ANALYSIS OF LNS IMPLEMENTATION OF THE QRD-LSL ALGORITHMS

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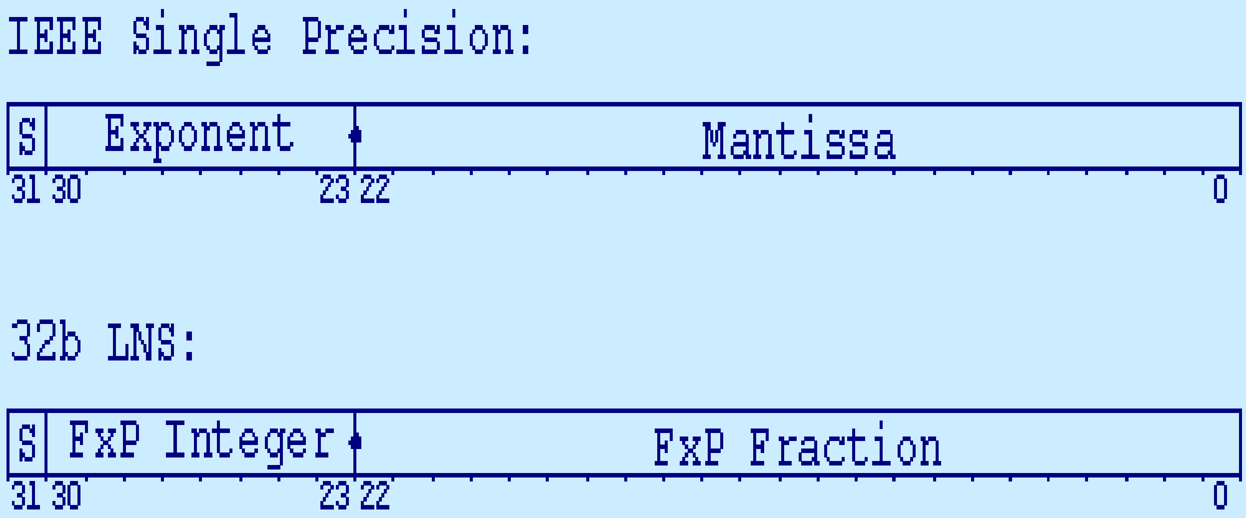
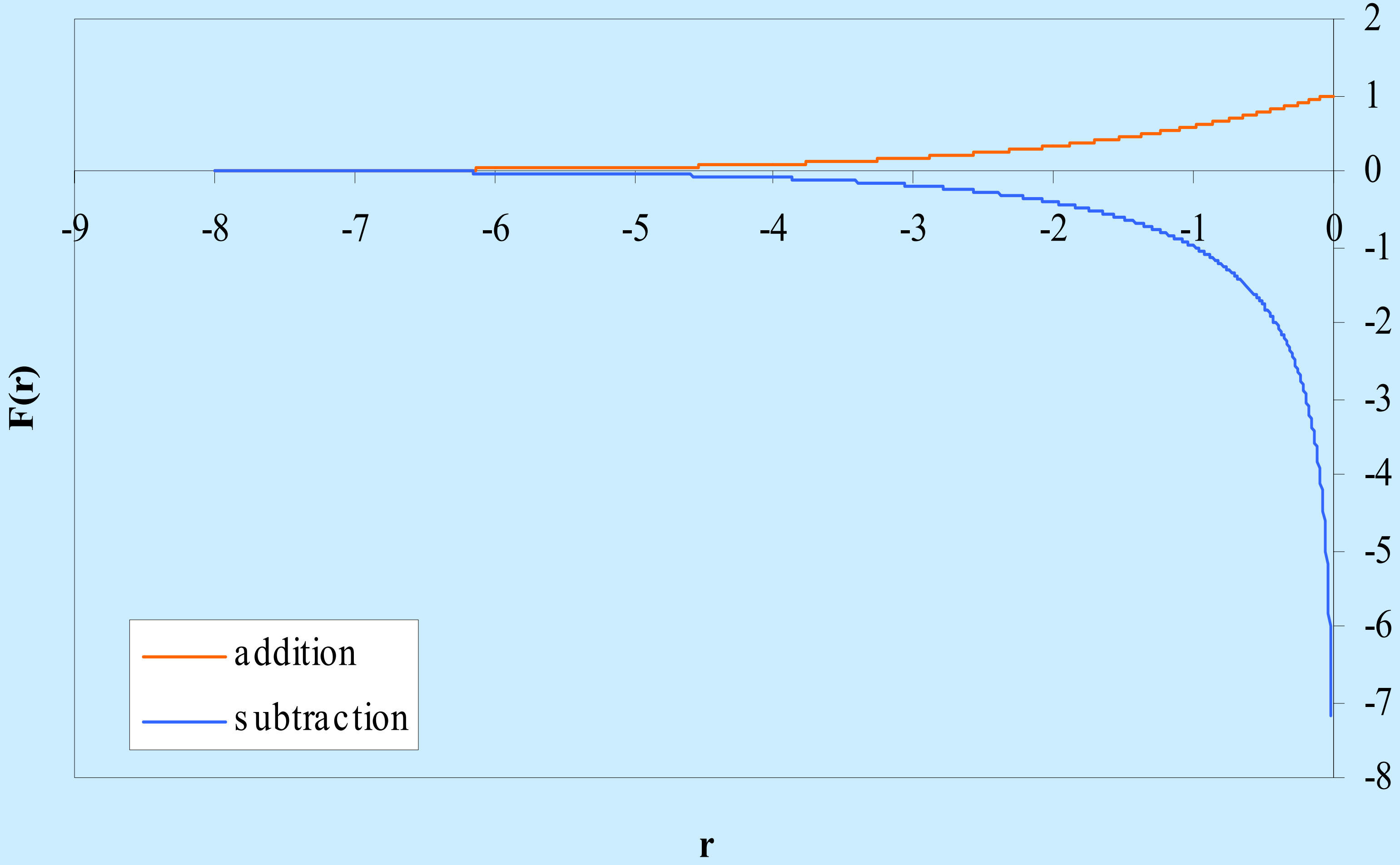
Logarithmic number system



