 - 9.85786983986881e-08i	49	0.000166149931881478 - 3.02710310837256e-05i
25	25	0.000327246300695515 - 8.72129171051381e-05i	50	0.00119684930423955 + 3.96954653504276e-05i
26				
27				

1.3 Optimum Finite-Length Equalizer Coefficients obtained from LMS Algorithm

Here, $\mathbf{SNR}_{av,b} = \mathbf{30}db$, $\mu = \frac{0.5}{LR_{vv,0}} = 1.753 \, \text{x} \, 10^{-5}$ and the channel is given below by equation(3) :-

$$\tilde{\mathbf{h}}_n = (1+j)n \;, \qquad \forall \mathbf{n}, \quad 1 \leq \mathbf{n} \leq 9 \tag{3}$$

Figure 2: Optimal Finite-Length Equalizer Coefficients obtained from LMS Algorithm

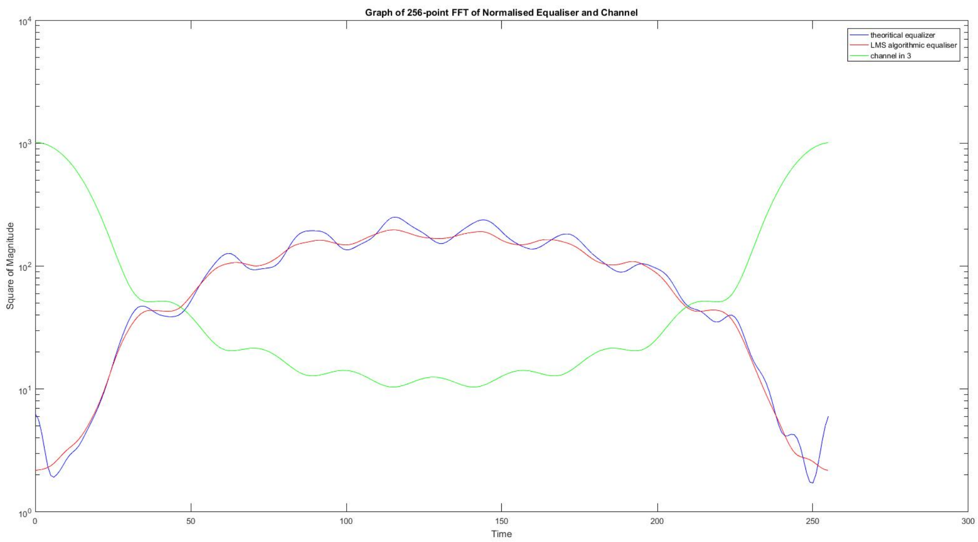
A	B	C	D
1	0.000399036321647777 + 0.000171076493170717i	26	-0.000246882861197990 - 4.24193048088839e-05i
2	-0.000283623439586267 - 2.95968846402600e-05i	27	0.000242210416553714 + 0.000155996712335944i
3	-0.000220562814200151 - 0.000207492158127244i	28	-0.000243903023666594 - 1.44907991639041e-05i
4	-0.000277632772364976 - 0.000190031898437914i	29	9.31329401322767e-05 + 2.85121665982335e-06i
5	-0.000354354985426457 - 0.000383665080871947i	30	-1.73614824908503e-05 - 1.48203629141056e-06i
6	-0.000359923447153198 - 0.000646213069817856i	31	-6.61843863785912e-05 + 3.99931689349072e-05i
7	-0.000301666075026181 - 7.64732400824352e-05i	32	-6.04825133042401e-05 - 0.000174999404884043i
8	0.00438611028333595 + 0.00420308135725788i	33	-7.32914692047462e-05 - 2.64521508526434e-05i
9	-0.00129440812446988 - 0.00114573149574502i	34	-0.000160457186359131 + 5.92658056338370e-05i
10	-0.00123395423148457 - 0.00140168221248005i	35	-4.91388031296519e-05 - 4.69442304244336e-05i
11	-0.00121805337338147 - 0.00112266434458793i	36	0.000119314863839419 + 9.32389819594412e-05i
12	-0.000811542108092383 - 0.00113757383019602i	37	-4.39171449541942e-05 + 4.13133728603358e-05i
13	-0.000986967846739336 - 0.000880327543251403i	38	7.96130370327673e-05 - 8.03316854463982e-06i
14	-0.000703324478645395 - 0.000853393868241526i	39	1.42060515948877e-05 + 9.52642049942054e-06i
15	-0.00120243010286654 - 0.00114713221470673i	40	4.15141628526012e-05 + 5.95755107133797e-05i
16	0.000175409994514161 + 0.000147852230867715i	41	-9.07153351831809e-05 - 6.26297500090232e-05i
17	0.0481039432747676 + 0.0480891084728057i	42	5.93660730099530e-05 - 6.95266387343887e-05i
18	-0.0544721473622419 - 0.0544100206213726i	43	-0.000240940303814084 + 1.89868203571026e-05i
19	-0.000779235667810695 - 0.000634964461020037i	44	9.30082357052810e-05 - 0.000100028150351170i
20	0.000290618276990362 + 0.000238795071831334i	45	-3.40148591025909e-05 - 3.92443540520281e-05i
21	-3.92713166451439e-05 - 0.000127992312469719i	46	9.27039905286259e-05 - 1.02641021669998e-06i
22	8.42355234232637e-06 + 0.000131224595317198i	47	-5.15612054224913e-05 - 6.06314254269390e-05i
23	0.000206398903901741 - 0.000103740064386730i	48	0.000276137365791466 - 7.32466428345653e-06i
24	-9.29755685842439e-06 - 4.88429062855579e-05i	49	-9.51702600486543e-05 + 5.83397510154407e-05i
25	0.000171601066920978 + 0.000104039978463709i	50	-4.84835425910922e-05 - 1.31881925354400e-05i

