

Ethernet over Coax

Siquira ECO-plug - Ethernet over Coax - SFP Module



Application Note

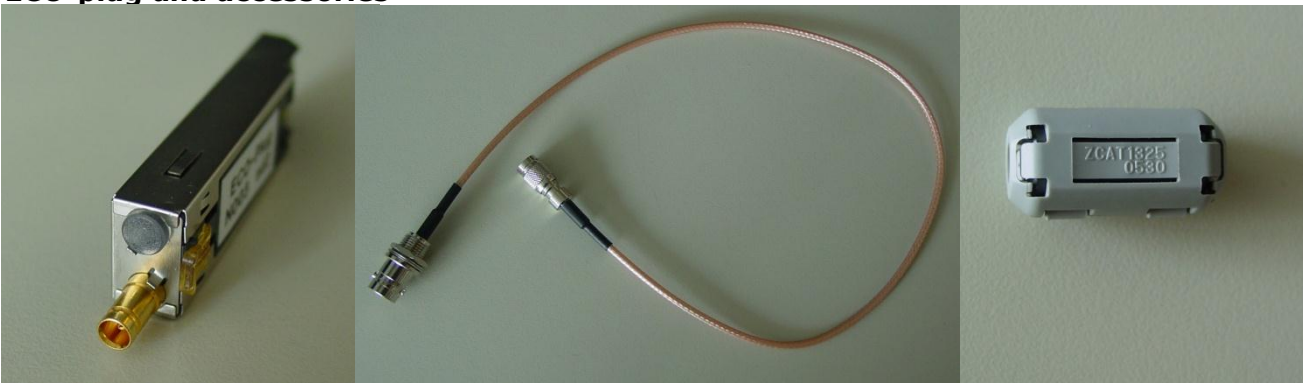
The maximum cable attenuation limit is 30dB at 125MHz.
For critical system requirements see page 4 and for Railway also see page 8.

ECO-plug Product Description

The ECO-plug is an electrical transceiver in SFP format for full-duplex, fully transparent Ethernet transmission over a single coaxial cable. It is used to upgrade legacy analogue CCTV systems to higher resolution IP camera systems without the need for installing new cabling.

The name ECO-plug refers to Ethernet over Coax. Plug refers to the pluggable module.

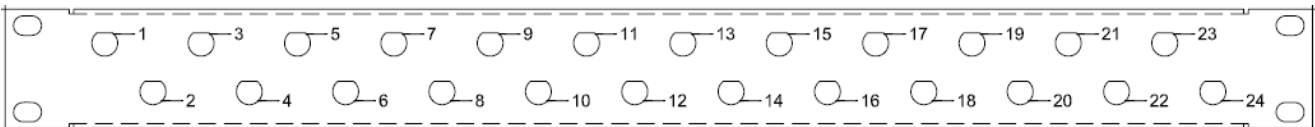
ECO-plug and accessories



ECO-plug SFP module

Adapter cable BNC Bulkhead 40cm

Ferrite 1325-0530
(clamp on cable)



BNC patch panel



Ground strap

Models	Description
ECO-plug	Ethernet over Coax, SFP Module, 100Mbps with accessory cable 40cm
ECO-plug BNC patch panel	Patch Panel, 19" Rack Plate, 24 channels, 1RU, for BNC bulkhead grounding
ECO-plug Adapter Cable BNC Bulkhead 40cm	Adapter Cable, 40cm, for ECO-plug, DIN 1.0/2.3 male to BNC bulkhead female
ECO-plug Adapter Cable BNC Bulkhead 2m	Adapter Cable, 2m, for ECO-plug, DIN 1.0/2.3 male to BNC bulkhead female
Ferrite 1325-0530 (cable clamp type)	Ferrite for ECO-plug, for 5mm cable
ECO-plug BNC Ground Strap 5cm	BNC grounding wire assembly for BNC bulkhead, 5cm

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Electrical

The ECO-plug takes its power directly from the camera or switch. No additional power supply is required.

