S32 Automotive Platform: Performance for Advanced Control Systems

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SECURE CONNECTIONS FOR A SMARTER WORLD

Agenda

- Advanced Controls Mathematics
- S32 Automotive Platform Overview
- Arm Cortex R52 and NEON
- Basic Performance Comparison

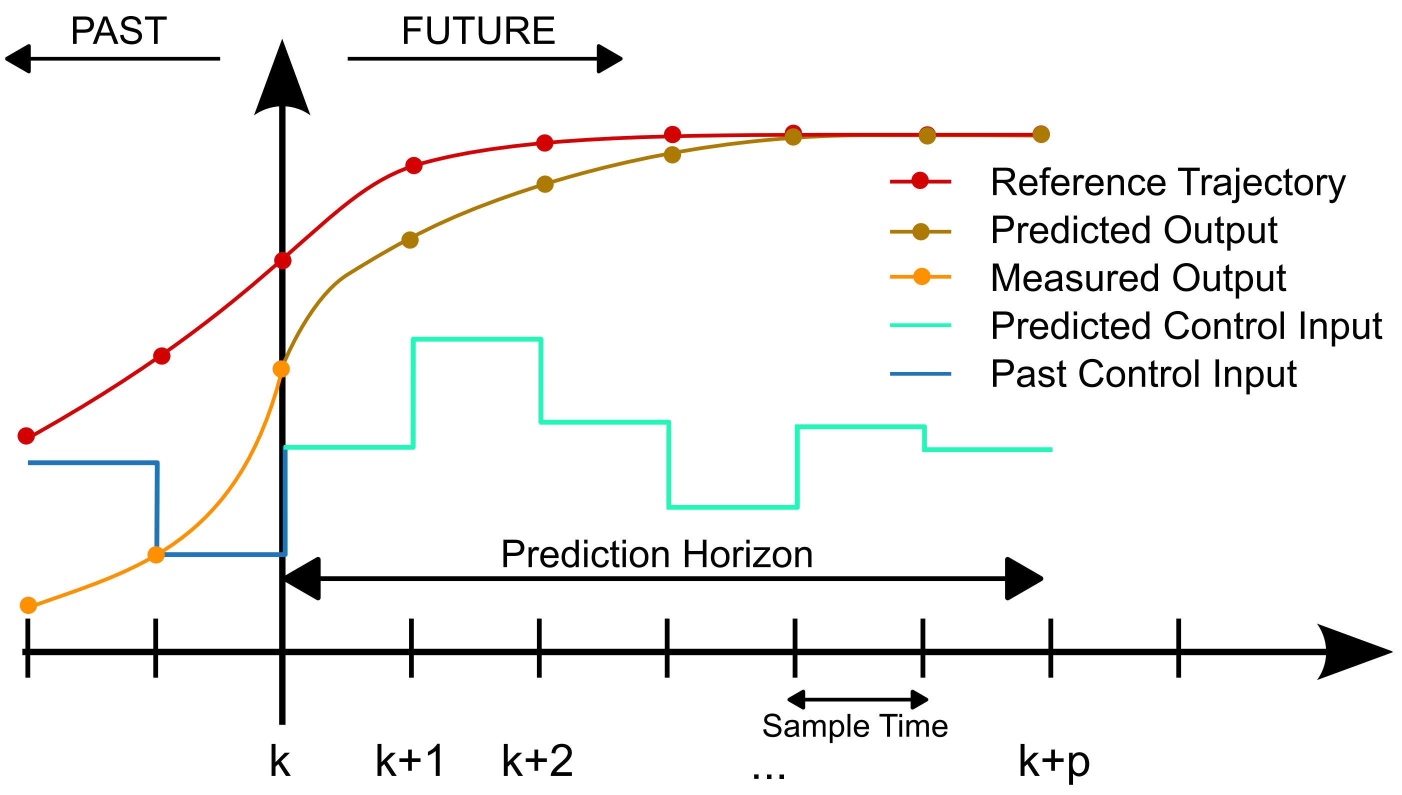
Advanced Controls Mathematics

Trend – Advanced Controls

Trend in the industry is for real-time embedded advanced control algorithms with rapidly increasing compute requirements:

Example: Model Predictive Control

- At each time interval, predict trajectory over a fixed period of time (“prediction horizon”).
- Compute “cost” and optimize for minimum cost.
- Use an exact model or approximate/simulated model that is computable.
- With an approximation, the amount of compute power you have determines accuracy, with eventual diminishing returns.