1.4 Normalized Energy 256-point FFT Plots of Equalizers and Channel(3)

Here, $\mathbf{SNR}_{av,b} = \mathbf{30}db$, $\mu = \frac{0.5}{LR_{vv,0}} = 1.753 \,\mathrm{x}\, 10^{-5}$ and the channel is given below by equation(3) :-

$$\tilde{\mathbf{h}}_n = (1+j)n \;, \qquad \forall \mathbf{n}, \quad 1 \leq \mathbf{n} \leq 9 \tag{3}$$

Figure 3: 256-point Normalized Energy Plot of Equalizers Channel(3)



1.5 Optimum Finite-Length Equalizer Coefficients obtained from Equation(1)

Here, $\mathbf{SNR}_{av,b} = \mathbf{10}db$ and the channel is given below by equation(3) :-

$$\tilde{\mathbf{h}}_n = (1+j)n \ , \qquad \forall \mathbf{n}, \quad 1 \leq \mathbf{n} \leq 9 \tag{3}$$

Figure 4: Optimal Finite-Length Equalizer Coefficients obtained from Equation(1)

A	B	C	D
1	0.00109914711268017 + 1.47494823670039e-06i	26	0.0350829753522750 - 0.0387415181755483i
2	0.000244190217868232 + 1.75816893039428e-06i	27	-0.0295897454656243 + 0.0332443229405951i
3	0.000145424783787023 + 1.58551570894306e-06i	28	-0.00287838856507839 + 0.00343560540442063i
4	0.000142475102568931 + 9.75319001594139e-07i	29	0.000469890873600309 - 0.000261569676923145i
5	0.000157206586031391 - 1.49579682265723e-06i	30	0.000947861221202029 - 0.000786098302617206i
6	0.000191608242323013 - 1.04300531883525e-05i	31	0.00108160171624539 - 0.000932921539488850i
7	0.000284656919520162 - 2.70737888387081e-05i	32	0.00118315467088866 - 0.00104000763028712i
8	0.000476423019377166 + 3.50328112911583e-05i	33	0.00126974360698629 - 0.00113261416660841i
9	0.000222543284993924 + 1.38842477459463e-05i	34	0.00125300399344966 - 0.00111338364290002i
10	0.000186567776777810 + 3.47500053405711e-06i	35	0.000658180747756300 - 0.000453816476719383i
11	0.000122405393410318 + 6.78916250150834e-07i	36	-0.00205495927423189 + 0.00255834822055538i
12	0.000123048727560669 - 2.66771559149592e-07i	37	-6.38434807909338e-05 + 0.000332595088093405i
13	0.000140679945577924 - 2.74148326461952e-06i	38	0.000434815859430767 - 0.000226957117284057i
14	0.000174599202685742 - 1.68388487347470e-05i	39	0.000490115475928172 - 0.000292708738805089i
15	0.000297201965605420 - 8.83223189601079e-05i	40	0.000461934429999653 - 0.000250949345727560i
16	0.000872383545888283 - 0.000311780990067690i	41	0.000457468423302404 - 0.000175272316790300i
17	0.00281858547722835 + 0.000840499847681455i	42	0.000353600362892645 - 8.13201853241399e-05i
18	-0.00334309790219160 - 0.000311781287098065i	43	0.000226433402710928 + 3.02737701204996e-05i
19	-0.000144699853585408 - 8.83415411475282e-05i	44	9.90841933015469e-05 + 0.000143741641885237i
20	0.000200286181604763 - 1.69843923025737e-05i	45	3.90959280655247e-05 + 0.000184915241542794i
21	0.000238521371717341 - 3.81351103501538e-06i	46	0.000196053072369871 - 1.24213214049950e-05i
22	0.000250347816185183 - 8.83384398101027e-06i	47	0.000226464690204507 - 6.48639108976075e-05i
23	0.000306929063512307 - 6.94573124971113e-05i	48	0.000213155293500695 - 5.45440294912524e-05i
24	0.000759724989020595 - 0.000572623916835626i	49	0.000276488287702441 - 2.74231280213613e-05i
25	0.00448154211167727 - 0.00471511446710050i	50	0.00106028789361541 + 2.22360466911180e-05i

1.6 Optimum Finite-Length Equalizer Coefficients obtained from LMS Algorithm

Here, $\mathbf{SNR}_{av,b} = \mathbf{10}db$, $\mu = \frac{0.5}{LR_{vv,0}} = 1.670 \, \mathrm{x} \, 10^{-5}$ and the channel is given below by equation(3) :-

$$\tilde{\mathbf{h}}_n = (1+j)n \ , \qquad \forall \mathbf{n}, \quad 1 \leq \mathbf{n} \leq 9 \tag{3}$$

Figure 5: Optimal Finite-Length Equalizer Coefficients obtained from LMS Algorithm

