KC908英文手册

1. Introduction

KC908 is a versatile radio frequency testing equipment, it is capable of measuring radio frequency spectrum and field strength as well as demodulating and monitoring common signals. As for uncommon signals, KC908 can record the raw IQ signal and save them for later analysis. When it comes to output, KC908 can produce all kinds of signals to enable experiments as well as to carry out the maintenance of other devices.

The essence of the receiver resembles daily life radio's, that is amplifying and processing signals at a specific frequency, then extract useful information from it. While radio only cares about the voice in the signals, the testing equipment also needs to care about all other technical parameters of the signals.

As a reconnaissance equipment, KC908 is capable of sweeping swiftly and discovering signals. Being different from traditional sweeping spectrum analyzer, KC908 obtains spectrums of certian width using FFT and then splice them together to acquire a panorama. In this manner, KC908 reaches a speed of 3GHz bandwidth per-second with a 5kHz precision, which is equivalent to 120,000 25kHz channels. We're proud of such a decent performance on a micro-size hand-held equipment.

What's more, this speed is still far below the theoretical upper limit, and the main reason is that both tuning and data processing would take time. As a matter of fact, a measurement with FFT at 5kHz precision would take only 0.1ms, no matter how large the frequency range is, theoretically. Practically speaking, the speed can approach this theoretical limit within the real-time bandwidth. Being limited by its hand-held tier volume and power, the real-time bandwidth is not that wide, so KC908 needs splicing if the tested frequency range is wider than the real-time bandwidth. Thus, it takes time to lock and tuning, which are much slower than FFT.

KC908 comes with a built-in signal source whose range equals to the receiver's. (6GHz upper limit for KC908W). This signal source supports outputing constant amplitude signals as well as simple modulated signals, also it's capable of outputing relatively complicated digitally-modulated signals after connecting to GNURadio. The amplitude of the output signal can be adjusted within a wide range, for most frequencies it reaches more than 10dBm and attenuates below -70dBm. In reconnaissance scenario, this function can be used to perform an on-field validation for other reconnaissance instruments and direction finders.

KC908 is based on SDR theory. Different from other SDR receivers, KC908 integrates complete digital signal processor and user interface, so there is no need to depend on a computer. KC908 supports SDR software like HDSDR and is able to connect to GNURadio for further analysis.

1.1 Theory

To lower complexity, KC908 adopts a method consists of superheterodyne and zero IF to process signals. For frequency ranges that are within the optimal efficiency range of zero IF, zero IF would be used directly. Otherwise, the signals would firstly be shifted to certain frequency utilising mixing, and then be processed by zero IF transceiver.

The so called ”zero IF” technology, by its definition, adopts zero intermediate frequency. Yet, it’s still a heterodyne receiver/transmitter with components like local oscillators and mixers. For receiver, the signal is first shifted to certain intermediate frequency and then processed progressive. However, for transmitter, this process is reversed, which means the intermediate frequency is coverted to RF by the mixer. The point is this intermediate frequency is zero, which is why it’s also referred to as DC.

For instance, to receive a signal at 878.5MHz, the local oscillation needs to be set as 878.5MHz as well. After processed by the mixer, the output would be DC. Any signal carrying information comes with a bandwidth, thus it cannot be a pure 878.5MHz. Those signals that slightly deviate from 878.5MHz would be transferred to AC signals with lower frequency. These AC signals would be mixed up with the mentioned DC signals, and together they are referred to as the base-band signals.

It’s not hard to discover that since IF is zero, signals on either side of 878.5MHz would definitely become negative frequency. Energy inside this negative part would not vanish, but actually has been mixed inside the postive side of the frequency(it would be helpful to swap signal and local oscillation for better understanding), and the energy is indistinguishable. Take 878.4MHz and 878.6MHz as an example, mix them with 878.5MHz LO and we get 0.1MHz. In real-world scenarios, it’s common to use two mixers and two LOs simultaneously, and the phase difference is set to be 90 degrees. In this manner, two ways of IF signals with a phase displacement of 90 degrees, which is called the IQ signal, are generated. Although the positive and the negative frequency part of both I and Q are mixed together, the mixed parts’ phases are reversed and can be cancelled. Thus, is’ possible to distinguish the positive part from negative part. The extent of this distinction is called image rejection. To describe definitively, it’s necessary to introduce the math formulas, which is beyond this manual.

Through sampling the mentioned signal, digital IQ signal is obtained. As for KC908, the bandwidth of digital IQ signal is 40MHz-45MHz, spectrum result can be obtained by FFT. The center of this kind of spectrum is DC, while the negative and positive frequency distribute themselves on both sides respectively. Because baseband is generated by an analog mixer, local oscillation leakage can not meet the high requirement for spectrum analysis. In order to solve this problem, the instrument discards a sideband and poor performance part of the FFT result and only takes 15MHz width to display, and that is the origin of effective real-time bandwidth (15MHz). If the sweep span is wider than the effective real-time bandwidth, the LO scans the whole sweep width with 15MHz intervals and splices the results.

The ranges of zero IF receivers differ among different models of KC908. For KC908A, 0.75GHz-6GHz. For KC908U/V/W, 500MHz-6GHz.

Due to the wide frequency coverage, in order to avoid the receiver’s overload caused by the total energy of external signals and improve the anti-interference performance, there are several pre-selectors in the front end of KC908. The pre-selector segmentation methods of the two ports (if they are both capable of receiving like KC908A/B) are different, and the anti-interference performance of the two ports in different frequency bands will vary. Normally it’s advised to use the right port (Port 2). The specific technique will be described later. Although a large proportion of RF circuits’ size is preselectors, they can only perform rather preliminary filtering due to the limited size of the instrument. Therefore, if it is used in complex interference environment, additional external filters should be used.

The processing procedure of zero IF transmitter function (signal source function) is the reversed version of the receiver's. The digital circuit of the instrument produces the digital IQ signals, which would be translated to analogical baseband signals through DAC. These analogical baseband signals would be radio frequency modulated with up-converter. The frequency range of zero IF transmitter is 1GHz-6GHz (1Ghz-4.2GHz for KC908U). If user desires to output signals outside this range, signals would be shifted by mixing.

Digital signal processing is implemented by FPGA and MCU. While demodulating the signal, FPGA converts the digital IQ signal again for strict filtering. The demodulation bandwidth of KC908 is from 150Hz to 300kHz, which is suitable for most private network signals analysis. If wider demodulation bandwidth is needed, USB3.0 can be used to transmit the original digital IQ signal to the computer, and the third-party software (such as GNUradio) can be used for processing. The bandwidth of IQ signal can reach up to 40MHz.

Since the spectrum is generated by splicing FFT results, the display effect, as well as certain concepts, would definitely differ greatly from conventional sweeping spectrometers. RBW, resolution bandwidth, for example, no longer means the bandwidth of resolution filter. Instead, it means the equivalent resolution bandwidth of the windowed FFT result. Limited by the computing power, RBW can only be set within a certain range under a certain sweeping bandwidth. As for time-varying signals that are larger than the real-time bandwidth, the amplitude on the splicing point could possibly leap due to the fact that those two sides of the splicing point are sampled at different moments.

What's more, the shape of the signals could be quite different from those in the conventional sweeping spectrometer. Take the spectrums of modulated signals as an instance, what KC908 displays is the peak value (or average value, according to the setting), without the "illusion", which is caused by the concept of sweeping from left to right, that at any moment only one frequency can be swept. For this reason, the experience of analysing signals on a traditional spectrometer, which is mostly abstracted from those "illusions", may not work anymore.

From another persepective, real-time spectrometer does not necessarily represent the "truth". The fact is there is a limit for the time resolution. In other words, even there is some sort of machine that are capable of achieving 10k FFT/s, no monitor can match this speed, let alone human eyes to catch up with that monitor. It's believed that no matter what amount of data is to be dealt with, there will always be some kind of method to abstract the essence in it and present those essence within a budget of several dozens of data frames. This process is known as "detection". The detection mode setting is to set the rule to which the abstracting process is made according. Options are like extracting the peak value of each frequency point frame by frame, or averaging the results of all the frames. In this manner, the result shown on the display no longer represents the instantaneous situation of the signal, thus it's no longer the "truth".

As a matter of fact, the "truth" of a varying signal can only be described with a time domain waveform or a mathematical formula. Why? Because a decent frequency resolution requires a large amount of FFT sampling points (like, 2048) to achieve, and during the sampling and processing time, the original signal has probably changed. Yet, compared to the sweeping spectrometer, normally the real-time spectrometer is much closer to the "truth".

What's more, there is a limit for frequency resolution of displaying, as well. Each frame of FFT produces more than a thousand data points, and with splicing, these data points can even reach a magnitude of hundreds of thousands. Due to the fact that the maximum displaying capability of KC908's horizontal axis is 800 pixels, each pixel has to represent multiple frequencies. How to define "represent" is another major concern of detection. In KC908, the solution is displaying the peak value of all those frequencies a single pixel represents, to ensure **no signal is missed**, which is the basic principle a reconnaissance equipment should live up to. However, this method of presentation may make certain frequency/phase modulated signals look like stable signals. Thus, while analysing a single signal, it's advised to reduce frequency span and change the dectection method to "**Sample**" to mitigate this confusion.

1.2 Basic Functions

1. Spectrum analyzer
2. Receiver
3. Signal source

1.3 Useful Features

1. Better than 10kHz frequency measurement accuracy with any sweep span, a single measurement can get the accurate frequency.
2. Comfortable monitoring with multiple squelch mode
3. Automatically log strong signals for reconnaissance
4. Storing up to 999 channels
5. Analogical and digital intercom demodulation
6. Record IQ and audio to TF card
7. Level tone function for tracing on foot
8. Analogical demodulation with high volume audio for noisy environment

1.4 Applications

KC908 can be used as a traditional spectrum analyzer as well as hand-held spectrometer. It's also the ideal choice for digital, pulse or unstable signals(like magnetron output).

1. Professional communication engineering
2. IoT project
3. Interference searching
4. Concealed signal source searching
5. Electromagnetic radiation measurement
6. Radar and satellite station
7. Radio reconnaissance and monitoring
8. Spectrum resource occupancy analysis
9. Industrial microwave engineering
10. Electromagnetic environment evaluation

1.5 Demodulation Methods

(1) Analogical demodulation

CW(A1A), AM, LSB, USB, FM(PM), IQ

Analogical demodulation is a standard function, it can output analog audio as well as record WAV format files.

(2)Digital intercom demodulation

This function is an optional function, which comes either as components or as custom requirements.

Available components are:

Standard: DMR, D-star, YSF, P25, NXDN, etc.(MBE vocoder).

Optional: DMR, PDT, Tetra.

Note that DMR and Tetra are also standard components within civilian and business frequency band (136-174MHz, 410-470MHz).

The amount of supported prototols will increase as development proceeds.

Custom demand: Uncommon protocols or special vocoders needs to be custom-developed under the intellectual property authorization from the client. And the typical development cycle would be 3-6 months.

The support of digital demodulation is determined not only by protocols but also vocoders. To better illustrate, the chart below groups different vocoders. The support situations of vocoders in the same group are identical.

Vocoder Group	Vocoder Type
A	AMBE (2.4k, 2.45k, 4.4k, etc. Interlaced/Deinterlaced)
B	IMBE
C	SELP1.5, SELP1.7, SELP1.8
D	ST24, F100
E	ACELP

The chart below shows support detail, and symbols mean:

●Stand Support ○Civilian/Business Frequency Support

△Optional Support ◇Customizable Support ×Not Support

//Not Relevant

Digital System	Bandwidth	Mode	Modulation	Vocoder Groups and Support Detail				
				A	B	C	D	E
DMR	12.5k	Cluster	C4FM	○ △	//	△	◇	//
		Double Time Slot		○ △	//	△	◇	//
		Single Time Slot		○ △	//	△	◇	//
dPMR	6.25k		C4FM	●	//	△	◇	//
P25	6.25k	PHASE1	C4FM	//	●	//	//	//
	12.5k	PHASE2	QPSK	◇	//	×	×	//
NXDN	6.25k		C4FM	●	//	◇	◇	//

NXDN	12.5k		C4FM	◇	//	×	×	//
Tetra	25k	Cluster 4 Time Slot	¼πQPSK	//	//	//	//	○△
	25k	Offline 2,4 Time Slot	¼πQPSK	//	//	//	//	◇
	25k	Cluster	FMT	//	//	//	//	×
YSF	12.5k	V, D	C4FM	●	//	//	//	//
	12.5k	VFR	C4FM	●	//	//	//	//
PDT	12.5k	Cluster	C4FM	◇	//	△	◇	//
	12.5k	Offline	C4FM	◇	//	△	◇	//
D-STAR	12.5k	DV	GMSK	●	//	//	//	//

Part of those protocols not inclueded above, under customer's authorization and information provided, can be developed.

All encrypted modes are not supported or needs to be developed accordingly, KC908 series comes without decryption function.

1.6 Main Parameters (note 1)

The main design goal of KC908 is not absolute high performace, but sufficient performance with convenience, affordability and mobility at the sweet spot.

