TECHNICAL SPECIFICATION

ISO/TS 19567-1

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Photography — Digital cameras — Texture reproduction measurements —

Part 1: Frequency characteristics measurements using cyclic pattern

Photographie — Caméras numériques — Mesurages de la reproduction de la texture —

Partie 1: Mesurages des caractéristiques de fréquence en utlisant un modèle cyclique

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 42, *Photography*.

Introduction

Texture generally means the visual and tactile surface quality derived from the physicality of the material and the roughness or graininess of the surface. For digital still cameras, texture is of course the visual surface quality and the characteristic of texture reproduction in the captured image is interpreted into the reproduction of the low contrast fine details. This Technical Specification specifies the measurement of how cameras reproduce texture defined as low contrast fine details.

The tendency to utilize small sensors with high pixel counts in some cameras leaves a very small amount of light reaching the individual pixel. With the signal getting smaller and the noise level remaining at a certain level, it is necessary to reduce the noise in the image processing after capturing the image. Although the algorithms used for noise reduction have been developed over time, they are still not able to differentiate texture in the actual scene from the unwanted noise introduced by the capturing system. This decreases the image quality and it is therefore helpful to have a method to measure the loss of texture. Texture can also be enhanced to increase the acutance of the image. The texture reproduction is dependent on frequency and contrast because the noise reduction and the acutance enhancement, etc. are nonlinearly dependent on the pixel value and the difference among the surrounding pixels.

This part of ISO 19567 specifies methods to measure texture reproduction using test charts with cyclic patterns. The test charts are based on the established measurement methods, multiburst (IEC 61146-1) and siemens star (ISO 12233). This part of ISO 19567 newly defines the density of the test charts and exposure setting of measured cameras. The measurement results are presented in the spatial frequency response (SFR) curves.

If one SFR is larger than the other in all frequency range, larger amount of texture is reproduced in the corresponding image. If two SFRs have a cross point and the larger SFR depends on the frequency range, the superior image in the subjective evaluation is dependent on the dominant frequency of the image. Comparison of the measurement result provides important information in the texture comparison of the captured images.

Texture in a real scene consists mostly of non-structured or random patterns as shown in Annex A. Although it has been confirmed by experiments (Annex C and Annex D) that the texture reproduction characteristics of most cameras are well represented by the measurements in this Technical Specification, some cameras are found to indicate different characteristics for structured patterns compared to those for non-structured patterns. Measurement methods using non-structured or random patterns are under study and are expected to be included in consequent parts to this Technical Specification.

Photography — Digital cameras — Texture reproduction measurements —

Part 1: Frequency characteristics measurements using cyclic pattern

1 Scope

This part of ISO 19567 specifies a protocol to measure the texture reproduction in the images captured and processed by digital cameras including cameras in other devices, e.g. in camera phones.

This part of ISO 19567 specifies protocols for the measurement of the texture reproduction using test charts with cyclic pattern.

This part of ISO 19567 excludes the acceptable range of value for texture reproduction.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61966-2-1:1999, *Multimedia systems and equipment — Colour measurement and management — Part 2-1: Colour management — Default RGB colour space —sRGB*

IEC 61966-2-1/Amd 1:2003, *Multimedia systems and equipment — Colour measurement and management — Part 2-1: Colour management — Default RGB colour space —sRGB*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
texture
low contrast fine details, which appear in objects

EXAMPLE Low contrast fine details, which is visible in *foliage, fur, sand, textiles, grass, or masonry surfaces*.

3.2
texture reproduction
response in the output image of cameras to the texture of the object in the scene

4 Test conditions

4.1 General

The following measurement conditions should be used as nominal conditions when measuring the texture reproduction of a digital camera.

4.2 Environments for measurement

The measurement shall be carried out in the following environment unless otherwise stated:

— Temperature: 23 °C ± 3 °C

4.3 Apparatus and hardware

Either a reflective chart or a transmissive chart may be used. The light flux from the target shall be diffused and shall not include any specular component.

4.4 Arrangement of measuring equipment

4.4.1 Reflective test chart

The arrangement of the measuring equipment for a reflective test chart shall be set up as shown in Figure 1. The camera shall be positioned so that it casts no shadow on the chart. The lamps shall be positioned at an angle which avoids direct specular reflection from the test chart entering the camera.

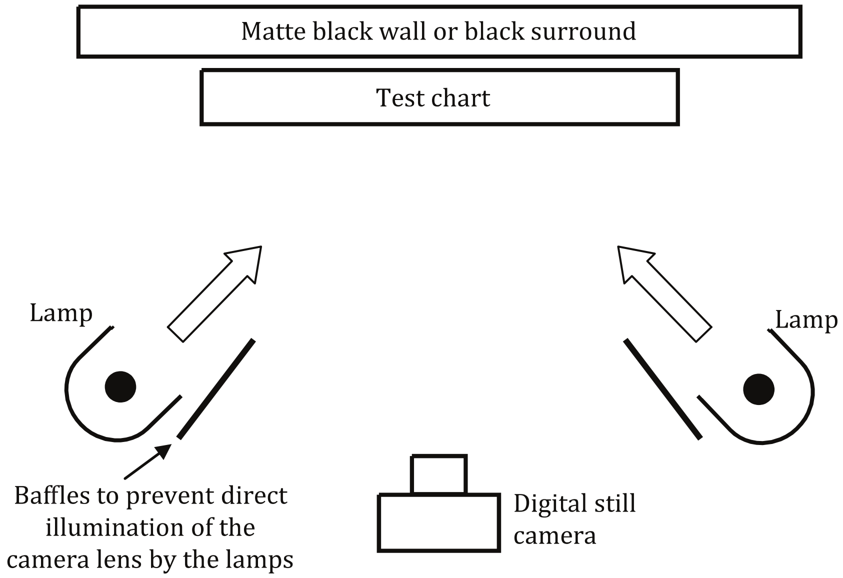


Figure 1 — Arrangement of measuring equipment for reflective test chart

4.4.2 Transmissive test chart

The arrangement of the measuring equipment for a transmissive test chart shall be set up as shown in Figure 2.