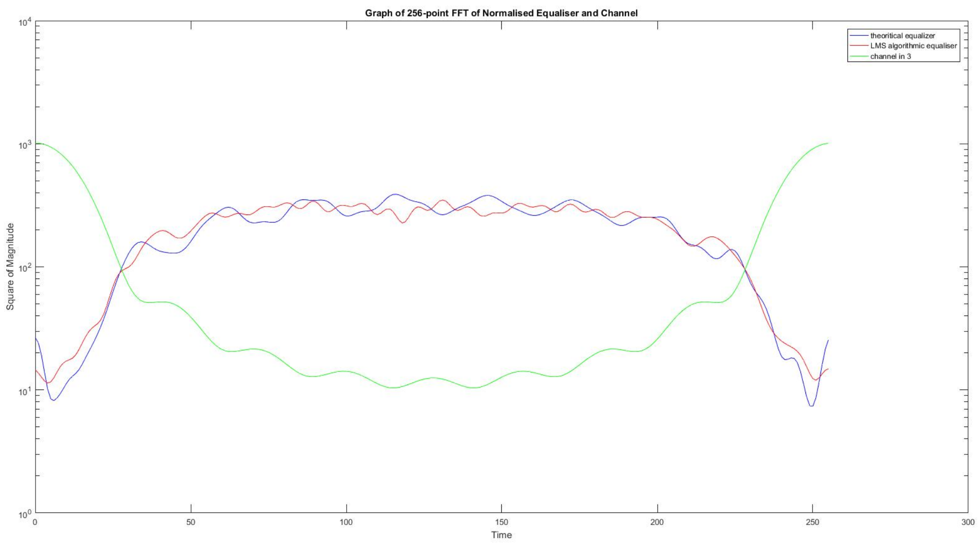
A	B	C	D
1	0.000530942877327910 + 0.000509132730210306i	26	-0.000279979145154997 - 0.000657538637116476i
2	-0.000387347487855809 + 0.000182458445144455i	27	0.00217154670910422 + 0.00158484393770659i
3	0.000440964880750146 - 0.000659972043693120i	28	-0.000715095796568769 - 0.000450623748775438i
4	-8.27177051622865e-05 - 0.000662418572590368i	29	1.02072034409935e-05 + 4.17267420144769e-05i
5	-0.000912233689178953 - 0.000163235360753576i	30	-0.000345528554071138 + 0.000385819040945937i
6	0.000129885951603659 - 0.00108888521580258i	31	0.000335361809536439 - 4.46849302474820e-05i
7	0.000603791106942871 + 0.00114460045738200i	32	5.09286993471386e-05 - 0.000816787092197814i
8	0.00183483697164192 + 0.00180917799147337i	33	-8.42683262523393e-06 + 0.000254069704461900i
9	0.000276862421128123 - 0.000211583727677852i	34	-7.40677476223692e-05 - 0.000295762680459208i
10	-0.00116672234885029 - 0.00112119188626436i	35	0.000465663864489285 + 5.62906717764212e-05i
11	-0.00119006513708176 - 0.00145733492028926i	36	0.000105352608635139 - 0.000100575159783167i
12	-0.00120508193856711 - 0.00161732095672975i	37	-5.34969980463760e-05 + 0.000105307775050747i
13	-0.00101464314480573 - 0.000707261758709547i	38	0.000191518416688415 - 0.000351470096735469i
14	-0.00104131867355960 - 0.000816149540551110i	39	0.000183670606926804 - 0.000410791441049100i
15	0.000125945091185008 + 0.000179820010275206i	40	9.69613433128477e-05 - 0.000461695191353040i
16	0.00501769821183752 + 0.00467167956099446i	41	8.21114411821548e-06 + 0.000145958825291607i
