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**Digital Imaging and Communications in Medicine (DICOM)**

*Supplement 231: Variable Modality LUT Softcopy Presentation State*

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### Scope and Field of Application

5 This supplement defines a new Presentation State SOP Class for both grayscale and pseudo-color. This new SOP class differs from existing SOP classes in that it allows the Modality LUT to be controlled for each image or frame. This is intended for modalities in which the dynamic range varies between images or frames, resulting in each referenced image having a different Modality LUT.

10 In DICOM, Presentation States are intended to be a complete specification of the presentation in order to provide consistent presentation. An aspect of this is that PS3.4 N.2.1.1 requires the Modality LUT in the image be ignored in the presence of a GSPS object, even if no Modality LUT is explicitly defined in the GSPS. Since the GSPS only supports one Modality LUT, there can be a problem in the case of PET or MR, when the dynamic range of the measured values varies between images. Without this new SOP Class, the GSPS creator would be forced to render multiple GSPS objects, one per Modality LUT change.

**Modifications to PS3.3**

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Add Variable Modality LUT Softcopy Presentation State in PS3.3 Section A.1.4, Table A.1-6

**Table A.1-6. Composite Information Object Modules Overview - Presentation States**

<b>IODs Modules</b>	<b>Gray Pres State</b>	<b>Col Pres State</b>	<b>Pseudo Col Pres State</b>	<b>Blend Pres State</b>	<b>XA RF Pres State</b>	<b>Planar MPR Vol Pres State</b>	<b>Vol Rend Vol Pres State</b>	<b>Adv Blend Pres State</b>	<b>Var Mod LUT Pres State</b>
Patient	M	M	M	M	M	M	M	M	<u>M</u>
Clinical Trial Subject	U	U	U	U	U	U	U	U	<u>U</u>
General Study	M	M	M	M	M	M	M	M	<u>M</u>
Patient Study	U	U	U	U	U	U	U	U	<u>U</u>
Clinical Trial Study	U	U	U	U	U	U	U	U	<u>U</u>
General Series	M	M	M	M	M	M	M	M	<u>M</u>
Clinical Trial Series	U	U	U	U	U	U	U	U	<u>U</u>
Presn. Series	M	M	M	M	M	M	M	M	<u>M</u>
Frame of Referenc e						M	M	M	
General Equip.	M	M	M	M	M	M	M	M	<u>M</u>
Enhanced General Equip.					M	M	M	M	<u>M</u>
Mask	C		C						<u>C</u>
Display Shutter	C	C	C						<u>C</u>
Bitmap Display Shutter	C	C	C		C				<u>C</u>
Palette Color LUT			M	M					<u>C</u>
Overlay Plane	C	C	C		C				<u>C</u>

Disp. Area	M	M	M	M	M			U	<u>M</u>
Overlay Actvn.	C	C	C		C				<u>C</u>
Graphic Annot.	C	C	C	C	C	U	U	U	<u>C</u>
Spatial Trans.	C	C	C	C	C			C	<u>C</u>
Graphic Layer	C	C	C	C	C	C	C	C	<u>C</u>
Graphic Group	U	U	U	U		U	U	U	<u>U</u>
Modality LUT	C		C						
<b>Variable Modality LUT</b>									<u>C</u>
Softcopy VOI LUT	C		C		C				<u>C</u>
Softcopy Presn. LUT	M				M				<u>C</u>
Presn. State Ident.	M	M	M	M	M			M	<u>M</u>
Presn. State Reln.	M	M	M		M				<u>M</u>
Presn. State Shutter	M	M	M		M				<u>M</u>
Presn. State Mask	M		M						<u>M</u>
Presn. State Blending				M					
Adv. Presn. State Blending								M	
Adv. Presn. State Display								M	
XA/XRF Presn. State Mask					C				

XA/XRF Presn. State Shutter					C				
XA/XRF Presn. State Presn.					C				
Volumetric Presentation State Identification						M	M		
Volumetric Presentation State Relationship						M	M		
Volume Cropping						C	C		
Presentation View Description						M	M		
Multi- Planar Reconstruction Geometry						M			
Volume Render Geometry							M		
Render Shading							U		
MPR Volumetric Presentation State Display						M			
Render Display							M		
Volumetric Graphic Annotation						U	U		
Presentation Animation						U	U		

