

# IMPOSSIBLE Camera Design Specification

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## IMPOSSIBLE Camera Design Specification

Specification Number 200813

Draft 0.13 in progress

22<sup>nd</sup> April 2016

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## Revision History

Issue	Nature of Change	Initials	Date
Draft 0.01	Initial version.	KD	25/11/13
Draft 0.02	Minor updates	KD	09/12/13
Draft 0.03	Added Bluetooth	KD	07/04/14
Draft 0.04	Updated after review meeting	KD	28/05/14
Draft 0.05	Updated following meeting with Impossible @ Wideblue on 3 <sup>rd</sup> July: <ul style="list-style-type: none"> <li>Added Bluetooth section 1.3.6</li> <li>Too close &amp; low light indications removed.</li> <li>Out of film – rapid flash of all eight LEDs</li> <li>Reset button – clears Bluetooth pairing information.</li> <li>No lens cap</li> <li>Take button inhibited when in Bluetooth mode &amp; not connected to a device.</li> </ul>	KD	04/07/14
Draft 0.06	Added <i>in situ</i> firmware update	KD	24/11/14
Draft 0.07	Updated to reflect 5 zone optics, 12 LED strobe and initial mechanical prototype build	GK	13/02/15
Draft 0.08	Updated to incorporate ambient exposure map Updates to Strobe measurements Best focus points	GK SM CW	03/04/15
Draft 0.09	Updated to include ranging and photometer acceptance angles plus various test clarifications following meeting with manufacturing team	GK	12/05/15
Draft 0.10	Forces added for switches, Min Exposure times added (1.3.1) Hand strap detail added (1.3.4) Bluetooth range section added (1.3.7) Source voltage re-defined (3.1.1) Macro lens max aperture added (3.2.1) IR LED output distribution corrected (3.6.1.1) Tripod nut torque redefined (3.9.5) Endurance testing details added (3.10.2.1 – 3.10.2.7)	BP GK GK GK GK GK GK GK GK GK GK GK	19/08/15 07/10/15 07/10/15 07/10/15 07/10/15 07/10/15 07/10/15 07/10/15 07/10/15 07/10/15 07/10/15 07/10/15
Draft 0.11	Additional inhibit conditions added (1.3.5) Battery status display added (3.9.8) Added shutter and focus step motor calibration (3.2.2) Changes to film count display(1.3.2) Changes to lens ranges and focus zones (1.3.1, 3.2.1 and 3.2.3.2) Updated Shutter Aperture Profile	GK GK GK GK CW CW	8/12/15 8/12/15 8/12/15 8/12/15 10/12/15 10/12/15

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Draft 0.12	Shutter aperture table added, 3.5.4.3	GK	19/1/16
Draft 0.13	Updated Spectral Energy Distribution 3.4.4 Update Ambient Exposure 3.5.1 Shutter Control Profile 3.5.4.4 LUTs updated First Light latency motor shift 3.5.4.2 removed (SM) Bluetooth range updated		

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## 1 GENERAL INFORMATION

Key to highlights:

Information to be added by Wideblue  
Decisions to be agreed Impossible / Wideblue

### 1.1 Purpose

This is the design specification for the Impossible Camera. It also establishes the performance limits of the Impossible Camera and details the criteria for their acceptance.

### 1.2 Description

The camera is the first new camera to use the IMPOSSIBLE film (600 ISO PX, 3 1/2" x 4 1/4" corresponding to 88.9mm x 107.8mm). The intent is to create an IMPOSSIBLE camera with its own particular identity. The camera should not be a clone of an historical Polaroid design. The camera should therefore offer features that are unique and take advantage of the currently available technology. Basic operation should be point and shoot automatic but with the potential for advanced exposure features accessed via an external device such as a Smartphone. Areas of new technology to be considered are:

- Microprocessor control of camera systems and exposure
- Step motor controlled scanning aperture shutter
- Photometer decoupled from shutter
- Macro and close up capability via step motor controlled radial disc discrete multi zone autofocus system
- Multi element LED strobe illumination under microprocessor control
- Utilise LED strobe to communicate camera status to user
- Open frame flip up viewfinder
- Smartphone control of camera functions via Bluetooth interface

Camera to utilise current IMPOSSIBLE film processing unit (FPU) with minimal changes to external mouldings and no changes to spread system

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## 1.3 Features

### 1.3.1 Exposure/Ranging Features

- Five-zone autofocus with reflective IR ranging
  - Macro (0.23 – 0.47m)
  - Close-up (0.47 – 1m)
  - Near-field (1.0 – 2.2m)
  - Mid-field (2.2 – 4.5m)
  - Far-field (4.5 –  $\infty$  m)
- Exposure times as slow as 1/12 second in automatic mode. User defined (can be held open indefinitely) under Bluetooth control
- Lighten and darken trim +/-1/3 exposure value (EV)
- Two part taking button/control:
  - First part - activate auto-focus.  
(Any autofocus over ride would be an advanced feature provided under Bluetooth control).
  - Second part - take image
- Scanning aperture shutter system under microprocessor, control ranging from first light to a final aperture of F/7.5 for macro and F/10 for Far

### 1.3.2 Strobe-Related Features

- LED strobe
- Strobe range of max 2.5m.
- Strobe override control (Strobe on/off)
- Red eye reduction (via strobe in torch mode under microprocessor control – via Bluetooth application only)
- Film frame counter decrementing eight to zero under microprocessor control (strobe LEDs operating in low power mode).
  - Frame count is displayed when the camera is turned on
  - Frame count is displayed when the taking button position 1 is selected and released
  - A frame count of zero is not displayed

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## 1.3.3 Optical-Related Features

- Two lenses
  - Front element fixed
  - Second element five lenses in a rotating disc under microprocessor control via step motor
  - Focal length for 5 ranges as follows (note at finite distances the focal length is different for each range):
    - Macro: 82.15mm
    - Close-Up: 94.96mm
    - Near: 102.35mm
    - Mid, 106.37mm
    - Far: 109.07mm
  - Field of view 41 degrees vertical, 40 degrees horizontal
- Exposure control via shrouded visible light photodiode (ambient light sensor)
- Ranging via reflective IR, able to discriminate between four zones
- Manual viewfinder:
  - Fixed FOV
  - 90% of taking lens FOV
  - Manually folding front and rear lenses
  - Eye relief of 50mm

## 1.3.4 Mechanical or Electronic-Related Features

- Tripod socket (via existing FPU)
- Hand strap (mounted onto thumb screws on rear of external shell)

