RFcreations
...a different perspective

morephE.
etherstore

Record and playback over 3 hours of the entire 2.4GHz ISM band. Replay any section of the entire recording at your convenience. With dual control options, either via a GUI or a comprehensive Python library it will become your default reference RF test environment generator. Due to the moreph SDR at the core you can upgrade morephE to also be a RF- PHY Layer Tester, a blueSPY Protocol Analyser, or both at any time!

KEY FEATURES:

CREATE REFERENCE RF ENVIROMENTS:

- Record cluttered RF environments and reproduce in lab.
- Real world environment testing i.e.: airports and railway stations.
- Reproducible interference scenarios.
- Interoperability testing.
- 3 hours and 40 minutes of storage.

TEST SCENARIOS FOR BT DEVICES:

- Defined level of interfering signal.
- Playback multiple BT/WIFI signal simultaneously.

ADVANCED CAPABILITIES

- Replay generated waveforms (matlab) vector signal generator
- Record and transfer to host computer and analyser in any package.
- AUTONOMOUS mode – Execute test scenarios independently of any host.

UPGRADABLE WITH APPLICATIONS

- LE, BR/EDR, 802.15.4 and Qualcomm QBHSL RF-PHY Test applications.
- Channel Sounding RF- PHY Test.
- WiFi Traffic Generator.
- blueSPY Protocol Analyser (Sniffer).

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OVERVIEW:

morephE is a RF record and playback option for the moreph30 hardware platform. The morephE hardware and the Etherstore application are capable of recording and playing back the entire 2.4GHz ISM band. The recorded data is stored within the morephE hardware and has a maximum duration of 3hours and 40 minutes. morephE may be operated either standalone or attached to a controlling host platform via USB or Ethernet. It can also playback RF recorded files or user downloaded waveforms.

The Etherstore application can analyse captured files to provide, but is not limited to the following:

- Generate a score indicating how challenging the environment is for Bluetooth devices to operate in.
- Generate a clear channel assessment for Bluetooth devices.
- Generate a clear channel assessment for WiFi devices.
- Analyse the energy within the band to determine the likely source of that energy.

TECHNICAL SPECIFICATION:

RECORD	
Record frequency range	2395MHz to 2485MHz
Record instantaneous bandwidth	90MHz
Noise figure	6dB typ
IP3 @ max sensitivity	+7dBm typ
SNR in 1MHz bandwidth	80dB typ
Maximum input signal	27dBm
Maximum usable signal	-10dBm typ

PLAYBACK	
Playback frequency range	2395MHz to 2485MHz
Playback instantaneous bandwidth	90MHz
IP3 @ max output	+30dBm typ
Maximum peak output	>0dBm

CAPACITY	
Maximum record/playback duration	3.4 hours approx

RF INPUT/OUTPUT	
Connector type	SMA
Impedance	50Ω
Coupling	AC
Maximum DC voltage	50V

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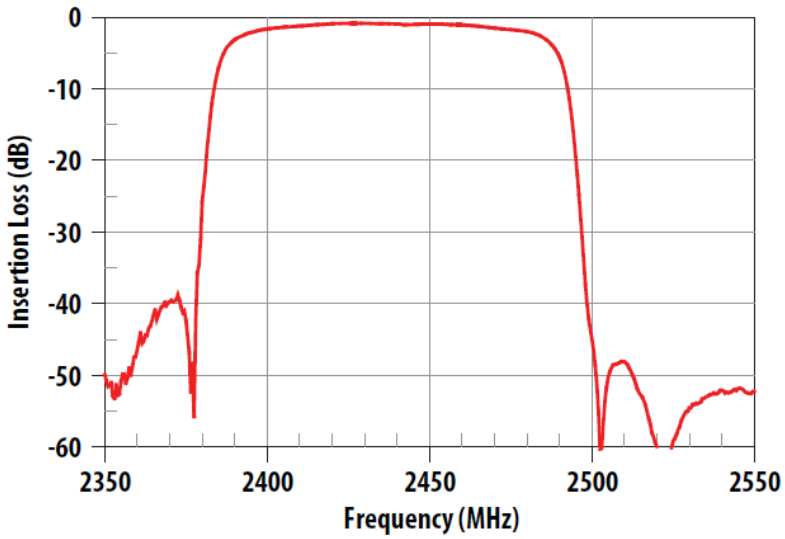
POWER	
Connector type	2.5mm jack
Input voltage	12V DC
Power	10W typ
Reverse polarity protection	Yes
Over voltage protection	Yes
Under voltage protection	Yes