Source: Wikipedia

MPC using AI – UC Berkeley Paper

- Dynamic Traffic Feedback Data Enabled Energy Management in Plug-in Hybrid Electric Vehicles
- https://ecal.berkeley.edu/pubs/Traffic_Integrated_TCST.pdf

- COMPARISON OF VELOCITY FORECASTING STRATEGIES FOR PREDICTIVE CONTROL IN HEVS
- https://ecal.berkeley.edu/pubs/DSCC14-VelPred.pdf

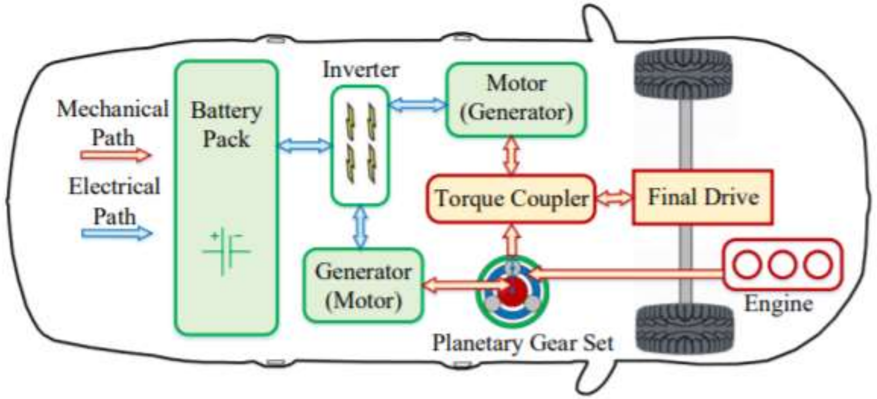
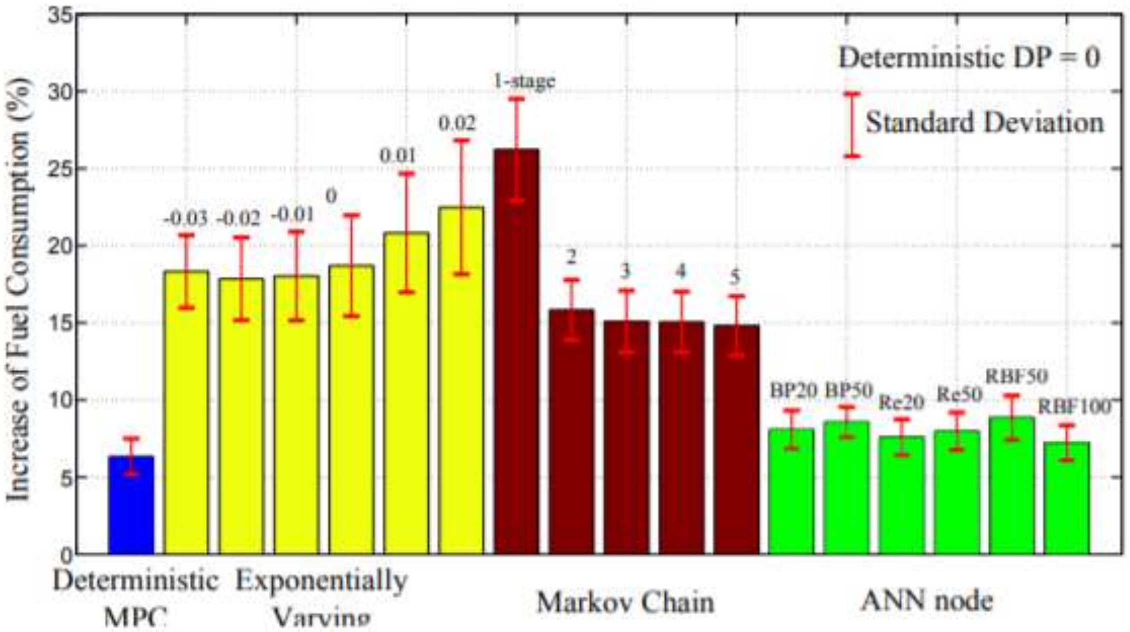


FIGURE 3. HEV POWER-SPLIT CONFIGURATION.