An ECO-plug link needs a point to point coax cable connection. The ECO-plug is not compatible with legacy equipment such as analogue video amplifiers.

Use the supplied adapter cable (DIN 1.0/2.3 male to BNC female) to connect the legacy coaxial video cable to the ECO-plug.

Interface	Small Form-factor pluggable (SFP) Multi-source Agreement (MSA)compliant
Power consumption	0.7W typical
Connector type	DIN 1.0/2.3 female – 75 ohm
Cable impedance	75 ohm
Data throughput	100 Mbps full duplex (200 Mbps total up + down)

Network communication over coax is established automatically. The green LED indicator on the ECO-plug will show the link status. (Blinking LED means power OK but no link, solid green LED means link over coax OK)

ECO-plug modules can be used in 100BASE-SFP equipment. Gigabit Ethernet SFP ports are not supported. Some Gigabit SFP ports may be capable of switchover to 100Mbps speed.

Switch / Host compatibility

The ECO-plug is Small Form-factor Pluggable (SFP) Transceiver MultiSource Agreement (MSA) compliant, for a nominal bit rate of 100Mbps.

Suitability of the switch / host for use in video networks should be taken into account in addition to compatibility with the ECO-plug. The switches listed on the ECO-plug data sheet or Quick Start Guide are also recommended for use in video networks.

Although there is a large degree of standardization (MSA) with SFPs, some care must still be taken in determining compatibility. The ECO-plug data interface, with the Host Equipment, runs at 100 Mbps. So in most cases it is best to select a host that has SFP slots that are specifically designed to run at 100 Mbps only. At the time of writing, Siquira camera, codec and switch models (specified on the ECO-plug data sheet) have SFP slots that run at 100 Mbps only, or can be set to run at 100Mbps.

Unfortunately an SFP slot that runs at 100 Mbps only does not completely guarantee compatibility. Some major switch vendors, notably Cisco and HP, will only accept SFP modules that have their official approval. There may be a workaround for this issue. However, this is not recommended. Please consult Siquira/TKH for projects requiring switches that do not appear on our compatibility list.

Some SFP slots will operate at both 100 Mbps and at 1 Gbps. However, in order to run at 100 Mbps some of these devices require that the SFP module has an external data rate of 100 Mbps while still transferring data with the host at 1 Gbps via an SGMII. The ECO-plug will not function in this manner. Some equipment will work at both speeds without requiring a special SFP. Again it would be best to discuss the options with your contact at Siquira/TKH if you have questions.

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The ECO-plug module – How does it work?

The ECO-plug module can be plugged into the SFP slot of the camera, network switch or codec, such as the Sigura BC620WDR camera. It takes its power directly from the camera through the MSA compliant SFP electrical interface. The same SFP interface supports the Ethernet communication to and from the ECO-plug module. This is the same standard MSA protocol that is used for fiber optic SFP modules. It is a bidirectional and transparent 100Mbps Ethernet link.

Internally in the SFP the Ethernet packets are stored for a very short time, less than 100us, and transmitted at a higher speed to the other side of the coax link. After transmitting a package of Ethernet data, the coax link will wait for data from the other end. Thus, transmitting and receiving data over the coax is separated in time. The overall delay of the Ethernet over Coax system (latency) is less than 250us.

The actual transmitted signal on the coax cable has an amplitude of 800mV. The coax cable will cause attenuation of this signal. This attenuation (loss) is usually specified in dB per 100m. In the ECO-plug at the other end of the link, a dedicated receiver with built-in cable equalizer is used to compensate for the cable loss. It can compensate up to 30dB of cable loss at 125MHz. Most cable manufacturers specify cable loss at 200MHz. The cable loss at 125MHz can be calculated from the cable loss at other frequencies.

