

Development of the New RADspeed Pro V4 General Radiography System

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1. Introduction

Previously, Shimadzu Corporation released the RADspeed safire general radiography system, equipped with a 17-inch direct-conversion flat panel detector (FPD). Along with its high spatial resolution, its high sensitivity characteristics provide high image quality even at low dose levels. However, some customers wanted further improvements in workflow efficiency, as well as applicability to joint axial projection, which was not possible with the direct conversion FPD. Therefore, Shimadzu Corporation developed the RADspeed Pro V4, which incorporates a portable FPD, a newly developed digital radiography unit, and an integrated control system, to meet these requirements.

2. System Configuration and Key Specifications

A photograph of the overall RADspeed Pro V4 system is shown in Fig. 1.

The system includes two FPDs, a fixed 17 × 17-inch unit and a portable 17 × 14-inch unit, which enable a variety of radiography types, including axial projection. Two types of scintillators are used, a gadolinium oxysulfide (GOS) scintillator and a cesium iodide (CsI) scintillator.

The key components and specifications of a typical system are indicated in Tables 1 and 2.



Fig. 1 RADspeed Pro V4 System

SFD-1717A Fixed Flat Panel Detector	
X-Ray Conversion Method	Indirection conversion
Fluorescent Material	CsI/GOS
A/D (Grayscale)	14 bit
Effective Field of View	17 × 17 inch (424 × 424 mm)
Pixel Size	139 μm
Max. Imaging Matrix	3052 × 3052
SFD-1714AP/1714APW Portable Flat Panel Detector (Wired/Wireless)	
X-Ray Conversion Method	Indirection conversion
Fluorescent Material	CsI/GOS
A/D (Grayscale)	16 bit
Effective Field of View	14 × 17 inch (350 × 421 mm)
Pixel Size	139 μm
Max. Imaging Matrix	3032 × 2520
Load Capacity	150 kg over entire panel or 100 kg over 40 mm diameter area
Weight	3.5 kg
DRU-200 Digital Radiography Unit	
Monitor	19-inch color LED monitor
Operation	Touch panel or mouse
X-Ray Generator Control	Possible
Image Display Speed	3 to 4 seconds (preview image)
Image Processing Functions	Grid line elimination, irradiation field extraction, image exposure normalization, image parametric equalization, and noise reduction
Output Gradation	16/14/12 bit
Network Compatibility (optional)	DICOM Print, DICOM Storage, DICOM MWM, DICOM MPPS
Information Monitor for Examination Room (optional)	
Monitor	10 or 12-inch color LED monitor
Operation	Touch panel

Table 1 Key Specifications for FPDs and Digital Radiography Unit

BR-120 Bucky Stand	
Vertical Movement	Manual or electric (optional)
Bucky Center-to-Floor Distance	380 to 1880 mm
Grid Detachment	Possible
Grid Type	Fixed
BKU-200 Bucky Table	
Tabletop Size	2350 × 810 mm
Tabletop Up/Down	535 to 850 mm
Grid Detachment	Possible
Grid Type	Fixed
CHU-200 X-Ray Tube Support	
X-Ray Tube Up/Down Stroke	1600 mm
Horizontal Axis Rotation	120 to -180 degrees
Vertical Axis Rotation	±180 degrees
Auto Positioning (optional)	Linked to protocols (90 positions) plus 4 default positions
D150BC-40/D150LC-45 X-Ray High Voltage Generator	
Nominal Maximum Output	80 kW/50 kW
Generation Method	Max. 50 kHz inverter
X-Ray Tube	
Focus Size	0.6/1.2 mm (two foci)
Focus Material	Tungsten
Cumulative Anode Heat Capacity	400 kHU/200 kHU (selectable)
Target Angle	12/16 degrees (selectable)
Max. Tube Operating Voltage	150 kV

Table 2 Key Specifications of Bucky Table, Tube Support, and Other Components

3. System Features

3.1 DRU-200 Digital Radiography Unit

This unit is based on the concept of improving workflow efficiency by improving the control system.

(1) Integrated Console

The X-ray high voltage generator control console is integrated with the digital radiography unit control console.