Item	Min value	Typical value	Max value	Note
Frequency range	100kHz		43.5GHz (note 2)	can be set to 0Hz
Spectrometer/Receiver (Port 2)				
Real time bandwidth	1kHz	Continuously Adjustable	15MHz	
Analysis bandwidth (Note3)	1Hz	Continuously Adjustable	2MHz	can be set to 8MHz
Demodulation bandwidth	150Hz	Continuously Adjustable	200kHz/ 300kHz	
Demodulation method	CW/AM/LSB/USB/FM/PM/IQ/YSF/ DSTAR			Digital demodulation comes as optional component
100% POI(note 4)			210us	When SPAN==15MHz
Level measurement range			+20dBm	
Level measurement uncertainty		1.5dB		
Noise floor		-120dBm		@12kHz BW, avg
Instrument noise coefficient		13dB		With max Gain@1GHz
Third input Intercept Point		-42dBm 46dBm		REF=-70dBm REF= 20dBm
First image suppression	50dB	70dB		
IQ image suppression		60dB		
Residual response (note 5)		-110dBm		Port N.C
		-90dBm		With whip antenna
Spurious response		-50dBc		
Signal Source (Port 1)				
Level range (note 6)	-80dBm		10dBm	1dB stepping
Level uncertainty		2dB		
Modulation method	AM/FM/PM			
General				
Battery life		4h		
Weight		908g		

Note:

1. This table just shows the parameters that are commonly concerned about, for detail please refer to the technical parameter table in the user manual.

2. Depends on the specific model the user bought. As for the details refer to the product overview.

3. The setable range of RBW is relevant to the real-time bandwidth it adopts, and RBW is determined by the instrument.

4. We define the intercept in POI as the accurate measurement, it's capable of discovering signals that are 1-2 magnitudes shorter.

5. KC908 will transmit EMI during the measurement. If the antenna is close to KC908 it will receive the EMI. This parameter is measured with a 0.2m whip antenna, 1m from the KC908, placed on the same side of KC908 in the microwave anechoic chamber.

6. Output level range varies among different version, different frequencies. For 18.6GHz version, it reaches 13dBm for all usable frequencies.

1.7 Differences between KC908 Models

There are 5 variants of KC908. Among them, KC908A and KC908B belong to the standard series, while KC908U, KC908V and KC908W belong to the disseminating series.

Every port on standard series is capable of transmiting and receiving, and it's possible to examine the amplitude difference / phase difference of the input signals in both ports. Signal source (port 1) can operate up to 10.8GHz or 18.6GHz, which is identical to port 2's frequecy range.

As for disseminating series, only one port for receiving and another for signal source outputing, and the output frequency is below 6GHz.

The left port (port 1) of KC908U and KC908V provides signal source ouput, and the right port (port 2) is used to receive. The frequency ranges of receiver and signal source function are identical. The left port of KC908W is used for signal source output as well, with a frequency range of 100kHz-6GHz.

Except sensitivity, other parameters are similar within same frequency band.

Within 3-6GHz, standard series's typical sensitivity is 3-10dB better than disseminating series's. As for frequency band below 3GHz, consider this superiority 2dB.

Model	Port 1 Func	Port 1 Freq Range	Port 2 Func	Port 2 Freq Range
KC908A	receiver/spectrometer	100kHz-6GHz	receiver/spectrometer	100kHz-10.8GHz
	signal source	100kHz-10.8GHz	signal source	80MHz-6GHz
KC908B	receiver/spectrometer	100kHz-6GHz	receiver/spectrometer	100kHz-18.6GHz
	signal source	100kHz-18.6GHz	signal source	80MHz-6GHz
KC908U	signal source only	100kHz-4.3GHz	receiver/spectrometer	100kHz-4.3GHz
KC908V	signal source only	100kHz-6GHz	receiver/spectrometer	100kHz-6GHz
KC908W	signal source only	100kHz-6GHz	receiver/spectrometer	100kHz-43.5GHz

As for KC908W, 32-43.5GHz frequency band is implemented by shifting the testing signal to 6-18.6GHz, and the upper limit is 50GHz. However, the segmentation above

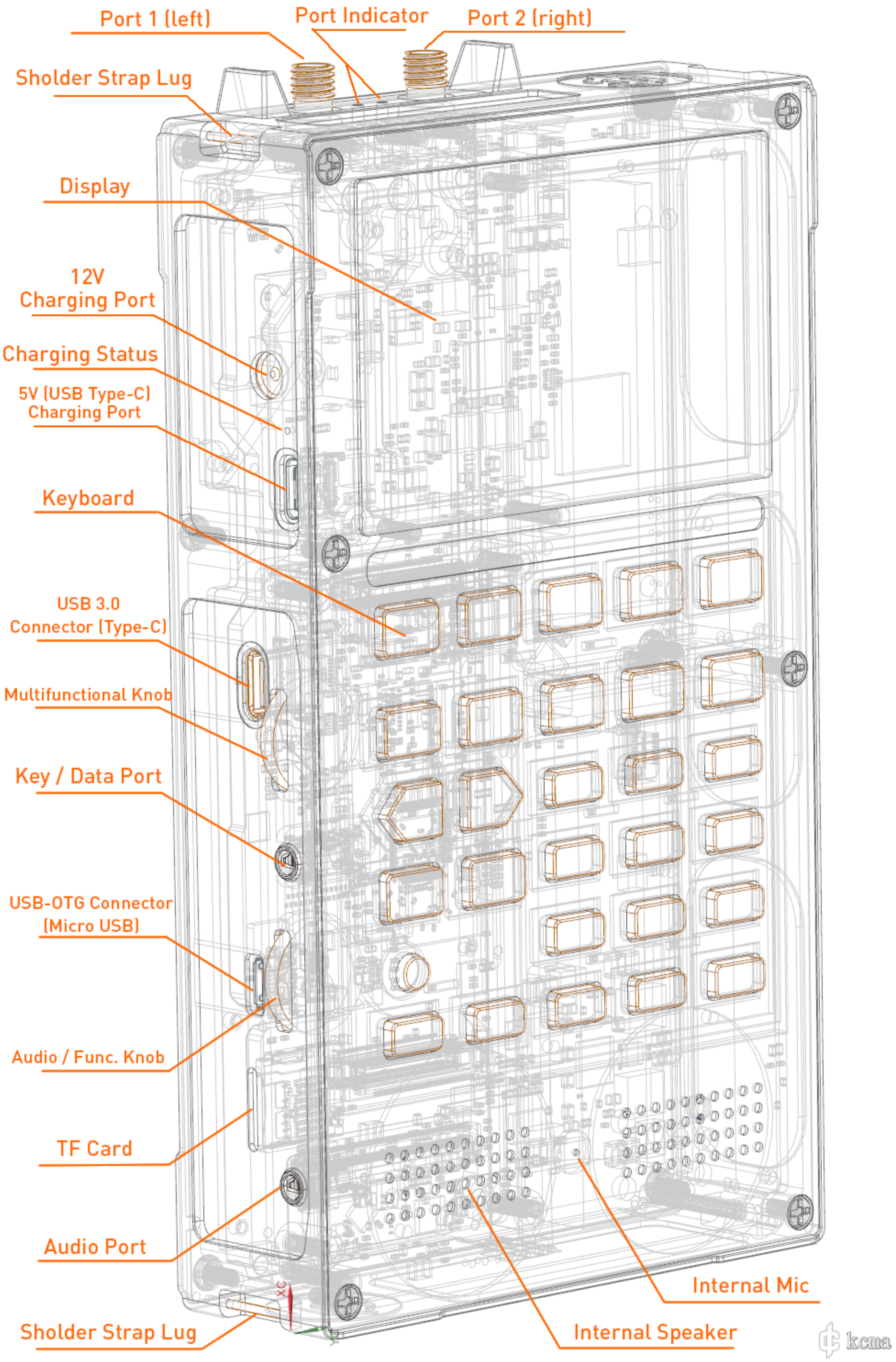
43.5GHz has not been calibrated, thus the sensitivity decreases rapidly. This segmentation is only advised to perform as a qualitative measurement when necessary.

Both KC908U and KC908V adopt negative SMA connector, while other models adopt compatible 2.92mm standard positive connector.

KC908U/V come with limiters, thus their ports are less vulnerable.

2.Description of instrument

This picture shows each part of KC908. The RF port is at the top of KC908. On the left part is mainly the data port and the knobs. Speaker and microphone are at the bottom of front panel. There is no other functional port o n other sides of the equipment.



2.1 Top panel

There are 2 RF ports on the top of KC908, left port is PORT1, right port is PORT2. The function of the port is labelled below the port. Two LEDs in the middle of two ports are used as indicators to show which port is selected.

For KC908A/B/W, both RF ports(adopt K type positive connector, also known as 2.92 connector) are compatible with SMA standard. For KC908U/V, since their frequency ranges are relatively low, negative SMA connectors are adopted.

Connectors are mounted on the PCB directly. The PCB, metal shell and metal cavity together support the RF ports. Shield of RF ports can withstand a 1Nm bending force for a prolonged period, yet the core pin is much weaker, which can only withstand a 1N force or 0.02Nm torque (deem the smaller one as the limit). And the max tightening torque is 0.7Nm, in actual test the user just need to tighten it slightly with finger.

Attention:

SMA connector is weak, user needs to use soft cable or antenna to connect. User should avoid dragging antenna or cable which is connected to KC908. Disconnect the antenna or cable when KC908 is not being used, to avoid accidental impact. User must use high quality and right size connectors and never rotate the SMA core pin when connect to KC908.

2.1.1 PORT 1 (Left Port)

Port 1 supports 100kHz – 4/6/10.8/18.6GHz range output, and KC908A/B support 100kHz – 6GHz input. The output comes with necessary filtering, and KC908B is equipped with a synchronous tuning filter for 6 – 18.6GHz. If the left port comes with a receiving function, only preliminary preselectors are equipped.

Port 1 is mainly used as an output port, it can output full range RF signals, and the amplitude is relatively large.

As for KC908B, the left port is also used to connect GPS antenna.

2.1.2 PORT 2 (Right Port)

Port 2 supports 100kHz – 4/6/10.8/18.6/43.5GHz input, KC908A/B support 80MHz – 6GHz output.

Port 2 is mainly used as a receiving port. It has 7 band preselectors, for KC908A, there are 6 bands below the 6GHz and the last band within 6–10.8GHz. As for KC908B, 7 bands below 6GHz and 6–18.6GHz adopts tracking preselector. For KC908W, tracking preselector is adopted in whole 6–33GHz range, and the range above 33GHz is another band.

The output RF signals from port 2 (if available) is relatively weaker. It can effectively suppress the FM broadcast interference.

Both ports have 30dB attenuator(10dB step) and 40dB variable gain preamplifier(20dB step). The total gain of front end is 70dB, and the output/input signal strength can be adjusted precisely.

2.1.3 Port limitation

Both ports' max input power(average) in short time is 20dBm, above this level will damage the port.

It allows long time input level of 10dBm. But as for frequency under 100kHz, input power should be less than 0dBm to avoid low-probability damage.

For frequency above 10MHz and the attenuator set to more than 10dB, the peak power pulse input should be less than 30dBm and its pulse width needs to be narrower than 100us time.

Attention:

Although both ports have ESD protectors, due to the wide RF bandwidth and other reasons, the protection ability isn't very strong, which is meant for the prevention of human electrostatic shock under normal conditions. Avoid using or connecting to outdoor antenna in thunderstorm weather. When an external HF antenna is connected, it is necessary to be careful of the electrostatic hazards of the antenna. Before use, discharge the antenna. User should avoid using the antenna in windy weather. While using large size HF antenna, it is recommended to connect a high pass filter with DC grounding outside to protect the KC908. It is suggested that the suppression of frequency below 500KHz is better than 30dB.

Before connecting the circuit to be tested, user needs to contact the shield of the connector with KC908, to make sure the circuit's electric potential equals KC908's.

2.2 Left side panel

The KC908 has two charging ports, both of which can charge the instrument. There is a charging indicator LED between the two charging ports. After the charger is inserted, the indicator light shows red to indicate that it is charging. Red light means charging slowly, while blue light means charging rapidly. When it keeps green, it means that it is charged completely; when the LED flashes quickly, it means that the charging fails, so it is necessary to check the applicability of the charger.

2.2.1 12V charging port

The charging port supports 9–26v charging voltage, and the recommended voltage is 12V. It can be directly connected to 12V, 13.8V or 24V automobile batteries. The maximum charging current of 12V charging port can reach 2A (the current can reach 2.5A while it's charged and turned on at the same time), which can fully charge KC908 in about 3 hours.

For continuous measurement, 12V charging port should be used for power supply, and the voltage should be 12~18V. KC908 is generally not recommended for continuous operation all year round. If the measurement is more than 30 days, the battery shall be removed. After removing the battery, the external power supply must be robust enough to support the large current (5A) at startup.

2.2.2 USB charging port

In order to reduce the burden of carrying a charger, KC908 supports USB charging, user can use ordinary mobile phone charger and "power bank" to charge. USB charging port uses type–C connector, which supports most quick charging protocols. The maximum charging voltage can reach 20V, and the limit current is 3A. The charging current can be adjusted automatically according to the voltage drop rate of the charger, so as to support most mobile phone chargers. If the charger's output capacity is insufficient, the charging current may be less than 500mA.