ICC Profile		M	M	M				M	<b>C</b>
Common Instance Reference						M	M	M	
SOP Common	M	M	M	M	M	M	M	M	<b>M</b>

Add the following new section in PS3.3 Annex A.33

**A.33.8 Variable Modality LUT Softcopy Presentation State IOD**

20 **A.33.8.1 Variable Modality LUT Softcopy Presentation State IOD Description**

The Variable Modality LUT Softcopy Presentation State Information Object Definition (IOD) specifies information that may be used to apply transformations to monochrome or pseudo-color images for which one or more Modality LUT transformations are intended for presentation control. This IOD supports presentation control for a set of images for which the Modality LUT varies on a frame-by-frame basis.

25 It includes capabilities from the Grayscale Softcopy and Pseudo-color Presentation State IODs for specifying:

- a. the output grayscale space in P-Values
- b. the output color space in PCS-Values
- 30 c. grayscale contrast transformations including Modality LUT and VOI LUT
- d. a color palette to map the transformed grayscale values into pseudo-color
- e. mask subtraction for multi-frame images
- f. selection of the area of the image to display and whether to rotate or flip it
- g. image and display relative annotations, including graphics, text and overlays

35 **Note**

40 *This IOD may only reference monochrome images or pseudo-color images, i.e. images with a Photometric Interpretation (0028,0004) of MONOCHROME1, MONOCHROME2 or PALETTE\_COLOR. For other Photometric Interpretations, presentation behavior is not defined. See Section A.33.2 for the Color Softcopy Presentation State IOD, which allows for referencing color images, e.g. images with a Photometric Interpretation (0028,0004) of RGB.*

**A.33.8.2 Variable Modality LUT Softcopy Presentation State IOD Module Table**

Table A.33.8-1 specifies the Modules of the Variable Modality LUT Softcopy Presentation State IOD.

**Table A.33.8-1. Variable Modality LUT Softcopy Presentation State IOD Modules**

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U



Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Presentation Series	C.11.9	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Presentation State	Presentation State Identification	C.11.10	M
	Presentation State Relationship	C.11.11	M
	Presentation State Shutter	C.11.12	M
	Presentation State Mask	C.11.13	M
	Mask	C.7.6.10	C - Required if the referenced image(s) are multi-frame and are to be subtracted
	Display Shutter	C.7.6.11	C - Required if a Display Shutter is to be applied to referenced image(s) and the Bitmap Display Shutter Module is not present
	Bitmap Display Shutter	C.7.6.15	C - Required if a Display Shutter is to be applied to referenced image(s) and the Display Shutter Module is not present
	Overlay Plane	C.9.2	C - Required if Overlay is to be applied to referenced image(s) or the Bitmap Display Shutter Module is present.
	Overlay Activation	C.11.7	C - Required if referenced image contains overlay data that is to be displayed or Presentation State Instance contains Overlay data other than Bitmap Shutter
	Displayed Area	C.10.4	M
	Graphic Annotation	C.10.5	C - Required if Graphic Annotations are to be applied to referenced image(s)
	Spatial Transformation	C.10.6	C - Required if rotation or flipping are to be applied to referenced image(s)
	Graphic Layer	C.10.7	C - Required if Graphic Annotations or Overlays or Curves are to be applied to referenced image(s)
	Graphic Group	C.10.11	U
	Variable Modality LUT	C.11.35	C - Required if a Modality LUT is to be applied to referenced image(s)
	Softcopy VOI LUT	C.11.8	C - Required if a VOI LUT is to be applied to referenced image(s)
	Palette Color Lookup Table	C.7.9	C - Required if the Softcopy Presentation LUT Module is not present.
	Softcopy Presentation LUT	C.11.6	C - Required if the Palette Color Lookup Table Module is not present.
	ICC Profile	C.11.15	C - Required if the Palette Color Lookup Table Module is present.
	Specimen	C.7.6.22	U
SOP Common	C.12.1	M	

In the Variable Modality LUT Softcopy Presentation State IOD, the Presentation Series Module specializes some Attributes of the General Series Module, the Presentation State Mask Module specializes some Attributes of the Mask Module, and the Presentation State Shutter Module specializes some Attributes of the Bitmap Display Shutter Module and Display Shutter Module.