17	0.0312310764259145 + 0.0313776056299413i	42	-0.000229689580504304 - 0.000801795298953717i
18	-0.0374842428835050 - 0.0368820868228106i	43	-0.000300516676174306 - 3.00791685247393e-05i
19	-0.00551351927624186 - 0.00556712295558458i	44	-0.000213818591804827 + 0.000819062230010693i
20	-0.000325395689384037 - 0.000675141148803070i	45	0.000301927741706493 - 0.000496845629157450i
21	-0.000285950453138155 + 0.000671706998083126i	46	0.000105898593607028 - 0.000735490271017873i
22	0.000217405058695486 - 0.000221483963977975i	47	6.00722054466106e-06 + 0.000169623526097177i
23	-0.000401305592811881 - 9.44913610380191e-06i	48	-6.73135509986550e-05 - 8.73553967954330e-05i
24	6.22328056086792e-05 + 0.000344850778701070i	49	-0.000402014105110487 - 0.000270668454179853i
25	-0.000134087661087143 + 0.000384595218437682i	50	0.000395371606534715 - 9.37969280983211e-05i

1.7 Normalized Energy 256-point FFT Plots of Equalizers and Channel(3)

Here, $\mathbf{SNR}_{av,b} = \mathbf{30}db$, $\mu = \frac{0.5}{LR_{vv,0}} = 1.670 \,\mathrm{x}\, 10^{-5}$ and the channel is given below by equation(3) :-

$$\tilde{\mathbf{h}}_n = (1+j)n \ , \qquad \forall \mathbf{n}, \quad 1 \leq \mathbf{n} \leq 9 \tag{3}$$

Figure 6: 256-point Normalized Energy Plot of Equalizers Channel(3)



1.8 Optimum Finite-Length Equalizer Coefficients obtained from Equation(7)

Here, $\mathbf{SNR}_{av,b} = \mathbf{30}db$ and the channel is given below by equation(7) :-

$$\tilde{\mathbf{h}}_n = \begin{cases} (1+j)n \ , & 1 \leq \mathbf{n} \leq 5 \\ (1+j)(10-n) \ , & 6 \leq \mathbf{n} \leq 9 \end{cases}$$

(7)