GENERAL	
Supported hosts	Windows 7 or higher Linux on request macOS on request
Regulatory approvals	CE, EN55032, EN61326, FCC

RECORD HARDWARE:

The morephE contains a high-performance receiver specifically tailored for the 2.4GHz ISM band. For example, the front-end contains two high performance F-BAR filters to protect the receiver front-end from nearby cellular and similar transmissions (see graph below). By developing only for the 2.4GHz ISM band, the morephE receiver dramatically out-performs general purpose data recording systems.

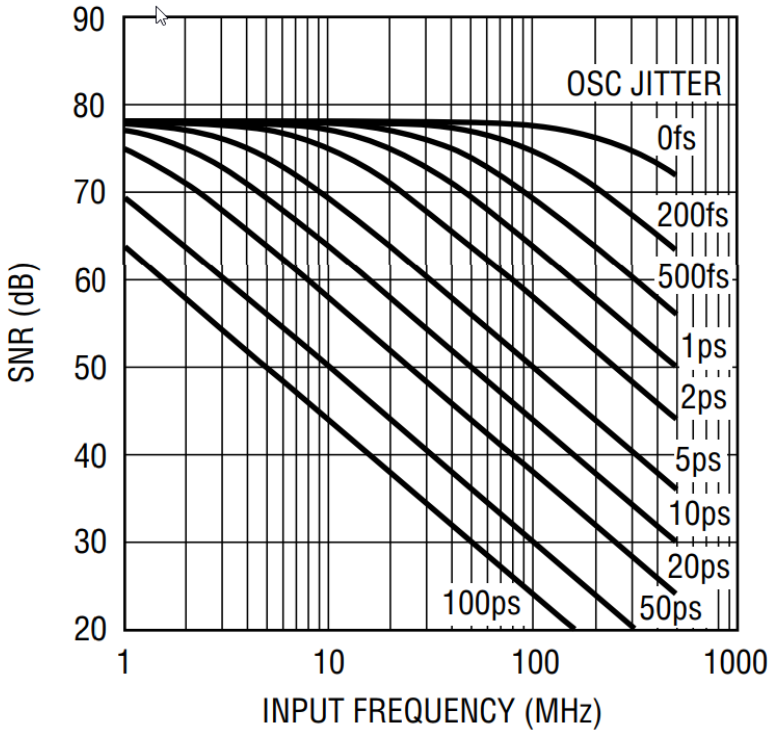


A particularly important receiver parameter is the IP3 figure. This determines the levels of spurious products created by the non-linear mixing of loud signals. For example, two loud Bluetooth signals can mix together to generate a third signal.

Of particular concern are loud WiFi signals which can mix to generate wideband noise, effective increasing the noise floor of the receiver. The morephE receiver has been specifically designed to maximise the IP3 figure and achieves an IP3 of +7dBm at maximum sensitivity.

The receiver architecture consists of a single mix to a 150MHz IF frequency which is digitised directly. This avoids the image and DC offset issues associated with many software defined radios.

The IF is digited by a 12bit ADC. According to the ADC specification, this should be capable of achieving an SNR of 69dB at 150MHz. The effective number of bits at 150MHz is quoted as 11.2. There are ADCs available with far larger numbers of bits. However, these extra bits contain no additional information when digitising a signal at 150MHz. The quoted dynamic ranges of the devices with more bits are no greater than that of the 12bit ADC employed in the morephE. Part of the reason for this is the impact of clock jitter on SNR. The graph below shows how the jitter on the ADC clock impacts the SNR which can be achieved. This graph indicates that a clock jitter of 200fs or less is required if it is not to dominate the ADC performance (the ADC is clocked at 200MHz). Such low levels of jitter are difficult to achieve. The morephE incorporates TI PLLatinum range clock cleaner chip which uses two PLLs to minimise the clock jitter. Thus, although other data collection systems may specify a greater number of bits in the ADC, these bits contain no additional information and merely add to the storage requirements.