IEEE standard single precision floating point representation and the 32-bit LNS format

Logarithmic number system



Logarithmic number system

x + y	ADD	Lz = Lx + log(1+2^(Ly-Lx)), Sz depends on sizes of x,y
x - y	SUB	Lz = Lx + log(1-2^(Ly-Lx)), Sz depends on sizes of x,y
x * y	MUL	Lz = Lx + Ly, Sz = Sx OR Sy
x / y	DIV	Lz = Lx - Ly, Sz = Sx OR Sy
x^2	SQU	Lx << 1, Sz = Sx
x^0.5	SQRT	Lx >> 1, Sz = Sx
x^-1	RECIP	Lz = Lx, Sz = ¬Sx
x^-0.5	RSQRT	Lz = Lx >> 1, Sz = ¬Sx

LNS Arithmetic Operations

MQRD-LSL Algorithm

Adaptive Algorithm	QRD-LSL	MQRD-LSL
Multiplications	25M+11	22M+10
Divisions	4M+2	4M+2
Additions/subtractions	8M+3	8M+3
Square-root operations	4M+2	0

Computational complexities (number of operations per iteration) for the QRD-LSL algorithms.

MQRD-LSL Algorithm

Assumptions

$$r_{m-1}(n-1)=\sqrt{\frac{\beta_{f,m-1}(n-1)}{\beta_{b,m-1}(n-1)}}=\sqrt{1+\frac{\beta_{f,m-1}(n-1)-\beta_{b,m-1}(n-1)}{\beta_{b,m-1}(n-1)}}\cong$$

$$\cong 1+\frac{1}{2}\cdot\frac{\beta_{f,m-1}(n-1)-\beta_{b,m-1}(n-1)}{\beta_{b,m-1}(n-1)}=$$