Figure 7: Optimal Finite-Length Equalizer Coefficients obtained from Equation(1)

	A	B	C	D
1	1	0.00210152959316809 + 1.12140951638769e-05i	26	-0.00471737601592811 - 0.00125791345503921i
2	2	0.00119380368720082 - 6.34871173975231e-06i	27	-0.000255371633037352 - 0.00426611775482201i
3	3	0.000672018258749509 - 2.66255562146312e-05i	28	0.00185297195941845 - 0.000445006435790288i
4	4	0.000473673481413736 - 3.04515505782217e-05i	29	0.00215088227611269 + 0.00107165431760111i
5	5	0.000516326179273303 - 2.72010247958677e-07i	30	0.00151316523788785 + 0.00111340326516113i
6	6	0.000698007539769226 + 5.85650799638469e-05i	31	0.000735466222196441 + 0.000493017523584344i
7	7	0.000862927382545748 + 0.000101747529093175i	32	0.000347890574875321 - 0.000128244196999525i
8	8	0.000928112622637602 + 6.21624372046711e-05i	33	0.000380236910301997 - 0.000333883503786133i
9	9	0.000832938798805770 - 6.79337395296947e-05i	34	0.000598068628769752 - 0.000244081005398763i
10	10	0.000607206467129659 - 0.000243900375834361i	35	0.000796214854357828 - 6.81858350454206e-05i
11	11	0.000365521032574101 - 0.000333873015311516i	36	0.000875909143521408 + 6.20191790662349e-05i
12	12	0.000330347211449598 - 0.000128325729163362i	37	0.000830162384040613 + 0.000101916007944655i
13	13	0.000727375263764578 + 0.000492939433191377i	38	0.000743011890878131 + 5.91916618530785e-05i
14	14	0.00151481852867256 + 0.00111337422221604i	39	0.000684966402705049 + 6.79500749245019e-07i
15	15	0.00215651347629071 + 0.00107166794090265i	40	0.000683835584305228 - 3.00594996997283e-05i
16	16	0.00185722880908703 - 0.000444979249077314i	41	0.000730704017356318 - 2.77857036908255e-05i
17	17	-0.000254272944465795 - 0.00426609936578230i	42	0.000782897775152932 - 9.76550527632061e-06i
18	18	-0.00471845348561906 - 0.00125791025653154i	43	0.000808688561363749 + 5.29716824520044e-06i
19	19	-0.00149595536103500 + 0.000160004919683098i	44	0.000782188018016225 + 9.82208748806097e-06i
20	20	0.00138546013362313 + 0.00167172567049988i	45	0.000686749459327628 + 6.28897774016148e-06i
21	21	0.00575694719181519 + 0.00513612414100954i	46	0.000547675999694991 + 6.88869697859938e-07i
22	22	0.0133013828189953 + 0.0122982993632901i	47	0.000507806733860044 - 2.62559810917733e-06i
23	23	0.00575736244131558 + 0.00513613019604369i	48	0.000686378108161849 - 2.67881147092895e-06i
24	24	0.00138651700301568 + 0.00167173524010823i	49	0.00118842836603750 - 8.80364304638695e-07i
25	25	-0.00149438419662784 + 0.000160012090492392i	50	0.00208801454849775 + 9.42436281619256e-07i
26				

1.9 Optimum Finite-Length Equalizer Coefficients obtained from LMS Algorithm

Here, $\mathbf{SNR}_{av,b} = \mathbf{30}db$, $\mu = \frac{0.5}{LR_{vv,0}} = 3.636 \, \mathrm{x} \, 10^{-5}$ and the channel is given below by equation(7) :-

$$\tilde{\mathbf{h}}_n = \begin{cases} (1+j)n \ , & 1 \leq \mathbf{n} \leq 5 \\ (1+j)(10-n) \ , & 6 \leq \mathbf{n} \leq 9 \end{cases}$$

(7)

Figure 8: Optimal Finite-Length Equalizer Coefficients obtained from LMS Algorithm