The output of the ADC is passed via an FPGA into DRAM which forms part of a dual-core ARM processor system running Linux. From the DRAM, it is transferred by block writes directly to an SSD without intervention of the Linux kernel. This permits transfer rates in excess of 1GB/s to be achieved. The SSD has a storage capacity of approximately 2TB, permitting up to 3hrs and 40mins of recordings to be stored.

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PLAYBACK HARDWARE:

During playback, data is transferred to the DRAM using block reads without intervention from the Linux kernel. The FPGA pulls data from the DRAM and applies equalisers for the receiver and transmitter analogue passbands. The data is then passed to a 16bit DAC clocked at 800MHz. As with the receive hardware, great care is taken to obtaining an extremely low jitter clock to drive the DAC. The output of the DAC is at an IF of 150MHz, which is then mixed to 2.4GHz. The final signal is cleaned up using an identical F-BAR filter to the receive chain.

As with the receiver, a key parameter of the transmit chain is its linearity, as indicated by the IP3 figure. Insufficient IP3 will lead to mixing between the different components of the transmitted signal, effectively increasing the noise floor and generating spurious products. The morephE transmitter achieves a remarkable IP3 of +30dBm at maximum output.

The peak output of the morephE transmitter is limited to just over 0dBm. The reason for this, and the means of adding additional external amplification, are discussed later in the document.

AUTONOMOUS OPERATION:

The morephE can also run without the need for a host to be connected. The application plus the control script must be copied onto a USB memory stick. The memory stick is then attached to the morephE USB connector prior to the unit being powered on. When the unit powers up, the Etherstore application will launch and read in the control script. The script may direct the Etherstore application to either playback an existing file or start a new recording.

CONTROL AND GUI:

The GUI permits the recording of data to be started and stopped. The length of recording can be specified prior to the start of recording, or it can be terminated manually, or when the storage capacity is full. Prior to recording data, the receiver frontend attenuation can either be automatically or manually adjusted so that the dynamic range of the receiver is matched to the environment which is to be recorded.

Recorded files are held on an internal 2TB SSD. Multiple files can be stored. Individual files can be deleted. Recording can only take place to contiguous sections of the SSD. A facility is provided to defragment the SSD to maximise the contiguous space prior to starting a new recording.

Recorded files can be transferred to a host via either USB or Ethernet. Due to the potential size of the recorded data files, transfer times can be long. When transferring data via USB, data is transferred at 3x real time. When transferring data via Ethernet, data is transferred at 6x real time. The transferred files can either be raw data or can be equalised to compensate for the receiver analogue passband.