With previous systems, changing X-ray radiography parameters required operating both the digital radiography unit and the X-ray high voltage generator separately, but by strengthening the link between the DRU-200 and X-ray high voltage generator units and including X-ray high voltage generator control buttons on the DRU-200 control console, this new system allows operating both the

digital radiography unit and X-ray high voltage generator from a single control console. Furthermore, a touch panel is used for the control screen. This allows changing parameters or performing post-processing operations intuitively using the DRU-200 touch panel, which improves the workflow (**Fig. 2**).

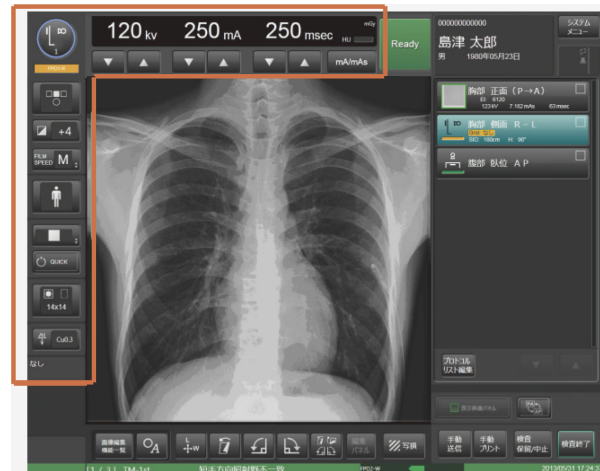


Fig. 2 DRU-200 Control Console

Serving also as a digital image processing console, it includes features to improve workflow, such as a preview display that appears about 3 seconds after exposures to allow checking for patient movement and transitioning to the next exposure without having to wait for image processing to finish.

(2) Mini-Console (Optional)

This improves ease-of-operation by using dials and buttons to set X-ray exposure parameters and improves visibility by using light to indicate the status (**Fig. 3**).



Fig. 3 Mini-Console

3.2 Extensive Image Processing Technology

(1) Grid Line Elimination

Scattered X-rays can cause decreased contrast in X-ray images. Therefore, for areas that require higher contrast resolution, such as the chest or lumbar spine, a grid is normally used to eliminate scattered X-rays. Consequently, this system includes a detachable fixed grid and a grid line elimination process that are used to achieve superior contrast resolution for the target object, by detecting and eliminating grid lines from radiography images.

(2) Image Exposure Normalization

Image exposure normalization (IEN) maintains a stable balance of darkness levels in images, regardless of the radiography method, exposure parameters, or other factors.

IEN involves extracting the irradiation field, identifying areas of interest (characteristic features), analyzing a histogram of those areas, and converting results to darkness levels so that images are displayed with a proper balance of darkness levels.

(3) Irradiation Field Extraction

To obtain radiography images with balanced darkness levels, this process automatically identifies and eliminates areas where X-rays are blocked by the collimator before exposure normalization. In addition, it automatically identifies any areas unnecessary for diagnosis, such as the collimator, and black out those areas to make it easier to read the images.

(4) Image Parametric Equalization

Two image parametric equalization (IPE) features are included.

The first controls the sharpness by specifying the degree of enhancement for specific frequency bands. For example, low frequencies can be enhanced to enhance the edges of soft tissues (or tumors) or the kidney or high frequencies can be enhanced to enhance detailed bone tissues (such as the trabecula) or other small structural objects.

The second is a dynamic range compression feature that specifies the degree of enhancement for specific frequency bands and darkness ranges to suppress under exposure and overexposure without sacrificing contrast in areas of interest.

Examples of images obtained using the image processing features described in (1) to (4) are shown in **Fig. 4, 5, and 6.**



Fig. 4 Front View of Chest



Fig. 5 Front View of Abdomen



Fig. 6 Side View of Cervical Spine

3.3 Improved Workflow Due to Integrated Control System

By displaying images and exposure parameters on the control panel of the ceiling-mounted X-ray tube support and on the examination room information display monitor (optional), operations and confirmation that were previously possible only in the control room are now possible in either the control or examination room.

The controls for the ceiling-mounted X-ray tube support allow viewing patient information and images, selecting or resequencing protocols, or changing exposure parameters (kV, mAs, and sec).

