Whitepaper

ACUSON CV70 Cardiovascular System

A Benchmark Technical and Performance Achievement in Diagnostic Cardiovascular Ultrasound

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Introduction

The ACUSON CV70™ cardiovascular system combines next-generation innovations with a proven technological baseline of performance. The first all-digital cardiovascular ultrasound system in its class, the CV70 system engineering design extensively employs technologies migrated from both the ACUSON Sequoia™ and SONOLINE™ ultrasound system families. Original creative design elements are added to key technologies from those two sister platforms and are integrated and optimized into the CV70 system for its mission of premium performance and high value.

Image quality, reliability, workflow dependability, system stability, and exam predictability result from the all-digital design. Digital technology is employed throughout the entire CV70 system signal processing architecture including the mid-processor, where an analog conversion is often performed on conventional systems. There are significant benefits to this design approach. Utilizing cutting edge technology and state of the art electronics, the CV70 system achieves performance levels in speed and signal processing typically found on more expensive systems. Digital electronics benefit image quality as well since there are fewer components to experience electronic drift - a serious drawback with all-analog components. A digital beam former, mid-processor, and back-end processor provide proven stability. This in turn means fewer service calls because the image quality is consistent over time - a cost-saving advantage.

The CV70 system uses modular electronic and mechanical designs to offer service accessibility and to reduce image noise. Eleven individual Field-Replaceable Units (FRUs) can be changed out quickly for fast and efficient system service. The extended interface control boards, the CPU and Video I/O are physically separated and shielded from the main electronic module to reduce image noise. The modular architecture includes the DIMAQ™ integrated ultrasound workstation, dedicated to patient data and image management, specialty applications, and connectivity, without affecting or compromising the core processing power of the system (Figure 1).

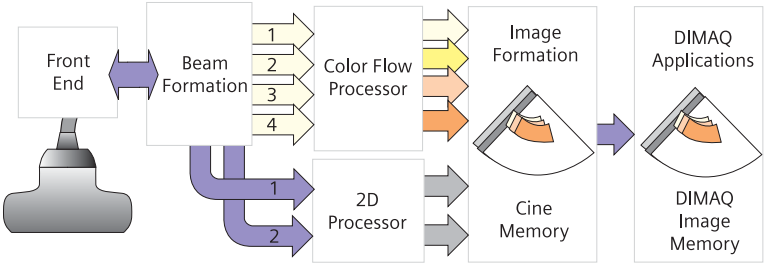

Figure 1. *CV70 system all digital imaging architecture*

Fully Digital Imaging Chain: Signal integrity Throughout the Entire Signal Path - From Transducer to Display

Obtaining maximum benefit from digital performance requires that digital components replace analog components as closely as possible to the front end of the imaging chain. Throughout the entire signal path, from the point of digitization onward, the ultrasound information is maintained with fidelity.

The Front End - Where Imaging Begins

The battle for image quality begins in the front end. Transmit beam formation and receive beam formation are separate for each mode. Independent control of transmit and receive adds front end flexibility, allowing for optimization of image quality for each particular examination type.

Transducers

Transducers for the CV70 system are designed for excellent imaging performance and utilize advanced ergonomic designs. Ultra-sensitive lens materials preserve and process more of the echoes returning from the tissues to improve penetration, contrast resolution and color sensitivity in low flow situations and for deep organs. CV70 system transducers have wide bandwidths to preserve fine spatial details and enable frequency agility. Frequency agility allows user selection of individual B-mode and Doppler frequencies to optimize resolution and penetration (Figure 2). This expands clinical versatility of each transducer by offering up to five fundamental and tissue harmonic frequencies and two color/spectral Doppler frequencies (Figure 3).

High-density 192 element arrays provide excellent image detail and anatomical coverage. Signals from the many elements are combined in the system beam former with SynAps™ synthetic aperture technology, providing improved penetration and far field resolution for wide aperture linear and convex array configurations. Ergonomically, microCase™ transducer miniaturization technology and SuppleFlex™ transducer cables make the transducers lighter and easier to manipulate, thereby producing less stress on hands, wrists, arms, and shoulders.

The CV70 system utilizes the ACUSON designed and engineered proprietary Micro Pinless (MP) connector. The MP connector provides superior signal integrity when compared to conventional connectors with pins. Because the electrical contacts are solid, there is less susceptibility to noise and signal strength is higher and more consistent.