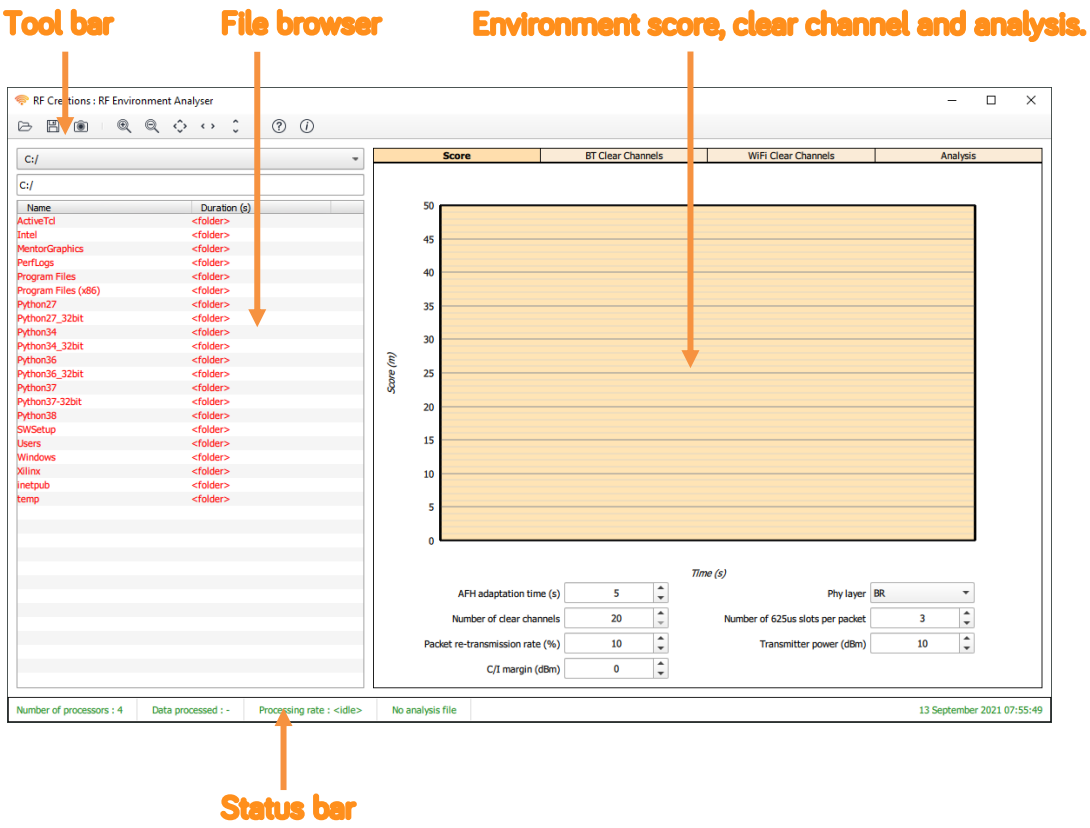
The GUI permits a particular file to be selected from the internal SSD and played back. It is possible to play back just a section of a file by specifying a start time and duration.

The selected section can also be looped, with the EtherStore application automatically removing discontinuities between the end and start of the section. By default, the data will be played back at the same level as it was recorded. However, the GUI also permits play back at other levels. The peak output power of the Moreph30 is limited to just over 0dBm. Files can also be downloaded from the host to the morephE. These may either be files previously recorded by the morephE or scenarios which a user has generated.

GUI EXAMPLES

See the morephE User Guide for further information with respect to the GUI and application capabilities.