The examination room information display monitor allows viewing patient information and images, selecting or resequencing protocols, or specifying failed exposures (**Fig. 7**).

3.4 Linked Functions

(1) Auto Positioning (Optional)

Auto positioning is linked to radiography protocols, so that the ceiling-mounted X-ray tube support can be moved to a pre-specified exposure position with a single press of a button. Furthermore, electrically driven vertical axis rotation of the X-ray tube was added to the current system, which allows moving the tube to exposure positions more quickly than previous manually rotated models (**Fig. 8**).

(2) Auto-Stitching (Optional)

The FPD automatically tracks the X-ray tube rotation to obtain long view images. During radiography in the standing position, a screen placed in front of the FPD ensures safety by preventing patients from direct contact with the FPD. When auto-stitching radiography is finished, the stitched image is automatically displayed on the digital radiography unit console and the examination room information display monitor.

The maximum exposure range of the bucky stand is 43 × 175 cm, which is large enough to capture the entire spine of even tall patients.

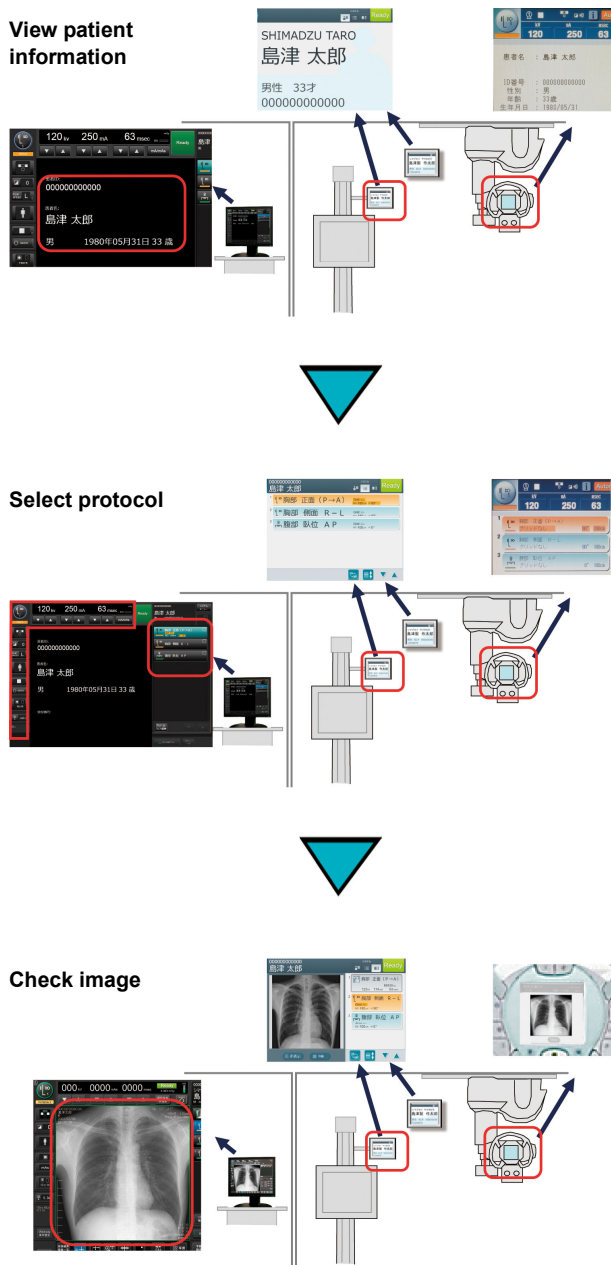


Fig. 7 Workflow

3.5 Lower Exposure Levels

The X-ray grid can be manually removed from the stand or table for radiography of children or extremities. Removing the grid allows obtaining images using lower exposure dose levels.



Fig. 8 Auto Positioning

The type of grid inserted is displayed on the control panel of the ceiling-mounted X-ray tube support, which can be checked while in the examination room.

4. Summary

The portable FPD unit, new digital radiography unit, and integrated control console included in the new RADspeed Pro V4 general radiography system minimize the workload of operators and improve operating efficiency and diagnostic quality. Finally, the authors would like to thank the doctors and others that offered generous help and valuable advice during the development of this system.