$$=\frac{1}{2}+\frac{1}{2}\cdot\frac{\beta_{f,m-1}(n-1)}{\beta_{b,m-1}(n-1)}$$

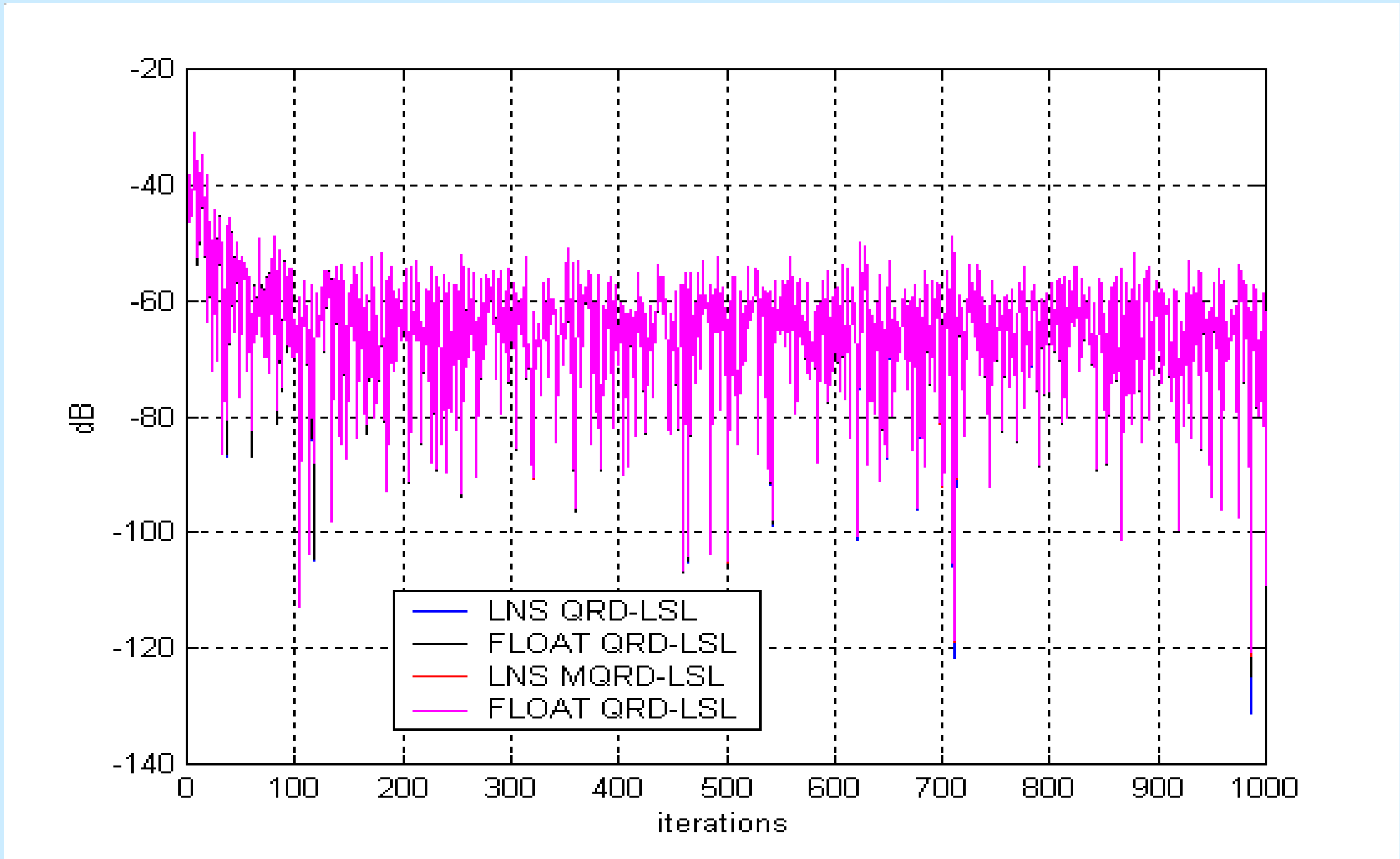
$$\frac{\beta_{f,m-1}(n-1)-\beta_{b,m-1}(n-1)}{\beta_{b,m-1}(n-1)}<<1$$

$$\frac{\left|e_{m-1}^{f}(n)\right|^2}{\sum_{i=1}^{n-1}\left|e_{m-1}^{f}(i)\right|^2}<<1 \qquad \frac{\left|e_{m-1}^{b}(n-1)\right|^2}{\sum_{i=1}^{n-2}\left|e_{m-1}^{b}(i)\right|^2}<<1$$