## 1.3.5 Inhibits

- Inhibit picture taking button:
  - during ejection of dark slide
  - film pack empty / no film pack
  - battery low level
  - when camera switched off
  - when camera in Bluetooth mode with no device connected
- Inhibit film ejection motor
  - until user releases taking button
  - if film door open
  - if film count zero
  - if engineering mode is selected
- Dark slide and part used film pack eject (allows part used film packs to be swapped without automatically processing top frame in pack)
  - with camera switched off and USB disconnected and film door open:
  - insert film pack
  - press and hold taking button to position 2
  - close film door
  - release taking button
  - dark slide or top frame in part used pack will not be ejected
- Dark slide eject delayed by 1.5 seconds following door closure

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## 1.3.6 Bluetooth

- The camera has a Bluetooth interface built-in.
- It is only powered-up when the rotary select switch (Off > On > Bluetooth) is in the Bluetooth position – otherwise it is powered down to save battery life.
- When the camera is switched to Bluetooth mode, it will attempt to re-connect with the device to which it was last paired. This is indicated by a slow flash of the top (north or 12 o'clock position) LED. The take button is disabled while the LED is flashing.
- If the camera finds the device, it stops flashing the top LED and the take button is enabled. If the take button is then used, it uses the settings provided by the Bluetooth App – overriding any camera settings e.g. trim position & strobe select.
- If the camera fails to connect to the device within 3 minutes, it will switch to accepting pairing requests from any device. This is indicated by a sequence of slow flashes of the top (north or 12 o'clock position) LED.
- If the camera finds a new device, it stops flashing the LEDs and the take button is enabled. If the take button is then used, it uses the settings provided by the Bluetooth App – overriding any camera settings e.g. trim position & strobe select. The camera will overwrite the previous pairing information with the new device's details.
- If, after 10 minutes, no Bluetooth connection is established, the camera will shut down and go to sleep. It can then be woken up by turning the rotary selector switch to the On position. Note: the camera does not go to sleep when the rotary select switch is in the On position.
- The camera can be forced to forget the pairing information by performing a pairing reset: with the camera switched off, press and hold the take button and turn the camera on. This will clear the Bluetooth pairing information. Note: the rotary switch does not need to be rotated to the Bluetooth position.
- An alternative method to clear the pairing information is to perform a camera reset. This involves opening the film door and pressing the reset button. Note: this will clear all camera data – not just Bluetooth pairing information.
- A third method is for the Bluetooth App to send a command to the camera to clear its pairing information.
- With the camera paired to a Bluetooth device all the camera controls will be overridden by the Bluetooth device however picture taking can be initiated from either the Bluetooth device or the camera's own taking button.

## 1.3.7 Bluetooth range and direction

- The Bluetooth connectivity to have a up to 10m when measured in a horizontal plane through an angle of 360 degrees from the vertical axes of the camera

## 1.3.8 Additional Features for Future Cameras (potentially remove with agreement from Oskar)

- Factory reset for advanced camera control functions – accessible via Bluetooth?
- Future requirement to operate 10 frame film pack

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## 2 GENERAL REQUIREMENTS

### 2.1 Related Documents

- 1) Impossible Camera System Flowchart
- 2) Impossible Camera Microprocessor IO
- 3) Impossible Camera Bluetooth Interface

### 2.2 Operating Temperatures

The camera shall operate and meet the requirements of this specification over the temperature range of 4° to 38°C and over a range of 5% to 90% relative humidity.

In addition, the camera shall not be damaged if operated over the temperature range of 0° to 49°C and 5% to 90% RH.

### 2.3 Temperature Cyclic Testing

The camera shall be exposed to 65°C 35% RH for 1 hour then cycled to 45°C 90% RH for 1 hour then cycled to (minus) – 20°C for a final hour. This temperature cycle to be repeated for 8 complete cycles and once normalised the camera function demonstrated by a standard picture taking test.

### 2.4 Temperature Shock Testing

The camera shall be exposed to a temperature of (minus) – 20°C for 1 hour followed by a temperature of 70°C for 1 hour. This temperature cycle to be repeated for 10 complete cycles and once normalised the camera function demonstrated by a standard picture taking test.

### 2.5 Temperature Storage Testing

The camera shall be exposed to a storage test at each of the following:

- High temperature, 65°C 35% RH for 24 Hrs
- High temperature, high humidity, 45°C, 90% RH for 24Hrs
- Low temperature, (minus) -20°C for 24 Hrs

Once normalised the camera function to be demonstrated by a standard picture taking test after each cycle

### 2.6 Shock Testing

Shock testing will subject the camera to a series of accelerations ranging from 25 to 250g with a duration time of 2 to 11 ms with a drop height of 650mm and a maximum loading of 80Kg. Camera function to be demonstrated by a standard picture taking test after test cycle has been completed.

### 2.7 Vibration testing

Vibration testing shall be random frequency ranging from 3 Hz to 500Hz for 6 minutes in each of three axes as follows:

x -axis: Parallel to the optical axis of the camera and perpendicular to the length of the shutter housing.

y -axis: Parallel to the length of the shutter housing and the width dimension of the camera.

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**z -axis:** Perpendicular to the x and y axes and parallel to the height dimension of the camera.

Camera function to be demonstrated by a standard picture taking test after the full test cycle has been completed.

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## 3 PERFORMANCE ACCEPTANCE REQUIREMENTS

### 3.1 Test Conditions and Tolerances

#### 3.1.1 Test Measurement Conditions

Unless otherwise specified herein, test measurements shall be determined using the following applicable conditions:

- Temperature:  $22^\circ \pm 2^\circ\text{C}$
- Relative humidity:  $45\% \pm 5\%$
- Source voltage:  $4.2\text{V} \pm 2\%$  VDC (Open circuit)
- Light source spectral output: (colour temperature D65K)

#### 3.1.2 Camera Test Orientations

Camera assumed to be used only in upright orientation i.e. portrait mode with  $90^\circ$  forward and  $45^\circ$  backward tilt.

#### 3.1.3 Electrostatic Discharge

Electrostatic discharge shall meet the requirements of **EC Low Voltage Directive (LVD) 2006/95/EC**.

A self recovering temporary degradation of performance or loss of function that is permissible when subjected to an ESD discharge of 4Kv (air) or 4Kv (contact)

## 3.2 Taking System

### 3.2.1 General Description

The optical components of the taking system are comprised of a front meniscus lens, a secondary five element zone focus lens and a front surface mirror of approximately 94% average reflectivity. Aspheric surfaces are limited to the primary meniscus lens.

