

# Medical Diagnostic Ultrasound Software v1.0.1

## 1 Introduction

The purpose of the Medical Ultrasound Software Toolkit is to facilitate and ease development of ultrasound systems using Texas Instruments SoCs that contain leading edge programmable C64x+™ Digital Signal Processor (DSP) cores. You are encouraged to visit the following links for medical application offerings from Texas Instruments:

- Medical: [www.ti.com/medical](http://www.ti.com/medical)
- Medical Imaging: [www.ti.com/medicalimaging](http://www.ti.com/medicalimaging)

This toolkit consists of optimized C64x+ Little Endian implementation of the following modules:

- Optimized kernel implementations of Doppler Processing functions for 1D flow, 2D flow, Wall Filter and Power Estimator
- Optimized kernel implementations of RF demodulation and detection
- Optimized kernel implementations of DAS (Delay and Sum) receive beamforming
- Optimized system implementation of Scan Conversion on DSP (C64x+) of DM6437, DM6446 and OMAP3530 SoCs
- Optimized math utilities

Relevant white papers/application reports can be found at the following links:

- *Using TI's Embedded Processor Software Toolkit for Medical Diagnostic Ultrasound* ([SPRAB33](#))
- *Ultrasound Scan Conversion on TI's C64x+ DSPs* ([SPRAB32](#))
- *Efficient Implementation of Ultrasound Color Doppler Algorithms on Texas Instruments' C64x™ Platforms* ([SPRAB11](#))
- *Signal Processing Overview of Ultrasound Systems for Medical Imaging* ([SPRAB12](#))
- *Digital Signal Processor (DSP) for Portable Ultrasound* ([SPRAB18](#))

Project collateral discussed in this document can be downloaded from the following URL:  
<http://www-s.ti.com/sc/techlit/sprugq7.zip>.

## 2 Documentation

**Table 1** lists components and types of delivery (object/source) of the components for full or evaluation release and links to the corresponding documentation. A component may contain more than one module. The component abbreviation is the top-level directory name and used as the API prefix. The dpu component consists of modules dpucolor1d, dpucolor2d, dpuwallfiltercolor and dpupower.

**Table 1. Evaluation Links to Corresponding Documentation**

Component Abbreviation	Name	Type of Delivery for Production Release (Source or Object)	Type of Delivery for Evaluation Release (Source or Object)	Documentation Links Within the Package
dpu	Doppler Processing Unit	Source	dpuwallfiltercolor as source, rest as object	<ul style="list-style-type: none"> <li>• Doppler Color Flow Estimator (1D) Product Brief</li> <li>• DPU.chm</li> </ul>
rfdemod	RF demodulator	Source	Object	<ul style="list-style-type: none"> <li>• RF Demodulator Product Brief</li> <li>• rfdemod.chm</li> </ul>

**Table 1. Evaluation Links to Corresponding Documentation (continued)**

Component Abbreviation	Name	Type of Delivery for Production Release (Source or Object)	Type of Delivery for Evaluation Release (Source or Object)	Documentation Links Within the Package
scu	Scan Conversion Unit	Source	Object	<ul style="list-style-type: none"> <li>• Scan Converter Product Brief</li> <li>• Scan Converter Software the Release Notes</li> <li>• scu.chm</li> </ul>
rxbf	DAS Receive Beamformer	Source	Source	<ul style="list-style-type: none"> <li>• Receive Beamformer (RXBF) Product Brief</li> <li>• rxbf.chm</li> </ul>
util	Math utilities	Source	Object	<ul style="list-style-type: none"> <li>• Four Quadrant Inverse Tangent (Low Precision) Product Brief</li> <li>• util.chm</li> </ul>
iface	Interface among some modules to share common structure definitions	Source	Source	<ul style="list-style-type: none"> <li>• APIs, source, etc</li> </ul>
types	Portable base type definitions	Source	Source	<ul style="list-style-type: none"> <li>• APIs, source, etc</li> </ul>
sdk	Supportive software for testing	Source	Source	<ul style="list-style-type: none"> <li>• APIs, source, etc</li> </ul>

General directory organization under a component (<comp>) is as follows. The scu may differ somewhat; refer to its release notes for more information.