$$\sum_{i=1}^{n}\lambda^{n-i}f(i)\cong\sum_{i=1}^{n}f(i)$$

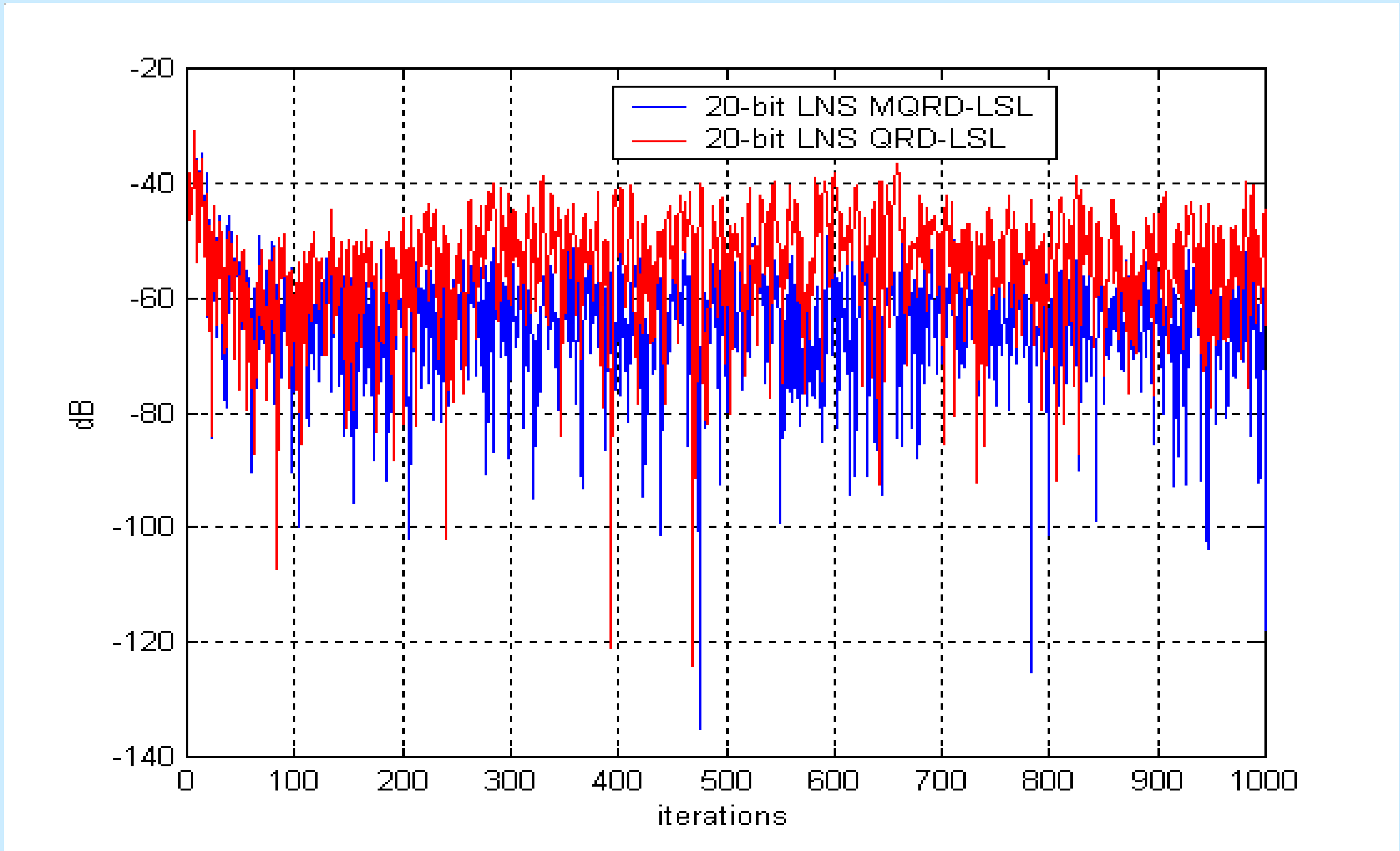
Simulations

The square errors for 32-bit FLOAT and 32-bit LNS implementations of MQRD-LSL and QRD-LSL algorithms