All lenses will have anti-reflection coatings on their first surface plus hard coatings on all external surfaces.

NOTE: Items 1 through 4 below are included in this specification only for design reference purposes:

1. Maximum aperture: f/7.5 for macro to f/10 for far
2. Focal lengths of 5 focus ranges

Macro:	82.15mm
Close-Up:	94.96mm
Near:	102.35mm
Mid:	106.37mm
Far:	109.07mm

3. Vignetting: Combined vignetting and  $\cos^4\phi$  losses shall not exceed 0.90 stop at the corners when measured at full aperture.
4. Total field angle:  $41.0^\circ$  Vertical,  $40.0^\circ$  Horizontal

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The best focus positions for each focus range are:

Range	Min (m)	Max (m)	Best Focus (m)
Macro	0.23	0.47	0.4
Close-Up	0.47	1	0.65
Near	1	2.2	1.6
Mid	2.2	4.5	2.6
Far	4.5	Inf	5

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## 3.2.2 Shutter and focus system step motor calibration

The shutter and focus systems are both driven by step motors. Two optimise performance of both systems a one time calibration of both step motors is performed once and is stored in non-volatile flash memory. The procedure as detailed below is performed in manufacture and need not be repeated, even after a firmware update. The procedure is performed as follows:

- Switch off the camera
- Disconnect the USB
- Open the film door
- Remove any film pack
- Press and hold the taking button
- Then press the reset button

## 3.2.3 Optical Performance

The optical performance of the camera shall meet the requirements defined in sections 3.2.3.1 through 3.2.3.2, below.

### 3.2.3.1 System Resolution on Axis

At aperture step 4 or less the camera (lens and film) shall resolve to at least 8.0lp/mm at the "Best Focal Distance" and 6.0lp/mm at the far-side boundary of each of the five distance zones. The resolution is measured at the film plane, and NOT the resolution in lp/mm of the object being imaged.

### 3.2.3.2 System Resolution off Axis

At aperture step 4 or less the camera shall resolve to at least 6.0 lines/mm when measured 20° off-axis at the Best Focal Distance" of each of the five distance zones, or 5.0lp/mm at the far-side boundaries of each of the five distance zones.

#### Optical Zones

Zone Number	Range (m)	Best Focus (m)
1	0.23 – 0.47	0.4
2	0.47 – 1.0	0.65
3	1.0 - 2.2	1.6
4	2.2 - 4	2.6
5	4.5 – $\infty$	5.0

### 3.2.3.3 Flare

In general, flare shall be equal to or better than the 600 ONE camera. Process shall be monitored through use of control photo samples. Flare to be generated by a series of high and low angle illumination sources pointed towards the lens at the periphery of the field of view. Illumination sources to be placed at 45 degree increments, rotating around the optical axes of the lens.

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## 3.2.4 Optical Surface Cleanliness

### 3.2.4.1 Taking Mirror

Ensure that the taking mirror is free from scratches on either surface and free from dust, foreign matter and aesthetic blemishes on the mirrored first surface prior to build.

### 3.2.4.2 Taking & Focus Lens

Ensure that the taking and focus lens are free from scratches, dust, foreign matter and aesthetic blemishes on either surface prior to build. Ensure front surface of taking lens is free from scratches, dust, foreign matter and aesthetic blemishes after build.

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## 3.3 Viewfinder System

### 3.3.1 Image Brightness

N/A due to open viewfinder design

### 3.3.2 Distortion

Barrel distortion will be better than the limit defined by the gold standard samples.

### 3.3.3 Aiming and Framing

#### 3.3.3.1 Aiming

The field of view of the viewfinder shall match the field of coverage of the taking system to within 90% of the FOV.

#### 3.3.3.2 Framing

The viewfinder frame image shall show 90% of the vertical image at the centre of the vertical image at the crossover distance 2m.

#### 3.3.3.3 Viewfinder Parallax

No horizontal parallax, vertical parallax as shown in table below

Distance (m)	Parallax (mm)
0.25	42.09
0.5	36.08
0.8	28.86
1	24.05
1.5	12.03
2	0.00
2.5	-12.03
3	-24.05
3.5	-36.08
4	-48.10
5	-72.15
6	-96.20

#### 3.3.3.4 Viewfinder Display

There will be no camera status indicators in the viewfinder display.

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## 3.3.4 Display Indicators

### 3.3.4.1 Good Picture

There is no good picture indication on the camera.

### 3.3.4.2 Low Light / Turn Strobe On Indication

There is no “low light” feature implemented in the camera.

### 3.3.4.3 Beyond Strobe Range

There is no “beyond strobe range” feature implemented in the camera.

### 3.3.4.4 Too Close

There is no “too close” feature implemented in the camera.

### 3.3.4.5 Out of Film

After the 8th picture is processed, any attempt to take another photograph will cause the camera to indicate an out-of-film condition:

- Take button is inhibited
- There is no zero film indication i.e. no LED's flash

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## 3.4 Strobe System

### 3.4.1 Light Distribution

Maximum light fall-off over the object plane field of view shall not exceed 2.0 stops throughout the range of 0.23m to Target value **2m (to be finalised with first production cameras)**. (Object plane refers to strobe fall-off only and does not include camera effects.)

### 3.4.2 Light Output

Nominal (for reference): 3360 Lumens

Flash-to-flash variation (for reference): 100 Lumens, over 10 shots.

### 3.4.3 Light Output Degradation

The Lumens output shall not degrade by more than 10% during the first 500 flashes at a rate of 4 flashes-per-minute.

### 3.4.4 Spectral Energy Distribution

A typical normalized spectral energy distribution of the strobe at full light, chosen to suit film response) is created through a mix of white (10-off), red (1-off) and blue (1-off) LEDs as shown in **Error! Reference source not found.** (white LED at 5700K) and **Error! Reference source not found.** (LED's labelled Red and Blue only).