Drilling down to compute requirements

Examples of algorithms in use in this space

Item	Description
1	Kalman Filter / Observer
2	Vector exp( ) for Gaussian estimation
3	Neural network
4	Cholesky decomposition
5	Heat quantity calculation
6	State Space
7	Navier-Stokes airflow model

Kalman observer

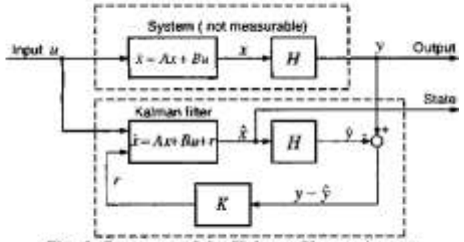
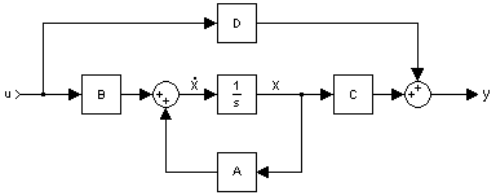
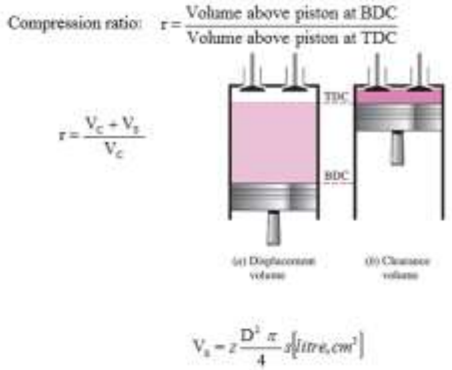


Fig. 2. Structure of the Kalman filter estimator.

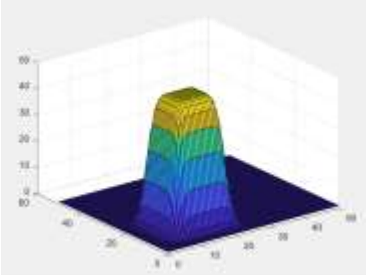
State Space



Cylinder Volume



Navier-Stokes



$$\frac{\partial u}{\partial t} + c\frac{\partial u}{\partial x} + c\frac{\partial u}{\partial y} = 0$$

Drilling down to compute requirements (cont.)