50 **Note**

1. *Subtraction between different images is not supported.*
2. *The Mask Module condition implies that it need not be supported by an SCP that supports presentation states only for single-frame image storage SOP Classes, or Instances of multi-frame image Storage SOP Classes that contain only one frame.*
- 55 3. *The Display Shutter may be used to darken image areas that surround important information and exclude extraneous bright areas that increase glare and ambient lighting impairing image interpretation. For example, unexposed areas in a CR image might be obscured using the Display Shutter, rather than permanently replacing image pixels in those areas.*
- 60 4. *This IOD does not support the storage of a multi-frame overlay in the IOD itself, but does support selective activation of multi-frame overlays within the referenced images via the Overlay Activation Module.*

<i>Insert after C.11.34</i>
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### C.11.35 Variable Modality LUT Module

65 Table C.11.35-1 specifies the Attributes of the Variable Modality LUT Module, in which each item of the Variable Modality LUT Sequence describes a Modality LUT for a subset of images listed in the Presentation State Relationship Module.

**Note**

70 *This differs from the Grayscale and Pseudo-color Softcopy Presentation States which apply a single Modality LUT or Rescale Slope and Intercept to all images and frames listed in the Presentation State Relationship Module.*

**Table C.11.35-1. Variable Modality LUT Module Attributes**

Attribute Name	Tag	Type	Attribute Description
Variable Modality LUT Sequence	(0028,3001)	1	Modality LUTs or Rescale Slopes and Intercepts for specific images and frames.  Any given image or frame shall not be referenced in more than one item of this Sequence.  One or more Items shall be included in this Sequence.
>Referenced Image Sequence	(0008,1140)	1	The images and frames to which this Modality LUT or Rescale Slope and Intercept applies. All images referenced here shall also be referenced in the Presentation State Relationship Module.  One or more Items shall be included in this Sequence.
>>Include Table 10-3 "Image SOP Instance Reference Macro Attributes"			
>Include Table C.11-1b "Modality LUT Macro Attributes"			

**Modifications to PS3.4**

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Add the following to PS3.4 Table B.5-1 Standard SOP Classes

**B.5 Standard SOP classes**

**Table B.5-1. Standard SOP Classes**

SOP Class Name	SOP Class UID	IOD Specification (defined in PS 3.3)	Specialization
...			
<u>Variable Modality LUT Softcopy Presentation State Storage</u>	<u>1.2.840.10008.5.1.4.1.1.11.12</u>	<u>Variable Modality LUT Softcopy Presentation State</u>	
...			

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Modify PS3.4 Section B.5.1.15 Enhanced PET Image Storage SOP Classes as follows

### **B.5.1.15 Enhanced PET Image Storage and Legacy Converted Enhanced PET Image Storage SOP Class**

85 An SCP of the Enhanced PET Image Storage or Legacy Converted Enhanced PET Image Storage SOP Class shall also support the Grayscale Softcopy Presentation State Storage SOP Class, **and optionally the Variable Modality LUT Softcopy Presentation State Storage SOP Class**, as an SCP.

#### **Note**

90 *This requirement is present in order to allow the exchange of graphical annotations created by an acquisition or conversion device.*

Modify PS3.4 Section B.5.1.16 Enhanced PET Image Storage SOP Classes as follows

### **B.5.1.16 Enhanced PET Image Storage SOP Classes**

95 An SCP of the Enhanced PET Image Storage SOP Class shall also support the Grayscale Softcopy Presentation State Storage SOP Class, **and optionally the Variable Modality LUT Softcopy Presentation State Storage SOP Class**, as an SCP.

#### **Note**

*This requirement is present in order to allow the exchange of graphical annotations created by an acquisition device.*

100 Modify PS3.4 Section N.2 Pixel Transformation Sequence

### **N.2 Pixel Transformation Sequence**

The Softcopy Presentation State Storage SOP Classes support a sequence of transformations that completely define the conversion of a stored image into a displayed image.