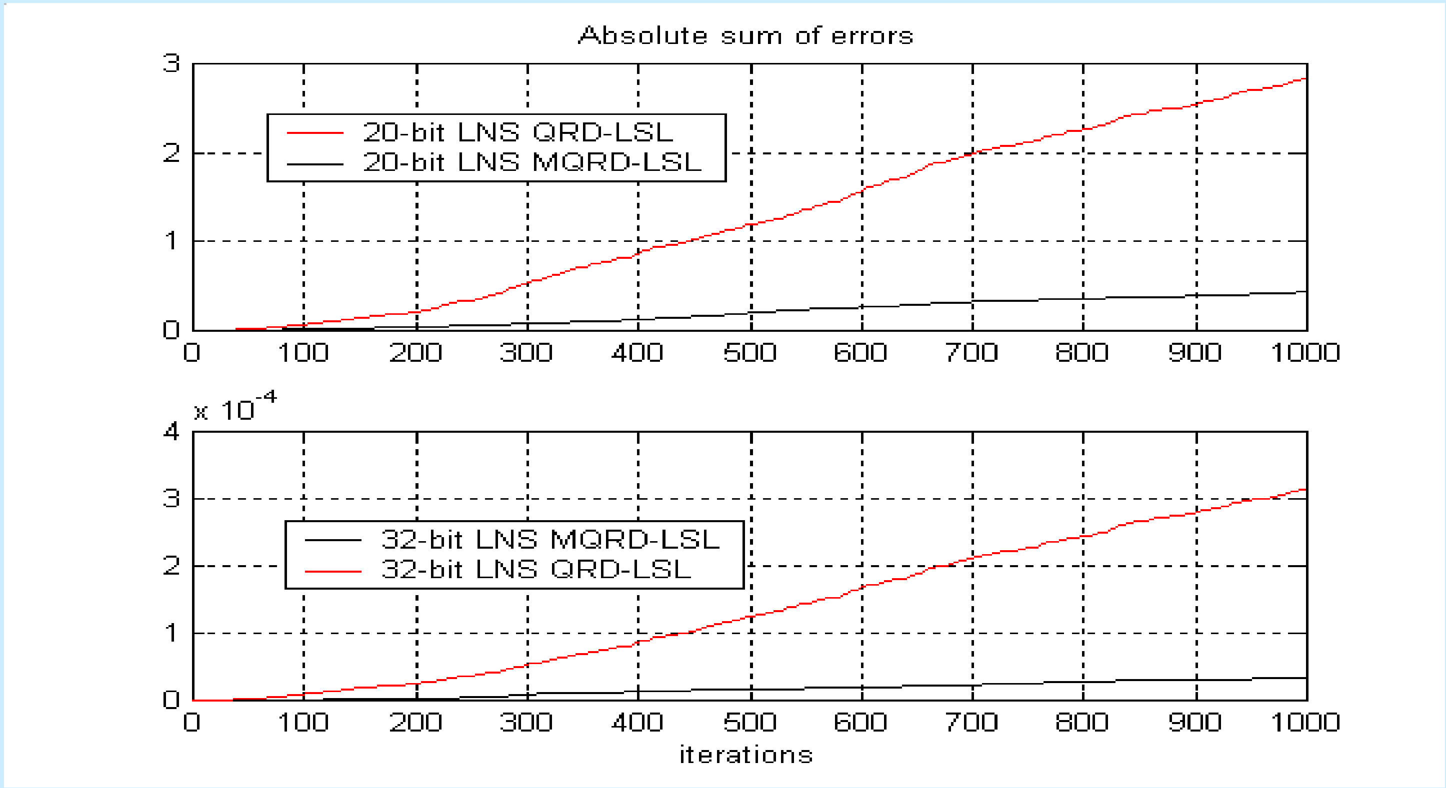
Simulations

The square errors for 20-bit LNS implementations of the classical and modified QRD-LSL algorithm