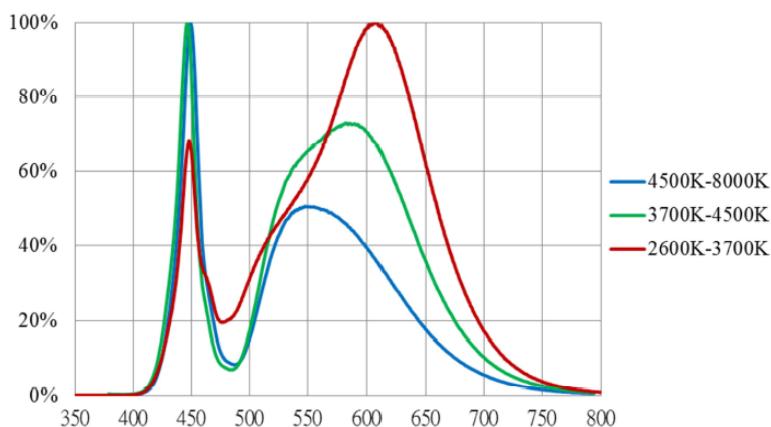
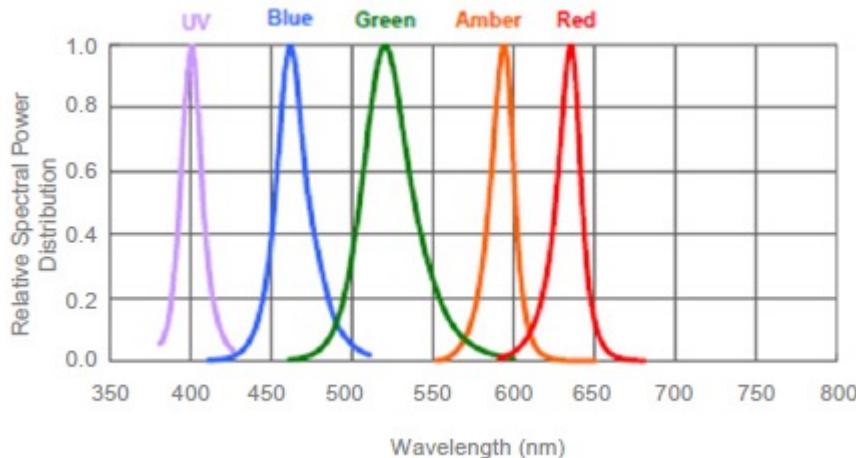


Figure 1: 5700K White Light LED Spectra

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**Figure 2: Red and Blue LED Spectra**

## 3.5 Exposure

All exposure is single shot using the ambient or strobe exposure testers unless otherwise specified.

### 3.5.1 Ambient Exposure

#### 3.5.1.1 Ambient Exposure Peak

A 13-point photo sensor array at the film plane and concentric to the centre of the picture frame shall be used for an exposure measurement with light sourced from an integrating sphere. The measured result is an integration of the light from the integrating sphere falling on the sensor as a function of time, i.e. the *area under the curve*. The ambient exposure is measured over 4 transmission ranges with resulting irradiations shown below.

- 100% corresponding to 17,000lux
- 79% corresponding to 13,430lux
- 10% corresponding to 1700lux
- 1% corresponding to 170lux

#### 3.5.1.2 Ambient Exposure Distribution

The peak on-axis Exposure Value (EV) will be

- 100%  $230,000 \pm 15\%$
- 79%  $250,000 \pm 15\%$
- 10%  $22,000 \pm 15\%$
- 1%  $15,000 \pm 15\%$

The resultant film plane distribution over the 13 photometer points at the 4 transmission ranges will be measured with an integrating sphere light source of incident irradiance 17000lux. Vignetting allows for 0.9 stop. This results in an allowable loss relative to the centre peak of 55% of the peak value.

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### 3.5.1.3 Exposure Repeatability (NOT TESTED)

The ambient exposure (over 10 shutter actions) on the film plane for a light level of 17,000 lux will result in the following

- 100% corresponding to 17,000lux: <5% variation in on-axis peak
- 79% corresponding to 13,430lux: <5% variation in on-axis peak
- 10% corresponding to 1700lux: <5% variation in on-axis peak
- 1% corresponding to 170lux: <5% variation in on-axis peak

### 3.5.1.4 Brightness Detect

The camera will detect scene brightness with the first stage press of the taking button.

### 3.5.1.5 Backlight Detect

The camera will be restricted to a single centre weighted photometer. It will not have multiple photometer zones and therefore will not be able to detect multiple EV values from the scene.

## 3.5.2 Strobe Mode

### 3.5.2.1 Indoor Flash Range (Reference only)

Minimum range 0.23m

Maximum range 1.5m

Under control via a Bluetooth link from the camera App the shutter open period can be extended indefinitely, and the strobe on time to 800ms in order to extend strobe range or to blend additional ambient exposure

### 3.5.2.2 Exposure Repeatability (10 Exposure Range)

Maximum on axis flash onto a white wall measured at film plane horn.

Distance (m)	Exposure Range
0.42m	75,000±15%
1.39m	46,000±15%

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### 3.5.3 Exposure Trim Control (Exposure delta from nominal trim setting)

The effect of applying the +/- trim switch to the measured exposure value is to be tested on distribution of cameras with finalised Firmware **(to be finalised with first production cameras)**.

### 3.5.4 Photometer System

#### 3.5.4.1 Acceptance Angles

IR/Photometer acceptance angle is  $\pm 17^\circ$  at 50% power **(to be finalised with first production cameras)**.

IR/Photometer acceptance angle is  $\pm \text{TBD}^\circ$  at 90% power. **(to be finalised with first production cameras)**.

#### 3.5.4.2 Spectral Filtering

For normal working of the photometer system a VIS cut off filter is required. Cut off up to 750nm to reduce visible light allowing the sensor module not to saturate.

### 3.5.5 Shutter Action

#### 3.5.5.1 Brightness Detect

The photometer operates independently of the shutter, feeding back to the microprocessor, which in turn controls the blade position of the shutter and exposure time. The system therefore has real time exposure control, translating exposure information from the photometer into strobe fire and shutter position control referenced to a series of pre-determined exposure value (EV) look up tables located in memory. These look up tables once established shall form the basis of the exposure control within the camera. Since they are maintained in software they can be updated as required.

It is anticipated that versions of the camera with connectivity to a Smartphone will be able to access or call on specialist or creative exposure modes contained within an extended or dynamic area of the look up tables.

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## 3.5.5.2 Shutter apertures

The shutter opens from fully closed to fully open in a series of nine discrete steps. Step 0 is fully closed; step 1 is also closed but with minimal light baffling and first light occurs at step 2. Step 2 to step 9 therefore form the photographic apertures with the equivalent f numbers as detailed in the table below.

Because the shutter is a scanning aperture shutter not all apertures are available at every shutter speed.