105 The sequence of transformations from stored pixel values into P-Values or PCS-Values is explicitly defined in a conceptual model. The actual sequence implemented may differ but must result in the same appearance. Figure N.2-1 describes this sequence of transformations.

#### **Note**

1. *Even though a Composite Image Storage SOP Class may not include some Modules that are part of the described transformations, the Softcopy Presentation State Storage SOP Classes do include them. For example, the CT Image Storage SOP Class includes Rescale Slope and Intercept in the CT Image Module, but does not include the Modality LUT Module, and hence is restricted to the description of linear transformations. A saved presentation state that refers to a CT Image Storage SOP Instance may include a Modality LUT, and hence may apply a non-linear transformation.*
  2. *For the shutter, annotation and spatial transformations, the order in which they are applied relative to the other transformations should not result in a different appearance. The one exception is when a spatial transformation is applied that involves magnification implemented with interpolation. In this case, whether the interpolation is performed before or after the contrast transformations (such as VOI LUT) may result in a slightly different appearance. It is not considered necessary to constrain this sequence more precisely.*
- 110  
115  
120

125 The transformations defined in the Softcopy Presentation State Storage SOP Classes replace those that may be defined in the Referenced Image SOP Instance. If a particular transformation is absent in the Softcopy Presentation State Storage SOP Class, then it shall be assumed to be an identity transformation, and any equivalent transformation, if present, in the Referenced Image SOP Instance shall NOT be used instead.

Values of MONOCHROME1 and MONOCHROME2 for Photometric Interpretation (0028,0004) in the Referenced Image SOP Instance shall be ignored, since their effect is defined by the application of the grayscale presentation state transformations.

**Note**

130 *These requirements are in order to achieve complete definition of the entire transformation in the Softcopy Presentation State Storage SOP Classes, and not to depend on the content of the Referenced Image SOP Instance, which may change.*

135 The Referenced Image Storage SOP Instance may also contain bit-mapped overlays. The Softcopy Presentation State Storage SOP Classes specify a mechanism for turning these on or off (i.e., displaying them or not).

The presentation related Attributes of the Softcopy Presentation State Storage SOP Classes are immutable. They shall never be modified or updated; only a derived SOP Instance with a new SOP Instance UID may be created to represent a different presentation.

140 When a Supplemental Palette Color LUT is present in a grayscale Referenced Image Storage SOP Instance:

- 145 • The grayscale pipeline in any applicable Grayscale Softcopy Presentation State Storage SOP Instance, ~~or~~ Blended Softcopy Presentation State Storage SOP Instance, **or Variable Modality LUT Softcopy Presentation State Storage SOP Instance** shall be applied only to the range of grayscale stored pixel values, and the presentation state shall not affect the rendering of the indexed color values.
- A Color Softcopy Presentation State Storage SOP Instance shall not be applied.
- A Pseudo-color Softcopy Presentation State Storage SOP Instance, **or a Variable Modality LUT Softcopy Presentation State Storage SOP Instance** may be applied, in which case the Supplemental Palette Color LUT information shall be ignored.
- 150 • No mechanism for separately specifying color consistency of the colors in the Supplemental Palette Color LUT is presently defined, only the optional inclusion of an ICC profile in the image instance.

**Modifications to PS3.6**

155 *Add the following to Table 6-1 Registry of DICOM Data Elements:*

**Table 6-1. Registry of DICOM Data Elements**

Tag	Name	Keyword	VR	VM
...				
<b>(0028,3001)</b>	<b>Variable Modality LUT Sequence</b>	<b>VariableModalityLUTSequence</b>	<b>SQ</b>	<b>1</b>

Add the following UID to Table A-1. UID Values:

**A Registry of DICOM Unique Identifiers (UIDs) (Normative)**

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**Table A-1. UID Values**

UID Value	UID NAME	UID TYPE	Part
...			
<b>1.2.840.10008.5.1.4.1.1.11.12</b>	<b>Variable Modality LUT Softcopy Presentation State Storage</b>	<b>SOP Class</b>	<b>PS 3.4</b>
...			