Simulations

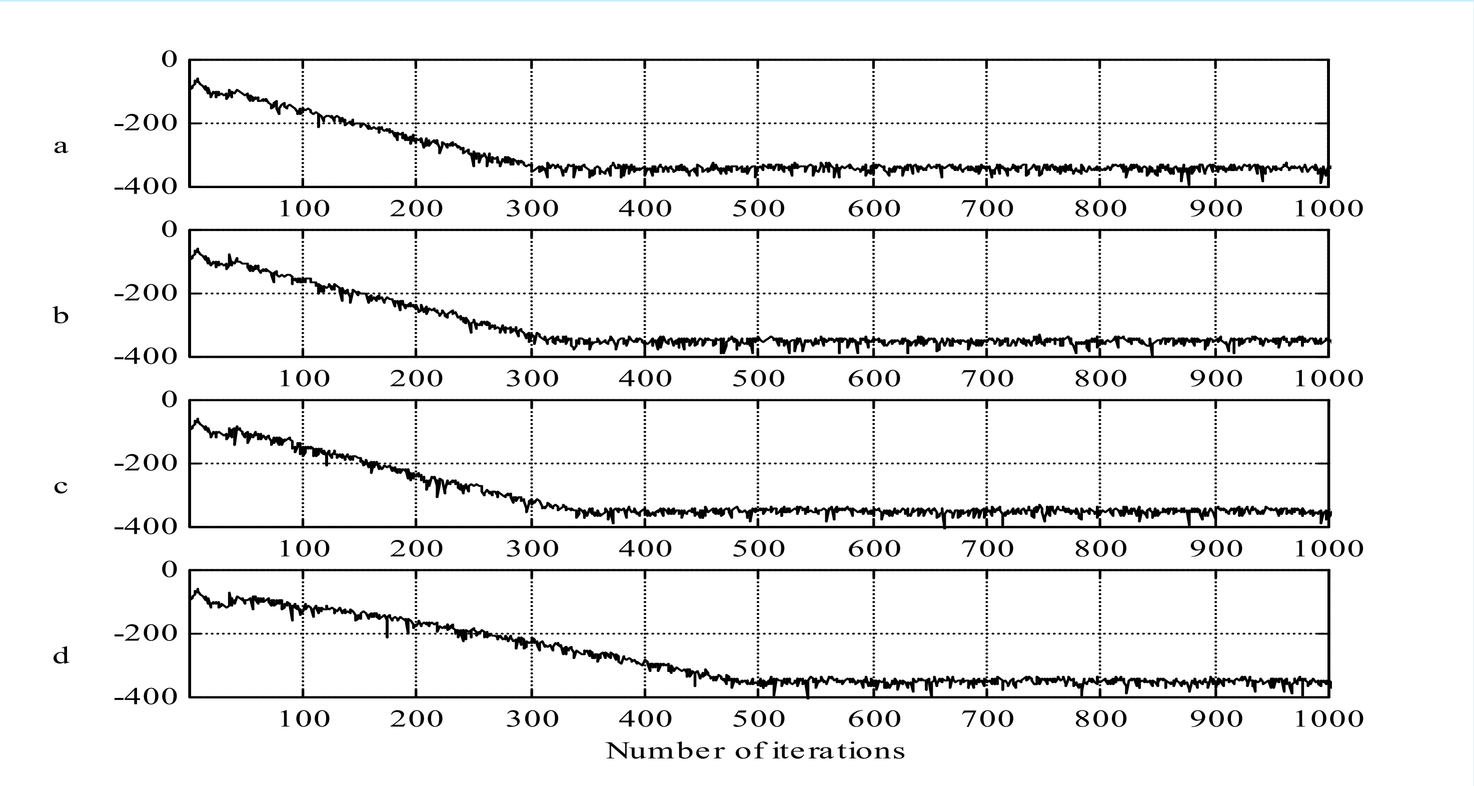
The absolute sum of errors for 20-bit LNS (up) and 32-bit FLOAT or LNS implementations (down) of the QRD-LSL Algorithms