For frequencies around 125MHz, cable loss is dominated by the skin effect. This attenuation is proportional to the square root of the frequency. So if the loss at 200MHz is 6dB per 100m, the loss at 125MHz will be (approximately) $6 \cdot \sqrt{125} / \sqrt{200} = 4.7$ dB per 100m.

For cables with a very thin inner conductor (core) or with a core of copper clad steel, the resistance of the inner conductor will cause additional attenuation. At longer cable runs this resistance becomes significant with respect to the rated 75Ohms of the cable. For this reason the maximum cable length is limited according to the coax cable compatibility table (next page).

Network Integrity

Coaxial cables may exhibit gradual performance degradation over time. Poor video quality from an analogue camera you are replacing can indicate bad coax. You are strongly advised to test the line. To avoid compromising system integrity, you may need to replace BNC connectors (not just recrimp them) and degraded coaxial cables.

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Critical system requirements

- The maximum cable attenuation limit is 30dB at 125MHz, including connections.
- For Railway Environments a limit of 24dB and proper grounding applies (see Railway Environments page 8).
- For RG59 style cables with very thin inner cores or copper clad steel cores the typical distance will be less, see table below.
- Cables and connections must be in good shape. Replace degraded connectors.
- An ECO-plug link needs a point to point coax cable connection. Coax must be 75Ohm. Splitters or T-connections are not allowed. The cable frequency characteristics must show a normal roll-off up to 250MHz (see pictures page 5). No reflections or impedance mismatches allowed.
- The ECO-plug is not compatible with legacy equipment such as analogue video amplifiers.
- Keep the number of coax connectors to a minimum. A typical link will work with up to 6 connections.
- Due to the nature of an existing (maybe old) installation the distances in the table below cannot be guaranteed, but will be typical values.

Coax cable compatibility (table)

List of 75 Ohm CCTV coax cable types – typical cable lengths and specifications

Cable Class	Cable	Outer Ø mm	Core Size [AWG]	Core Ø [mm]	Core type *	Core Rdc Ω/km	Att/100m @125MHz dB	Max. Distance [m]*
RG59 Small core Up to 200m (650ft)	Nexans RG59 390650	6.1	23	0.58	1x0.58 CCS	280	12.7	150-200
	Prysmian VS6 K20	6.1	23	0.60	1x0.6 BC	57	12.7	150-200
	Nexans KX 6A	6.1	24	0.60	7x0.2 BC	~87	12.7	150-200
RG59 Large core Up to 300m (1000ft)	Belden 1505A	6.0	20	0.81	1x0.81 BC	33	8.6	270-350
	Cablewholesale RG59	6.1	20	0.81	1x0.81 BC	33	8.9	270-350
RG6 Up to 500m (1600ft)	Belden 1694A	7.0	18	1.02	1x1.0 BC	21	6.6	370-460
	TKF Coax 9	6.8	18	1.1	1x1.1 BC	17	6.2	400-500
RG11 Small core	Nexans KX 8 or RG11	10.3	18	1.2	7x0.4 BC	~19	7.5	330-410
RG11 Large core Up to 700m (2300ft)	Belden 7731A	10.3	14	1.63	1x1.6 BC	8.2	4.6	500-600
	Prysmian VS8 K20	10.3	14	1.7	1x1.7 BC	8	4.7	500-600
	TKF Coax 6	10.5	14	1.7	1x1.7 BC	8	4.1	600-720

*Note 1: CCS= copper clad steel, BC= bare copper

*Note 2: The lower end of the Max Distance range applies to environments with higher EMC noise levels, such as a railway electromagnetic environment. (See Railway Environments page 8)

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How to test the existing cable