Steps	Area (mm <sup>2</sup> )	Equivalent diameter (mm)	Lenses				
			Macro f/#	Close-up f/#	Near f/#	Mid f/#	Far f/#
2	2.0	1.6	51.5	59.5	64.1	66.7	68.3
3	8.0	3.2	25.7	29.8	32.1	33.3	34.2
4	18.5	4.9	16.9	19.6	21.1	21.9	22.5
5	31.8	6.4	12.9	14.9	16.1	16.7	17.1
6	46.9	7.7	10.6	12.3	13.2	13.8	14.1
7	63.3	9.0	9.2	10.6	11.4	11.8	12.1
8	80.5	10.1	8.1	9.4	10.1	10.5	10.8
9	95.0	11.0	7.5	8.6	9.3	9.7	9.9

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### 3.5.5.3 Ambient Exposure Values

The exposure time and aperture step of the shutter are defined by the Exposure Value (EV). The following Look-Up Tables list the useable ambient exposure parameters (exposure time and aperture step) for each of the five focus zones (yellow is usable values).

Macro

Light Level	Lux(Low)	EV(low)	Macro Step2	Step3	Step4	Step5	Step6	Step7
1	300	9.51	3643	911	394	229	155	115
2	400	9.92	2732	683	295	172	117	86
3	460	10.12	2376	594	257	149	101	75
4	550	10.38	1987	497	215	125	85	63
5	600	10.51	1821	455	197	115	78	58
6	700	10.73	1561	390	169	98	67	49
7	800	10.92	1366	342	148	86	58	43
8	880	11.06	1242	310	134	78	53	39
9	950	11.17	1150	288	124	72	49	36
10	1000	11.24	1093	273	118	69	47	35
20	1500	11.83	729	182	79	46	31	23
30	2100	12.31	520	130	56	33	22	16
40	2800	12.73	390	98	42	25	17	12
50	3300	12.97	331	83	36	21	14	10
60	3500	13.05	312	78	34	20	13	10
70	4000	13.24	273	68	30	17	12	9
80	4600	13.45	238	59	26	15	10	8
90	5200	13.62	210	53	23	13	9	7
100	6000	13.83	182	46	20	11	8	6
200	11000	14.70	99	25	11	6	4	3
300	16000	15.24	68	17	7	4	3	2
400	22000	15.70	50	12	5	3	2	2
500	26000	15.94	42	11	5	3	2	1
600	31000	16.20	35	9	4	2	2	1
700	35000	16.37	31	8	3	2	1	1
800	40000	16.57	27	7	3	2	1	1
900	45464	16.75	24	6	3	2	1	1
1000	50000	16.89	22	5	2	1	1	1
2000	100000	17.89	11	3	1	1	0	0

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## Close-Up

Light Level	Lux(Low)	EV(low)	Close-up								
			Step2	Step3	Step4	Step5	Step6	Step7	Step8	Step9	
1	300	9.51	4867	1217	526	306	208	154	121	102	
2	400	9.92	3651	913	395	230	156	115	91	77	
3	460	10.12	3174	794	343	200	135	100	79	67	
4	550	10.38	2655	664	287	167	113	84	66	56	
5	600	10.51	2434	608	263	153	104	77	60	51	
6	700	10.73	2086	522	226	131	89	66	52	44	
7	800	10.92	1825	456	197	115	78	58	45	38	
8	880	11.06	1659	415	179	104	71	52	41	35	
9	950	11.17	1537	384	166	97	66	49	38	32	
10	1000	11.24	1460	365	158	92	62	46	36	31	
20	1500	11.83	973	243	105	61	42	31	24	20	
30	2100	12.31	695	174	75	44	30	22	17	15	
40	2800	12.73	522	130	56	33	22	16	13	11	
50	3300	12.97	442	111	48	28	19	14	11	9	
60	3500	13.05	417	104	45	26	18	13	10	9	
70	4000	13.24	365	91	39	23	16	12	9	8	
80	4600	13.45	317	79	34	20	14	10	8	7	
90	5200	13.62	281	70	30	18	12	9	7	6	
100	6000	13.83	243	61	26	15	10	8	6	5	
200	11000	14.70	133	33	14	8	6	4	3	3	
300	16000	15.24	91	23	10	6	4	3	2	2	
400	22000	15.70	66	17	7	4	3	2	2	1	
500	26000	15.94	56	14	6	4	2	2	1	1	
600	31000	16.20	47	12	5	3	2	1	1	1	
700	35000	16.37	42	10	5	3	2	1	1	1	
800	40000	16.57	37	9	4	2	2	1	1	1	
900	45464	16.75	32	8	3	2	1	1	1	1	
1000	50000	16.89	29	7	3	2	1	1	1	1	
2000	100000	17.89	15	4	2	1	1	0	0	0	

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## Near

Light Level	Lux(Low)	EV(low)	Near Step2	Step3	Step4	Step5	Step6	Step7	Step8	Step9
1	300	9.51	5654	1414	611	356	241	179	141	119
2	400	9.92	4241	1060	458	267	181	134	105	89
3	460	10.12	3688	922	399	232	157	117	92	78
4	550	10.38	3084	771	333	194	132	97	77	65
5	600	10.51	2827	707	306	178	121	89	70	60
6	700	10.73	2423	606	262	152	103	77	60	51
7	800	10.92	2120	530	229	133	90	67	53	45
8	880	11.06	1928	482	208	121	82	61	48	41
9	950	11.17	1786	446	193	112	76	56	44	38
10	1000	11.24	1696	424	183	107	72	54	42	36
20	1500	11.83	1131	283	122	71	48	36	28	24
30	2100	12.31	808	202	87	51	34	26	20	17
40	2800	12.73	606	151	65	38	26	19	15	13
50	3300	12.97	514	129	56	32	22	16	13	11
60	3500	13.05	485	121	52	30	21	15	12	10
70	4000	13.24	424	106	46	27	18	13	11	9
80	4600	13.45	369	92	40	23	16	12	9	8
90	5200	13.62	326	82	35	21	14	10	8	7
100	6000	13.83	283	71	31	18	12	9	7	6
200	11000	14.70	154	39	17	10	7	5	4	3
300	16000	15.24	106	27	11	7	5	3	3	2
400	22000	15.70	77	19	8	5	3	2	2	2
500	26000	15.94	65	16	7	4	3	2	2	1
600	31000	16.20	55	14	6	3	2	2	1	1
700	35000	16.37	48	12	5	3	2	2	1	1
800	40000	16.57	42	11	5	3	2	1	1	1
900	45464	16.75	37	9	4	2	2	1	1	1
1000	50000	16.89	34	8	4	2	1	1	1	1
2000	100000	17.89	17	4	2	1	1	1	0	0