Simulations

Square errors [dB], λ=0.9

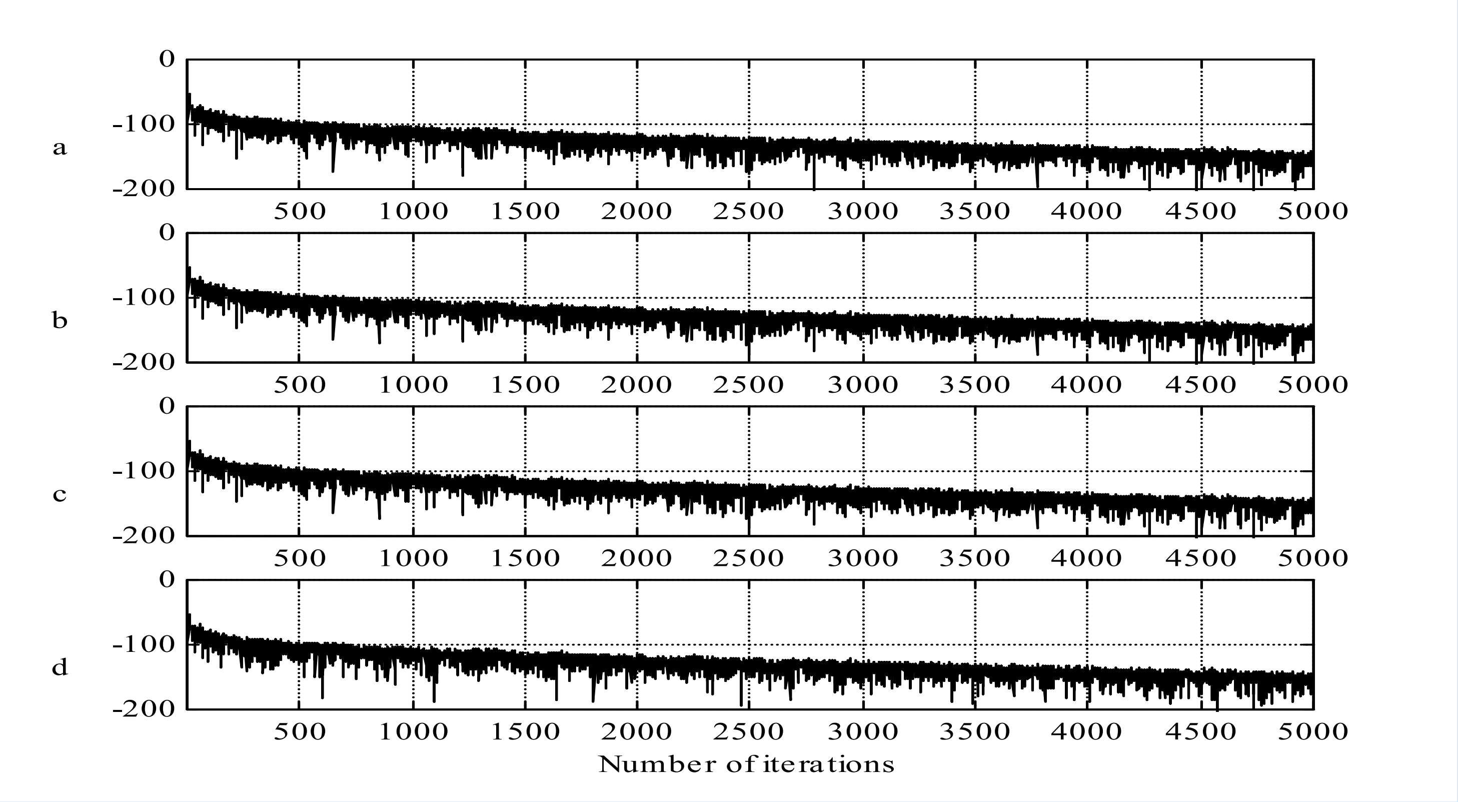
(a) QRD-LSL classical algorithm, (b) QRD-LSL-v1, (c) QRD-LSL-v2, (d) MQRD-LSL



