# The PC165-DNR Missing Manual

**with Special Emphasis on Its Use in Occultation Astronomy**

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1. **Introduction**. The camera sold by Super Circuits ([www.supercircuits.com](http://www.supercircuits.com)) as the PC165-DNR has many features packed into a small package. Unfortunately, the “OSD Quick Manual” is woefully inadequate, both in describing the features and explaining how to use them. This document is an attempt at a more complete user’s manual for the PC165-DNR, with special consideration given to its application to astronomy. In my effort to understand the PC165-DNR, I’ve found information about several closely-related cameras for which the documentation provides somewhat better explanation (see references). This is a distillation of those findings.

This manual is organized into sections covering definitions of terms, the meaning of the camera’s On-Screen Display (OSD) menus, how the camera’s output responds to settings changes, recommendations for occultation astronomy, technical specifications, a glossary, acknowledgements, and references and pointers to other information resources.

* 1. First off, a discussion of terms will help make sense of what you see in the “Quick Manual” and on the screen. There is plenty of jargon related to this type of camera, and it’s worth understanding what the terms mean.

**DNR** stands for “digital noise reduction”. You will see references to 2D-DNR, 3D-DNR, 2DNR, and 3DNR. These refer to two- or three-dimensional Noise Reduction. The three dimensions are horizontal (x), vertical (y), and time (t), corresponding to the horizontal and vertical spatial dimensions within a video image, and time corresponding to a series of video frames. Two-dimensional noise reduction involves some kind of smoothing (not rigorously defined in the manual) among adjacent pixels horizontally and vertically. In 3D-DNR, frames are processed across time, between consecutive frames. The on-screen controls allow adjustment in levels from 0 (zero) to 100, where “level’ isn’t rigorously defined (yet) either.

**OSD** stands for On Screen Display, the primary way in which the PC165DNR communicates with the operator. One uses the Enter, Up, Down, Left, and Right buttons on the side of the camera to navigate these on-screen menus and change settings. The on-screen display disappears after a short period of no button activity.

**Sense-up** (or Sens Up) is a way of increasing the camera’s light sensitivity by lengthening the exposure time. This comes at the cost of video frame rate (see Table \_\_). Exposure time increases in multiples of 2: 2x, 4x, 8x 16x, 32x, 64x, 128x, 256x. The 1x video frame rate is 30 frames per second (fps) for NTSC and 25 fps for PAL video.

**TVL** stands for TV lines. Since the lines are horizontal, this is a measure of vertical resolution.

**HSBLC** is Highlight Suppression Back Light Control or Compensation.

**Privacy Zone** enables the user to blank out portions of the screen. This might be useful if a permanently mounted security camera inadvertently includes an unintended view into someone’s home or office, and the camera operator wishes to maintain good relations with the neighbor. For astronomical applications, it might be useful for blanking out bright light sources such as the lunar limb. But the camera’s performance when this is turned would need to be investigated to make sure it does not adversely affect the measurement(s).

1. **The On-Screen Display Menus**. The PC165-DNR offers many adjustments through a set of on-screen display (OSD) menus, which you navigate using the four directional and the Enter buttons. Here is a listing of each menu in the order it appears in the PC165DNR. Several closely-related cameras have similar menus, though sometimes with slightly difference features (see References).

Setup

1. Lens *(This menu is probably not applicable for most astronomical applications, since the settings pertain to an auto-iris lens connected via the connector on the camera’s right side)*.
	1. DC-> Brightness (1 – 100)
	2. Manual
2. Exposure
	1. Shutter (Auto, 1/60, FLK (flicker free), 1/250, 1/500, 1/1K, 1/2K, 1/5K, 1/10K, 1/100K, x2, x4, x8, x16, x32, x64, x128, x256). *(For astronomical occultation applications, this should be set at 1/60 if the target is bright enough, or at the minimal multiple of longer exposure).*
	2. Brightness (0 – 100)
	3. AGC (Automatic Gain Control; Off, Low, Medium, High)
	4. Sense-Up (Off, Auto (x2 through x256 in 2x steps), Return
	5. BLC (Back Light Control; Off, BLC(Gain, Area(), Default(), Return)
	6. D-WDR (Digital Wide Dynamic Range; Off, Indoor, Outdoor)
3. White Balance (ATW, AWB, AWC-Set, Manual (Blue 0-100, Red 0-100, Return) ); NOTE: White Balance can be affected by Day & Night mode, below, and is not applicable if camera is in B&W mode.
4. Day & Night (Color- Affects White Balance above, B/W (Burst On/Off-puts color in B&W under some conditions, IR Smart On/Off- not applicable for PC165-DNR)
5. 3DNR (Off / On (Level 0-100) )
6. Special
	1. Camera Title (Off, On (Enter title letters and numbers) )
	2. D-Effect (Digital Effects)
	3. Motion [detection] (Off, On)
	4. Privacy (Off, On)
	5. Defect (Sense-Up (x4 – x64) – another camera’s instructions suggest x16 or x32, Difference 1 – 6 -? (Needs further investigation).