Charging time with USB charging is related to the charger. If the charger supports quick charging protocols (PD3.0, QC3.0, UFP), it may be 2 hours. If quick charging is not supported, it will take at least 7 hours. When charging with power turned on, the battery power will still be consumed, just the endurance time will be extended. When the battery is not installed, the USB charging port cannot support the instrument to power on. We can't guarantee the compatibility of all quick charging chargers.

No matter 12V or USB charging port is used, keep away from inflammable and explosive materials while charging, and a person shall keep an eye on it. When the ambient temperature is higher than 35° or the ventilation is poor, the battery can only be charged in the power off state.

2.2.3 USB 3.0 port

This port is only used to output the high speed IQ signal to host. The program manual shows the detail.

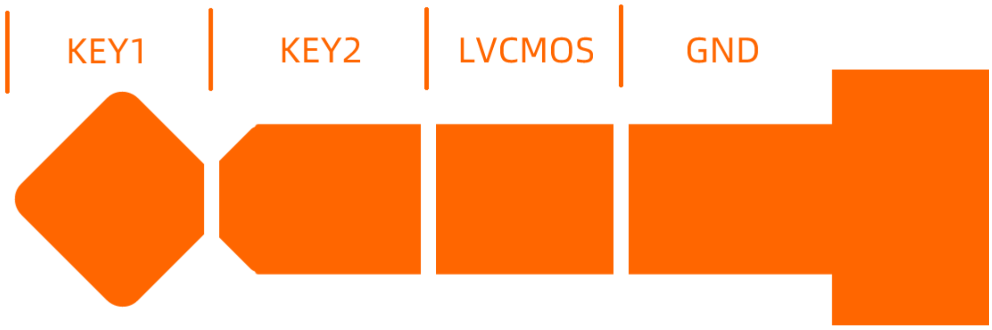
2.2.4 USB-OTG port

This is a USB 2.0 standard port that supports OTG, and it's mainly used to control dedicated accessories. It can also be converted to a ethernet port using USB/RJ45 converter. Please refer to the program manual for details.

This port supports 5V@500mA output. Avoid short-circuiting this output or pairing it with a load with a exceedingly large current.

2.2.5 KEY / TTL port

This 3.5mm port can be connected to telegraph key or automatic key to transmit operations. It can also output control signals to control specialized accessories like a T/R converter. This is the pin definition:



KEY1 and KEY2 are used to connect the telegraph key. While using a manual key it should connect to KEY1 and GND. To use an automatic key user should connect KEY1, KEY2 and GND. The driving voltage for key is usually 1.8V.

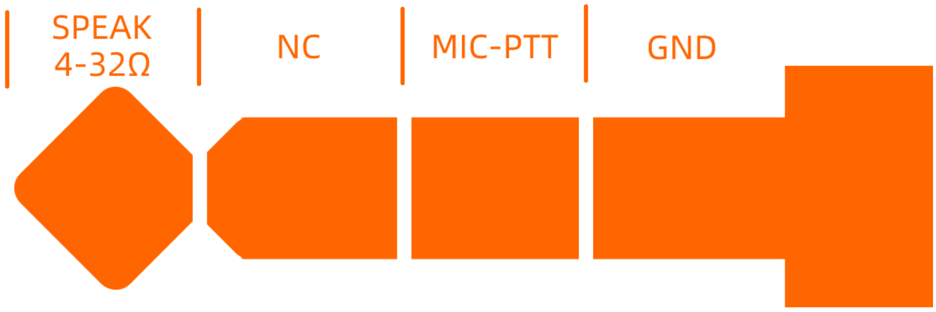
LVCMOS pin is used to output control signals. The high signal level is 3.3V with reference to GND.

This port does not support signal input, avoid inputting a high power signal or it may be damaged.

2.2.6 AUDIO port

This port is used to connect an external speaker or a speaker mic. The audio through this port is amplified. The max power at 4Ohm impedance can reach 1.5W. The impedance of the mic must be higher than 4Ohm. Early products only connect the last section of the plug to audio power amplifier output, while recent products have altered this design to connect the last two sections, to provide a stereo output. For this reason, the user **must pair it with a 4-section plug**. DO NOT short the second section to the ground.

Pin definition:



Those common hand speaker mic compliant to this pin definition can be used. When using normal Condenser or Dynamic microphone, Connect the microphone to MIC-PTT and GND then KC908 considered the PTT is pressed. The sensitivity of microphone is about 50mV. The speaker should be connected to the SPEAK and GND pin. When using headphone user should turn down the volume before plugging. In KC908's FUNC menu user can set turn off or not the built-in speakers after plugging in this port.

This port does not support other signal input, avoid inputing a high power signal or it may be damaged.

2.2.7 Knobs

KC908 has two knobs on the left side. The upside one is a multifunctional knob, in different menus it has different functions. Such as after RF/CF button has been pressed, this knob is used to switch the frequency. This knob can be pressed to confirm the input or move the marker.

The downside knob is used to control the audio function. Press the knob to activate the setting, in different setting conditions, it can be used to adjust volume, squelching, level tone volume as well the the central point of the level tone. Press the knob repeatedly to switch between currently effective audio settings.

2.2.8 TF card slot

KC908 support max 32GB TF card, which is used to save the measurement or firmware update. We suggest use high speed TF card if user needs to save the IQ data.

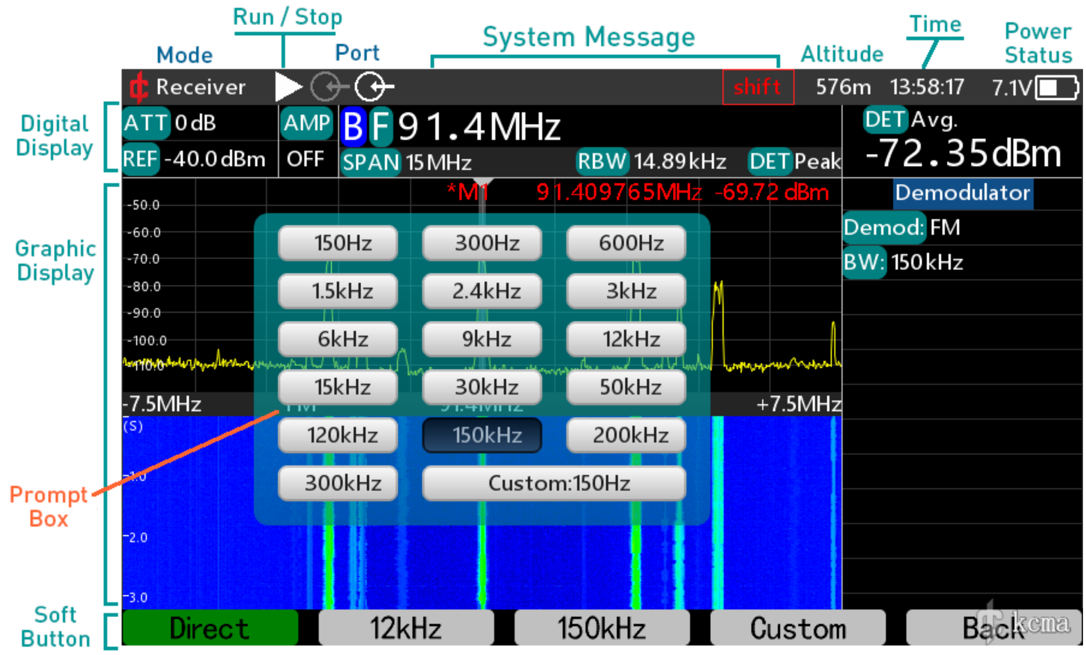
2.3 Front panel

Front panel is the main user interface of KC908, which includes LCD display, keyboard, speaker, knob, voice picker and headphone.

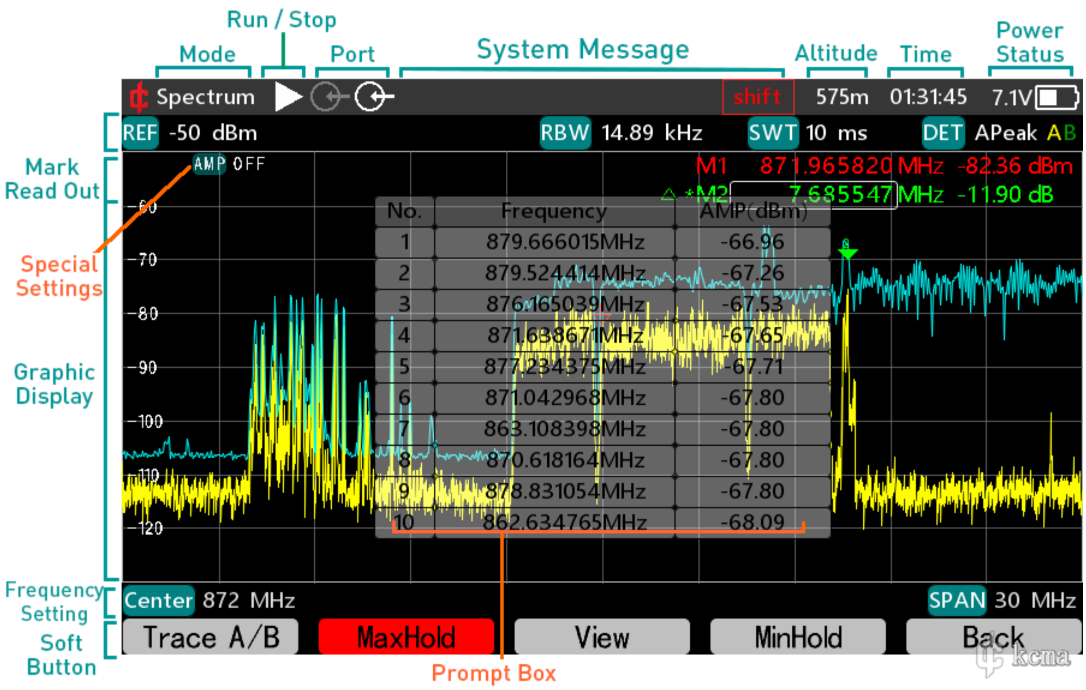
2.3.1 LCD display

KC908 has a 3.5 inch color LCD display, 800*480 resolution. It has backlight and can reflect few light so it can be used in direct sunlight. The display screen is protected by toughened glass, it is strong but avoiding impact would always help.

The display is divided into few areas, the following is the area of the receiver mode.



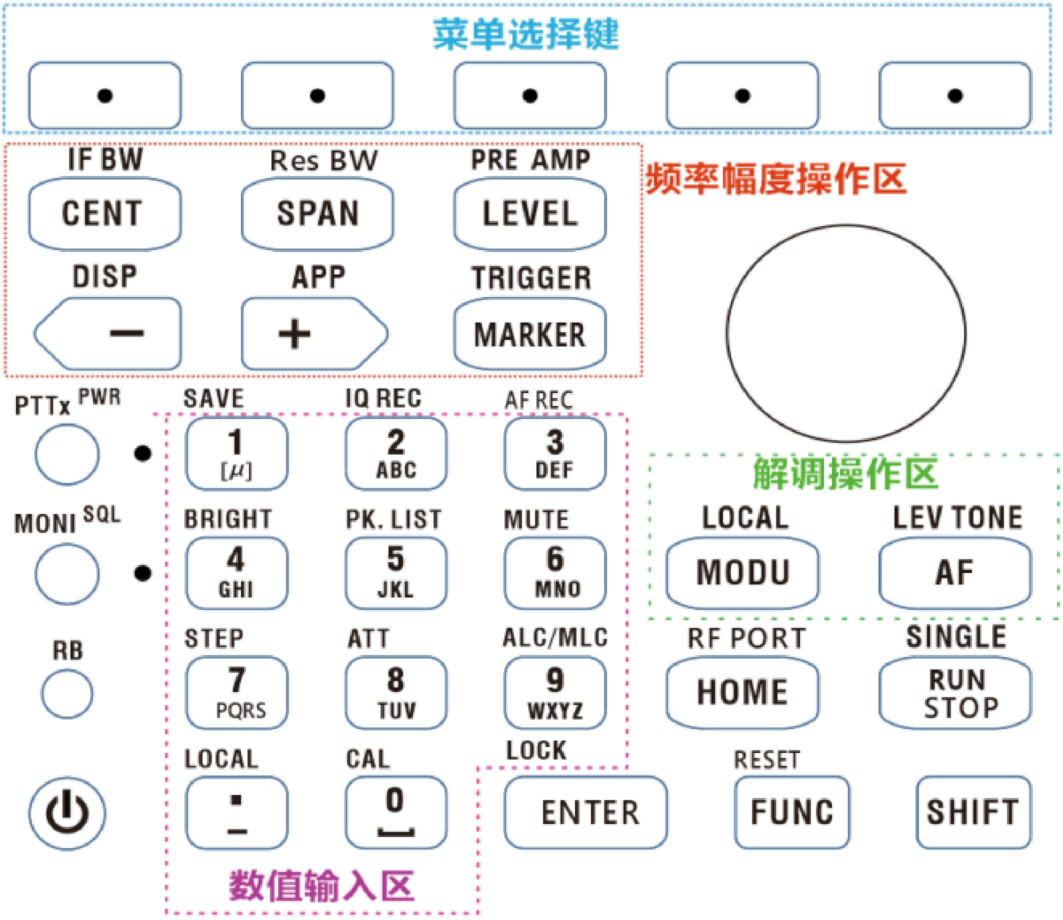
The styles of other mode are same. Following picture is the spectrum mode



There is no need to use a film screen protector. While cleaning the screen, first step is to wipe the sands off the glass, then use cleaning paper to wipe the screen. Avoid using alkaline detergent. If the screen is broken, user needs to send KC908 to our factory to repair.