GENERAL LAYOUT



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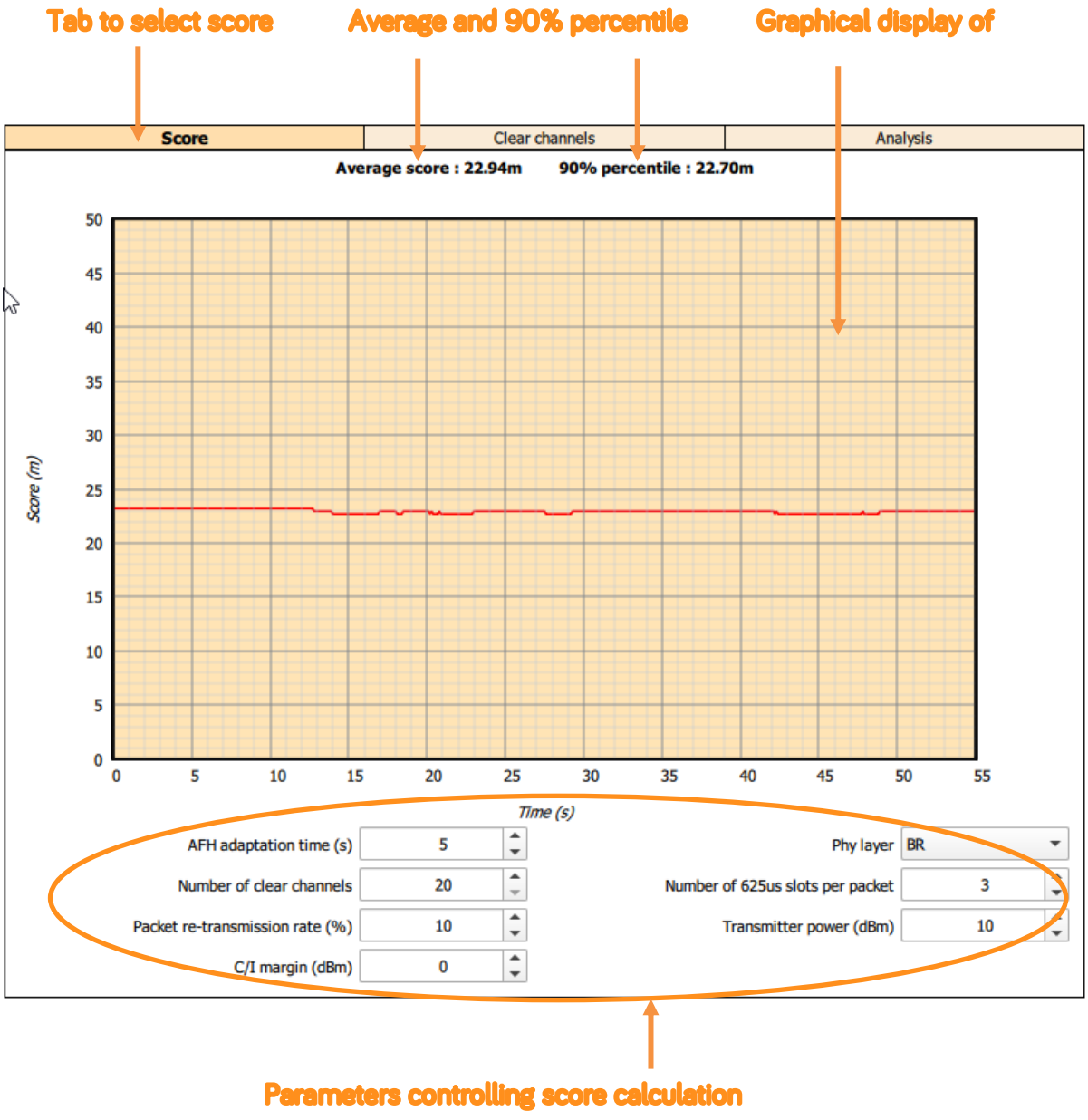
SCORE TAB

The score tab provides details of how difficult it is for a Bluetooth device to operate in the RF environment. The RF environment may be a capture file which is currently being processed or an analysis file which has been loaded into the Etherstore Application. The score tab also permits some of the parameters which control the score algorithm to be customised, for example, whether LE or classic Bluetooth should be considered.