 Start (Cover lens and press Enter)

1. Adjust
	1. Sharpness 0 – 31 (For astronomy: Leave at zero).
	2. Monitor (CRT (Level 0 – 67, Blue gain 0 – 100, Red gain 0 – 100), LCD (Gamma (0.05-1.00), Blue gain 0 – 100, Red gain 0 – 100), Level)
2. Reset (Set to Factory defaults, Return)
3. Exit

Table 1: Effect of Sense-up multiplier on “gain”, frame rate, and magnitude, output delay, and time correction. These are based on the author’s analysis of Gerhard Dangl’s still pictures of M67, collected March 2013.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sense-up Multiplier** | **1x** | **2x** | **4x** | **8x** | **16x** | **32x** | **64x** | **128x** | **256x** |
| Frame Rate, fps | 30 | 15 | 7.5 | 3.75 | 1.87 | 0.94 | 0.47 (2.13 s) | 0.23 (4.27 s) | 0.12 (8.53 s) |
| Magnitude “Gain” (Note 1) | 0.0 | 0.8 | 1.5 | 2.3 | 3.0 | 3.8 | 4.5 | 5.3 | 6.0 |
| Delay, sec (Note 2) |  0.017 |  0.025 | 0.042 | 0.075 | 0.142 |  0.275 |  0.542 |  1.076 |  2.144 |
|  Exposure Time, sec. (Note 2) |  0.017 |  0.033 | 0.067 | 0.134 | 0.267 |  0.534 |  1.068 |  2.136 |  4.271 |
| Time correction in fields (Note 2) (0.017s) |  -0.017 |  -0.025 | -0.042 | -0.075 | -0.142 | -0.275 |  -0.542 |  -1.076 | - 2.144 |
| Time correction in frames (Note 2) (0.033s) |  -0.017 |  -0.033 | -0.05 | -0.083 | -0.15 | -0.284 |  -0.551 |  -1.084 |  -2.152 |
| Time resolution in fields (Note 2) (0.017s) | ±0.008 | ±0.017 | ±0.033 | ±0.067 | ±0.134 | ±0.267 | ±0.534 | ±1.068 | ±2.136 |
| Time resolution in frames (Note 2) (0.033s) | ±0.017 | ±0.017 | ±0.033 | ±0.067 | ±0.134 | ±0.267 | ±0.534 | ±1.068 | ±2.136 |

(1) This “Gain” is theoretical. Experimentally measured values derived in Appendix A are in rough agreement with the theoretical values, but are affected by background noise for higher gains.

(2) Timing values from Gerhard Dangl’s measurements (see web site URL in References):

**Digital Noise Reduction Discussion**

The PC165-DNR is a relative newcomer to the field of occultation astronomy (e.g., first mentioned in the IOTA Yahoo discussion in Sept 2011). Its performance and characteristics are still being evaluated by members of the occultation community (see References, Dangl’s web site). Understanding these is vital to enable accurate interpretation of the video information that comes out of the camera. Photons go into the camera, and information as analog video comes out, but in between, the signals are extensively changed by the signal processor inside the camera, depending on operator-selectable settings. This is “better” if it expands a useful feature of the camera, such as sensitivity, but “worse” if we do not understand what the signal processing has done to the signal in brightness, location, extent, or duration. The PC165DNR’s settings can affect the spatial domain and the time domain:

Spatial domain considerations

Two-dimensional noise reduction (2D-DNR) assigns brightness values to a given pixel depending on the values of neighboring pixels. This tends to reduce the random pixel-to-pixel noise, but smooths out and changes the spatial extent of features in the image. For astronomical applications, this may or may not be a problem, depending on the application, and the operator must evaluate settings with and without noise reduction.

Time domain considerations (Sense-Up)

“Sense-Up” is a widely-used marketing term that refers to “upping the sensitivity” by increasing the exposure duration, or integration time. As shown in Table 1, “Sense-up” is set to 2x, the camera integrates two video fields into one video frame, increasing the light sensitivity while simultaneously reducing the time resolution from one video field to two fields, or one frame. At 4x, the camera integrates over two video frames; at 8x, over four frames, and so on.