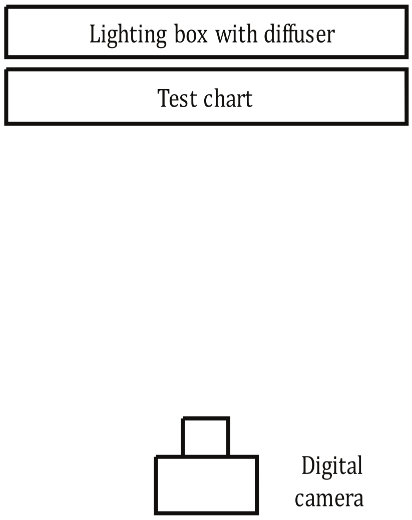


Figure 2 — Arrangement of measuring equipment for transmissive test chart

4.5 Lighting

Colour temperature of illumination shall be 5 700 K ± 1 000 K. Any illuminance level of the test chart may be applied for the texture reproduction measurement; however, the illuminance level in the range from 1 000 lx to 2 000 lx (in the case of transmissive chart, from 57,3 cd/m2 to 115 cd/m2 for 18 % gray) is recommended when the measurement has no specified purpose (e.g. low light performance). Non-uniformity of illumination on the chart shall be less than 10 %. The light source(s) should be positioned to provide uniform illumination and produce no glare or specular reflections from the target. A flickering light source is not recommended as it may cause banding artefacts to occur in the captured image. In the case of using a flickering light source, although it is not recommended, the exposure time shall not be shorter than one period of the flickering to minimize the banding artefacts caused by the light source.

4.6 Camera settings

The exposure should be adjusted to give the output value for the background gray near the centre of the measured chart to be the value corresponding to the input value defined below in the camera's output colour space.

(input luminance for gray) = (max input luminance) × (gray reflectance)

For sRGB cameras, the output Y for 18 % gray is 118 (8-bit).

The deviation of the exposure should be between +5 % and −10 % of the aforementioned target exposure. For example, the mean output luminance Y value for the 18 % gray should be 118 (8-bit) +2, −6 when the output colour space of the camera is sRGB 8-bit (IEC 61966-2-1 and IEC 61966-2-1/Amd 1).

The exposure shall be in the range of the aforementioned deviation when the measurement results of multiple cameras are compared (Annex B explains the basic concept for this stipulation). The exposure may be adjusted by the exposure bias setting of the camera or by adding a white or black card to the test chart.

White balance should be adjusted to render the centre of the image, as neutral as possible.

The focusing shall be in the best practically attainable focus.

For a camera with user selectable compression ratio (e.g. JPEG), the compression ratio should be minimum to minimize the artefacts of compression. The texture reproduction for RAW format image data should be measured for the output of the RAW converter software. The name and the setting of the RAW converter shall be reported with the results of the measurement.

Other settings, such as “sharpness”, “noise reduction”, shall be in the default mode (factory shipping condition) if those settings are not reported.

5 Texture reproduction measurement procedure

5.1 General

Texture reproduction is measured by the amplitude of a sine waveform in this part of ISO 19567. The frequency characteristics of the texture reproduction are measured for various frequencies in the sine chart to be captured.

Two measurement methods, the multiburst and siemens star, are defined in this part of ISO 19567. The multiburst chart consists of several low contrast sine waves of discrete frequency (see Figure 3). Each sine wave consists of multiple cyclic patterns along a single direction in the multiburst chart. The siemens star chart consists of a low contrast sine wave-modulated star burst pattern (see Figure 4), which includes continuous frequency variation in all directions. Based on the structure of each chart, the multiburst and the siemens star can be used in the cases shown in Table 1.

Table 1 — Guidance for selecting the measurement

Multiburst		Siemens star	
(1)	In the case of measuring SFR with verification of the waveform and the amplitude of the captured image. (1–1) In the case when skilled engineer recognizes the SFR approximately from the waveform of the captured image of the multiburst and verifies that the measured SFR matches the recognized outline. (1–2) In the case of measuring SFR and the waveform simultaneously to see the transient response such as overshooting and undershooting.	(1)	In the case of measuring SFR by simply applying the software to the captured image.
(2)	In the case of measuring SFR with high precision along a single direction for a discrete frequency. The result of multiburst has higher precision especially for lower frequency than siemens star by averaging the pixel value in the direction perpendicular to the measurement direction and by averaging the amplitude of multiple cycles of the equal frequency along the measurement direction. The alignment of the chart and the width of averaging shall be adjusted to avoid miscalculation especially for higher frequency.	(2)	In the case of measuring SFR along multiple directions for continuous frequencies.
(3)	In the case of using software generally applied for measuring and displaying the digital value and the waveform of the image. For multiburst, it is easier to measure the amplitude for a certain frequency using such software because it consists of multiple cycles at the same frequency.	(3)	In the case of using software specially designed for the measurement of the texture reproduction.

5.2 Multiburst measurement

5.2.1 Low contrast multiburst chart

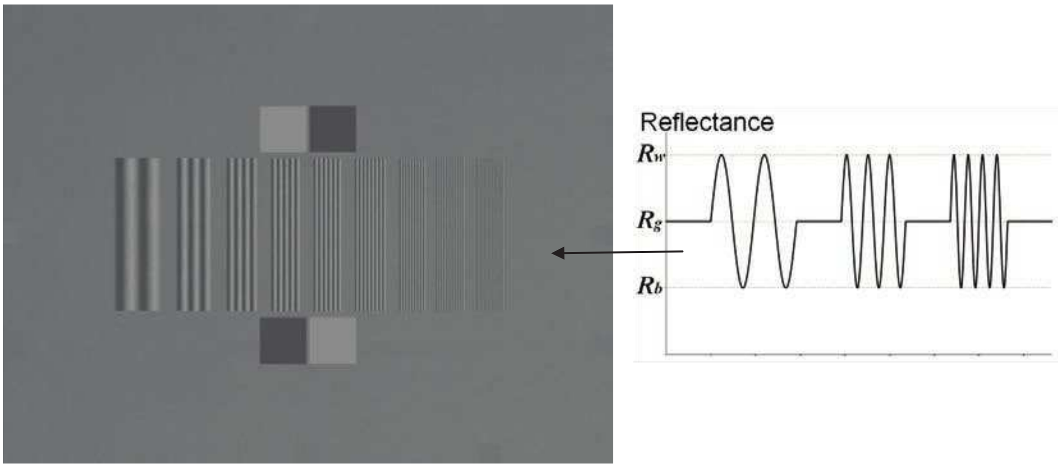


Figure 3 — Low contrast sine multiburst chart (general specification)

$$\frac{R_w}{R_g} = 1{,}5 \pm 0{,}05 \quad (1)$$

$$\frac{R_b}{R_g} = 0{,}5 \pm 0{,}05 \quad (2)$$

$$\frac{R_w - R_b}{R_g} = 1{,}0 \pm 0{,}05 \quad (3)$$

$$R_g = \left(18 \pm 2\right)\% \quad (4)$$

where

R_w is reflectance of bright peak;

R_b is reflectance of dark bottom;

R_g is reflectance of gray centre which is equal to reflectance of the background gray.

The chart includes light and dark patches adjacent to sine waves, which serve as reference areas for bright peak and dark bottom values. The reflectance of the patches is equal to the bright peak (R_w) and the dark bottom (R_b) of the sinusoidal chart.

For transmissive chart, equivalent transmittance is applied.

The relative size of the chart shall be less than or equal to 1/3 of the imaging area to suppress the risk of vignetting.