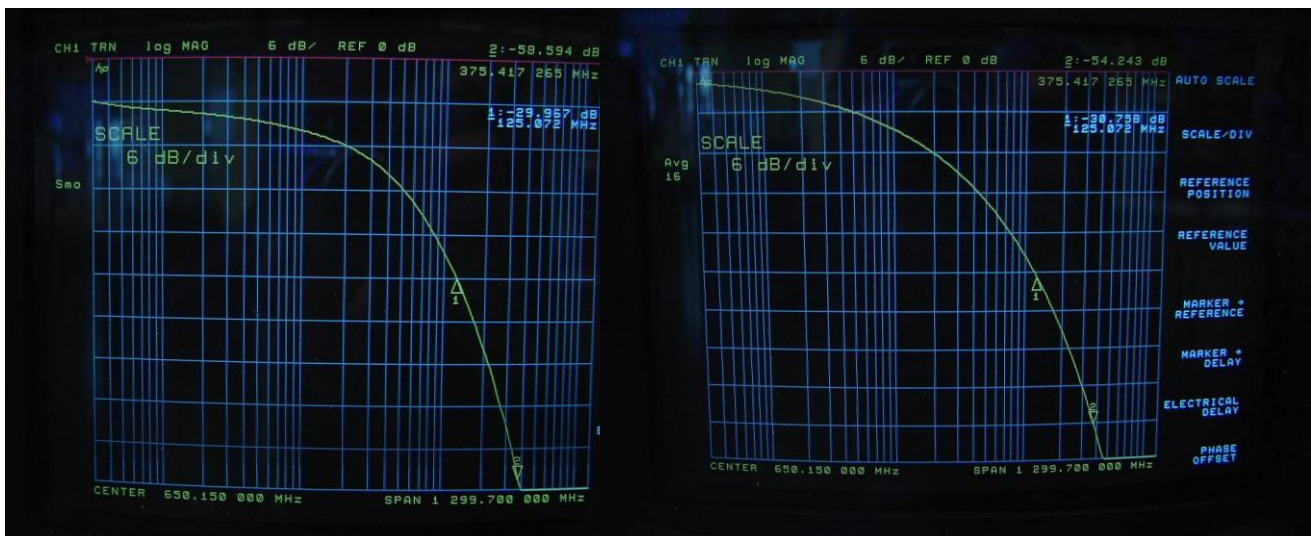
In the lab, a network analyzer is used to test several coaxial cables for their attenuation characteristics. In the curves below the results are shown.

The acceptance limit is 30dB of cable loss at 125MHz.

Analyzer HP8752B: Start frequency 300kHz, Stop freq 1300MHz, log scale. The reference level is the red line (just visible) at the top of the scale. Each division is an attenuation of 6dB.

In both cases the marker is set at 30dB attenuation for 125MHz. For the Nexans RG59 cable (left curve) that is at 200m, for the low loss RG11 type of cable (TKF coax 6 right curve) that is at 720m. These measurements confirm the cable lengths that can be bridged by the ECO-plug with very small packet loss. (Tested at Sigura Gouda)

Examples of 2 types of cables: Attenuation per length of cable



Low quality RG59 cable:
Nexans RG59 CCS 200m

High quality cable:
TKF Coax 6 720m

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How to determine the length of a cable with a TDR (or a pulse generator + scope)

A Time Domain

Reflectometer (TDR)

can be used to determine cable length.

The TDR puts a pulse with fast rising edges on the cable. This pulse is travelling along the cable and will be reflected (more or less) on the end of the cable.

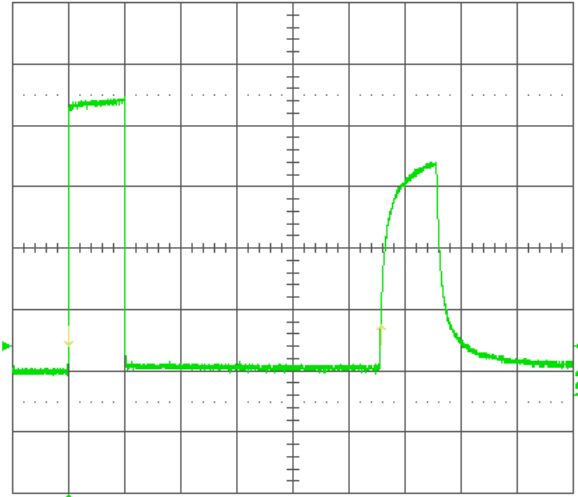
The travelling time is a measure for cable length.