Directory	Description
<comp>	Top level component directory, may contain data sheet and release notes
<comp>/<moduleX>.h	Public API headers of modules (may be more than one).
<comp>/make_c64P_lib/<moduleX>.pj	Directory containing Code Composer Studio™ project to build library in <comp>/c64P/ for source deliveries
<comp>/c64P/<moduleX>.lib	C64+ little endian object libraries. The library of scu is named scu.l64P instead of scu.lib for XDAIS compliance.
<comp>/src/c64p/	Contains C64+ specific sources containing optimized implementation for modules that are delivered as source. May be C with intrinsics or linear assembly files.
<comp>/test/	Top level directory for component's testing, may contain multiple module tests.
<comp>/test/src	Source code tree for test.
<comp>/test/lnkr/c64p/	Linker command files
<comp>/test/ccsProj_c64p/	Test project to build and run test in Code Composer Studio
<comp>/test/vectors/inp	Input test vectors containing signal and configuration files
<comp>/test/vectors/out	Placeholder directory where output vectors will be generated when executing the test
<comp>/test/vectors/refOut	Fixed point reference output that is expected to match /out/

### 3 Device Support

- dpu, rfdemod, util, rxbf: Any SoC containing C64x+ DSP core configured in Little Endian. Test projects provided in the release are limited to running on the C64x+ CPU Cycle Accurate Simulator and C6455 EVM targets, the same test project can be used for either target. All components except rxbf are expected to show good cycle performance on C6455 EVM. The rxbf shows optimal cycle performance only for the simulator target.
- scu: DM6437, DM6446, OMAP3530 and C6455 SoCs, C64x+ DSP core configured in Little Endian. Note the C6455 platform is only supported for convenience of being able to run the scan conversion functionally like other components, the scu implementation is not optimized for cycle performance on this platform.

## 4 Tools and Infrastructure Software Dependencies

- Code Composer Studio Version 3.3
- C64x+ Code Generation Version 6.1.12. Note Code Compser Studio v.3.3 comes with code generation version 6.0.8 by default. Must upgrade compiler to 6.1.12 through the standard component update process in Code Composer Studio.
- IQMath library, version 2.1.3 (scu dependency only). For more information, see the scu release notes.
- DSP BIOS 5.33.03 (scu dependency only). For more information, see the scu release notes.
- Framework components release 2.24.1 (scu dependency only on XDAIS and ACPY3). For more information, see the scu release notes.

## 5 Validation Information

All kernel modules of dpu, rfdemod, util and rxbf are validated on the following platforms:

- Code Composer Studio C64x+ little endian CPU cycle accurate simulator
- C6455 EVM board (<http://focus.ti.com/docs/toolsw/folders/print/tmdsdsk6455.html>).

Scan conversion (scu) software has been validated on the following platforms:

- DM6437 EVM (<http://focus.ti.com/docs/toolsw/folders/print/tmdsvdp6437.html>)
- DM6446 EVM (<http://focus.ti.com/docs/toolsw/folders/print/tmdxevm6446.html>)
- OMAP3530 Mistral EVM (<http://focus.ti.com/docs/toolsw/folders/print/tmdxevm3503.html>)
- C6455 EVM (<http://focus.ti.com/docs/toolsw/folders/print/tmdsdsk6455.html>)

## 6 New in Release v1.0.1 (previous release v1.0)

- API changes in dpu, rfdemod to improve clarity and simplicity and improvement in API documentation.
- Implementation of programmable Q formats for dpu's wall filter and power
- Correction in implementation of Q formats for rfdemod
- Small improvement in accuracy by rounding and proper scaling for dpucolor1d's autocorrelation and power
- Wall filter removal of saturation in internal 32-bit accumulation
- Representation of pi at full scale (Q7 for 8-bit and Q15 for 16-bit version) in util module's atan2 APIs (8-bit Q7 version used for velocity estimation in dpucolor1d)
- Documentation of test bench file formats to facilitate creation of custom test cases
- Improvement in padding logic in test benches of dpu to better demonstrate non-multiplicity cases
- Changes in scu to remove usage of EDMA3 and provide compliance with iDMA3 interface using ACPY3. Changes in scu test bench to illustrate use of DSKT2 and DMAN3 framework components. Support for IUNIVERSAL interface for usage in Codec Engine. Generation of scu.tar and types.tar packages for consumption in Codec Engine for back-end devices like OMAP™ and DaVinci™. Addition of test case to demonstrate non-zero output stride. Fix of defect related to large radius causing artifacts.
- Upgrade to 6.1.12 compiler

## 7 Upgrade and Compatibility Information

Not API compatible with MED-STK 1.0 release for dpu, rfdemod, scu and util's atan2 API. API compatible with MED-STK1.0 release for rxbf and util's div and cplxMag APIs.

## 8 Benchmarks

Refer to the device-specific data sheets.

## 9 Known Issues

- Significant degradation in dpucolor2d performance due to upgrade to 6.1.12 compiler version.
- Power and input Q-formats not used (not implemented) for dpucolor2d; this was also the case in STK 1.0, but found after making the release.

## 10 Technical Support and Product Updates

Send e-mail to [medical-imaging-support@list.ti.com](mailto:medical-imaging-support@list.ti.com).

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