The test chart defined in Figure 3 shall be used in texture reproduction measurement. Other test charts with different gray centre level and/or the different amplitude value may also be used for measuring the reproduction of smaller or larger amplitude of texture.

5.2.2 Measurement method

The measurement is performed as follows.

— A low contrast sine multiburst chart, as shown in Figure 3, shall be captured and the amplitudes of each sine wave in the multiburst pattern shall be measured.

— The measured amplitude values shall be linearized in the output colour space encoding.

— The linearization shall follow the formula of the colour encoding of the output image. In case of sRGB image, the linearization shall follow the formula of the sRGB standard (IEC 61966-2-1 and IEC 61966-2-1/Amd 1).

— The procedure to obtain the linearized amplitude $A[i]$ of the i-th frequency of the multiburst chart shall be as follows.

  — Measure the mean of peak pixel value $S_{max}[i]$ and mean of bottom pixel value $S_{min}[i]$ for each frequency. The noise should be suppressed by averaging along the peaks and bottoms of the sine wave perpendicular to the variation.

  — Calculate each linearized value $S'_{max}[i]$ and $S'_{min}[i]$.

  — Calculate the linearized amplitude $A[i]$ by the formula $A[i] = S'_{max}[i] - S'_{min}[i]$.

— Calculate the modulation $A\_norm[i]$ by the normalizing $A[i]$ by the linearized amplitude between the darkest patch and the brightest patch.

$$A\_\text{norm}[i] = A[i] / (S'_w - S'_b) \quad (5)$$

where

S'_w is a linearized value for bright patch;

S'_b is a linearized value for dark patch.

— The modulation as a function of the frequency shall be the result of the measurement.

NOTE 1 It is possible to measure texture reproduction responses in any given position and given frequency orientation by varying the position and angle of the multiburst chart with respect to the camera.

NOTE 2 When shooting with an exposure level which gives the output value for the 18 % gray to be 118 (8-bit) as specified in 4.6, the corresponding input level before sRGB gamma processing, will be approximately 46 (8-bit digital) and the difference between bright peak and dark bottom will be approximately 46 (8-bit digital), resulting in approximately 18 % in contrast signals. In case of other bit depth, those values will be replaced by corresponding code values.

NOTE 3 This is based on the concept of measuring characteristics when reproduced and displayed on an ideal display (the concept of “= output referred”).

5.3 Siemens star measurement

5.3.1 Low contrast sine siemens star chart

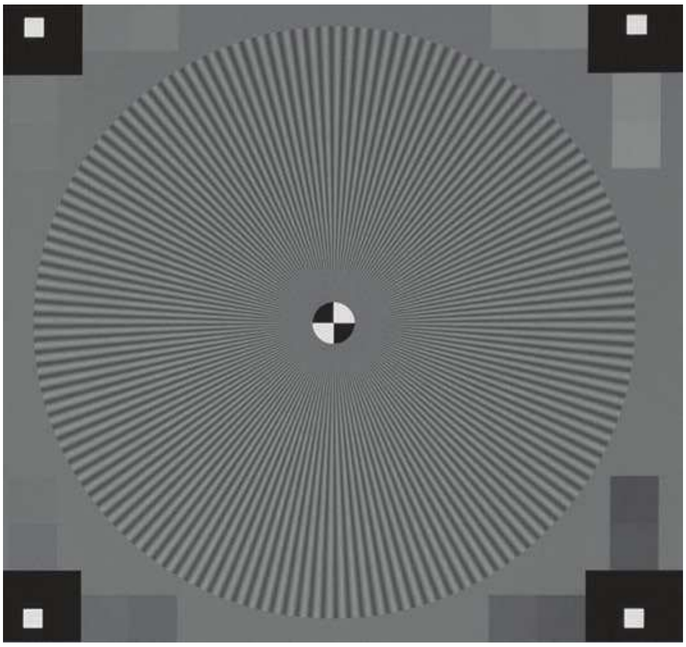


Figure 4 — Low contrast sine siemens star chart

Reflectance of bright peak (R_w), reflectance of dark bottom (R_b), and reflectance of gray centre (R_g) is given in Formulae (1), (2), (3) and (4).

The patches around the siemens star shall include a patch for the bright peak (R_w) and a patch for the dark bottom (R_b). The brightest patch shall be the bright peak (R_w) and the darkest patch shall be the dark bottom (R_b).

For transmission chart, equivalent transmittance is applied.

The relative size of chart shall be less than 1/3 of the imaging area to suppress the risk of vignetting.

The test chart defined in Figure 4 shall be used in texture reproduction measurement. Other test charts with different gray centre level and/or the different amplitude value may also be used for measuring the reproduction of smaller or larger amplitude of texture.

5.3.2 Measurement method

The measurement is performed as follows.

— Step 1: The star shall be located using the four surrounding markers for the region of interest.

— Step 2: The image data value shall be linearized following the formula of the colour encoding of the output image. In case of sRGB image, the linearization shall follow the formula of the sRGB standard (IEC 61966-2-1 and IEC 61966-2-1/Amd 1).

— Step 3: A user-selectable segmentation of the star may be made.

— Step 4: A minimum of 32 radii shall be analysed by localizing the pixels along the radius and selecting the digital code values for the linearized image as a function of the angle.

— Step 5: A sine curve with the expected frequency shall be fitted into the measured values by minimizing the square error.

— Step 6: The contrast of the sine curve shall be determined by normalization to modulation between the darkest patch and the brightest patch.

— Step 7: The modulation as a function of the frequency shall be the result of the measurement.

6 Presentations of results

6.1 General

The measurement results shall be presented as a graph of the frequency characteristics (SFR) of the texture amplitude. The performance of the digital cameras can be compared using the SFR. Given SFR measurements of two different cameras, if one measured SFR is greater than the other across all measured spatial frequencies, then a larger amount of texture is reproduced in the corresponding image. On the other hand, if the greater SFR depends on the frequency, then the superior texture reproduction in a subjective evaluation is dependent on the frequency structure of the image. Comparison of the measurement results can provide important information about the relative texture reproduction of the captured images.

The illuminance level and the output luminance Y value for background gray near the centre of the measurement chart shall be reported. If the centre of the measurement chart is not occupied by the background gray, the output Y shall be reported for the background gray at a measurable area nearest to the centre of the chart. If a target with densities other than those defined in 5.2 and 5.3 is used, the reflectance or transmittance of the target shall be reported.

6.2 Multiburst measurement

In the following example, the SFR is measured in one direction. The results may be presented in the graph shown in Figure 5 when the SFR is measured in multiple directions by rotating the multiburst chart.