Reflection at the end will be best when the cable is not terminated by any equipment; it should be left open during this test.

If the cable is perfectly terminated by 75Ohm equipment there will be no reflection.

8-Jun-12
10:32:54

1 μ s
200mV
75mV



1 μ s
1 trig only
2 .2 V DC
3 .1 V DC $\times 10$
4 trig only

Δt 5.577 μ s $\frac{1}{\Delta t}$ 179.31 kHz

1 GS/s

2 DC 0.156 V

STOPPED

The picture shows a 1us wide pulse made by a pulse generator. An oscilloscope is connected to the output of the generator and the coax cable to be tested. The other end of the coax cable is left open. The second pulse on the picture is the same pulse but reflected back by the open end of the cable. This pulse travelled the cable length twice, in this case 5.6us. The length of the cable is determined by the travelling speed of the signal divided by the travelling time.

In this coax the signal travels with 88% of the speed of light (see datasheet of cable manufacturer), so the length of the cable is $X=0.88*3.10^8*2.8\mu s=735m$

In the shown picture the source pulse and the reflected pulse are nicely separated. For a shorter cable or a longer pulse, these pulses will overlap. In that case there will be a step in amplitude that can be used to determine the cable length (and termination impedance).

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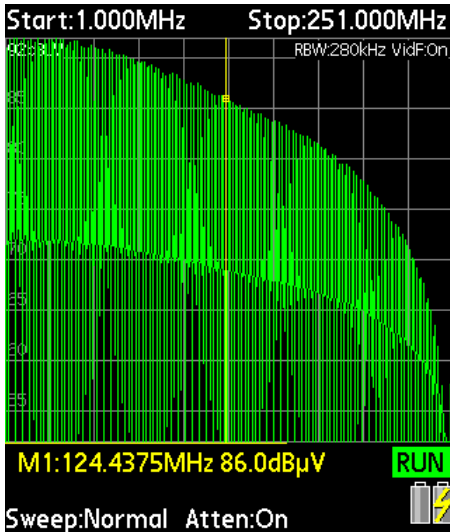
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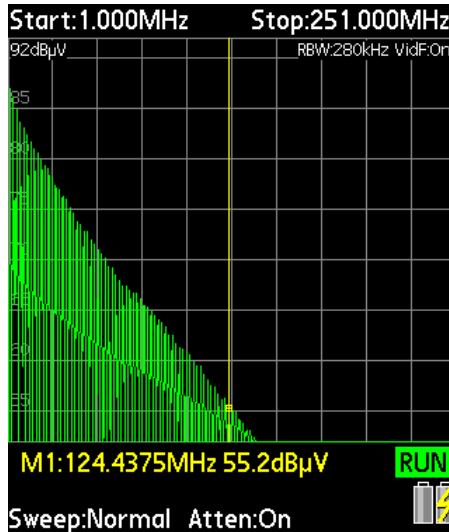
How to test the existing cable in the field

In the field the existing cable can be qualified almost the same way. In this case a separate known transmitter, an ECO-plug SFP module programmed with 'PRBS7-Generator' firmware can be used on one side of the cable. On the other side a spectrum analyzer can be used. Siquira proposes to use the TTI PSA1301T handheld spectrum analyzer. Contact Siquira for the use and availability of these tools.