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Mid

Light Level	Lux(Low)	EV(low)	Mid Step2	Step3	Step4	Step5	Step6	Step7	Step8	Step9
1	300	9.51	6107	1527	660	384	260	193	152	129
2	400	9.92	4581	1145	495	288	195	145	114	96
3	460	10.12	3983	996	431	251	170	126	99	84
4	550	10.38	3331	833	360	210	142	105	83	70
5	600	10.51	3054	763	330	192	130	96	76	64
6	700	10.73	2617	654	283	165	112	83	65	55
7	800	10.92	2290	573	248	144	98	72	57	48
8	880	11.06	2082	521	225	131	89	66	52	44
9	950	11.17	1929	482	209	121	82	61	48	41
10	1000	11.24	1832	458	198	115	78	58	46	39
20	1500	11.83	1221	305	132	77	52	39	30	26
30	2100	12.31	872	218	94	55	37	28	22	18
40	2800	12.73	654	164	71	41	28	21	16	14
50	3300	12.97	555	139	60	35	24	18	14	12
60	3500	13.05	523	131	57	33	22	17	13	11
70	4000	13.24	458	115	50	29	20	14	11	10
80	4600	13.45	398	100	43	25	17	13	10	8
90	5200	13.62	352	88	38	22	15	11	9	7
100	6000	13.83	305	76	33	19	13	10	8	6
200	11000	14.70	167	42	18	10	7	5	4	4
300	16000	15.24	115	29	12	7	5	4	3	2
400	22000	15.70	83	21	9	5	4	3	2	2
500	26000	15.94	70	18	8	4	3	2	2	1
600	31000	16.20	59	15	6	4	3	2	1	1
700	35000	16.37	52	13	6	3	2	2	1	1
800	40000	16.57	46	11	5	3	2	1	1	1
900	45464	16.75	40	10	4	3	2	1	1	1
1000	50000	16.89	37	9	4	2	2	1	1	1
2000	100000	17.89	18	5	2	1	1	1	0	0

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Far

Light Level	Lux(Low)	EV(low)	Far Step2	Step3	Step4	Step5	Step6	Step7	Step8	Step9
1	300	9.51	6421	1605	694	404	274	203	160	135
2	400	9.92	4816	1204	521	303	205	152	120	101
3	460	10.12	4188	1047	453	263	179	132	104	88
4	550	10.38	3503	876	379	220	149	111	87	74
5	600	10.51	3211	803	347	202	137	101	80	68
6	700	10.73	2752	688	298	173	117	87	68	58
7	800	10.92	2408	602	260	151	103	76	60	51
8	880	11.06	2189	547	237	138	93	69	54	46
9	950	11.17	2028	507	219	128	86	64	50	43
10	1000	11.24	1926	482	208	121	82	61	48	41
20	1500	11.83	1284	321	139	81	55	41	32	27
30	2100	12.31	917	229	99	58	39	29	23	19
40	2800	12.73	688	172	74	43	29	22	17	14
50	3300	12.97	584	146	63	37	25	18	15	12
60	3500	13.05	550	138	60	35	23	17	14	12
70	4000	13.24	482	120	52	30	21	15	12	10
80	4600	13.45	419	105	45	26	18	13	10	9
90	5200	13.62	370	93	40	23	16	12	9	8
100	6000	13.83	321	80	35	20	14	10	8	7
200	11000	14.70	175	44	19	11	7	6	4	4
300	16000	15.24	120	30	13	8	5	4	3	3
400	22000	15.70	88	22	9	6	4	3	2	2
500	26000	15.94	74	19	8	5	3	2	2	2
600	31000	16.20	62	16	7	4	3	2	2	1
700	35000	16.37	55	14	6	3	2	2	1	1
800	40000	16.57	48	12	5	3	2	2	1	1
900	45464	16.75	42	11	5	3	2	1	1	1
1000	50000	16.89	39	10	4	2	2	1	1	1
2000	100000	17.89	19	5	2	1	1	1	0	0

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## 3.5.5.4 Strobe Exposure Values

To correct the EV to accommodate the increase in illuminance of the scene due to the flash an offset is applied to the measured ambient value, which in turn corrects the EV. These are:

Macro1:	100
Macro2:	65
Macro3:	32
Close-up1:	28
Close-up2:	22
Close-up3:	14
Close-up4:	5
Close-up5:	3
Near:	1
Mid:	0
Far:	0

## 3.5.5.5 Shutter Aperture Profile

Chart describing F number against stepper motor position is shown below for each lens.

Steps	Area (mm <sup>2</sup> )	Equiv diameter (mm)	Macro f/#	Close-up f/#	Near f/#	Mid f/#	Far f/#
2	2	1.60	51.48	59.51	64.14	66.66	68.35
3	8	3.19	25.74	29.75	32.07	33.33	34.17
4	18.5	4.85	16.93	19.57	21.09	21.92	22.47
5	31.8	6.36	12.91	14.92	16.08	16.72	17.14
6	46.9	7.73	10.63	12.29	13.24	13.77	14.11
7	63.3	8.98	9.15	10.58	11.40	11.85	12.15
8	80.48	10.12	8.12	9.38	10.11	10.51	10.77
9	95	11.00	7.47	8.63	9.31	9.67	9.92

## 3.5.5.6 Exposure Timeout (For Reference Only)

Maximum exposure timeout 1/12<sup>th</sup> second (80ms)

Longer manually timed exposures are to be a future camera feature (Bluetooth via smartphone etc.)

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## 3.6 Automatic Ranging System

### 3.6.1 System Zone Limits

Dynamic scaling is active when light entering photometer measures less than or equal to 30. IR ranging will be carried out at high gain. If above 30 then medium gain will be applied. The focus zones are as defined in Section 3.2.3.2 .

### 3.6.2 Output Distribution

Infra-red LED to match central area of focus zone up to 2.5m. IR LED emission angle at 50% power is  $\pm 10^\circ$  with a hard cut-off at  $\pm 17^\circ$  limited by exit aperture.

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## 3.7 Electrical

### 3.7.1 Processing Current

To be determined by Impossible FPU **(to be finalised with first production cameras)**.

### 3.7.2 Power Profile

- To be determined by Impossible FPU and finalised with first production cameras.
- To be determined by main camera system and finalised with first production cameras.

### 3.7.3 Static Current Drain

The microprocessor will have a number of states to be defined. The current drain each of these states will be **(to be finalised with first production cameras)**.

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## 3.8 Firmware

### 3.8.1 Camera Reset

We do not switch off the processor – it is only put into sleep mode. To guard against the processor locking-up, a camera reset button is available which forces a processor reset.

The camera reset button is located inside the film door.