Analog-to-Digital Conversion with Fast Clocking and High Dynamic Range

Conversion of RF echo signals from analog to digital is performed for each transducer element. In this way the digitization process is as close as possible to the origin of the analog information. The incoming ultrasound RF analog signals are sampled and digitized into very fine time increments and into very fine amplitude levels. The resulting large dynamic range provides finely detailed image contrast resolution in B-mode and excellent depth of penetration in the Doppler modes. Fast sampling in time along with wide bandwidth transducers together support the large frequency bandwidths required for Tissue Harmonic Imaging and for imaging at high frequencies. Highly precise and

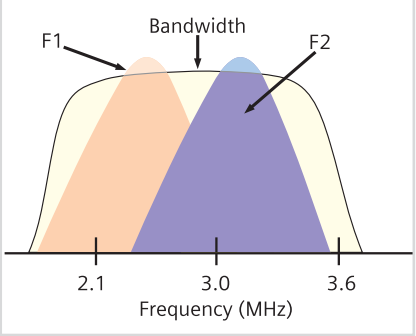

Figure 2. *MultiHertz™ Multiple Frequency Technology*

Provides a flexible choice of imaging frequencies and utilizes the entire frequency range of each broadband transducer. Receive and transmit frequencies are matched according to the application. B-mode and Doppler frequencies are separately optimized for resolution and penetration.

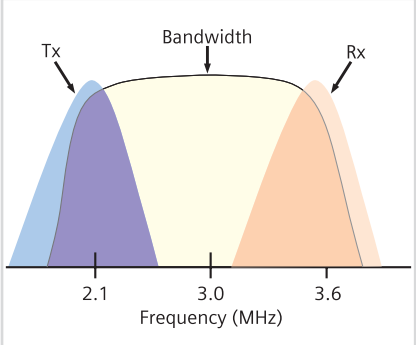

Figure 3. *CV70 System Frequency Agility*

Is possible because of the wide transducer bandwidth and ultrasensentivity. The Tissue Harmonic mode operates by transmitting at a lower frequency and receiving at a higher one. B-mode and Doppler frequencies may be widely separated for individual optimization.

Micro Pinless (MP) connector

stable time sampling yield high quality Doppler displays and excellent channel separation.

The Receive Beam Former

Digitized RF data from each transducer element, finely sampled in time and in amplitude, passes directly to the beam former. Each analog-to-digital converter provides a large range of signal that the beam former combines into an output of 18-bits. From this point on, the ultrasound image information is encoded in digital form and can be stored temporarily in memory. It can be processed and combined with other signals in many ways using a myriad of signal processing devices and methods. Furthermore, the digital data can be manipulated quickly and flexibly so that the beam formed data can be routed over any one of a number of signal pathways. B-mode, color Doppler, Spectral Doppler, and other types of images may be computed by switching the beam former output to the appropriate mode-processing modules in the system.

The beam former is designed with patented Siemens technology. A new generation of ASICs (Application Specific Integrated Circuit) technology is used in the circuitry design and implementation, making the beam former compact in size, with reduced power consumption. This allows for faster processing with a higher dynamic range. The beam former uses a special method for reaching very fine time resolution. By timing the data passage through the beam former with a device called a four-phase clock, the effective time sample resolution is 168 MHz. When converted to a length measure, 168 MHz is equivalent to a remarkable 4.6-micron depth resolution. So the resulting image presentation is sharp and crisp. Every CV70 system image contains far more echo information than one derived from a traditional beam former.

Image Formation Technology

Direct RF filtering is performed on the beam formed data for the computation and construction of images. This technology, migrated from the ACUSON Sequoia and SONOLINE products, boosts the power of the CV70 system beyond others in its class. By operating directly on the RF data, the CV70 system image former processes and preserves both the phase and amplitude information in the received echo.

Cascaded RF filters dynamically restore and reshape the receive pulse to correct for distortions and spatial resolution losses due to attenuation. This capability provides sharp images even at depth. The entire range of information in the signal is maintained throughout the processing chain, a unique feature contributing to the extraordinary performance of the CV70 system. Specially designed two-dimensional signal processing filters improve edge definition while retaining gray scale information in the myocardium. These filters significantly reduce noise for a clean display of cardiac chambers and sharply defined chamber boundaries. Tissue Harmonic Imaging on the CV70 system, with its inherently finer resolution than that of conventional gray scale imaging, is significantly enhanced with the high fidelity direct-RF filtering.

The CV70 system image former has programmable flexibility. Signal processing is adjusted for each transducer frequency and tailored to each examination, enabling the Siemens engineering and clinical development teams to provide optimal presets for CV70 image quality. The professional user has the ability to further fine-tune the examination results to individual clinical situations. Precision control in the image former also translates to image consistency and homogeneity. Line density and line spacing are carefully controlled to eliminate geometric distortion and to provide image uniformity.