2.3.2 Keyboard

The keyboard has three areas, those 5 keys on the top area are the soft key to operate the soft menu, and the function buttons are used to set and adjust the functions. The number buttons are used to input the value.



For quick operation, The common menu function set to the second layer key, press SHIFT key to access. Following is the first layer of keyboard:

CENT Set the central frequency

SPAN Set the horizontal scanning width

LEV setting the vertical level parameter(REF, gain)

MARK Enable marker

MODU receiver mode: setting the demodulation parameter

Spectrum mode: setting the MAKER

AF   receiver mode: setting parameter about audio

spectrum mode: setting the span parameter(same as span setting in RF/CF)

HOME Selecting functions, switching between function selection menu and current main page

RUN/STOP start and stop measurement. It will save power in stop situation

FUNC   system setting

PWR   power switch

SHIFT   press to access second layer keyboard(functions)

RB   Hard reboot, neither the current settings would be saved, nor the pass data would

be erased.

PTTx   Transmitting button to start signal source ouput.

MONI   Press and hold to disable all squelching temporarily, release to reenable

squelching.

The power button is designed to become active after pressing for 0.5 second. The "+", "–" buttons become active once is short pressed, if the "+", "–" is held more than 0.5s, it will repeat the action. Other button just act once when pressed.

For those functions that are commonly used yet hidden in depth inside the menu. For the sake of a clear logic, we've prepared shortcuts for them. To use shortcuts, user needs to press SHIFT key first, and after there is a red "SHIFT" on the upper right part of the screen, user can access the functions with the corresponding keys.

Following is the second layer button functions:

IF BW call the IF bandwidth setting menu
Res BW call resolution bandwidth setting menu
PRE AMP Switch the gain of preamplifier
DISP Turn on/off the screen. The keyboard, except DISP button, becomes locked
when screen is turned off.
APP call out practical tools menu.
Trigger call out triggering menu in the current mode
SAVE save the screen shoot, in some mode will save the data same time.
IQ REC record the IQ signal, only works in receiver mode. Record bandwidth
is relevant to demodulation bandwidth.
AF REC record the audio, only works in receiver mode and demodulation turned on.
BRIGHT set the screen brightness
PK.LIST Turn on the peak list function(in spectrum mode)
MUTE mute the demodulation audio
STEP call the frequency step setting menu
ATT Adjusting attenuator, press repeatedly to switch between common
attenuation values
ALC/MLC Switch receiver mode between gain following REF or following external
input.(That is, auto gain)
./LOCAL Turn on/off frequency segmentation.
CAL Calibration, effective in those modes allowing user to calibrate.
LOCK Lock/unlock keyboard, knobs(effective ranges vary depending on setting)
Local Call out demodulation setting menu
PORT Switch RF port swiftly
SINGLE Pause, press RUN/STOP key to launch once
RESET Reset to default settings, but not erasing stored channels.
PWR Adjust transmitting power(only works with certain accessories)
SQL Swiftly switching squelcher on/off.

2.4 Battery

The KC908 uses 4x 18650 lithium batteries with a limit voltage of 4.2V for each individual and a total capacity about 50Wh.

The battery is located in the middle layer and with circuit boards on both sides, it is not swiftly-replaceable, thus spare batteries or chargebanks should be prepared for a long period usage. To replace or remove batteries, proceed as follows.

Turn off the power, insert dedicated tools below the external thread of the RF port and remove the thread. There may be tightening glue on the nut, user must try dealing with caution. Remove the nut on the RF port, remove the back cover of the instrument, separate all visible cables, and remove the larger screws on the board (do not remove the smaller screws). Use a tool with a hook to lift the board to slightly higher than the shell from the end far away from the RF port, exit the RF port in the opposite direction from the RF port, then remove the board. Then user can see the battery. Pay attention to protect the cables and connectors during operation.

In order to ensure the endurance after a charge, the capacity of a single battery should be greater than 3200mAh. Use the same model and batch of batteries, and the voltage difference between the four batteries should be less than 50mV before installation. Choose those batteries with excellent quality, like qualified products from well-known manufacturers. In normal use, the temperature of the instrument can reach 60°C; if used at the limit temperature (55°C), the temperature of the batteries may exceed 80°C, and using inferior batteries is dangerous in that situation. 4 batteries should be installed as soon as possible to avoid unbalance caused by part of the batteries being connected first.

Before reinstallation, make sure there is no misalignment of the RF port on the circuit board, user can simple observe whether there is any gap between the side of circuit and the shell. With any gap, user needs to reinstall correctly and tighten it firmly.

To reinstall the PCB, install the screws on the board back but do not tighten, install and tighten the thread and nut on the RF port, then tighten the screws on the board, connect the cables, turn on the power to confirm everything is working normally, then close the back cover.

2.5 Ports inside KC908, Reference Clock

KC908 adopts TCXO as main clock. TCXO is highly power-efficient, **yet its instantaneous stability can only reach approximately 10ppb(pk.). At 10GHz, there will be a 100Hz instantaneous shift.** Since FFT requires more sampling points when RBW < 100Hz, it possible that the frequency has already shifted while sampling. In this situation, the CW signal could be displayed as irregular band spectrum. It's possible to calibrate the frequency of TCXO, user just needs to enable Ref Clock Adj in system setting, and then observes the known signals in receiver mode or uses signal source function to generate signals and observe them through other machines. At the same time, user needs to perform refined adjustment according to the notification on the screen, until the frequency is accurate.

There are two ports inside the KC908, which are used to input and output the reference clock signal. Clock frequency 20MHz, IPX type connector, at the down right corner under the back case.

2.6 GPS Receiver (KC908B Only)

There is a built-in GPS receiver designed to receive time and position signals. To enable GPS function, turn the GPS setting to on in the system setting menu. After this function is turned on, there will be a blinking satellite icon on the top of the screen, which indicates that GPS is turned on but not locked. After GPS is locked, the blinking icon will become constantly on.

The position and time data GPS received can be accessed in the horizon interface in APP menu. Also, these data can be attached to the data tables to be stored or to the screenshots. To attach positional data in screenshots, simply turn on the screenshot info attaching option in the system setting.

The reference clock of KC908 cannot be tamed by GPS.

The system clock can be synced with GPS. After GPS is locked, navigate to FUNC-TIME setting, and click sync to GPS.

GPS Antenna

The left port of KC908 can be used as input port for GPS antenna. A GPS antenna needs to be connected before using GPS functions. After GPS function is enabled, the left port will be locked and it's no longer available to the measuring functions of the machine.

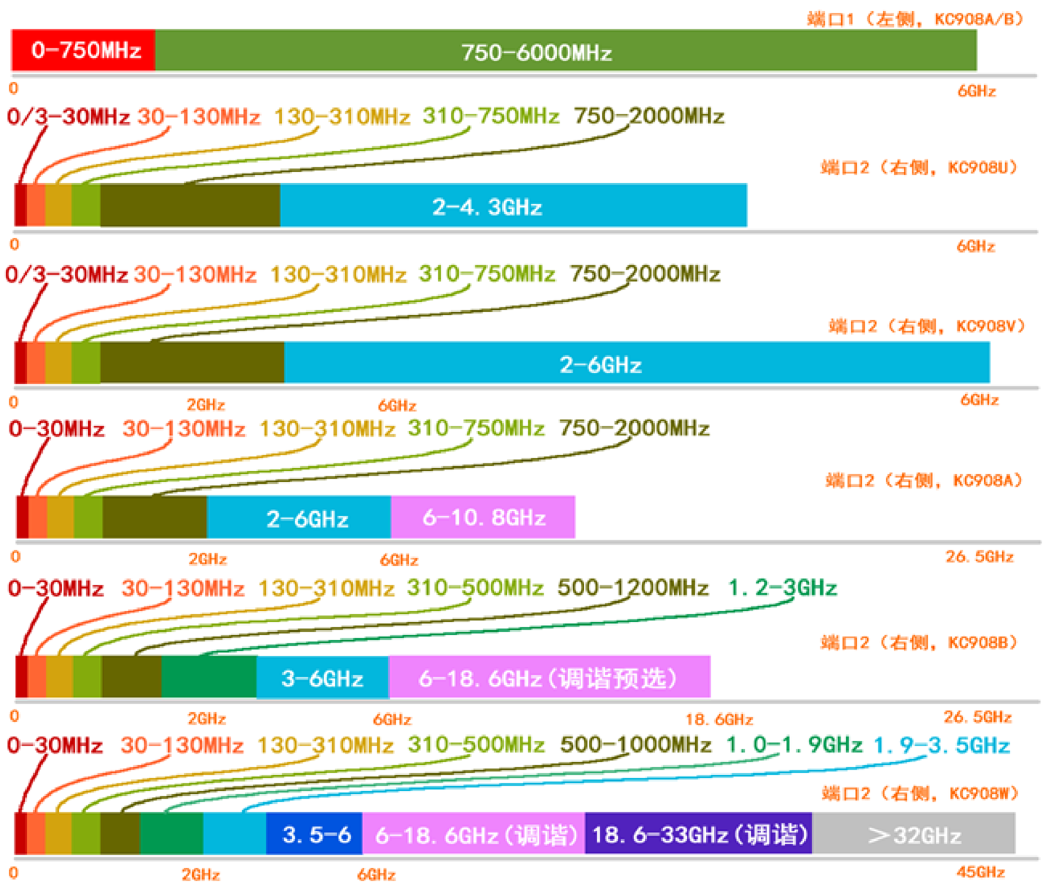
KC908 receives GPS signal at a relatively low sensitivity, mainly due to the fact that the left port is not dedicated to receiving GPS signal. Thus a decent GPS antenna should be paired for compensation.

If the working environment is a broad area on a plateau, a low-gain passive antenna can be used as GPS antenna, whose main lobe should be pointed to the sky. Normally, a whip antenna or a surveillance antenna at 1575MHz frequency band should be able to receive the signal.

For working environments like city, mountain areas, or somewhere with sever blockage, it's advised to use an active antenna. Since the ports of KC908 are not equipped with bias-T, the active antenna should be powered by external power source or battery.

2.7 Preselectors

The preselectors of the two ports are different. The left port's preselector is simlple (for KC908U/V/W the left port does not support receiving), while the one in the right port is complicated. The pic below shows the composition of the preselectors.



3.Measurement modes introduction

This part will introduce the measurement mode and the basic measuring logic of KC908. To know the difference between modes and choose one to get right result.

The KC908 can only operate in one of these modes, except in certain special cases. The MODE key is for mode selection, and the mode selection menu is displayed after the key is pressed. The mode selection menu is only displayed when the MODE key is pressed.

In different configurations and versions, different modes are available. Three modes, spectrum, receiver and signal source modes are included by default.

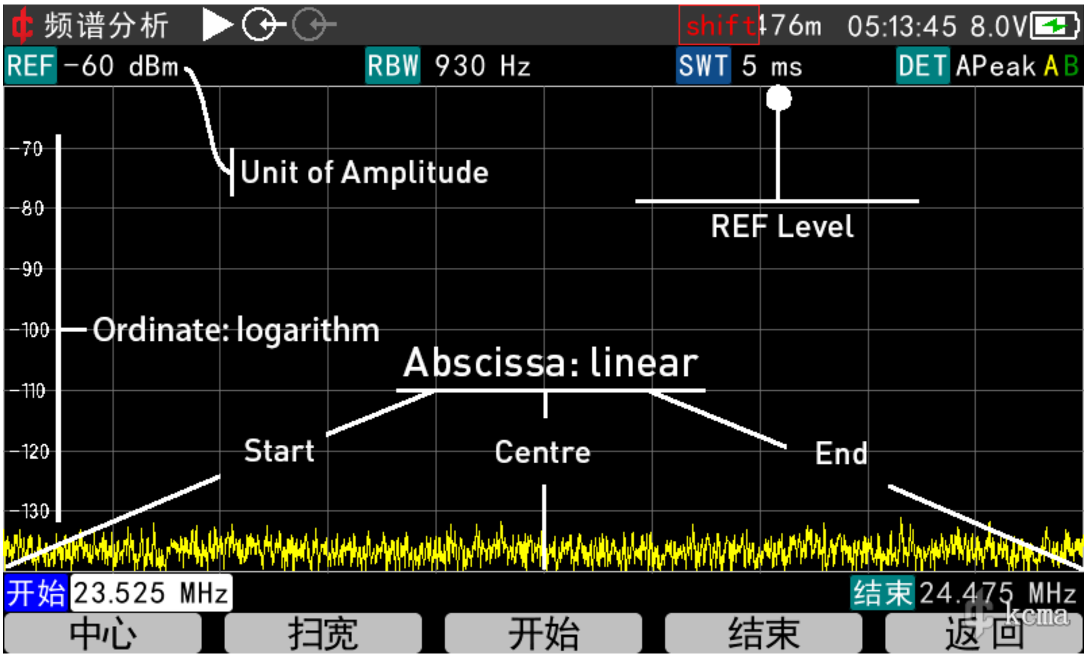
The various models are just applicable to different needs, making the machine more appropriate for the application scenario. Although based on same hardware, performance may vary slightly due to a preference for driving methods depending on the scenario.