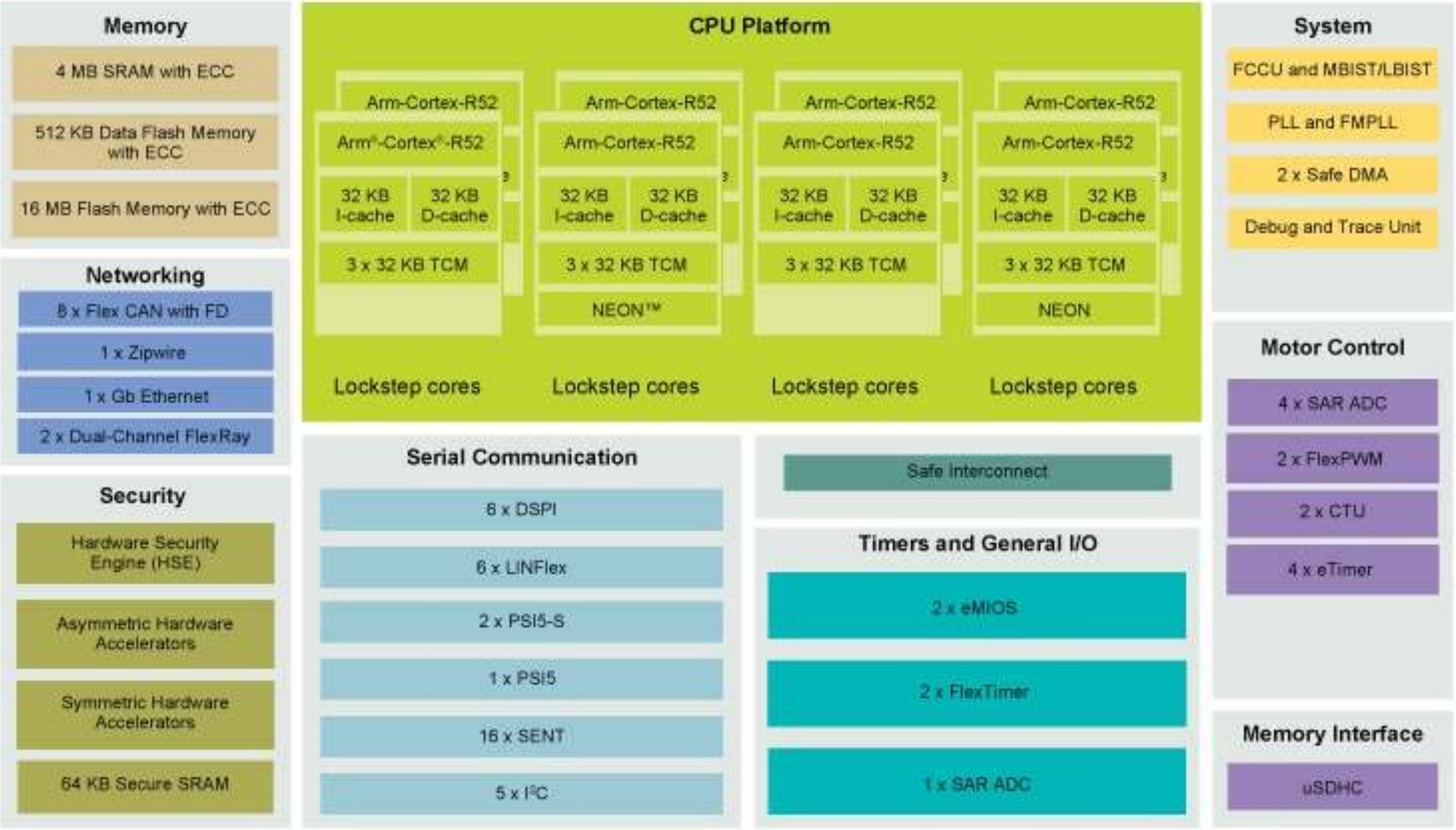
What’s Needed?

- Very fast single precision real floating point performance
- Vector and matrix math (add, subtract, multiply-accumulate, divide, reciprocal)
- Some non-linear requirements (exp, sqrt, 1/sqrt)
- Some parallelism