A camera reset will clear any Bluetooth pairing information.

### 3.8.2 Firmware Update

Firmware updates in situ will be possible only via the USB connection. Updates over Bluetooth will not be supported.

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## 3.9 Mechanical

### 3.9.1 Control Panel Switches and Indicators

#### 3.9.1.1 Taking button forces and travel

The taking button comprises a 2 position switch, the specification of which defines the button force and travel.

- Position 1: 1N at 0.15mm travel
- Position 2: 2.6N at 0.3mm travel

#### 3.9.1.2 Flash override and exposure trim buttons forces

The measured forces required to position the flash override and trim buttons are:

- $1.35N \pm 0.9N$

#### 3.9.1.3 Self-timer feature accessed via smartphone interface

When activated, the timer shall delay the exposure cycle for a period of time as defined by the user via the smartphone app.

#### 3.9.1.4 Autofocus Override feature accessed via smartphone interface

When activated, the override shall enable any of the focus zones to be manually selected.

#### 3.9.1.5 Flash Override Function

When activated, the override shall cause the camera to operate in the ambient exposure mode. Override to be controlled by a two position switch located on the lens barrel.

#### 3.9.1.6 Exposure Trim Function

When activated, this centre-nominal mechanical trim switch shall cause the exposure to be either lightened or darkened by approximately 2/3 f-stop. Trim to be controlled by a three position switch mounted on the lens barrel.

### 3.9.2 Hand Strap Assembly

The hand strap (in a typical adjustment position) and camera shall evidence no damage when the camera is tested as follows:

- a. 500 drop cycles, from a height of 2.5 inches (6.4 cm);
- b. 25 lb (11.3 kg) tension force in the normal direction of suspension.

### 3.9.3 Tripod Socket Existing FPU implementation

Extreme Torque	The tripod socket shall not rotate when a clockwise torque of 10.41 in-lbs (12 kg-cm) is applied.
Push-In Force	The tripod socket shall withstand a force of 25 lb (11.3 kg) applied perpendicular to the camera.
Socket Height	The tripod socket shall be flush with or below the surface of the camera body.

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NOTE: The tripod socket shall meet the requirements of **ANSI PH3.6**.

All of the above will be updated to reflect current FPU implementation

### 3.9.4 Frame counter reset

Reset of the frame counter will be achieved by removal of the film pack

### 3.9.5 Cover sheet (dark slide)

The cover sheet will be ejected automatically by the combination of film pack replacement and closure of the film door. Should a part used film pack be inserted into the camera the top frame will be automatically ejected in place of the cover sheet.

### 3.9.6 Battery Power Indication

Indication as to the status of the battery shall be given using the red LED on the Film Processing Unit (FPU). This LED will alert the user to one of four battery states as follows:

- a. LED on continuously. Indicates that the battery is being charged.
- b. LED off with battery charging lead connected. Battery is fully charged.
- c. LED slowly flashing (low battery). Indicates that the available battery power is reduced to the point where there is a capacity to take only one or two photographs.
- d. LED rapidly flashing (low low battery). Indicates that the available power in the battery is below that required to take any photographs and that the battery must be charged. Picture taking is inhibited.

The battery status is communicated on demand as follows:

### 3.9.7 Exterior finishes

### 3.9.7.1 Durability

The materials and finishes used must be resistant to corrosion, abrasion, and deterioration caused by normal handling during both manufacture and use, or caused by chemical reagents of the integral film process (in applications where contact with these reagents might occur).

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## **3.9.7.2 Texture/Colour Matching**

On individual cameras, exterior parts designed for identical colour and/or texture shall match each other within the range set by limit samples.

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## 3.10 Assembly Requirements

### 3.10.1 Light Tightness

#### 3.10.1.1 Camera Static Light Leak

Camera light tightness shall be determined by loading the camera with IMPOSSIBLE film. The camera, open or closed in any attitude, shall then be subjected to 86,080 lx illumination from all directions for  $6.0 \pm 0.5$  hours. The film shall not become fogged or light-struck upon completion of this test, beyond the level set by limit samples. Table II below shows the exposure duration for other light levels.

TABLE II

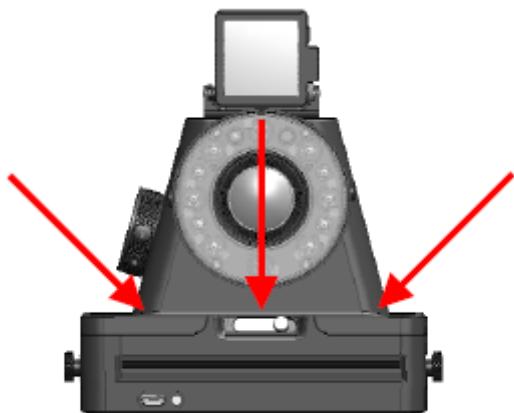
Brightness (lx)	Time in Chamber	
Average	(Camera Door Open)	Full Camera (door closed)
86,000	1.0	6.0
70,000	1.0	7.0
65,000	1.5	8.0
50,000	2.0	10.0
43,000	2.0	12.0

#### 3.10.1.2 Camera Door-Open Light Leak Test (Goal)

Camera light tightness shall be determined by loading the camera with a film pack. With the camera door fully open, the camera shall be subjected to 43,040 lx illumination from all directions for  $2.0 + 0.25$  minutes. The film shall not become fogged or light-struck upon completion of this test beyond the level set by the limit samples. (NOTE: For the purposes of monitoring the product, the time shall be ten seconds).

#### 3.10.1.3 Dynamic Light Leak

The film shall not become fogged or light-struck when subjected to 107,600 lx illumination from the directions shown during the exposure/processing cycle, beyond the level set by limit samples.