3.1 Spectrometer

A spectrometer is an instrument that displays a signal in the frequency domain, and the results displayed are called spectrograms. Usually, the frequency is represented horizontally and the amplitude vertically, with the physical meaning being the amplitude of the signal at different frequencies.

3.1.1 Horizontal Axis

The unit of frequency is hertz (Hz), which indicates the number of repetitions per second and used to be known as cycles per second (C/s). RF signals tend to be larger in frequency, so larger megahertz (MHz) and gigahertz (GHz) units are commonly used.



The horizontal coordinates of KC908 are on a linear scale. If the leftmost coordinate represents 0Hz, and the rightmost coordinate represents 10GHz, then the center is 5GHz, because people are more concerned about the center frequency, so the center frequency (CENT, CF) and sweep width (frequency span,SPAN) are often used to set the instrument.

The center frequency plus or minus half of the sweep width is equal to the start (far left) and end (far right) frequencies.

The spectrometer mode can be set to a very wide SPAN, where the spectrum is stitched together from the FFT results. Measuring and stitching take time, and the larger the SPAN, the longer it takes to refresh a screen. Due to the splicing, adjusting the RBW of KC908 to a large value would not obviously speed up the refresh rate.

3.1.2 Vertical Axis

In spectrum mode, amplitude can refer to power, voltage or current. A spectrum analyzer is a load-bearing instrument that measures the power flowing into its port, or the voltage and current on the port. These parameters are obviously load-related. According to Ohm's Law, if the resistance of the load (which can be generalized to impedance) is determined, then the power, voltage, and current on the load are interdependent, and by measuring one, one can know the other two.The nominal impedance of the KC908 is 50 Ω, so whether the power, voltage, or current is displayed, the amplitude of the signal is correctly represented. In RF measurements, power is often used, occasionally voltage, and rarely current. the KC908 displays the signal power by default.

The unit of power is watts (W), which is a linear unit. In RF measurements, the amplitude of the signal is very different from each other, perhaps a signal is only 1nW, while the signal next to it has 1mW, a difference of 1 million times. If a linear scale is used for the vertical coordinates, assuming you want to represent a 1nW signal with a 1mm height, then a 1mW signal is 1 kilometer high, and there is no such large display in the world. Therefore, amplitude is usually converted to logarithmic units.

The vertical coordinates of the KC908 default to a logarithmic scale. Logarithms are proportional relationships. For power, 60dB means 10^6 times, or 1 million times. Since it is a ratio, there is the question of who the denominator is. In RF measurement, if the power, customary milliwatt (mW) as a unit, 1mW as the denominator, corresponding to the logarithm is dBmW, referred to as dBm. 1nW power, can be expressed as -60dBm. if 1 pixel on behalf of 1dB, then 60 pixels will be 60dB, to be able to the two large disparity in the signal displayed in a spectrum chart.

An amplitude value expressed in logarithms is often called a level value.

The instrument can also display linear amplitude by selecting linear units in the "Units" menu under "Configuration" of the spectrum analyzer.

3.1.3 Frequency setting

The CENT(or RF/CF) button is used to set central frequency, and the SPAN button is used to set the sweeping width.

When the RF/CF button is pressed, a frequency setting menu appears, containing four options: CENT, SPAN, START and STOP. After selecting, you can enter the value directly, or you can fine tune it with the knob.

The SPAN setting menu appears after SPAN button is pressed, which contains options of Full SPAN, Last SPAN, Step Set and ZeroSpan.

The Full SPAN on KC908 is different from conventional spectrometers. In the conventional manner, the machine would scan the full frequency span, which is predictably from 0 to the upper frequency limit. Yet, KC908 would not alter the central frequency, but just set the SPAN to the max permitted value with the current central frequency.

3.1.4 Amplitude setting

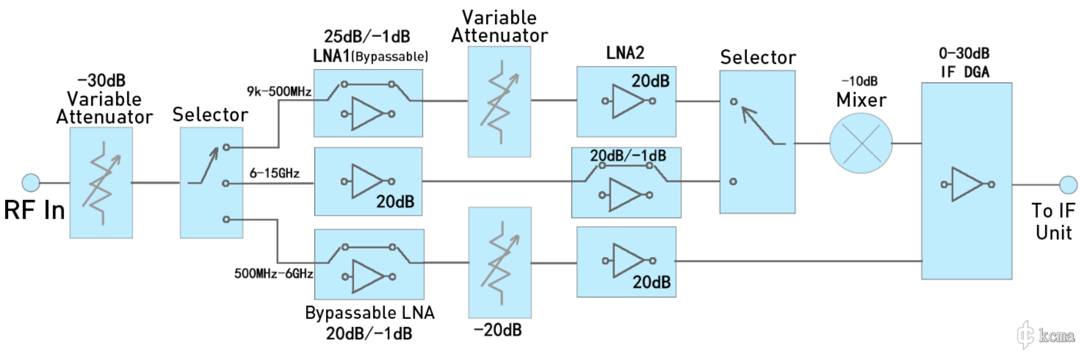
LEV is used to set various parameters related to amplitude, such as reference level, vertical scale, attenuation, gain and reference offset.

The level value represented by the inscribed line at the top of the spectrum chart is called the **reference level (REF)**, a name inherited from the analog era of oscilloscope display spectrometers, which requires counting the squares from top to bottom to read the chart. In short, it determines the maximum amplitude that a spectrum map can fit. In principle, the REF is linked to the instrument's attenuator, amplifier, and the larger the REF, the greater the attenuation and the smaller the gain. A high REF must be set for measuring large signals or the signal may overload or even damage the equipment; a low REF should be set for measuring small signals to obtain a high signal-to-noise ratio. Modifying the REF allows the spectrum line to move up and down. No spectral lines are allowed to go beyond the top of the frame throughout the spectral chart.

Attenuation and amplification are set automatically by default, and the parameters and characteristics of the settings are described in the next section. If you are not satisfied with the automatic selection, you can change it to manual in the menu. After changing to manual, the REF is no longer ganged to the attenuator or amplifier and needs to be prevented from being overloaded.

3.1.5 Relationship between REF AMP and sensitivity

The picture below, in which all the filters are neglected, shows the simplified structure of the RF front end. Restricted by the overall architecture, KC908 adopts a high-gain front end design. There are two levels of preamplifier in the front of the frequency mixer or the IF. Below 6GHz, the first level can be set to bypass, offering a maximum gain of 40dB. As for 6-10.8/18.6GHz, the second level can be set to bypass, offering a maximum gain of 40dB. When the frequency is below 6GHz, the placement of the amplifiers for these 2 ports are exactly the same. And port 1 on the left doesn't support receiving above 6GHz.



The gain of the IF amplifier can be numerically controlled, which is done automatically in spectrum mode. And the range is 0-30dB.

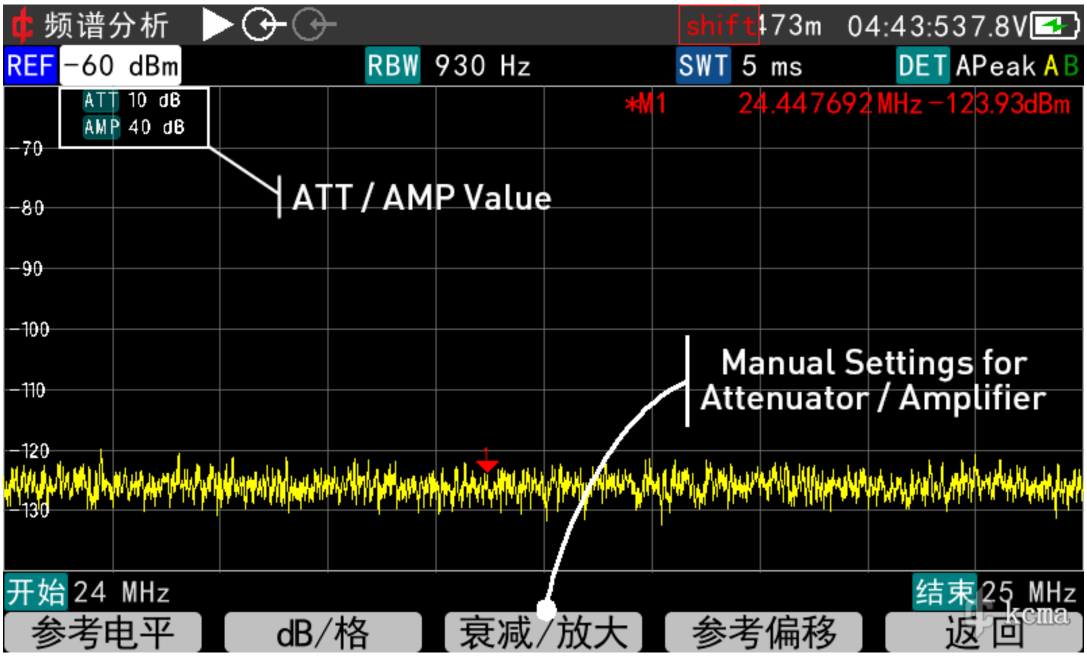
To sum up, a maximum gain of 70dB can be achieved with amplifier combination in the front of ADC. Take the loss in the circuit and the mixer into consideration, the actual maximum gain would be approximately 60dB. The total amount of attenuator available below 6GHz is 50dB. In circumstances with strong signal or severe interference, not only bypass amplifier but also attenuator is needed. The proper amount of gain and attenuation would be selected automatically according to the REF setting. In short, the goal is to ensure no overload appears when the amplitude of the signal is lower than the REF as well as to find to sweet spot between sensitivity and interference resistance.

Under different REFs, the typical gain configuration of port 2 is shown as the list below. In addition, the frequency below 6GHz in the list also applies to port 1.

REF	Frequency range	Attenuator	LNA1	LNA2	IF	Noise Floor (typical)
20dBm	5kHz~750 MHz	40	0	20	0	
	750MHz~6 GHz	50	0		0	
	6~10.8/18.6GHz	30	20	0	0	
10dBm	5kHz~750 MHz	40	0	20	10	
	750MHz~6 GHz	40	0		0	
	6~10.8/18.6GHz	30	20	0	0	
0dBm	5kHz~750 MHz	30	0	20	10	
0dBm	750MHz~6 GHz	30	0	20	0	
	6~10.8/18.6GHz	10	20	0	0	
-10dBm	5kHz~750 MHz	20	0	20	10	
	750MHz~6 GHz	20	0		0	
	6~10.8/18.6GHz	10	20	0	0	
-20dBm	5kHz~750 MHz	10	0	20	10	
	750MHz~6 GHz	10	0		0	
	6~10.8/18.6GHz	0	20	0	0	

−30dBm	5kHz~750 MHz	0	0	20	10	
	750MHz~6 GHz	0	0		0	
	6~10.8/18. 6GHz	0	20	0	10	
−40dBm	5kHz~750 MHz	0	0	20	20	
	750MHz~6 GHz	0	0	20	10	
	6~10.8/18. 6GHz	0	20	0	20	
−50dBm	5kHz~750 MHz	0	0	20	30	
	750MHz~6 GHz	0	0		20	
−50dBm	6~10.8/18. 6GHz	0	20	20	10	
−60dBm	5kHz~750 MHz	0	20	20	20	
	750MHz~6 GHz				10	
	6~10.8/18. 6GHz				20	
−70dBm	5kHz~750 MHz	0	20	20	30	
	750MHz~6 GHz		20		20	
	6~10.8/18. 6GHz		20		30	
−80dBm	5kHz~750 MHz	0	20	20	30	
−80dBm	750MHz~6 GHz	0	20	20	30	
	6~10.8/18. 6GHz		20		30	

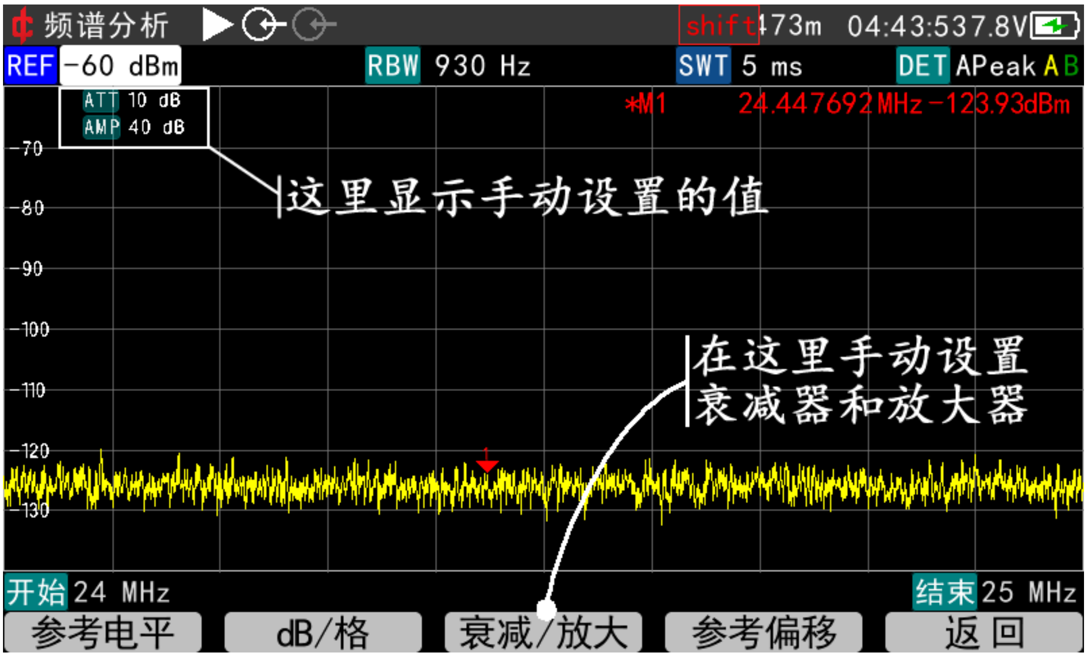
Attenuator and LNA (bypassable) can also be set manually. After pressing LEV button, ATT for attenuator and AMP for LNA would be displayed on the top-left part on screen respectively for manual setting.