A	B	C	D
1	0.000126603647388346 - 7.76824250097807e-05i	26	0.00235949249914280 + 0.00222339007136733i
2	3.62299098108262e-05 + 3.65626935231678e-05i	27	0.00585312229378584 + 0.00582382388826856i
3	-4.50671687654061e-05 + 0.000284160670637322i	28	0.000667726610915883 + 0.000657625630253380i
4	-7.18534698450042e-05 + 3.89942308749727e-05i	29	-0.00164013147788107 - 0.00153923781702998i
5	-0.000131860774007979 - 0.000181643352743748i	30	-0.00181726180857773 - 0.00151719177356846i
6	-0.000100084462828769 - 0.000237035716124976i	31	-0.00100053935680977 - 0.000879091703812900i
7	4.63160729289205e-05 - 0.000186681910052199i	32	0.000102656653797572 - 0.000200463168577519i
8	0.000129244828883419 - 0.000169140263460840i	33	0.000607782342337812 + 0.000291131770135608i
9	0.000264905605863174 + 0.000305480049228608i	34	0.000524459124230170 + 0.000397360817736139i
10	0.000426351449904132 + 0.000545564202874924i	35	0.000289372681836732 + 0.000231953387107414i
11	0.000264249265420030 + 0.000593081363254197i	36	-0.000148592604783065 + 9.96231771514244e-05i
12	-0.000244748099726678 + 5.27509297583528e-05i	37	-0.000200814562907390 - 1.06688378725702e-07i
13	-0.000920242129618224 - 0.00104091506953406i	38	-0.000239875176918867 - 0.000122515741041725i
14	-0.00154315034696555 - 0.00181994720918203i	39	-0.000161305814609076 - 0.000129085143362061i
15	-0.00150798784684462 - 0.00161002185193032i	40	4.63594409254805e-05 - 6.81748990782299e-05i
16	0.000751074037565740 + 0.000752190586972724i	41	0.000301314506413665 - 4.81565781610635e-05i
17	0.00586771003099310 + 0.00588294810079689i	42	7.82378888646698e-05 + 5.75493847779492e-05i
18	0.00219890873527983 + 0.00233347315761300i	43	1.34442383616777e-05 + 0.000102211726081519i
19	0.000168561714262660 + 0.000309935188928450i	44	5.66393590530755e-05 + 7.16235690076885e-05i
20	-0.00168460277668936 - 0.00172544492135227i	45	-0.000191459632857448 - 8.79785779386187e-06i
21	-0.00636873692793868 - 0.00651788476287532i	46	-0.000206253366665714 - 8.26503684157925e-05i
22	-0.0154804731489298 - 0.0154965429800251i	47	-6.96665543802450e-05 - 5.64931928962118e-05i
23	-0.00642595847151181 - 0.00623167952458169i	48	6.91597658260307e-05 + 7.97983571844922e-06i
24	-0.00163419847188930 - 0.00159818962623002i	49	2.59058967355460e-06 + 0.000135098451258055i
25	0.000368703422414297 + 0.000226533183875606i	50	0.000153742674546539 - 1.91666586511786e-05i

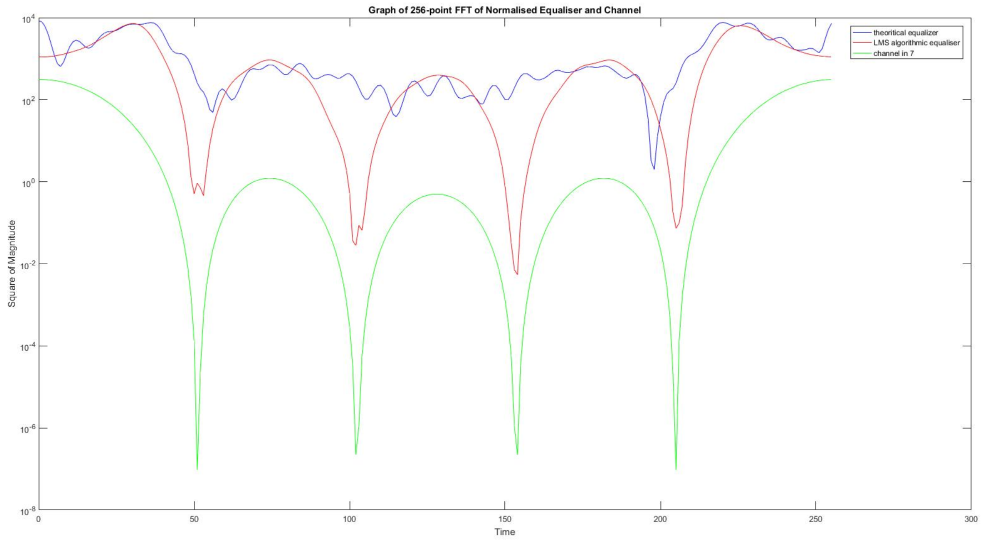
1.10 Normalized Energy 256-point FFT Plots of Equalizers and Channel(7)