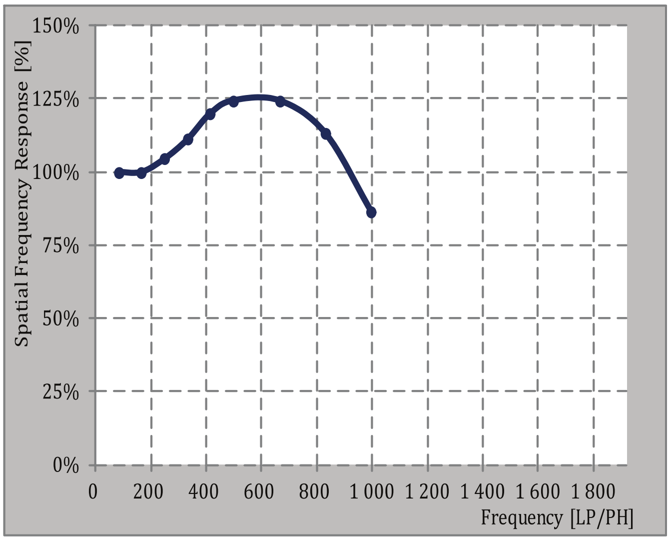


Figure 5 — Example of the result of multiburst measurement

6.3 Siemens star measurements

In the following example, the SFR is measured for eight segments, each of which occupies a 45° sector of the siemens star. The results may be presented in the graph shown in Figure 6 when the SFR is measured in a single direction.

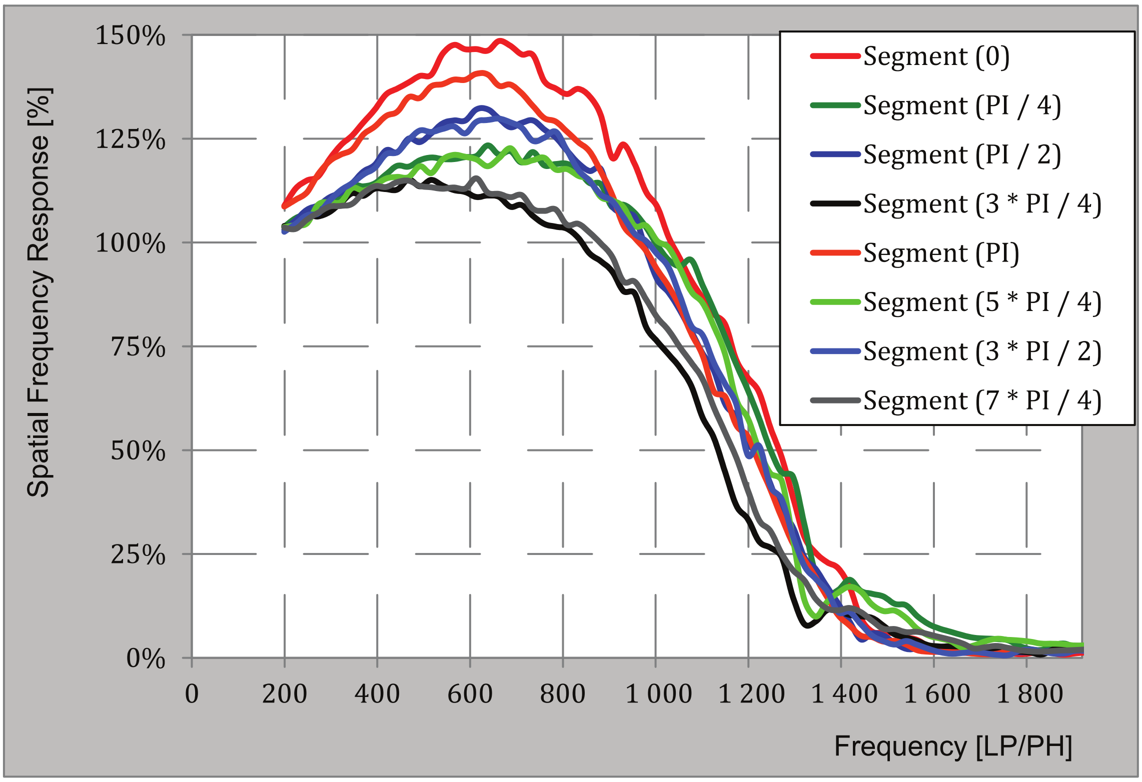


Figure 6 — Example of the result of siemens star measurement

Annex A
(informative)

Categorization of texture

Figure A.1 shows an overview of texture including multiburst and siemens star defined in this part of ISO 19567. The texture can be categorized into structured texture and non-structured, i.e. random texture. Texture with high autocorrelation is categorized as structured texture, and that with low autocorrelation is categorized as non-structured or random texture.

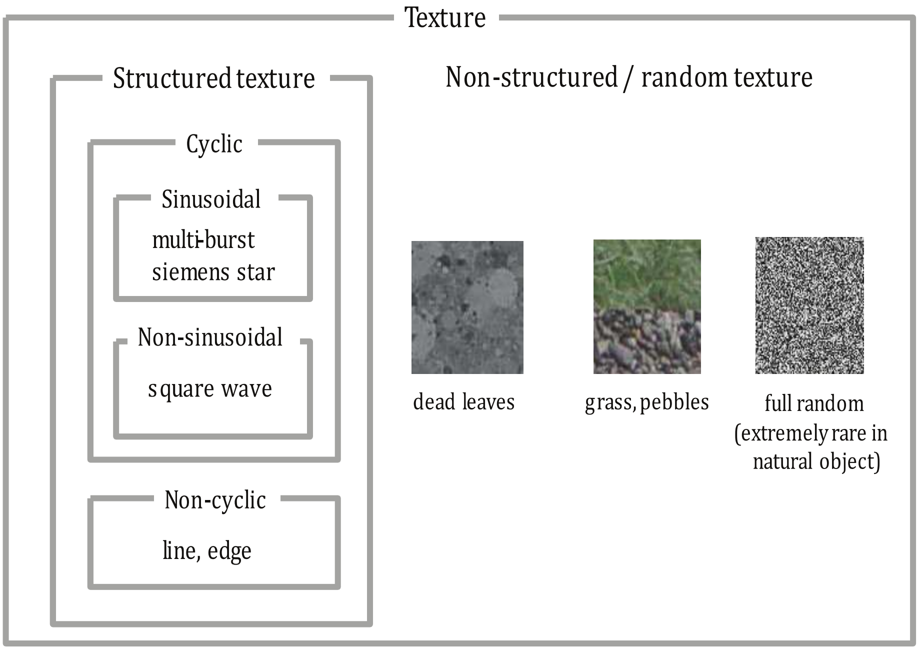


Figure A.1 — Categorization of texture

Annex B
(informative)

Exposure condition for the measurement

This Annex is provided in order to explain the concept of the exposure conditions which is specified in 4.6.