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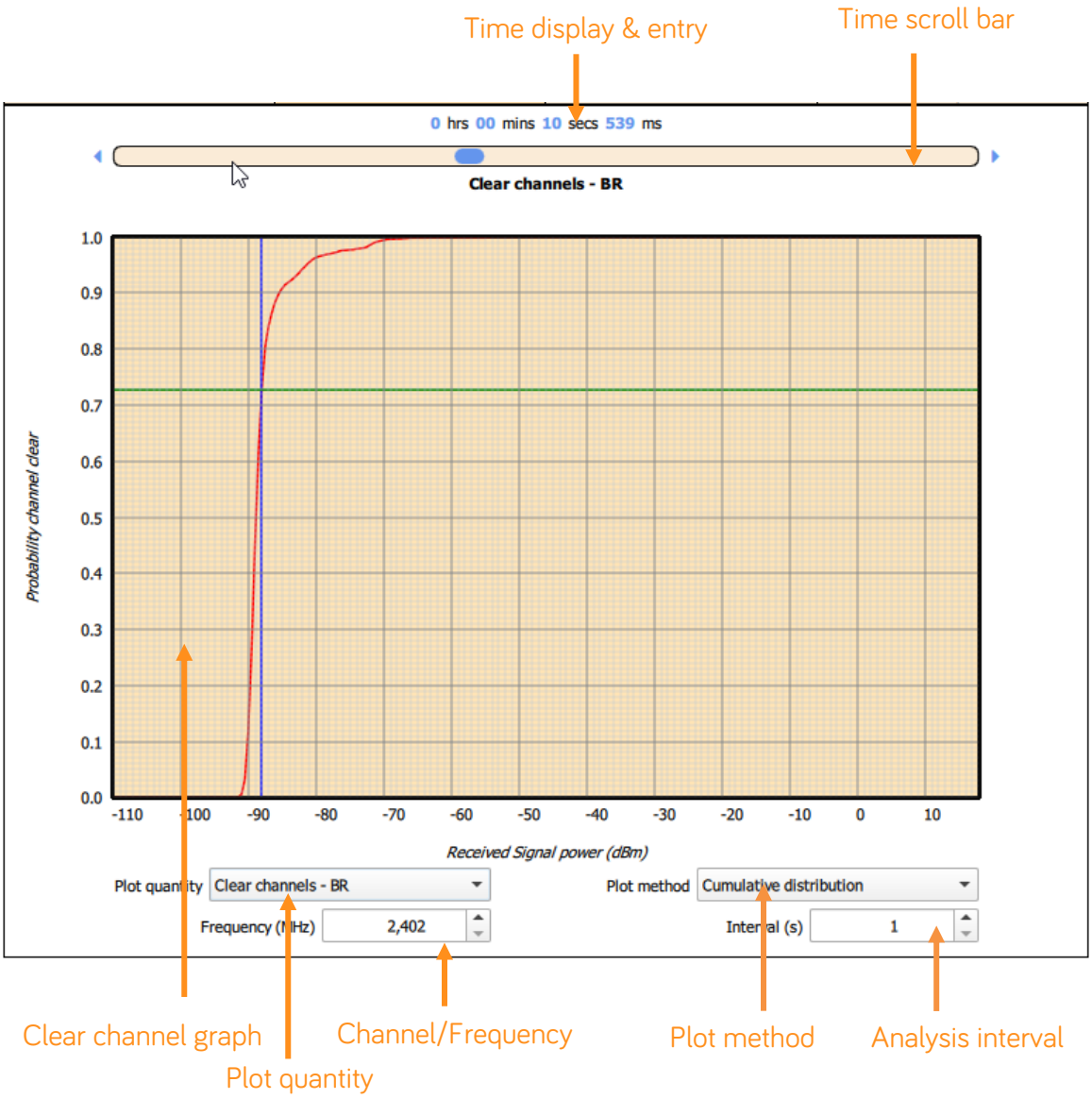
BT CLEAR CHANNELS TAB

The BT Clear Channels tab can be used to examine the likelihood of a particular channel being available for Bluetooth reception. The calculation is performed over a configurable interval of the recorded data.

To determine whether a channel is clear at a particular time, the energy across all channels is examined. This is combined with the C/I characteristics of the receiving device to determine the minimum required signal level for Bluetooth reception.



OUTPUT POWER:

The maximum peak RF output of the morephE is 0dBm. The reason for this restriction is due to intermodulation requirements. When multiple signals are being generated, intermodulation products between them can arise. The morephE has been specifically designed to minimise the level of these spurious signals. It is this feature which permits the morephE to generate both the weak and the strong interfering signals simultaneously with maximum fidelity.

It becomes more challenging to control the spurious signals as the output power increases. Hence the moreph30 E output power has been capped at around 0dBm. In some applications additional amplification may be required. When selecting an external amplifier, it is important that it has a high IP3 figure, otherwise the individual signals generated by the EtherStore application will mix together generating unwanted spurious signals. A 30dBm external amplifier is included in the box.

Another suitable external amplifier is the MiniCircuits ZHL-30W-262, which has a 1dB compression point of +43dBm, an IP3 of 51dB and a gain of 50dB. When using this amplifier, the output should be significantly backed off from the 1dB compression point. https://ww2.minicircuits.com/pdfs/ZHL-30W-262+.pdf

WHAT'S IN THE BOX

1 morephE Test Instrument.
1 soft dust bag.
1 USB-A to USB-C cable, grey, 1m
1 Antenna, black
1 12V PSU
1 30dBm External Amplifier (not pictured)

If an additional blueSPY PRO option has been purchased.

1 Logic Probe Pod
1 Hirose to Hirose cable, black, 300mm
1 Logic Cable, MK18
1 Set of EZ Clips (16 grey, 1 red & 1 black)
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