**Spectral response**

It’s important to keep in mind that all photosensors have a characteristic spectral response, or variation in response as a function of light wavelength. Silicon photosensors tend to have high sensitivity to infrared (IR) light. The PC165DNR contains an Infrared (IR) blocking filter.

**3.0 Recommendations for Occultation Astronomy**

For occultation astronomy we want to maximize the brightness signal to noise ratio (SNR) and time resolution, with radiometric (brightness) measurement as a secondary goal. Whenever possible, we want to collect video at the fastest refresh rate possible while maintaining a bright enough image to discern the light source from the surrounding dark background. Record, either as part of your occultation video, or by some other means such as observation notebook, all pertinent settings. Quickly scrolling through the OSD menus while recording video after an event is a convenient way of capturing the camera’s state.

Table 2. Recommended Settings for Occultation Astronomy.

|  |  |  |
| --- | --- | --- |
| Control variable | **Lunar occultations** | **Faint object occultations** |
| **Shutter speed** | 1/60 | 1/60, or minimal multiple |
| **AGC** | Medium | Medium or High |
| **3DNR** | Off | Off\* |
| **Sense-Up** | Minimal | Minimal |
| **BLC** | Off | Off |
| **D-**WDR | Off | Off |
| **Day/Night** | Night (B&W) | Night (B&W) |
| **WB** |  |  |
|  |  |  |
| **De**fect removal | Off | Off |

\* Use as conditions require, but with extreme caution and attention to recording all camera settings exactly and completely.

**4.0 Technical Specifications**

Camera PC165 DNR

Sensor 1/3” SONY Super HAD CCD

Total Pixels 811(H) \* 508(V)

Effective Pixels 768(H) \* 494(V)

Scanning System 2:1 interlace

Synchronization Internal

On Screen Display Available

Backlight OFF / HSBLC / BLC selectable

Resolution 600 TV Lines (Color), 650TV Lines (B/W)

S/N (Y signal) 52dB (AGC Off, weight on)

Min. Illumination 0.00001 Lux (B&W, integrating?)

 0.001 Lux (Color, integrating?)

White Balance ATW / AWB / Manual / AWCgSET

Electronic Shutter Speed AUTO (1/50 sec, 1/60 sec ~ 1/120,000 sec)

Sense-Up Off / Auto (selectable limit \*2 ~ \*258x)

Gain Control High, Middle, Low, Off selectable

3 DNR Off/On (1~50 level adjustable)

D-WDR Indoor / Outdoor / Off

Motion Detection On / Off (4 zones, alarm output)

Privacy On / Off (8 zones) [Block bright light sources?]

Mirror Off / On

Freeze On / Off

Sharpness 0~31’(level adjustable)

D&N Selection Color /BW/ Auto

Digital Zoom On (\*32) / Off

Blemish Compensation 256 point (even 128 point, odd 128 point)

Power Dual voltage: AC 24V or DC 12V

Power Consumption ??? mA

 CDS ON: 1,300 mA max

Lens DC Auto Iris Varifocal Lens (2.8mm- 12mm)

 DC Auto Iris Varifocal Lens (2.8mm- 12mm / 6mm-50mm)

 DC Auto Iris Varifocal Lens (5mm- 50mm)

(Similar camera?)

High Performance IR CCTV Bullet Camera User Manual 25SECTION 5: SPECIFICATIONS

Component

BLK-CPT235VH

BLK-CPT237VH/ BLK-CZT242VH

BLK-CZT243VH

Operating Temperature/ Humidity

-4 deg F ~ 140 deg F (-20 deg C ~ +60 deg C). RH 95% Max.

Storage Temperature/Humidity

-4 deg F ~ 140 deg F (-20 deg C ~ +60 deg C). RH 95% Max.

**5.0 Potential for alternative controls**

The Enter and four direction control switches on the left side of the PC165DNR are not laid out in an intuitive way, and call out to be altered. Ted Swift soldered a ribbon cable to the five button contacts plus one common and routed it out of the camera to an external pushbutton paddle (See references). This provides a more intuitive button layout and reduces vibration.

(Name) independently and about the same time (Feb 2012) discovered that the button contacts could be wired in parallel with transistor switches controlled by an Arduino microcontroller and a web interface (See references).

These examples provide the proof-of-concept to develop a robotic, remote-controlled and steerable occultation telescope.

**5.0 Glossary**

2D-DNR, 3D-DNR: Two- or Three-dimensional Noise Reduction. The three dimensions are the horizontal and vertical spatial dimensions, and time. Two-dimensional noise reduction involves some kind of processing between adjacent pixels horizontally and vertically. In 3D-DNR, frames are processed across time, in levels from 0 (zero) to 100, where “level’ isn’t rigorously defined.