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## **3.10.1.4 Mechanical Sound**

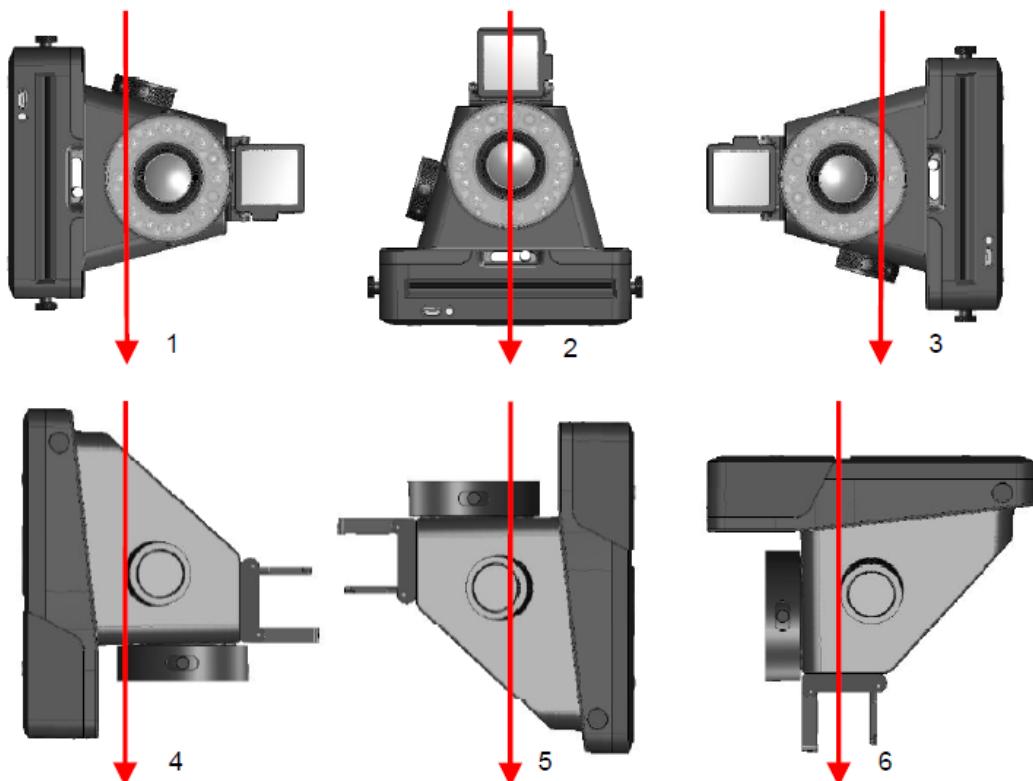
A camera shall not have any unusual grinding, resonant, or otherwise abnormally loud noise that may be indicative of unseated, irregular parts, etc

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## 3.10.1.5 Drop Test

A camera loaded with a full film pack shall be functional after 1 drop in any of the six attitudes shown, from a height of  $30 \pm 1$  inches (76.2 cm) onto standard hardwood flooring. Photographic performance shall remain satisfactory with no major structural damage to camera. Each test camera is to be dropped only once in a single orientation.



## 3.10.1.6 CARTON VIBRATION TEST

Carton will be subjected to 1.09g RMS in each of X, Y, Z axes. No significant damage to carton and camera photographic performance shall remain satisfactory without structural damage to camera.

## 3.10.1.7 CARTON COMPRESSION/PACKING STORAGE TEST

Carton to be subjected to its own weight for the following test cycles:

- 24 Hrs at  $50^{\circ}\text{C}$ , 95% RH
- 24 Hrs at  $60^{\circ}\text{C}$ , 60 RH
- 24 Hrs at (minus)  $-20^{\circ}\text{C}$

No significant damage to carton and camera photographic performance shall remain satisfactory with no structural damage to camera.

## 3.10.1.8 CARTON DROP TEST

Carton is to be dropped from a height of 70cm on to a concrete floor. No significant damage to carton and camera photographic performance shall remain satisfactory with no structural damage to camera.

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## **3.10.1.9 KIT BOX DROP TEST**

Kit box to be dropped from a height of 90cm on to a concrete floor.. To be dropped on all 6 faces plus 3 edges and one angle, each drop to be carried out a single time. No significant damage to box and camera photographic performance shall remain satisfactory with no structural damage to camera.

## **3.10.1.10 KIT BOX SHOCK TEST**

Kit box is to be subjected to an acceleration of 90G in the form of a sine wave for 4 ms. No significant damage to box and camera photographic performance shall remain satisfactory without any structural damage to camera.

## **3.10.1.12 KIT BOX SHOCK TEST**

Kit box is to be subjected to an acceleration of 90G in the form of a sine wave for 4 ms. No significant damage to box and camera photographic performance shall remain satisfactory with no structural damage to camera.

## **3.10.2.1 FPU INDURANCE TESTING**

The FPU lock switch is to be subjected to 9000 cycles of operation. No visible damage or deteriorating function should be observed. The operating force should be recorded at 2000, 4000, 6000 & 9000 cycles. Images should be taken & recorded with notes of operator comments during test cycle.

## **3.10.2.2 FPU OPEN/CLOSE ENDURANCE TESTING**

The FPU lock switch open/closed for 9000 cycles. No visible damage or deteriorating function should be observed. The operating force should be recorded at 2000, 4000, 6000, 9000 & 10000 cycles. Images should be taken & recorded with notes of operator comments during test cycle.

## **3.10.2.3 CAMERA FLASH ENDURANCE TESTING**

The camera flash should be turned on/off for 9000 cycles. No visible damage or deteriorating function should be observed. The operating force should be recorded at 2000, 4000, 6000 & 9000 cycles. Images should be taken & recorded with notes of operator comments during test cycle.

## **3.10.2.4 ON/OFF ENDURANCE TESTING**

The camera should be turned on/off for 9000 cycles. No visible damage or deteriorating function should be observed. The operating force should be recorded at 2000, 4000, 6000 & 9000 cycles. Images should be taken & recorded with notes of operator comments during test cycle.

## **3.10.2.5 TRIM SWITCH ENDURANCE TESTING**

Trim switch should be subjected to 9000 cycles of operation. No visible damage or deteriorating function should be observed. The operating force should be recorded at all positions for 2000, 4000, 6000 & 9000 cycles. Images should be taken & recorded with notes of operator comments during test cycle.

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## **3.10.2.6 USB CABLE ENDURANCE TESTING**

USB cable should be subjected to 3000 cycles of operation. No visible damage or deteriorating function should be observed. The operating force should be recorded for 'push in' & 'pull out' at 1000, 2000 & 3000 cycles. Images should be taken & recorded with notes of operator comments during test cycle.

## **3.10.2.7 SHUTTER KEY ENDURANCE TESTING**

Shutter key to be subjected to 10000 cycles of operation. No visible damage or deteriorating function should be observed. The operating force should be recorded at 2000, 4000, 6000, 9000 & 10000 cycles. Images should be taken & recorded with notes of operator comments during test cycle.

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## 4 IDENTIFICATION

Each camera shall be identified by a label located on the underside of the FPU base moulding as is currently the case with the FPU, content **TBD**.

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## 5 CERTIFICATIONS

- The camera will be CE certified and will be designed to comply with the ***Low Voltage Directive (LVD) 2006/95/EC***.
- The camera will not require ***UL*** certification