KC908 has been tuned for optimal performance while being used with hand-held antenna. Under ideal electromagnetic environment, setting ATT and AMP manually should be avoided, whereas under poor electromagnetic environment or using a outdoor antenna, the REF, ATT and AMP settings should be combined properly according to the spectrum. REF is still relevant while using manual setting, because REF is ganged with IF gain. The interference resistance level at highest gain is given in the technical parameter chart.

The anti-interference characteristics of these two ports are different. Normally it's recommended to use the right side port. And the left side port should only be used when there's no demand for anti-interference performance.

All amplifiers and attenuators have been calibrated in advance, and recalibration would be done automatically once the setting is changed. For example, adjustments in a certain frequency makes the total gain decreases by 25.8dB, in this case the raw data would be increased by 25.8dB as compensation to ensure the tested signal remains the same.(Prerequisite: the tested singal must be stronger than the background noise.) Yet the background noise would be constantly changing, it would drastically rise as the sensitivity of the machine drops. However, because the noise from the amplifer would also drop relatively, the background noise would not increase exactly 25.8dB, but a slightly smaller value.



Likewise, switching AMP off or increasing ATT value cannot reduce the interactive interference within the machine, yet it might even become unneglectable without the amplifer's noise.

3.1.6 Mode Setting

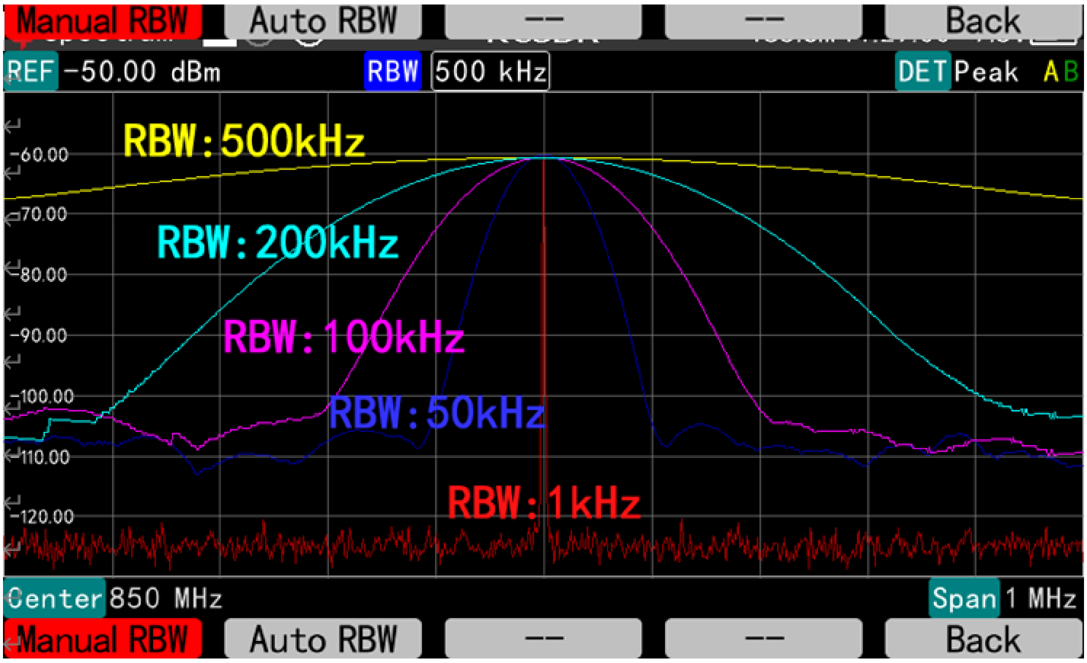
Mode setting is different from mode selection. Once a mode in selected, the mode setting menu becomes the top-level menu under that mode. The mode setting menu of the spectrometer includes bandwidth, sweeping parameters, port selection, marker, trajectory, peak table, detecting method and unit setting.

(1) Bandwidth/Sweeping

This menu includes resolution bandwidth, sweeping time, detection method, trigger method, and other settings.

Resolution bandwidth, also known as analytical bandwidth, is originally designed to map two signals on the same spectrum and make them distinguishable no matter how far they are from each other. Moreover, it's equivalent to the bandwidth of an intermediate-frequency filter on a scanning spectrometer. In a FFT spectrometer, two adjacent points in fourier series can naturally distinguish two different frequency, thus RBW(Resolution Bandwidth) is equivalent to FFT resolution to some extent. However, pure FFT is not enough. Assume that a signal lands exactly in the middle of that two adjacent points. This situation makes the reading of both points smaller than actual, inducing a measurement error. To solve this problem, the data must be put through a window process. Figuratively speaking, a window process means summing the weighted total power of several adjacent points and displaying the data of the central point as a result. This price of this process is the deterioration of the resolution. The performance of different window types varies. Taken the fact that it's a custom to adopt gaussian filter into account, KC908 adopts a gaussian window. In this situation, RBW represents an equivalent IF filter's 3dB bandwidth.

A simplified model would be that the spectrum line for measuring a simple-frequency signal should be infinitely narrow. Yet in the real world that width is not infinitesimal. Measure the width of the spectrum line at 3dB below the peak, and that width is RBW.



Apparently, RBW is relevant to SPAN, FFT points and window shape. The smaller the SPAN, the more FFT point, the smaller the RBW, the better the resolution. If the FFT points and window shape are set, RBW is only relevant to SPAN theoretically. In other words, there is a function mapping SPAN and RBW and SPAN is the variable. This fact brings inconvenience to real-world operation, thus KC908 adopts the minimum RBW of current SPAN by default. Also, it's allowed to manually adjust in a limited range. Effectively, this is adjusting FFT points and window shape.

With a relatively large value in SPAN setting, the resolution of the screen would be inferior to RBW. Each pixel on the horizontal axis represents several pixels that could have been distinguished from one another. In the worst scenario, one pixel would even represent a thousand adjcent frequencies. At this moment, "represent" needs a definition. This definiton is also known as detection method. For example, auto-peaking means displaying two dots on one column on the screen. One of them is max value and the other is min value. Connect these two dots with a line, and when the marker reads the value, the frequency and amplitude of the max point would be read.

(2) Marker

Spetrometer comes with 4 markers. Two locate in the first page of MARKER option in the mode menu, and the rest locate in MORE option. Enabled markers would be presented with green menu while the current activated maker would be presented with red menu. Markers distinguish themselves with different colors.

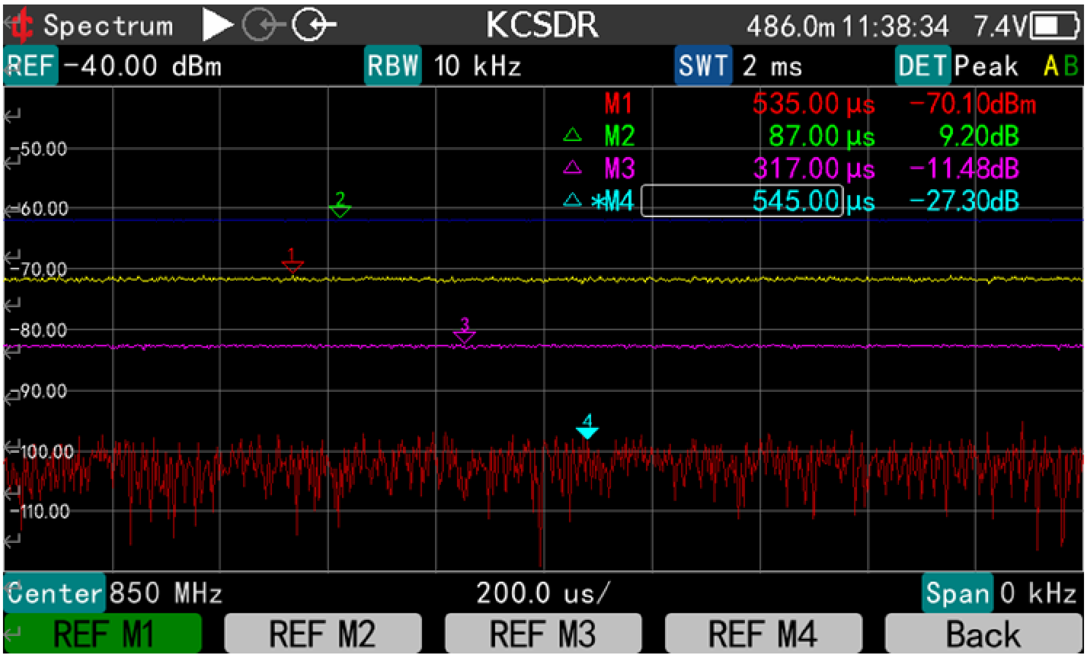
Press any marker botton to enter its function menu, where options like peak seeking, set marker frequency to central are included.

Transfer to receiver means switching to receiver mode as well as setting the marker frequency as receiving frequency.

After auto peak seeking is enabled, the marker would search for the highest spectrum line at real time.

In spectrometer mode, MODU button is used to enter MARKER menu as a shortcut. SHIFT+LEV would do the same.

Pic : Four markers in spectrometer. Capable of moving to different tracks and enabling substraction and field strength calculating function.



To receiver, this function is meant to switch to receiver mode, and set the marker frequency as the receiving frequency. With auto-peaking function enabled, the marker would stick to the peak spectrum line instantaneously.

MARKER button is used as the shortcut to enter the marker menu.

(3) Tracks

Two tracks, track A and track B can be enabled in the menu. Also, options like maintaining max/min value are available in the menu. These functions are mainly used for comparing spectrums and capturing instantaneous signals. The REF setting of track A and track B can be different, while other parameters remain the same.

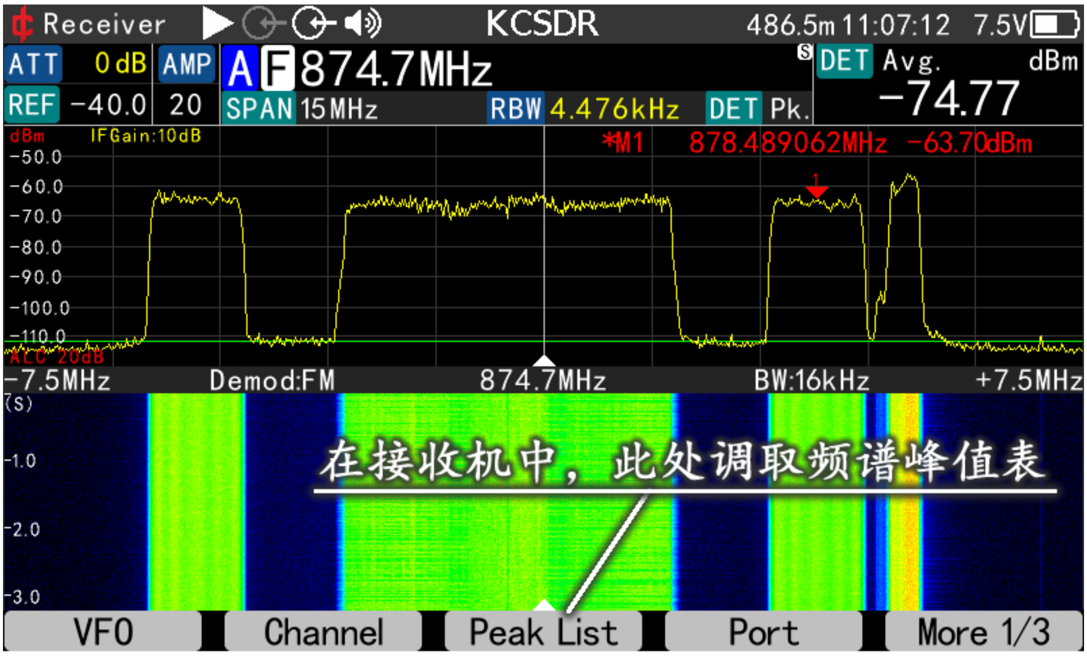
(4) Peak Table

This function is meant for searching strong signals within spectrum automatically and log them into a table.

While the top 100 strong signals have been logged, only 10 of them are to be displayed. Only signals meet the criteria set by the user would be logged.

Save table function is meant to save the peak table to the receivers. With a TF card equipped, the table would be saved to TF card simultaneously. In receiver mode, the saved table can be accessed.

Pay attention that each time the current table is saved, the former saved table will be overwritten. This happens in the built in storage, but would not happen in the TF card(would be stored as new file instead). Saved tables in the TF card can be accessed in receiver mode, and after this operation the peak list stored in the built-in memory would be overwritten.