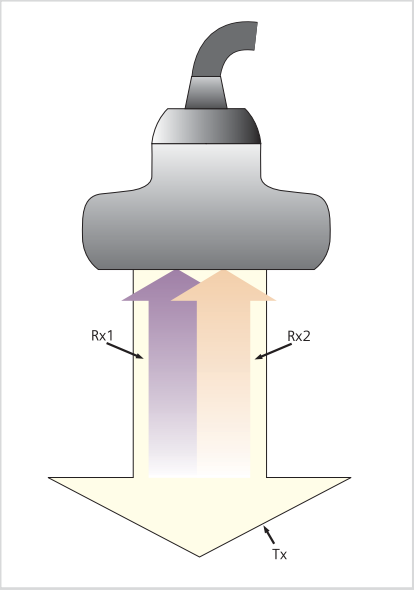

Figure 4. *Multiple Beam Formation*
Example of two receive beams for one transmit beam

Multi-Beam Beam Formation with Parallel Processing

Digital signals are easily replicated and directed along multiple pathways, all of them processing the data simultaneously, in a unique way defined for each particular pathway. The CV70 system is capable of forming multiple beams with parallel beamforming: two parallel beams in B-Mode and four parallel beams in Color Flow Mode (Figure 4). In the CV70 system Multi-Beam image formation architecture there are four parallel pathways that simultaneously generate up to four receive beams from one transmit pulse. This ability translates to high frame rate imaging capability, critical for high performance color flow quality and for tissue image motion visualization. The CV70 system Multi-Beam Image Formation Technology is fast and flexible, with the ability to create up to two tissue beams in "Dual B Mode" and four Color Flow beams in "Quad Color Mode", from each transmitted pulse.

Precision Motion Capture

Motion depiction is critical for proper diagnosis of fast blood flow, especially in the heart. B-mode motion depiction is critical to proper wall motion diagnosis. The MultiBeam Image Formation feature of the CV70 system provides high frame rates through simultaneous formation of multiple receive beams from one transmit beam. Furthermore, due to direct processing of the RF beam formed signals, motion is captured and displayed in detail and with precision. Consequently, acquisition rates in real-time B-mode imaging are greater than 350 frames per second for all array transducers. Slow motion review during post processing allows a careful study of motion details. Similarly, Dual Beam Parallel processing is implemented for Color Flow and Power/Directional Power Doppler on all imaging transducers. The P4-2 adult cardiology transducer supports Quad Parallel Processing in Color, Power/Directional Power Doppler modes.

Color Fidelity

The Digital Color Flow Processor makes full use of the RF amplitude and time information preserved through the imaging chain. Fine adjustments of line density and smoothing filters provide accurate flow geometry information. Velocity displays, color-coded in direction and magnitude, show hemodynamic functionality for straightforward determination of flow abnormalities. Preservation of the full RF signal range in Color Flow Imaging increases color sensitivity at depth and enables fine velocity resolution and flow visualization in low flow and fast flow organs.

DIMAQ Integrated Ultrasound Workstation

The DIMAQ™ integrated ultrasound workstation is an information management system that is an integral part of the CV70 system architecture (Figure 10). This onboard workstation has numerous valuable image and clip acquisition capabilities including storage, connectivity and analysis features. The DIMAQ workstation facilitates efficient workflow. It captures and stores true digital copies of static images and dynamic clips in its workstation memory without interrupting the examination. Cine clips are acquired in real-time at standard video rates of 30/25 frames per second (NTSC/PAL).

Figure 5

Figure 6

Figure 7

Figure 8

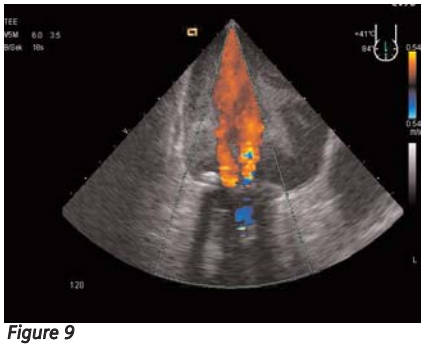

Figure 9

Figure 5. *The DIMAQ ultrasound workstation enables immediate post-examination and review analysis*

Figure 6. *Intra-operative cardiovascular solutions with the VF13-5SP transducer*

Figure 7. *Rodent heart in B-mode and M-mode imaging*

Figure 8. *V5M transesophageal echo-cardiography transducer*

Figure 9. *Transesophageal Imaging with the V5M transducer*

Data collection may be triggered by ECG gating and the sequences may be captured retrospectively or prospectively with the Dynamic Clip Capture feature. An editing tool may be used to manipulate the cine clips and review them in 1:1, 4:1, 9:1, and 16:1 formats.