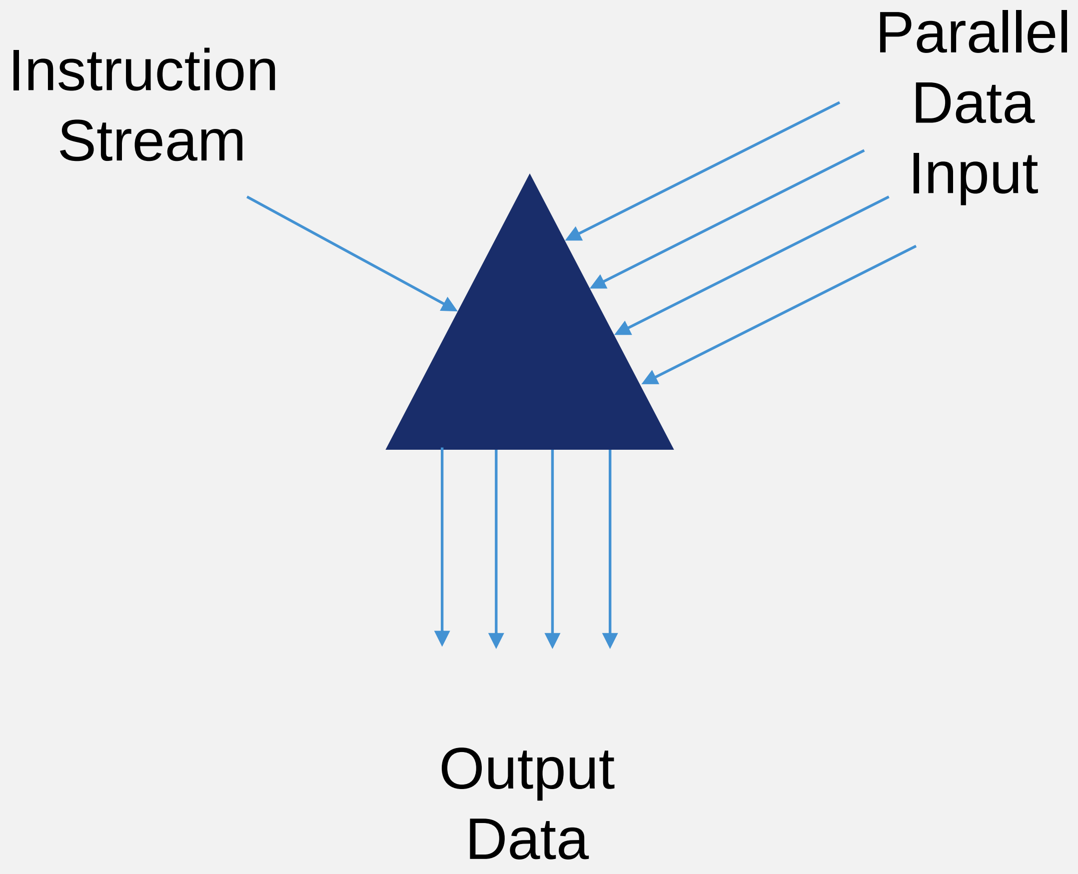
S32 Automotive Platform Overview

S32 Automotive Platform – S32S Block Diagram

- 4 x Arm-R52 cores in lockstep (8 cores total) operating at 800 MHz
- Large integrated flash memory (up to 64 Mbytes)
- On-the-Fly, Over-the-A update capability with zero processor downtin
- Advanced safety functionality and fault recovery to support AS D applications
- Hardware Security Engine supporting publ and private key encryption
- AEC-Q100 Grade 1 device with support up -40 to 150º C (junction)



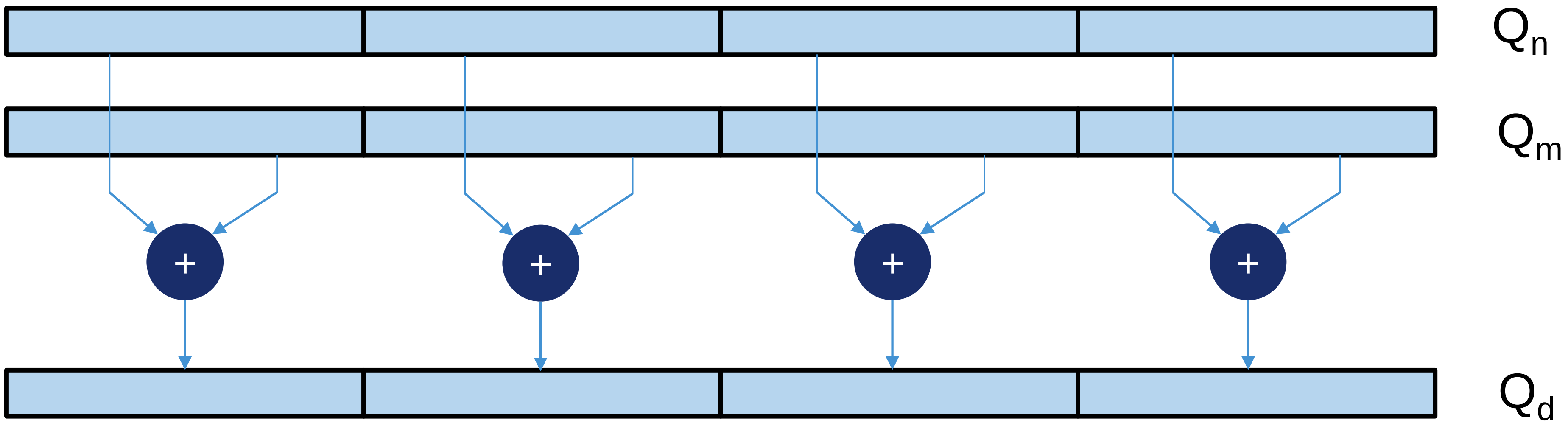
Arm NEON



- Single-Instruction Multiple Data (SIMD)
- Integer 16x8-bit, 8x16-bit, 4x32-bit, 2x64-bit
- Floating-Point 8x16-bit, 4x32-bit, 2x64-bit

Vector Example

NEON registers represent a vector of ‘n’ elements, e.g.