The frequency characteristics of the output image for low contrast sine charts are dependent on the input amplitude to the image processing of the camera because the input signals are enhanced or reduced nonlinearly depending on the amplitude and the frequency by the noise reduction, etc. The exposure value of the camera directly influences the input amplitude for the low contrast sine chart so the exposure condition influences the result of the texture reproduction measurement. Lower exposure tends to give worse texture reproduction because the smaller amplitude with high frequency is often reduced by the noise reduction. In order to give a fair comparison among multiple cameras, the exposure condition is limited in the range between +5 % and −10 % of the target exposure.

Figure B.1 and Figure B.2 show how the input amplitude and output Y value are influenced by the exposure which varies from +5 % to −10 % of the target exposure when the output colour space is sRGB 8-bit (see IEC 61966-2-1:1999, 5.3 and IEC 61966-2-1/Amd 1:2003, F.5). As shown in Figure B.1 and Figure B.2, the input amplitude is proportional to the exposure and the output Y value varies depending on the exposure. The output Y value for the 18 % gray is 118 (8-bit) for the target exposure and it varies from 120 (8-bit) to 112 (8-bit) for the exposure between +5 % and −10 % of the target exposure. Thus the output Y value for the 18 % gray is specified in the range shown in 4.6.

	Reflectance	target exposure	output Y value of sRGB 8-bit	target exposure ×1.05	output Y value of sRGB 8-bit	target exposure ×0.90	output Y value of sRGB 8-bit
	0.00	0.000	0	0.000	0	0.000	0
	0.01	0.010	25	0.011	26	0.009	24
	0.02	0.020	39	0.021	40	0.018	36
	0.03	0.030	48	0.032	50	0.027	46
	0.04	0.040	56	0.042	58	0.036	53
	0.05	0.050	63	0.053	65	0.045	60
	0.06	0.060	69	0.063	71	0.054	66
	0.07	0.070	75	0.074	77	0.063	71
	0.08	0.080	80	0.084	82	0.072	76
dark bottom (9%)	0.09	0.090	85	0.095	87	0.081	80
	0.10	0.100	89	0.105	91	0.090	85
	0.11	0.110	93	0.116	95	0.099	89
	0.12	0.120	97	0.126	99	0.108	92
	0.13	0.130	101	0.137	103	0.117	96
	0.14	0.140	105	0.147	107	0.126	99
	0.15	0.150	108	0.158	111	0.135	103
	0.16	0.160	111	0.168	114	0.144	106
	0.17	0.170	115	0.179	117	0.153	109
18% gray	0.18	0.180	118	0.189	120	0.162	112
	0.19	0.190	121	0.200	123	0.171	115
	0.20	0.200	124	0.210	126	[illegible]	118
	0.21	0.210	126	0.221	129	0.189	120
	0.22	0.220	129	0.231	132	0.198	123
	0.23	0.230	132	0.242	135	0.207	126
	0.24	0.240	134	0.252	137	0.216	128
	0.25	0.250	137	0.263	140	0.225	130
	0.26	0.260	139	0.273	143	0.234	133
bright peak (27%)	0.27	0.270	142	0.284	145	0.243	135
	0.28	0.280	144	0.294	148	0.252	137
	0.29	0.290	147	0.305	150	0.261	140
	0.30	0.300	149	0.315	152	0.270	142
	0.31	0.310	151	0.326	155	0.279	144
	0.32	0.320	153	0.336	157	0.288	146
	0.33	0.330	155	0.347	159	0.297	148
	0.34	0.340	158	0.357	161	0.306	150
	0.35	0.350	160	0.368	163	0.315	152
	0.36	0.360	162	0.378	165	0.324	154
	0.37	0.370	164	0.389	167	0.333	156
	0.38	0.380	166	0.399	169	0.342	158
	0.39	0.390	168	0.410	171	0.351	160
	0.40	0.400	170	0.420	173	0.360	162
	0.41	0.410	172	0.431	175	0.369	164
	0.42	0.420	173	0.441	177	0.378	165
	0.43	0.430	175	0.452	179	0.387	167
	0.44	0.440	177	0.462	181	0.396	169
	0.45	0.450	179	0.473	183	0.405	171
	0.46	0.460	181	0.483	185	0.414	172
	0.47	0.470	182	0.494	186	0.423	174
	0.48	0.480	184	0.504	188	0.432	176
	0.49	0.490	186	0.515	190	0.441	177
	0.50	0.500	188	0.525	192	0.450	179
	0.51	0.510	189	0.536	193	0.459	180
	0.52	0.520	191	0.546	195	0.468	182
	0.53	0.530	192	0.557	197	0.477	184
	0.54	0.540	194	0.567	198	0.486	185
	0.55	0.550	196	0.578	200	0.495	187
	0.56	0.560	197	0.588	202	0.504	188
	0.57	0.570	199	0.599	203	0.513	190
	0.58	0.580	200	0.609	205	0.522	191
	0.59	0.590	202	0.620	206	0.531	193
	0.60	0.600	203	0.630	208	0.540	194
	0.61	0.610	205	0.641	209	0.549	196
	0.62	0.620	206	0.651	211	0.558	197
	0.63	0.630	208	0.662	212	0.567	198
	0.64	0.640	209	0.672	214	0.576	200
	0.65	0.650	211	0.683	215	0.585	201
	0.66	0.660	212	0.693	217	0.594	203
	0.67	0.670	214	0.704	218	0.603	204
	0.68	0.680	215	0.714	220	0.612	205
	0.69	0.690	216	0.725	221	0.621	207
	0.70	0.700	218	0.735	223	0.630	208
	0.71	0.710	219	0.746	224	0.639	209
	0.72	0.720	221	0.756	225	0.648	211
	0.73	0.730	222	0.767	227	0.657	212
	0.74	0.740	223	0.777	228	0.666	213
	0.75	0.750	225	0.788	230	0.675	214
	0.76	0.760	226	0.798	231	0.684	216
	0.77	0.770	227	0.809	232	0.693	217
	0.78	0.780	229	0.819	234	0.702	218
	0.79	0.790	230	0.830	235	0.711	219
	0.80	0.800	231	0.840	236	0.720	221
	0.81	0.810	232	0.851	237	0.729	222
	0.82	0.820	234	0.861	239	0.738	223
	0.83	0.830	235	0.872	240	0.747	224
	0.84	0.840	236	0.882	241	0.756	225
	0.85	0.850	237	0.893	243	0.765	227
	0.86	0.860	239	0.903	244	0.774	228
	0.87	0.870	240	0.914	245	0.783	229
	0.88	0.880	241	0.924	246	0.792	230
	0.89	0.890	242	0.935	248	0.801	231
	0.90	0.900	243	0.945	249	0.810	232
	0.91	0.910	245	0.956	250	0.819	234
	0.92	0.920	246	0.966	251	0.828	235
	0.93	0.930	247	0.977	252	0.837	236
	0.94	0.940	248	0.987	254	0.846	237
	0.95	0.950	249	0.998	255	0.855	238
	0.96	0.960	250	1.008	255	0.864	239
	0.97	0.970	252	1.019	255	0.873	240
	0.98	0.980	253	1.029	255	0.882	241
	0.99	0.990	254	1.040	255	0.891	242
	1.00	1.000	255	1.050	255	0.900	243