Simulations

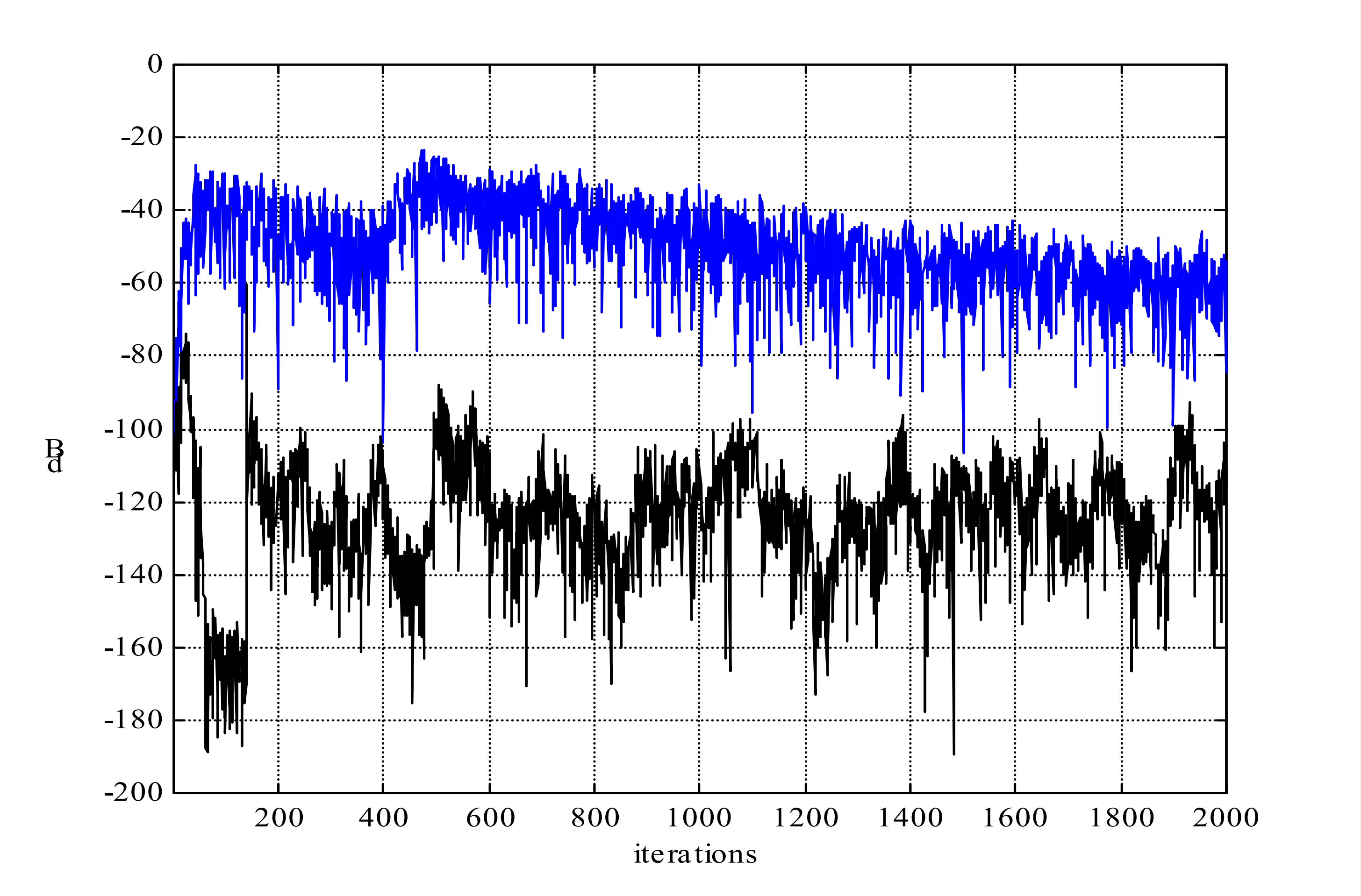
Square errors [dB], λ=0.999

(a) QRD-LSL classical algorithm, (b) QRD-LSL-v1, (c) QRD-LSL-v2, (d) MQRD-LSL



Simulations

Square errors for the NLMS and modified QRD-LSL algorithms



Conclusions

- The QRD-LSL algorithms have efficient LNS implementations because of their numerous divisions or square-root operations that are very time consuming in floating-point implementations.
- The QRD-LSL algorithms are attractive because of their fast convergence rate even for high length filters and high correlated signals.
- The proposed MQRD-LSL algorithm eliminates the square root operations and achieves a lower computational complexity than the classical QRD-LSL algorithm.
- We showed in this paper that the 20-bit LNS implementation of the MQRD-LSL algorithms offers better performances than the 20-bit LNS implementation of the classical QRD-LSL algorithm.

Questions ?

HSLA Project webpage

http://napier.ncl.ac.uk/HSLA