The criteria determine whether all the desired signals have found completely and accurately. Those criteria are in peak search setting and there are three options.

a. Threshold

Similar to ”squelching”. Only signals stronger than this parameter would be logged and it’s used to filter those small signals that are not of interest. While searching for nearby strong signals, it’s recommended to set it to –40dBm.

Altering this parameter while logging would **delete** those logged results that fail to fit the new criteria.

b. Frequency Gap

Defines the minimum frequency gap between two peaks. Given two peaks whose gap is smaller than this setting, then only the peak appears first or the peak with large peak value would be logged.

This setting is meant to prevent logging a wideband signal with multiple peaks as multiple signal. So as to improve informational accuracy.

We recommend setting this parameter slightly narrower than the channel gap of the frequency band to be tested. Specific parameter should be adjusted flexibly accroding to the scenario. A too small gap would result in repetition in logging while a too big gap would miss signals.

Altering this parameter while logging would **delete** those logged results that fail to fit the new criteria.

c. Time Occupancy Filtering

Time occupancy refers to the time ratio a signal occupies a frequency. For example, the time occupancy of a constantly transmitting control signal is 100%, while the time occupancy of a frequency that is just used to call the roll on a daily basis is less than 1%.

In many cases, neither the constantly appearing signals nor the randomly appearing signals is of interest. This is when time occupancy filter becomes useful.

A upper limit and a lower limit are needed to be set to use this function. Also, another parameter needs to be set to determine whether the value inside or outside the interval would be left after filtering. For instance, upper/lower limit is set to 99% and

1%, outside interval left, consequently only those signal less than 1% or more than 99% time occupancy would be left after filtering.

d. Amplitude Gap

Defines how many dB lower the bottom between two peaks must be, when compared to the lower peak. If there is no bottom that fits this criterion present between two peaks, KC908 would recognize these two peaks as one signal.

This function is meant to prevent logging wideband signals, especially those with a flat top (like CDMA), as multiple signals mistakenly.

The recommended value is 10dB. This value could be properly increased if a modulated signal with multiple peaks resulting in repetitions appears. But this parameter must be smaller than the signal noise ratio. If all the signals are so weak that the noise background is less than 20dB from the peak and the parameter is 20dB, then only the largest peak would be logged.

Altering this parameter while logging would **NOT** delete those logged results that fail to fit the new criteria.

e. Frequency Rounding

Since the deviation of the signal's frequency and the limit of detecting precision, the peak list contains a lot of data with multiple digits of non-zero tails. It's inconvenient because it's not the common interval of like 25kHz or 200kHz. This function is designed to trim these tails.

In the frequency rounding setting, rounding interval determines the interval to round the tails. For 25kHz channel, this parameter should be set to 25kHz or 12.5kHz, while for FM frequencies 50kHz or 100kHz. Start frequency determines where the interval starts. A MW broadcast starts from 531kHz with a interval of 9kHz would be rounded like 531, 540, 549, etc. For frequencies above VHF, the start freqeuncy would usually be set to 1MHz or 1GHz. The start frequency can be set to higher than the lowest frequency in the list.

After enabling this function, those signals within half the rounding interval higher/lower than the "integral" frequency would be deemed as that "integral" frequency.

Frequency rounding function's priority is lower than other filters.

(5) Port Switching

In config menu, port switching is used to swtich the port being used. Each press would switch once between left/right port. This function does not work on KC908U/V/W.

(6) Antenna Gain

Antenna gain setting is to determine the **total** gain of the external antenna system. With a correct setting, the apparatus can calculate the actual field strength within the resolution bandwidth with field strength unit switched to dBμV/m. Note that other field strength unit doesn't work whis way. **If the user want to pair with external attenuators and amplifiers**, press LEV button and set those parameters in "**Amplitude Shift**".

3.2 Receiver / Field-Strength Meter

Receiver is designed to measure the level of a signal as well as to demodulate and monitor it. In receiver mode, spectrum can also be displayed, however there are 4 major differences compared to spectrum mode.

(1) Gain and attenuation are irrelevant with REF in the spectrum by default. Gain and attenuation are set automatically according to the strength of the signal, to be precise, according to the total power within the entire sampling bandwidth. The user can also set it to be relevant to REF, or even set it to be full manual.

(2) It comes with level or field strength display. Bandwidth measurement is not based on the Gaussian filter in the spectrometer, but on the **rectangle filter**.

(3) It comes with analogue demodulation, where the demodulating frequency equals to the central frequency of the spectrum.

(4) The maximum frequency span of the spectrum is 15MHz. Instead of being the montage of the FFT result, it's now real-time.

3.2.1 VFO

VFO, abbreviation for Variable-Frequency Oscillator, refers to local oscillator in superheterodyne receiver. For the time being it's accustomed to use VFO to refer to the free frequency adjusting mode. ("free" compared to channel mode). For disambiguation, KC908 hereby adopts the latter definition.

The machine comes with 2 VFO, VFOA and VFOB. Settings between them are independent, just choose one of them when using. The main purpose of offering 2 VFO is to provide convenience switching between two monitoring frequencies swiftly. The two VFOs cannot work simultaneously, despite the possibility in the hardware layer.

Apart from setting frequency freely, VFO mode also enables the user to read channels and the peak list saved by the spectrometer.

To spare different frequency setting custom, both VFOA and VFOB chop frequency spectrum into a number of segments. The majority of parameters' settings in different segments are independent. By default, once the frequency is changed into another segment, the settings would be altered to exactly the last set of parameters of that segment. The isolated frequencies that don't belong to any segment would be regarded as the (N+1)th segment, which means these frequencise would be using the identical setting.

For example, user is listening to 101.7MHz broadcast, which adopts FM demodulation with 200kHz demodulation bandwidth. In the prior setting, user was receiving communication signal at 8.350MHz, which adopts USB demodulation with 3kHz demodulation bandwidth. Anytime when user wants to go back to the prior setting, the only necessary operation is to simply adjust the frequency back to 8.350MHz from 101.7MHz. Following this operation, KC908 would restore demodulation setting to USB with 3KHz bandwidth automatically.

The partition of frequency is shown below:

Number	Frequency Range(MHz)		Note
	Begin(included)	End(excluded)	
1	0	1.8	Long wave, medium wave
2	1.8	28	short wave
3	28	30	shor wave CB
4	30	76	
5	76	108	FM Radio
6	108	136	Aviation

7	136	174	
8	320	470	Private network
9	470	520	
10	800	865	Cluster
11	865	1050	
12	1200	1300	
13	2400	2500	WiFi
14	Other		

Volume, display style and port selection, etc, are considered to be settings desired to remain untouched while switching between frequency segments, thus they would not be changed automatically. In addition, frequency stepping, squelch and demodulation method are considered to be segment-relevant settings, which makes them aligned with their segment's default.

3.2.2 Channel

CH, the acronym for channel, refers to channel mode, yet it's also referred to as MR, memory mode. KC908 is capable of storing 1000 channels, most settings between channels (including port) are independent. But preference settings like volume and display sytle are exceptions.

In CH mode, although frequency and settings can still be changed freely, it's temporary. In other words, the changed settings would be overridden next time using the same channel unless changes are saved prior to that. What's more, there will not be any segment while adjusting frequency temporarily in CH mode. In CH mode, frequency and corresponding settings can be pushed to VFO.

3.2.3 Peak List

P, short for peak list, is not the peak list in the receiver, but the peak list saved in the spectrum mode. Refer to 3.1.6.4.

3.2.4 Auto Gain Control

The receiver is capable of auto gain control for both RF and audio. For disambiguation, we hereby define ALC, auto level control, for RF. And define AGC for audio. In essence, both these auto gains are implemented by analyzing the RF/IF signal strength and adjusting the gain automatically.

The front end of the receiver comes with a 30dB variable attenuator, whose stepping is 10dB, and a 40dB variable amplifier stepping 20dB. IF comes with a 30dB adjustable amplifier stepping 10dB.

In spectrometer mode, the combination and consequent value of these amplifiers and attenuators depend on the setting of reference level, and the whole adjustable range of gain can be up to 100dB.

In receiver mode, by default the attenuators and amplifiers would adjust themselves automatically according to input. Meanwhile, the user can forcefully set the criteria to be reference level like spectrometer mode, instead of input.

Receiver not only displays the measured results, but also vocalize it. In quite a few cases, hearing even replaces vision to play the major role. Receivers are frequently used to search signals in a mobile manner, in which level varies across a large range. In this case it would be inconvenient for the user to adjust the reference level.

Thus by default in the receiver mode the attenuator and IF amplifier are adjusted automatically according to the input, which is called ALC.

The adjustment is in accordance with the total level within the whole sampling bandwidth. Attention should not only be paid to the strength of the signal of receiving frequency, as overload can happen outside the demodulation bandwidth. In case like there is just a small signal on the receiving frequency, yet there is a large interferening signal beside that frequency, overload would still be possible to happen. If the total electric power level ADC receives is too high, KC908 would decrease the gain tentatively until the overload is gone. On the other hand, the gain would increase when the level drops to maintain a relatively high sensitivity. In addition, to prevent the possible gain oscillation caused by the rapid change od the signal, the stagnate interval is set to 20dB by default, and user can specify this setting in LEV–gain–follow signal–stagnate interval.

RF gain affects the anti–interference ability greatly. Since it's hard to assess the electromagnetic environment comprehensively in real–time bandwidth, adding RF gain into auto adjustment would probably get the wrong result. So the RF gain needs to be set manually, and the recommended value is 20dB. In places where the electromagnetic environment is ideal and the signal is weak, it can be set to 40dB to improve the sensitivity. Yet, a 40dB gain would drastically compromises the anti–interference ability. Use PRE–AMP button as the shortcut to set the RF gain.

NOTE

Due to the fact that the criterion of ALC control is the total level within the whole sampling bandwidth, signal changes outside the displayed part also account for ALC action, which can appear as rapid changing ground noise.

Since it's possible the overload happens before ADC, simply adjusting according to the sampling level might not be enough to be a prevention. Moreover, ALC is not capable of eliminating this kind of overload unless a radiodetector is attached after preselector. As a compensation, KC908 allows user to manually specify gain and attenuation and those unspecified parameters will still be adjusted automatically. In harsh electromagnetic environment, it's advised to specify a attenuation of 10dB or higher, and leave other settings at auto. Yet manual adjustment is not practical if the signal changes, at this time the function gain limit becomes useful.

NOTE

While working near a high power transmitter(or unknown strong interference source), interference outside the bandwidth could possibly jam the front end of the receiver, making the tested signal appears to be smaller than it actually is. While direction–finding on foot, the direction which the tested signal appears to be greatest might be the direction which outside–band–interference happen to be weakest. In this case, if the tested signal is at the same location of the interference source (commonly, the same iron tower), the user would be drived to the opposite direction. If in doubt of this scenario, view the band as wide as possible with the spectrum function of find out whether there is a strong interference. Or, simply trade it with a little bit of sensitivity and set the RF gain to 20dB(which is the default value).

This situation is not common, yet user should keep it in mind.

Gain Limit

Gain limit, which is meant to avoid the overload caused by the interference outside displayed range, is located at the gain/attenuation menu. This function comes as three options, minimum attenuation, maximum IF gain and maximum RF gain.

For instance, if the min attenuation is set to 10dB, the attenuation would be automatically adjusted to 20dB or 30dB if the signal is strong, yet however weak is the signal, the min attenuation would remain 10dB. Likewise, if the max IF gain is set to 20dB, the gain would be automatically adjusted to 0 if the signal is strong, yet however weak isthe signal, the max IF gain would remain 20dB. It's not advised to limit the IF gain unless the user knows exactly what is being done.

Gain limit **does not affect manual gain setting**. If manual gain setting and gain limit is turned on simultaneously, then those options with a manual gain setting apply the manual setting value, while the rest would be adjusted automatically and be restricted by gain limit.

Gain limit only works in receiver mode. After gain limit is turned on, the left-bottom part of the coordinate would display "limit" notification.

User can distinguish whether it's in auto mode or manual mode by the color of ATT and AMP displayed on the screen. Golden yellow means auto mode.

Whenever the gain is adjusted, KC908 would automatically adjust the reading. The actual parameters of amplifiers and attenuators corresponding to their covering frequency interval are embeded out of factory, as a foundation for reading adjustment.

When using ALC, REF setting only relates to the value interval of the vertical axis, subsequently affects the position of the curve. The color of the waterfall curve is linked with REF, user cannot specify the begin/terminate level separately. The color of the curve may suddenly change if the gain is automatically adjusted.

By default the audio AGC is enabled to keep the total audio power aligned to the volume setting. If there is no signal at this time, a noticeably loud noise would be heared no matter which demodulation mode is being used. The default time constant of audio AGC is 1s.

