

DSP-specific language extensions for C

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Today most DSP software used in hand-held consumer applications is written in assembly. In other DSP application areas where power consumption and the application's footprint is of less interest, the trend is that control code is written in C and time-critical inner loops are coded in assembly. In the microcontroller market, C gained favor over assembly-level programming for well-known reasons: reduced development time, portability and re-use of application code, and reduced maintenance cost. The tradeoffs were a limited penalty on code size and run-time performance. Since the complexity and size of DSP applications continue to increase, the same reasons that motivated the move from assembly to C for microcontroller applications are now applicable to DSP.

There is, however, one major problem: standard C as defined in C9X is neither designed nor suited to implement DSP applications. DSPs use many hardware architectural features to optimize the system performance versus system cost ratio. Examples include:

- Support of multiple on-chip and off-chip address spaces
- Special address modification types to implement circular buffers and optimize array indexing for FFT transformations
- Fixed-point arithmetic
- Accumulators with extended precision and saturation logic

Standard C supports none of the above listed features. DSP C compiler suppliers use two fundamentally different approaches to give the C programmer access to these hardware features. One group supports an extensive set of intrinsic functions and pragmas, whereas the other group introduces C-language extensions such as memory space qualifiers, array and pointer qualifiers, fixed-point data types and additional keywords.

This article describes the basics of both approaches and explains the pros and cons with respect to:

- Readability and maintainability of C code
- Quality of error checking that can be done by the compiler
- The effects on the debug process
- Portability of C code
- Effects on compiler technology and code generation

DSP-C language extensions are vendor specific, and no de-facto standard exists. However, generally shared best-practices are being created. This DSP-C derivative, an extension to ISO/IEC IS 9899:1990 has been submitted to ISO/IEC as background material for new functionality that can be included in new versions of the C standard. This article describes the reasoning behind the introduction of a subset of the DSP-C language extensions in an informal "explain by example" approach.