Images are immediately available for review on the system during the examination as well as anytime after the conclusion of the examination. Storage and archival of images and clips occurs seamlessly during a typical examination to enhance workflow, facilitated by the high frame rate Cine Transfer Capture feature. The DIMAQ workstation provides fast and comprehensive connectivity options to the hospital PACS system and to the world at large. Located in the data mainstream, DIMAQ automatically combines digital records of patient studies with post-processing results.

The DIMAQ workstation on the CV70 system is flexible. Its open architecture seamlessly integrates both DICOM and commonly used connectivity media including TIF and AVI. There are various patient data output choices for archiving through on-board CDRW, DICOM network/printer, or LAN communication through the Network Export feature. Patient studies may be stored on Hard Disk, CDRW. The built-in DIMAQ connectivity resides within the CV70 system, and can be utilized whether it is located in the ultrasound department or to the patient bedside. Mobile exams are easily transferred at post-examination to a workstation for instant review, quantification and analysis of images and clips.

DIMAQ post processing includes both standard and advanced applications features. In addition to being equipped with a comprehensive measurements and calculations software package, DIMAQ is configured with an open architecture to facilitate the addition of new post-processing applications as they are developed so that the user may keep pace with the latest technologies in ultrasound engineering. For example, Axius™ edge assisted Ejection Fraction, shortens the time for ejection fraction determination. The DIMAQ workstation also provides a gateway for advanced imaging procedures such as stress echo imaging, an option that is fully featured and integrated

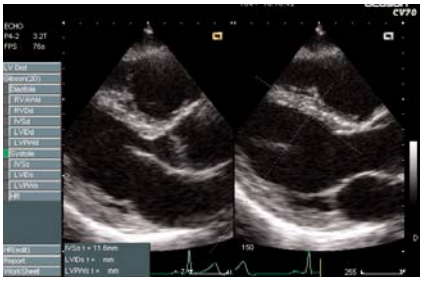

Figure 10

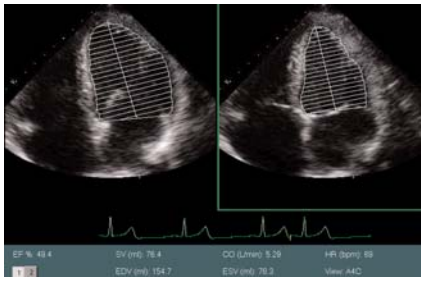

Figure 11

Figure 10 *Anatomically guided M-mode measurements*

Figure 11. *Axius™ edge assisted Ejection Fraction*

neatly into the workflow of the system (Figure 5).

High Frequencies and High Frame Rates for Special Applications

The imaging chain components in the CV70 system from transducer, through analog-to-digital converter, beam former, and digital processor are designed with sufficiently large bandwidths and fast acquisition rates necessary to image small, rapidly moving organs such as mouse hearts. Mouse imaging using the V513-5SP transducer is a growing application for investigations of phenotype changes after genetic manipulation and for monitoring functional changes during therapeutic interventions (Figures 6 and 7).

Flexible System Support for Special Transducers

The CV70 system is a versatile, adaptable system that will accommodate new transducers and new clinical applications as they are developed.

The V5Ms transesophageal echocardiography transducer provides excellent image quality and can be used in the operating room where small system size and premium performance are advantageous (Figures 8 and 9).

To round out the operating room capabilities of the CV70 system, an intraoperative cardiovascular transducer is provided for high frequency imaging during sterile procedures such as a carotid endarterectomy and epiaortic imaging. brachial artery, peripheral vascular and mouse heart imaging are cardiovascular applications where this transducer can provide an excellent high frequency imaging solution.

Wall Motion Quantification: Faster, with Improved Diagnostic Confidence

Conventionally, cardiac wall motion quantification relies on visual tracking of ventricle boundaries. The novel signal processing power of the CV70 system provides greater flexibility in motion measurement locations, more confidence in their reported values, and more reliable calculations of derived functional indicators such as ejection fraction.

Anatomically guided M-mode allows measurements of wall motion along a line of operator controlled location and orientation (Figure 10). This capability lets the clinician assess local function with improved anatomic relevance and, therefore with more confidence.

Axius ejection fraction measurement calculates a vital functional parameter quickly and reliably. Axius ejection fraction enhances workflow by allowing the user to indicate three boundary points for measurement instead of tracing the entire ventricular boundary (Figure 11).

Summary

The ACUSON CV70 cardiovascular system is a convergence of ACUSON and SONOLINE technologies. Superb image quality, long-term dependability, and reassuring diagnostic confidence result from this technological synthesis and its all-digital design. Integrated connectivity facilitates easy transfer of studies from the CV70 system to a wider clinical environment. It combines proven innovative engineering designs for diagnostic performance that is virtually unmatched in its class.

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