Input Amplitude = 0.270-0.090 = 18%
Input Amplitude = 0.284-0.095 = 19%
Input Amplitude = 0.241-0.081 = 16%
118 - 6
118 + 2

Figure B.1 — Input amplitude and output Y value depending on the exposure

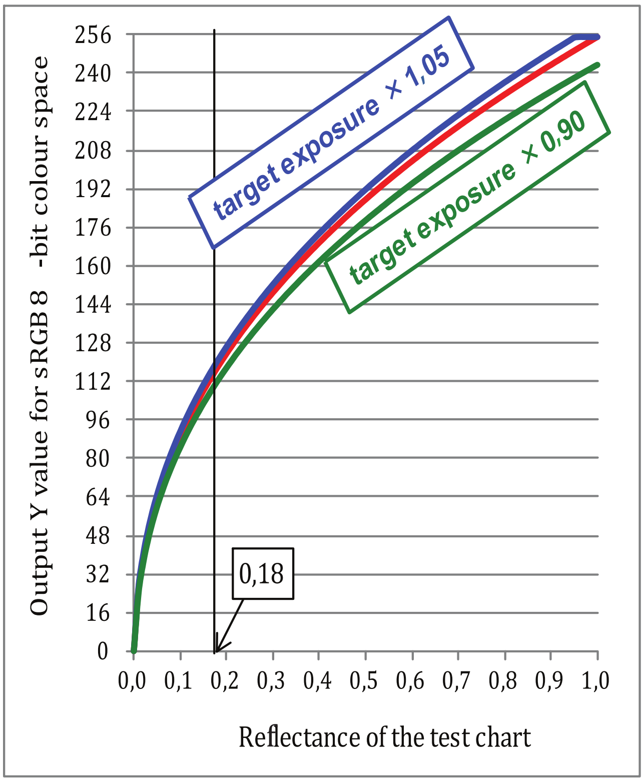


Figure B.2 — Output Y value for sRGB 8-bit colour space

Annex C
(informative)

Interpretation of measurement results

This Annex shows an interpretation of measurement results.

Figure C.1 shows measurement results of two cameras using siemens star chart. Camera #17 has higher SFR in lower frequency, while camera #11 has higher SFR in higher frequency. Figure C.2 shows a comparison of captured images by these cameras. Camera #17 has higher texture reproduction in pebble area (lower frequency), while camera #11 has higher texture reproduction in grass area (higher frequency). Measurement results in Figure C.1 correspond with the characteristics of captured images in Figure C.2.

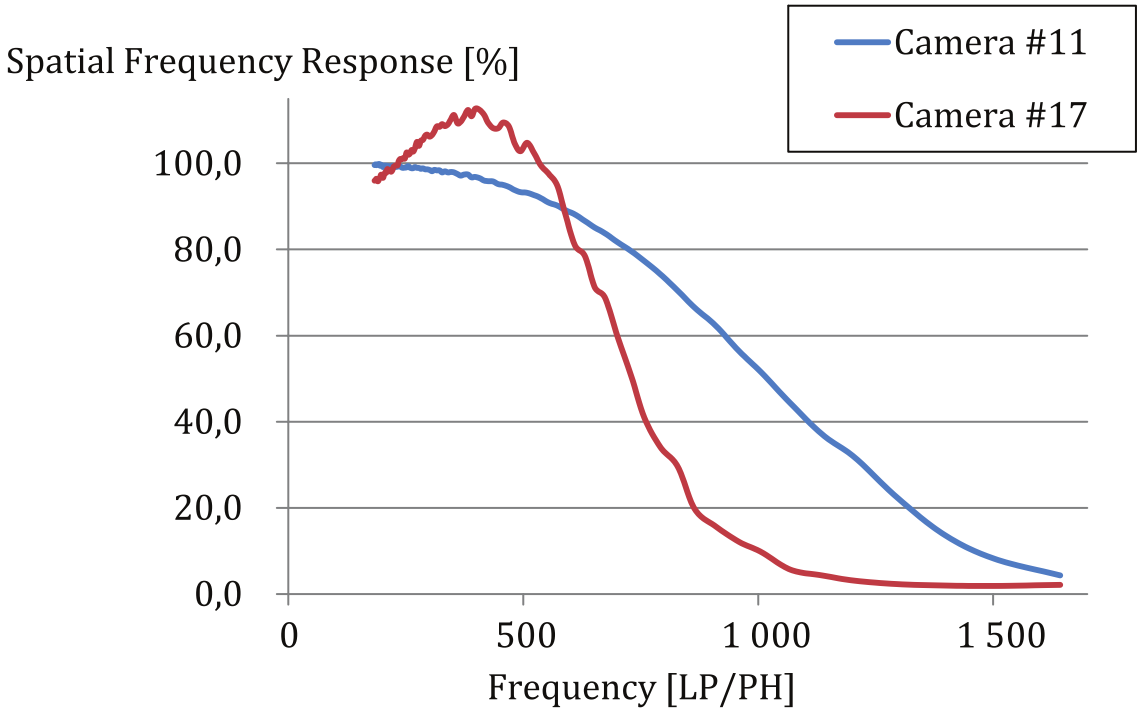


Figure C.1 — Measurement result of Camera #11 and Camera #17

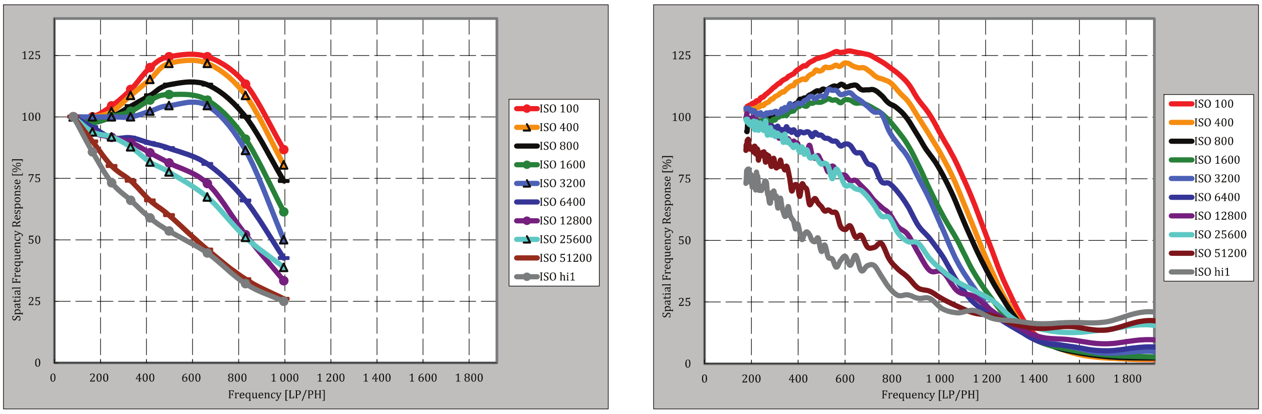
Figure C.2 — Image comparison between Camera #11 and Camera #17

Annex D
(informative)

Measurement results of multiburst and siemens star

Figures D.1 to D.8 show the measurement results of those using multiburst and those using siemens star chart. Both results exhibit a similar tendency. In general, as ISO sensitivity increases, the noise level increases and SFR decreases due to the stronger noise reduction processing. The following results of multiburst and siemens star correspond to this tendency.