Here, $\mathbf{SNR}_{av,b} = \mathbf{30}db$, $\mu = \frac{0.5}{LR_{vv,0}} = 3.636 \,\mathrm{x}\, 10^{-5}$ and the channel is given below by equation(2) :-

$$\tilde{\mathbf{h}}_n = \begin{cases} (1+j)n \ , & 1 \leq \mathbf{n} \leq 5 \\ (1+j)(10-n) \ , & 6 \leq \mathbf{n} \leq 9 \end{cases}$$

(7)

Figure 9: 256-point Normalized Energy Plot of Equalizers Channel(7)

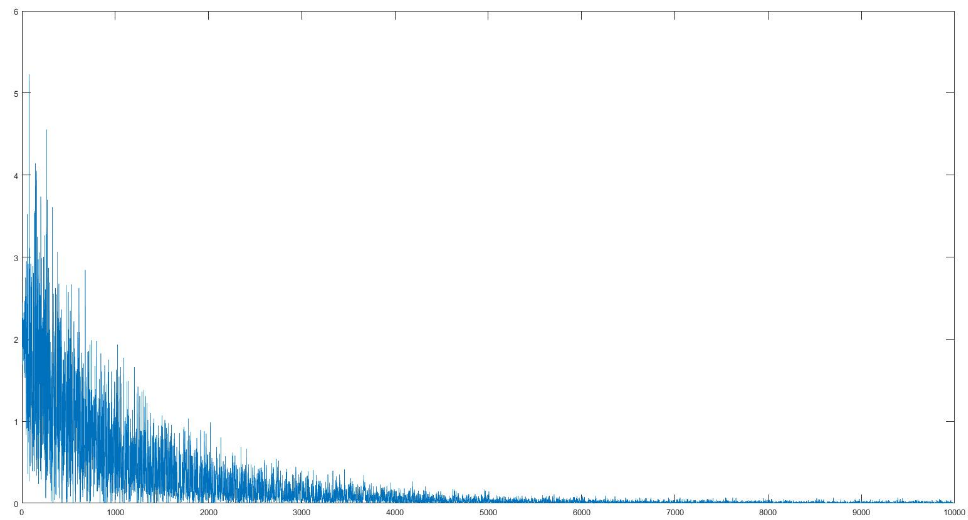


1.11 Squared Magnitude Error Response when using Channel(3)

Here, $\mathbf{SNR}_{av,b} = \mathbf{30}db$, $\mu = \frac{0.5}{LR_{vv,0}} = 1.753 \,\mathrm{x}\, 10^{-5}$ and the channel is given below by equation(7) :-

$$\tilde{\mathbf{h}}_n = (1+j)n \ , \qquad \forall \mathbf{n}, \quad 1 \leq \mathbf{n} \leq 9 \tag{3}$$

Figure 10: Squared Magnitude Error Plot using Channel(3)



1.12 Squared Magnitude Error Response when using Channel(7)

Here, $\mathbf{SNR}_{av,b} = \mathbf{30}db$, $\mu = \frac{0.5}{LR_{vv,0}} = 3.636 \,\text{x}\, 10^{-5}$ and the channel is given below by equation(2) :-

$$\tilde{\mathbf{h}}_n = \begin{cases} (1+j)n \;, & 1 \leq \mathbf{n} \leq 5 \\ (1+j)(10-n) \;, & 6 \leq \mathbf{n} \leq 9 \end{cases}$$

(7)

Figure 11: Squared Magnitude Error Plot using Channel(7)