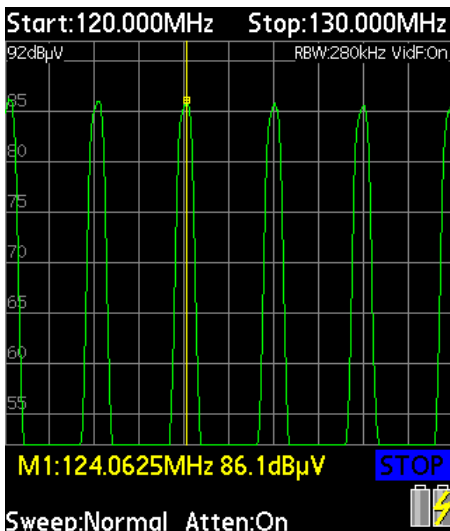
The PRBS7-Generator will generate a continuous random data signal, with a roll off at higher frequencies, see ref plot. The signal is made by discrete frequency 'spikes' at a 2MHz interval.



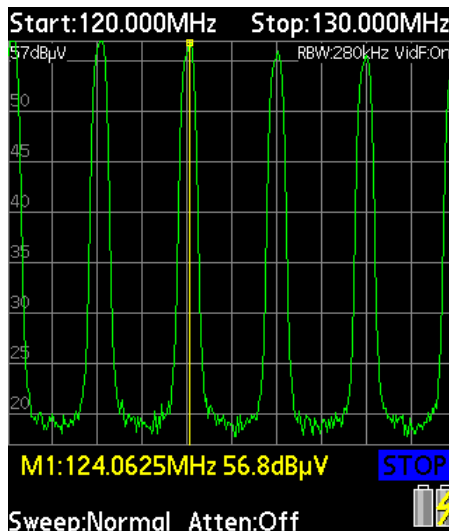
Ref plot. (86dBuV at 124MHz)
Output signal of PRBS7 random data generator in ECO-plug SFP
Note: linear frequency scale



Attenuated signal after 720m cable
RG11 type: TKF Coax 6. (56dBuV at 124MHz)
Signal at 125MHz is attenuated by 30.8dB
Note: all plots 5dB/div vertical



Ref plot. (86dBuV at 124MHz)
Same signal as above but other start stop limits, showing 2MHz interval of the PRBS7 signal.



Same signal as above but other start stop limits and 57dBuV ref level, showing Attenuated signal after 720m cable (56dBuV at 124MHz)

The maximum attenuation limit is 30dB of cable loss at 125MHz.
For Railway Environments a limit of 24dB and proper grounding applies (see Railway page 8).

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CE regulations

For CE regulations the camera must comply with the EMC directive and the low voltage directive (safety). The low voltage directive (LVD) is only applicable for working voltages above 50VAC or 75VDC. In case of the ECO-plug Ethernet over Coax SFP, only the EMC directive applies. The ECO-plug SFP module is tested in a Sigura BC620WDR camera.

EMC directive

The ECO-plug is designed to be used in an industrial or railway environment. These environments have higher noise levels. These EMC standards apply:

Applicable EMC standards

FCC 47 CFR 15	Class B, radiated emission only.
EN 61000-6-3	Generic, emission, residential.
EN 55022	Class B, emission, residential.
EN 61000-6-2	Generic, immunity, industrial.
EN 50121-3-2 :2006	Railway, EMC Rolling stock – apparatus.
EN 50121-4 :2006	Railway, EMC of the signaling and telecom apparatus.

Railway Environments

In a railway environment the ambient Electro Magnetic noise levels can be high. (refer to the applicable EMC standards for details). The ECO-plug is designed to operate in this environment. However, some measures, such as grounding of the coax and ferrites on the adapter cable, need to be taken for optimal performance. Additionally an extra margin of 6dB for the cable loss must be taken into account. This means that for Railway and other noisy EMC environments a maximum of 24dB of cable attenuation is allowed. This corresponds with the lower end of the distance range in the Coax cable compatibility table on page 4.