- Example code:

```
VADD.F32 Qd, Qn, Qm  // Vector add, single-precision, floating-point
```

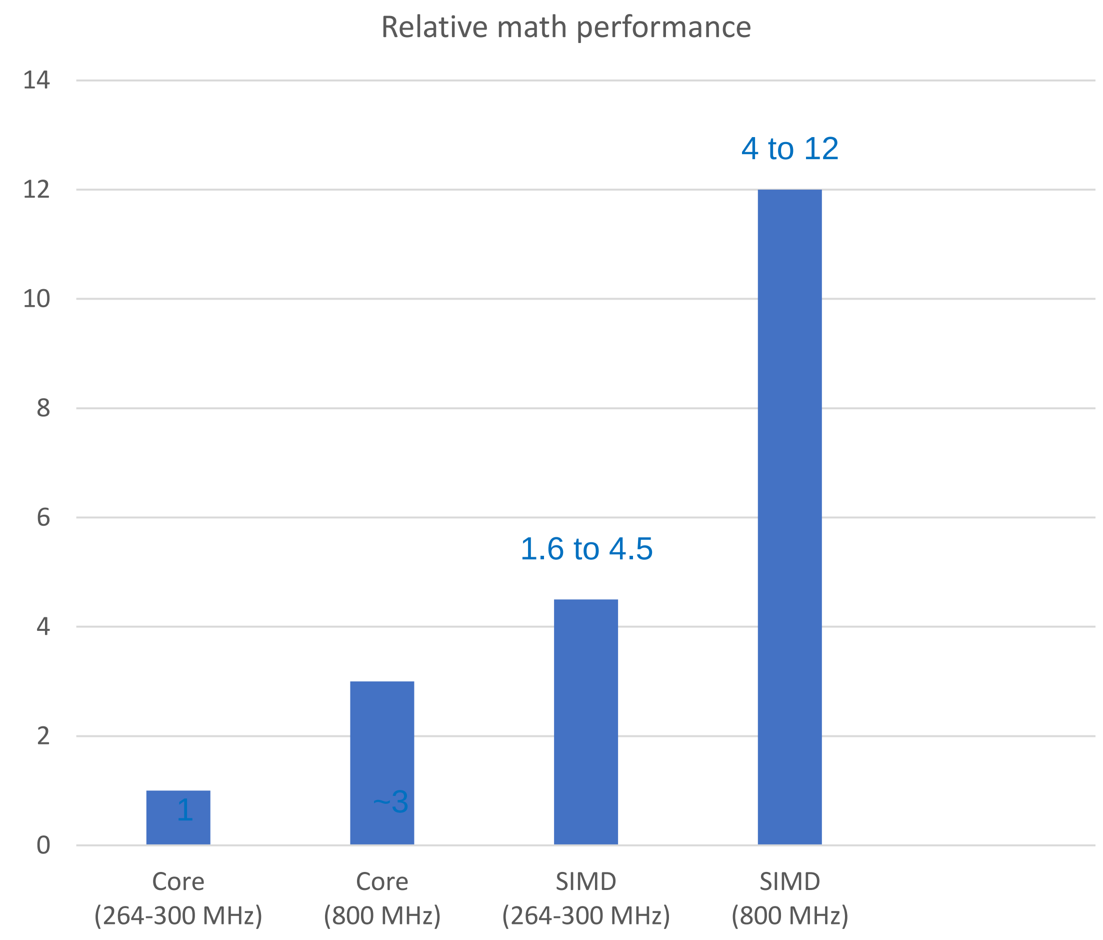
- Sixteen Quad-Word (128-bit) or Thirty-two Double-Word (32-bit) registers

Arm NEON Key Advantages

- Tightly integrated in the R52 core w/ direct access to memory
- Robust tools
- NEON code generation in the compiler and intrinsics support
- Optimized math libraries available from Arm and others

Math Acceleration Performance

- Math (matrix, vector) acceleration is most beneficial for data/math intensive operation with parallelism features.
- Relative performance very dependent on algorithm & data set



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