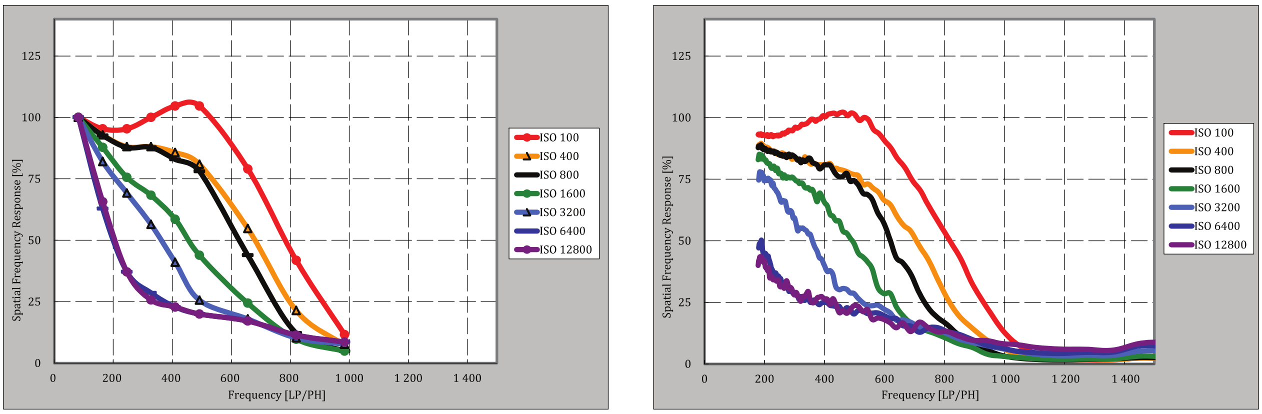
(1) Camera #1



(a) Multiburst (b) Siemens star

Figure D.1 — Measurement results of Camera #1

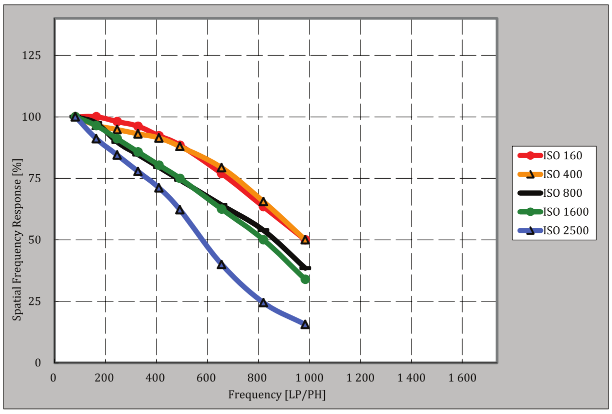
(2) Camera #6



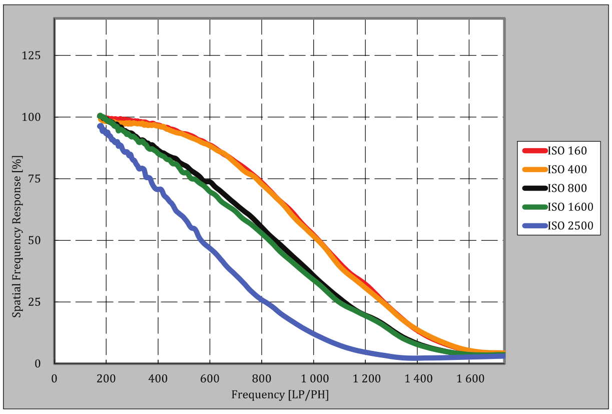
(a) Multiburst (b) Siemens star

Figure D.2 — Measurement results of Camera #6

(3) Camera #11



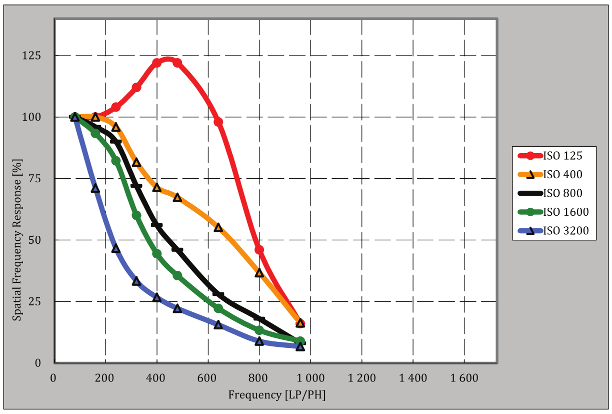
(a) Multiburst



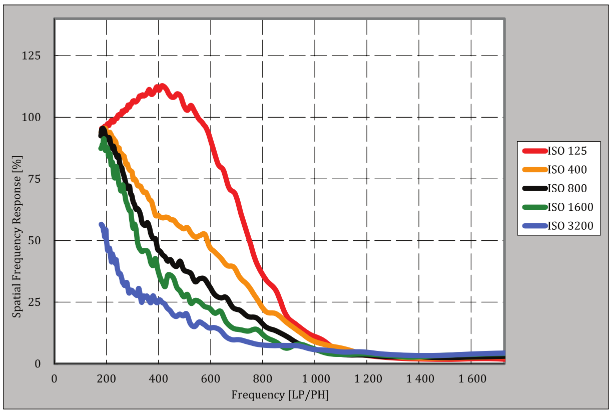
(b) Siemens star

Figure D.3 — Measurement results of Camera #11

(4) Camera #17



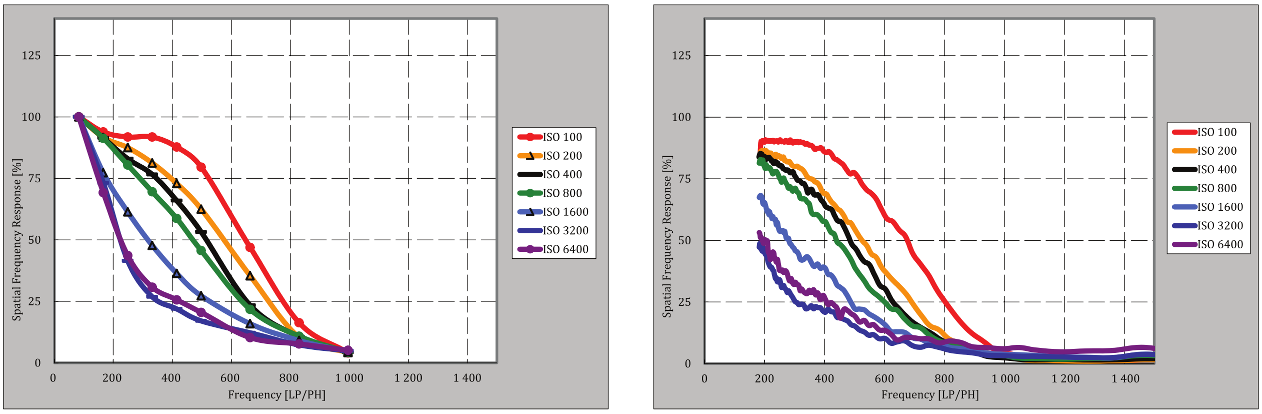
(a) Multiburst



(b) Siemens star