Rationale

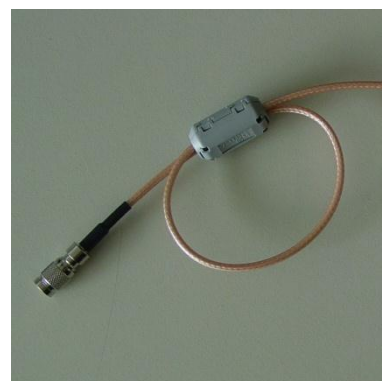
A long cable run, especially when it is laid in parallel to railway tracks, may pick up noise currents. These noise currents will flow in the shield of the cable and must be separated from the communication signal travelling through that cable. In case the cable is grounded at both ends, the noise current is deviated from the sensitive electronics. An additional ferrite on the cable will act as a common mode filter and will suppress high frequency noise.

Use of the patch panel

Grounding of the coax shield at both ends of the coax cable is mandatory for railway EMC levels. This could be achieved by a grounded 'patch panel' or a ground strap as shown in the list of accessories on the first page. This grounded patch panel is typically the joint between the existing field coax cable and the 40cm to 2m adapter cable. This joint must be firmly grounded and connected to the metal of the outdoor housing or installation rack.

Use of the ferrite

Additional to the grounding of the coax, cable clamp type ferrites should be used on the adapter cable. The flexible coax of the adapter cable should make an extra turn in the ferrite for extra attenuation. See picture. This ferrite will effectively block very high frequency noise currents picked up in the noisy environment. The ferrite, by its nature, will pass the communication signal on the cable.



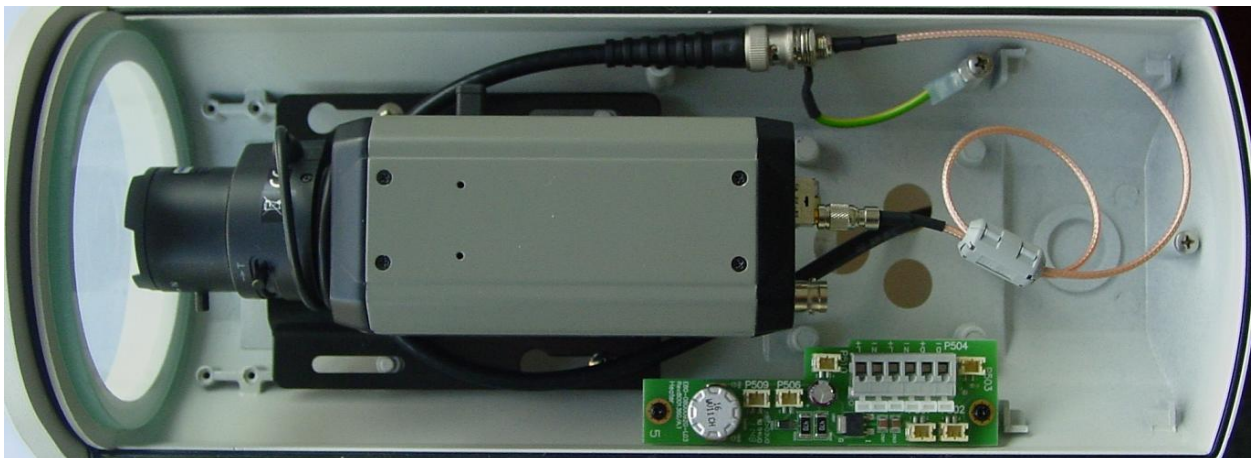
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Use of the ground strap

The ground strap (see green/yellow wire) is used to ground the joint between the existing field coax cable (black) and the 40cm (pinkish brown) adapter cable. This joint is firmly grounded by connection to the metal of the outdoor housing. Make sure that the outdoor housing is also grounded, preferably by a grounded construction.



Pictures of BC620WDR camera plus ECO-plug in an outdoor housing. Note that the ferrite is located close to the ECO-plug in the camera.