AGC: Automatic Gain Control. Under low light conditions, the camera increases its gain, or light sensitivity. As the scene brightness increases, gain is automatically reduced. In the PC165DNR, the AGC can be set to Off, Low, Medium or High. With increasing gain comes increasing noise (“speckle”).

BW: Black and White (B&W).

D-WDR: Digital Wide Dynamic Range

DSP: Digital Signal Processing

FLK: Flicker (reduction mode). The 60-cycle-per-second alternating current (AC) that powers lights (50 Hz in some parts of the world) interacts (“beats”) with the 29.97 frame-per-second video sampling rate to produce a flickering appearance in the video image.

HD: High Definition (in the case of the PC165DNR, “high” means 600 television lines in black and white, 550 lines in color).

HSBLC: Highlight Suppression Back Light Compensation

OSD: On Screen Display, the primary way in which the PC165DNR communicates with the operator.

Sense-up (or sens-up, or several other combinations of spelling and capitalization): An automatic increase in exposure time in 2x multiples of video frames under low light conditions.

Smart IR, IR Smart. This is a function that is available in cameras with an infrared (IR) LED (Light Emitting Diode) illuminator. This prevents saturation when a subject in the visible scene is close to the illuminator. Since the PC165DNR does not include an illuminator, these functions serve no purpose in occultation astronomy.

WDR: Wide Dynamic Range uses two shutter speeds in alternative video fields, high and normal, and combines these two fields into one frame. It allows every detail to be captured accurately even if one portion is bright while other portions are dark. As a result, combined fields yield a frame of high quality images.(1)

WB or White Balance: Enables a basic range of color adjustment in a color camera. Not applicable to black and white astronomical applications.

**6.0 Acknowledgements**

I thank the participants in the IOTAoccultations Yahoo group for advice, mentoring, and encouragement. In particular I thank Gerhard Dangl in Austria for information on the Digital Noise Reduction behavior of the PC165-DNR, Tony George in Umatilla, Oregon, USA, and Dr. Terrence Redding in Florida, USA.

**7.0 References and other Information Resources**

Good FAQ explaining much of the jargon related to these cameras, and the pros and cons of the features: <http://www.eaglevision1.com/security_camera_FAQ.htm>

Cameras with very similar specifications, with links to their respective manuals, which provide better documentation (though still terse) than the Super Circuits PC165-DNR “quick start manual”.

<http://www.securitycamera2000.com/products/600TVL-SONY-SUPER-HAD-CCD-D%252dWDR-Color-Board-Camera-with-OSD-Menu-DNR.html>

Manual linked from above: <http://www.securitycamera2000.com/download/PZ0420-User-Manual.pdf>

<http://www.supercircuits.com/media/docs/blk-cpt235vh2-manual-do.pdf>

Same camera(?):

<http://www.digiop.com/files/documents/Digiop_Black_HighPerformance_Bullet_Cameras.pdf>

Video on removing the IR-blocking filter: <http://nuigroup.com/forums/viewthread/4189/>

Gerhard Dangl’s web site:

Gerhard Dangl’s PC165DNR time response analysis <http://www.dangl.at/ausruest/vid_tim/vid_tim1.htm#pc165dnr>

Gerhard’s Video Camera Sensitivity measurements, M67, March 2013 <http://www.dangl.at/menu_hhe.htm> , then select Sensitivity Video Cameras, then scroll down to PC

Digiop\_Black\_HighPerformance\_Bullet\_Cameras.pdf <http://www.supercircuits.com/media/docs/blk-cpt235vh2-manual-do.pdf> accessed <date>

Kevin Palivec’s’s Instructable instructions on interfacing the PC165DNR to an Arduino microcontroller, along with the program listing to control the camera over a web site. <http://www.instructables.com/id/Adding-remote-OSD-button-control-to-the-SuperCircu/?ALLSTEPS> accessed 28 June 2014.

Swift, Ted. Feb 2012. A Paddle Control for the PC165DNR. (IOTA Files section), https://xa.yimg.com/df/IOTAoccultations/A+PC165+Directional+Control+Paddle\_doc.doc accessed 28 June 2014.

**Appendix A. Limiting magnitude and SNR analysis of Gerhard Dangl’s Messier 67 pictures.** *Still to be completed – TJS 28jun2014.*

**Background.**

Signal to Noise Ratio (SNR). The fundamental measurement of signal quality is the signal to noise ratio, SNR or S/N. SNR is the difference between the average signal and average background divided by the variation from sample to sample (e.g., video frames):

*𝑆𝑁𝑅=*