Four Quadrant Inverse Tangent (Low Precision)

Medical Imaging DSP Applications Team

1 Description

This is a low precision and low complexity implementation of the four quadrant inverse tangent (atan2) function. It operates on input complex vectors, $Z = X + jY$, where X = {x} and Y = {y} , and computes the result, θ = atan2(*y, x*) , for each point, where $-\pi \le \text{atan2} \le \pi$. The resulting output can be 8 bit (in Q7, [-128 (- pi), 127 (pi)]) or 16 bit (in Q15 format, [-32768 (-pi), 32767 (pi)]) vector. It uses the approximation [1] as given below:

$$\begin{aligned} r &= \frac{x - |y|}{x + |y|}, & \theta &= \frac{\pi}{4} - \frac{\pi}{4} r, & &(x, y) \in Q1, (x, y) \in Q4 \\ r &= \frac{x + |y|}{|y| - x}, & \theta &= \frac{3\pi}{4} - \frac{\pi}{4} r, & &(x, y) \in Q2, (x, y) \in Q3 \\ \theta &= -\theta & & & &(x, y) \in Q4, (x, y) \in Q3 \end{aligned} \quad (1)$$

The maximum error using this approximation is expected to be within 0.1 radians of the floating point result.

Project collateral discussed in this document can be downloaded from the following URL: http://www-s.ti.com/sc/techlit/sprs618.zip.

2 Kernel Complexity (C64x+™ CPU cycles, based on CPU cycle accurate Simulator)

- With 8-bit outputs, util_atan2_lp_16b_8b: 4.5 L + 53
- With 16-bit outputs, util_atan2_ lp_16b_16b: 4.5 L + 48

where,

L = Length of input/output vector,

3 Cycles on TMS320C6455 EVM

The performance is given for several example cases on the C6455 EVM in cycles. The test bench for math UTIL can be used to find cycles of interest for any other valid configuration.

API	L	Test Case	EVM Cycles
util_atan2_lp_16b_8b	1024	1	4661
util_atan2_lp_16b_8b	512	2	2357
util_atan2_lp_16b_16b	1024	1	4726
util_atan2_lp_16b_16b	512	2	2388

4 Memory

Memory	Size in Bytes
Data	None
Program	~1KB (util_atan2_ lp_16b_8b + util_atan2_ lp_16b_16b)

5 References

- J.M.Shima, *FM Demodulation Using Digital Radio and Digital Signal Processing*, MS Thesis, University of Florida, 1995.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DLP® Products	www.dlp.com	Broadband	www.ti.com/broadband
DSP	dsp.ti.com	Digital Control	www.ti.com/digitalcontrol
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Military	www.ti.com/military
Logic	logic.ti.com	Optical Networking	www.ti.com/opticalnetwork
Power Mgmt	power.ti.com	Security	www.ti.com/security
Microcontrollers	microcontroller.ti.com	Telephony	www.ti.com/telephony
RFID	www.ti-rfid.com	Video & Imaging	www.ti.com/video
RF/IF and ZigBee® Solutions	www.ti.com/lprf	Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265