**Modifications to PS3.17**

Add the following Section to PS3.17

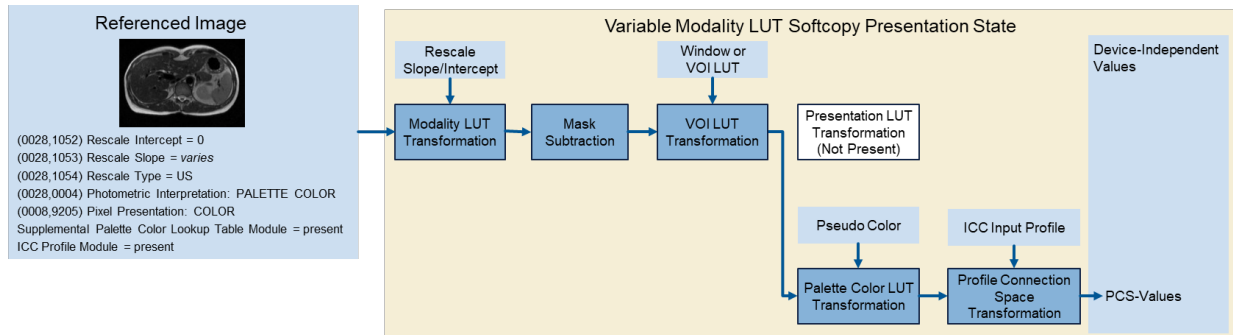
**ZZZZ Variable Modality LUT Softcopy Presentation State Storage (Informative)**

This Annex illustrates the display pipelines for different Variable Modality LUT Softcopy Presentation State scenarios.

**ZZZZ.1 Example 1 - Pseudo-color Transformations to a Pseudo-color Reference Image**

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In this scenario, the Rescale Intercept, Slope and Type for each referenced image is copied into the Variable Modality LUT Sequence. The Pixel Value Transformation, Supplemental Palette Color Lookup Table and ICC Profile of the referenced image are ignored, and the Variable Modality LUT, Palette Color Lookup Table and ICC Profile of the Variable Modality LUT Softcopy Presentation State are applied.

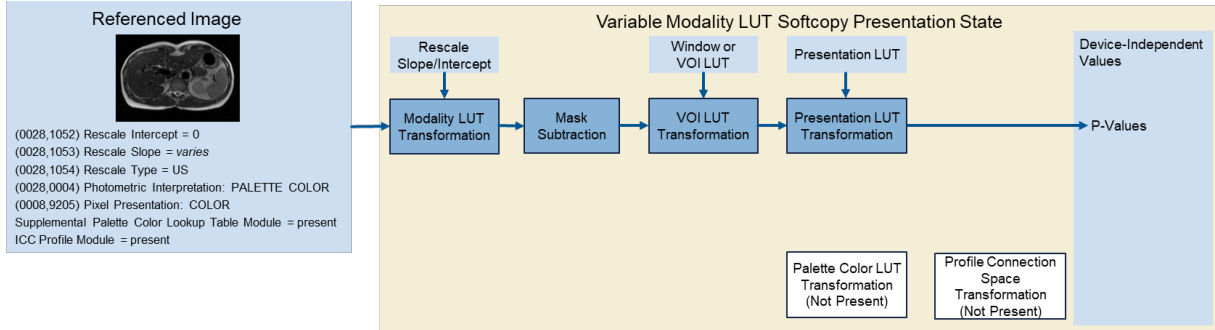


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**Figure ZZZZ.1-1. Variable Modality LUT Softcopy Presentation State Example 1**