Figure D.4 — Measurement results of Camera #17

(5) Camera #21

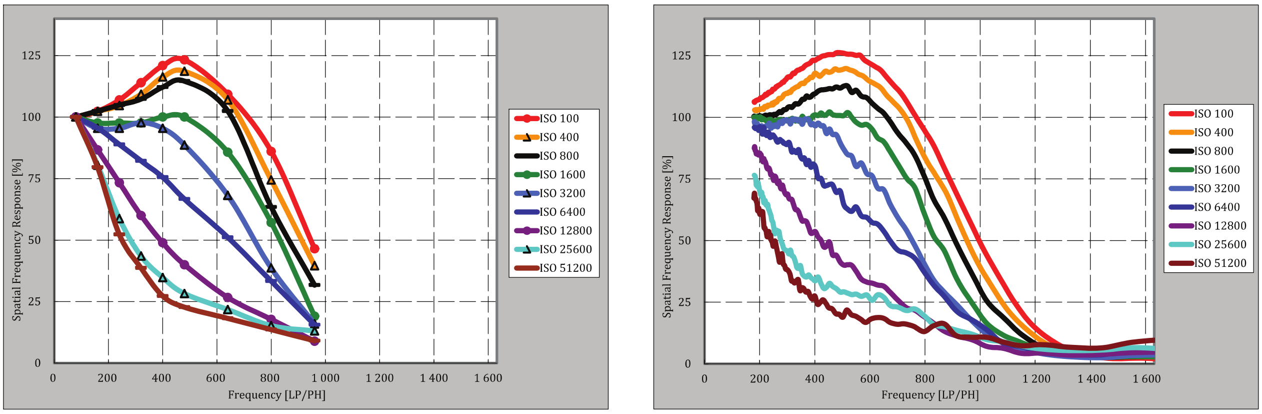


(a) Multiburst

(b) Siemens star

Figure D.5 — Measurement results of Camera #21

(6) Camera #26

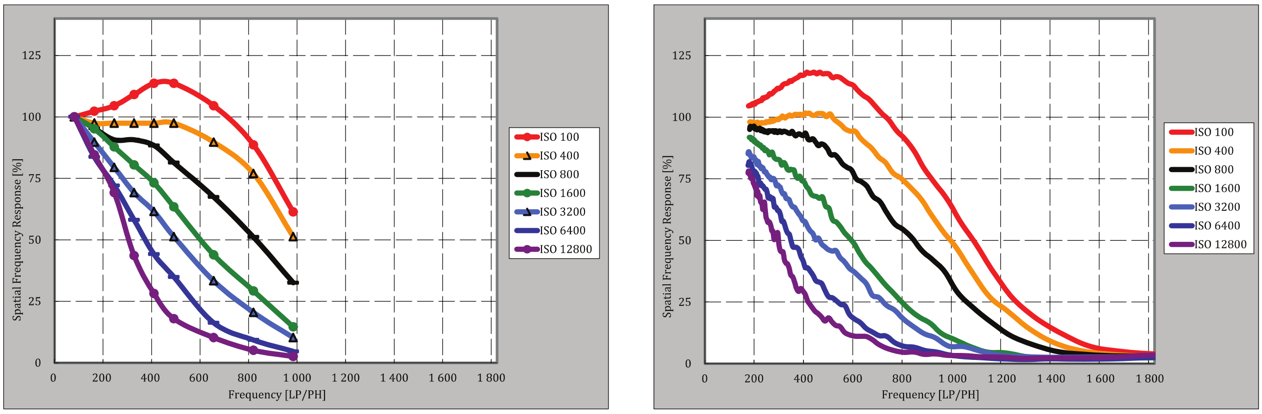


(a) Multiburst

(b) Siemens star

Figure D.6 — Measurement results of Camera #26

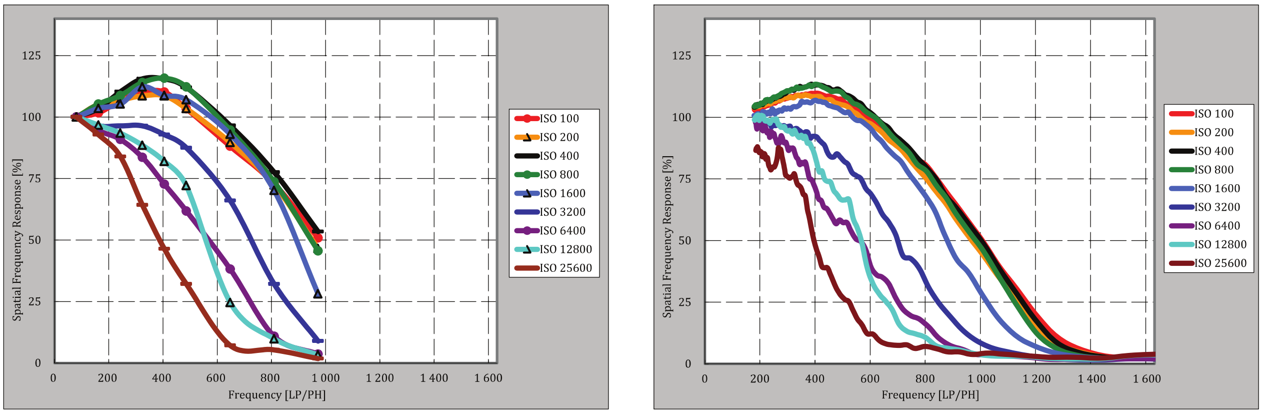
(7) Camera #31



(a) Multiburst (b) Siemens star

Figure D.7 — Measurement results of Camera #31

(8) Camera #36



(a) Multiburst (b) Siemens star

Figure D.8 — Measurement results of Camera #36

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