**ZZZZ.2 Example 2 - Grayscale Transformations to a Pseudo-color Reference Image**

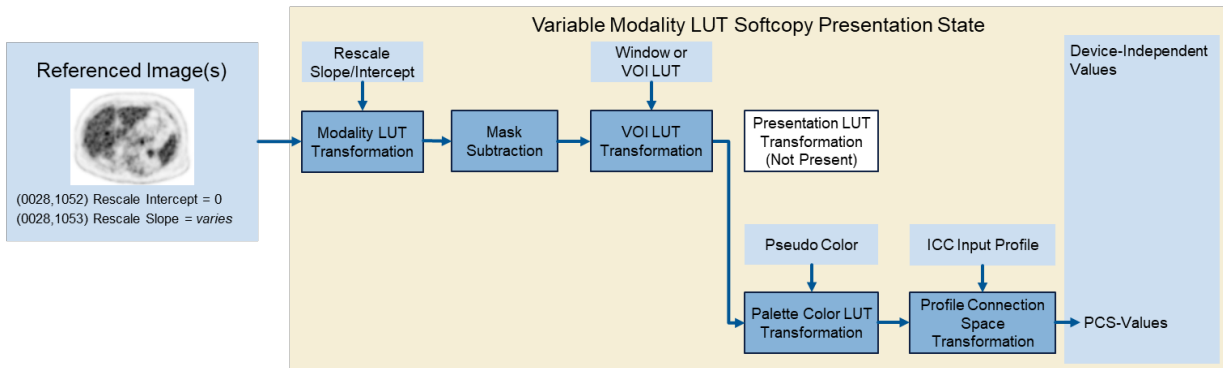
In this scenario, the Rescale Intercept, Slope and Type for each referenced image is copied into the Variable Modality LUT Sequence. The Pixel Value Transformation, Supplemental Palette Color Lookup Table and ICC Profile of the referenced image are ignored, and the Variable Modality LUT, Softcopy VOI LUT and Softcopy Presentation LUT of the Variable Modality LUT Softcopy Presentation State are applied.



185 **Figure ZZZZ.2-1. Variable Modality LUT Softcopy Presentation State Example 2**

**ZZZZ.3 Example 3 - Pseudo-color Transformations to a Grayscale Reference Image**

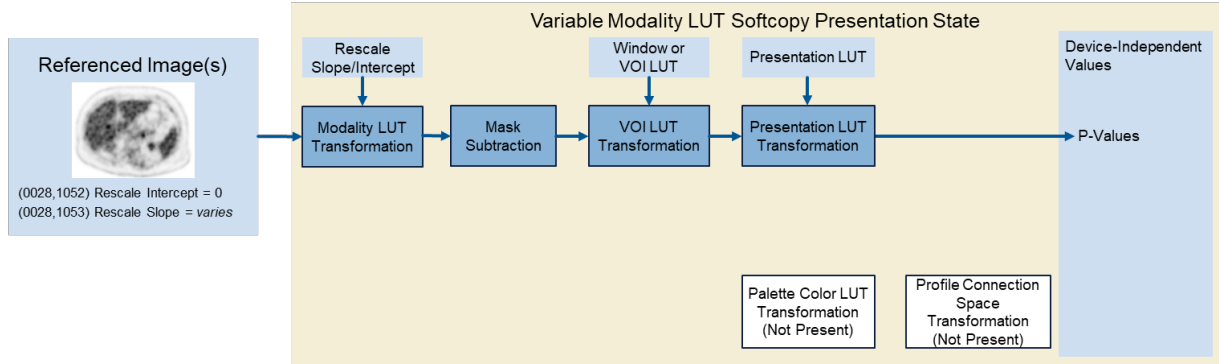
In this scenario, the Rescale Intercept and Slope for each referenced image is copied into the Variable Modality LUT Sequence. The Rescale Intercept, Rescale Slope and the VOI LUT of the referenced image are ignored, and the Variable Modality LUT, Palette Color Lookup Table and ICC Profile of the Variable Modality LUT Softcopy Presentation State are applied.



195 **Figure ZZZZ.3-1. Variable Modality LUT Softcopy Presentation State Example 3**

**ZZZZ.4 Example 4 - Grayscale Transformations to a Grayscale Reference Image**

In this scenario, the Rescale Intercept, Slope and Type for each referenced image is copied into the Variable Modality LUT Sequence. The Rescale Intercept, Rescale Slope and the VOI LUT of the referenced image are ignored, and the Variable Modality LUT, Softcopy VOI LUT and Softcopy Presentation LUT of the Variable Modality LUT Softcopy Presentation State are applied.



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Figure ZZZZ.4-1. Variable Modality LUT Softcopy Presentation State Example 4