3.2.5 Level/Field Strength

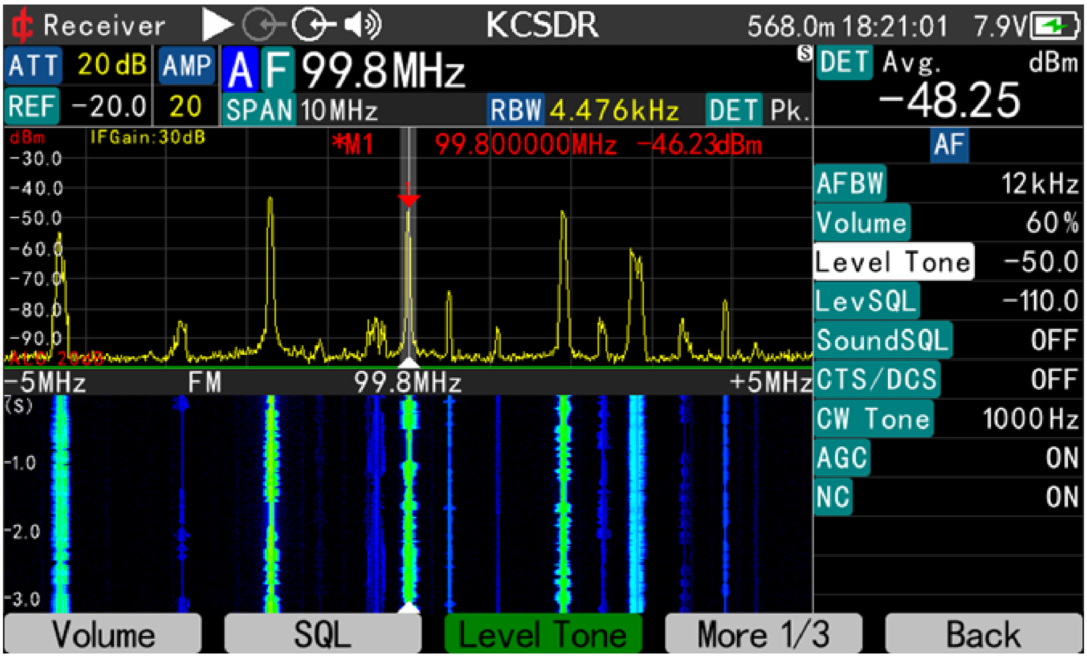
KC908 displays level on the top right corner of the screen. Level indicates the total power within the demodulation bandwidth, which makes it different from the marker on the spectrum. It can be adjusted by pressing MODU button-demodulation-demodulation bandwidth. Demodulates signal is extracted by rectangular filter, and this might makes its level not the same as the marker, even if demodulation bandwidth is corresponding with RBW.

To make it possible for the machine to calculate the field strength, set the unit to dBμV/m or dBW/m2 and set the antenna gain correctly. The calculated field strength would be displayed on the top right corner.

3.2.6 Level Tone

Level tone function means vocalising the signal level. In other words, the higher the tone, the higher the level reading is.

However, the varying range of the level might be huge (120dB or more). Mapping tone to such an large interval can barely reflect any detail. Thus the range must be narrowed and KC908 comes with a range of 80dB. **After enabling this function, a proper central point of the level must be selected and set.** As level changes within the interval of 40dB below/above central point, tone will change noticeably as well. When the level is more than 40dB below central point, there will barely be any change in the tone. If the level is more than 40dB higher than the central point, the sound would become intermittent. Higher it becomes, the more rapid the tone becomes, to warn the user adopt a higher central point. Intermittent notification offers another 20dB range.



Pic: In searching-on-foot scenario, setting the central point on the current reading level would be helpful to hear the change.

Level central point can be adjusted using the knob below. Press the knob twice until three beeps are played, it means central point adjustment is ready. If no adjustment has been made within 5 seconds, the knob function returns to volume setting automatically.

3.2.7 Squelcher and Denoiser

KC908 comes with a squelching function, which is designed to turn off sound ouput when no signal is present or the present signal is not desired, to avoid making unnecessary noise.

Squelchers are: level squelcher, conversational voice squelcher, CTS, DCS.

Level squelcher: When the level of the signal is lower than the threshold, sounds are muted.

When the level is higher than the threshold sounds are enabled. Level squelcher adopts stagnating-recursive comparison, whose intetval is 2dB by default. The threshold would be displayed with a horizontal green line in the spectrum.

Conversational squelcher: Analyze the audio and judge whether the non-noise component is larger, if so, sound would be turned on. Otherwise, sound would be muted. Since it's challenging to distinguish precisely, this squelcher is a negetive squelcher designed to detect noise, and should be used with level squelcher. In situation where the signal level is 10dB or even more, higher than level squelcher's threshold setting, the sound would be enabled without taking the conversational squelcher into account.

The criteria of CTS and DTS are both certain demodulated signal or data within the "sub-vocal" range, whose frequncy is lower than the response frequency of the speaker. The measured signal must be sufficiently fulfilling the rules to make these functions work.

The spaker icon on the upper part of the screen blinks whenever there is sound output.

The denoiser adopts a mathematic approach to deal with the white noise and make the sound clear. To prevent distortion, the denoiser works in a gentle manner. Denoiser should be disabled if the audio needs an external test.

Level tone, squelchers and audio-related settings can be accessed by pressing AF and enter the menu.

3.3 Simple Signal Source

The signal source function is capable of generating equal amplitude, modulated amplitude, modulated frequency, as well as modulated phase signals. When connected to GNU-Radio, it's capable of outputting digital modulated signals. KC908A/B support signal source function on both ports, while KC908U/V/W only support the left port to output. Due to the fact that the left port is the default port, the discussion below focuses on the left port alone.

For the left port, 100kHz-1GHz signal is produced by mixing. With a strict low-pass filter, it's relatively pure. Signals between 1GHz-6GHz are generated by the transducer on IQ. And there is no additional filtering since its purity is acceptable. Above 6GHz signals are produced by mixing. For KC908A, even with a simple filter, the signal contains severe impure clutters like local oscillation. Thus attention should be paid when using. KC908B comes with a synchronous tuning filter, which offers a 20-40dB out-of-band suppression. Apart from the leakage from strong clutters like LO and image, other stray is not that severe.

The maximum output amplitude varies as the frequency changes. The reason is mainly the fact that the saturated power of the amplifier decreases as the frequency becomes higer. What's more, the circuit loss, like the loss caused by the adjustable attenuator, increases drastically as the frequency rises. To maximize the output amplitude as much as possible, the gain potential held back by the instrument is quite much. Yet the gain suppression phenomenon is bound to happen as the saturated power of the amplifier is approached, as its severity is hard to predict. For this reason, the calibration is conducted under a scenario in which the drive power of the amplifier is constraint, and thus there is absolutely no suppression. In real-world usage scenario, as the user gradually increases the output power towards the limit, what the instrument does is simply increase the drive power, and the output level would not increase linearly. Note that the closer it comes to the limit, the less the output level gains.

For instance, at 13GHz, the calibration is done with an amplitude less than -10dBm. While using, each dB increase may be mapped to only 0.5dB increase in output power. Although the instrument has done a curve-fitting for output suppression, with a relatively high output amplitude, there must be a large deviation between the set value and the acutal value.

In short, to maintain a decent precision of output amplitude, it's advised to keep the output amplitude below -10dBm. While if the main concern is to get a high output power, the demand of high precision would not be satisfied at the same time.

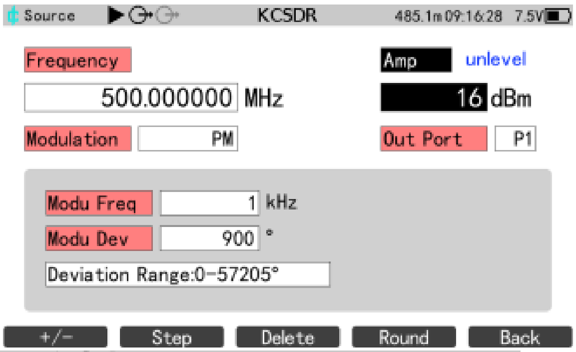
One more thing to notice is that while outputing a strong signal, the distortion would be relatively severe since the amplifier is almost saturated. On one hand more harmonic waves would be produced, on the other hand it would exert an impact on digital modulation. **If a signal source is used to produce digital modulation, it's advised to rollback at least 10dB from the max available amplitude of the current frequency, to ensure EVM lands within a acceptable level.**

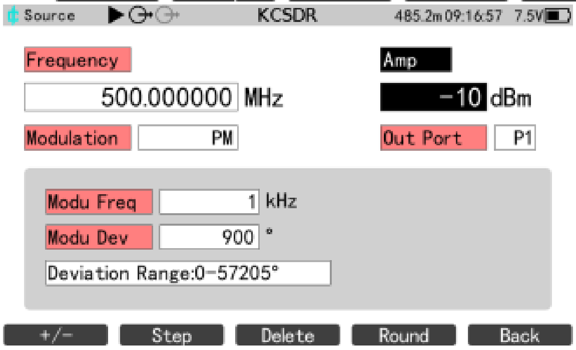
Under a strong driver, the left port is capable of outputing a large amplitude, like 10dBm@6GHz or even larger. As for frequency above 6GHz, KC908A can typically reach

0dBm, while KC908B can reach 10dBm for most frequencies, more satisfyingly, it can even reach 18dBm at a relatively low frequency(13GHz and below). As a matter of fact, the tail amplifier of KC908B can reach a power of 23dBm, yet as the frequency becomes higher, the circuit loss increases as well, making the max amplitude way smaller than the limit of the amplifier.

Both ports are capable of outputting relatively small signal, especially the right port. When attached to an power attenuator whose attenuation is more than 30dB, it is possible to serve as a sensitivity tester for radio transmitter. On the other hand, the left port is usually used under larger output amplitude scenario. It's necessary to pair a attenuator of more than 50dB for external sensitivity test. While outputting small signals, the accuracy looks promising, yet the linearity of the amplitude is not ideal. To be straight-forward, adjusting 1dB would result in a 0.3dB or a 2dB actual change, while adjusting 10dB would not result in a deviation of 10 times bigger than the deviation produced by adjusting 1dB. Since deviations towards all directions cancel each other, making the final deviation usually lands within 2-3dB. For this reason, the relative value of small stepping is just for reference under a small output amplitude(like lower than -40dBm).

The instrument has been tested in the factory to state an amplitude range within which enjoys decent accuracy clearly, and the range is normally a 30dB interval. If the amplitude is outside that range, the system would warn the user "Unlevel".





Since the signal source function is capable of outputting a high amplitude, it's vital to keep in mind not to interfere the radio service while testing on an open field.

4.Test Preparation

KC908 is equipped with two RF input/output channels, and it's capable of testing spectrum and field strength. Preparations are different as for different test.

4.1 Battery and Charging

The battery amount left would be displayed on the top-right part of the screen, and the user should check it before any further operation. If the battery voltage is higher than

8.2V, it means the battery is fully charged. A battery voltage lower than 7.0V indicates the available operating time is less than half an hour, the machine must be charged.

The rate the battery is consumed differs in different functions. After fully charged, the typical endurance time is shown below.

Function	Frequency Range	Endurance	Note
SPECTRUM & RECEIVER	<750MHz	4h	Amplifier 20dB, receiver volume 30%
	750MHz–6GHz	5h	
	>6GHz	4h	
Comparator	<750MHz	3h	Amplifier 20dB
	750MHz–6GHz	3.5h	
Signal Source*	<1GHz	4h	Simple signal source@max output amplitude
	1GHz–6GHz	4.5h	
	6–10.8/18.6GHz	4h	
Network Analyzer	<750MHz	3h	Receiver amplifier 20dB
	750MHz–1GHz	3h	
	1GHz–6GHz	3.5h	
	6–10.8/18.6GHz	3h	
Idle		10h	

*Endurance time just for reference. Some functions are optionally–shipped. Be subject to the machine.

Audio volume also affects endurance. At max volume, the power consumption increases 5W, and the endurance time will shrink noticably.

Charger and external battery packs should be prepared if a prolonged working period is desired. It’s possible for the user to DIY external battery packs, and a output voltage of 12–16.8V is suitable, which is almost 4 lithium cells in series connection. Every 60Wh doubles the endurance time. Utilising a mobile powerbank with quick charge function is also feasible.

It takes almost 3 hours to fully charge the battery with the stock charger at 12V@1.8A. With a USB charger, the fully–charged time is relevant to the output capacity of the charger itself. For 5V@1A charger, typical time is 15 hours, while 10 hours for 5V@2A charger. Quick charge compatible chargers would probably take less time. KC908 would measure the current and voltage to analyze the charger and subsequently adjust the charging current. Yet, even with the exact same parameters, two different chargers can possibly perform quite differently. In addition, the length and quality of the charging cable would exert influence on charging time as well.

Standard 12V(13.8V) car power sources like car battery, on–board radio power source, cigarette lighter, are compatible for charging. While charging on a car, a 2A fuse shoule be put in series in the circuit. In an emergency, a 12V AC source is acceptable for a temporary charging.

Once the battery voltage drops below 6.5V, the machine alarms for low battery and shuts down within one minute. Any operation prior to shutdown would interrupt and restart the countdown. After the shutdown, user can turn it on and continue to use for a short period of time.

However, if the battery voltage continues to drop below 6.0V, the machine would be forcefully shutdown to protect the battery. User cannot turn on the machine until it has been charged.

4.2 Connector

KC908A/B/W adopts a RF socket with a inner diameter of 2.92mm, which is compatible with SMA standard, and the actual cutoff frequency can reach 43.5GHz. KC908U/V adopts SMA connector and although the socket has been strictly reinforced, it cannot withstand massive force due to its structure, inherently. User must always bear in mind that the core of the connector is extremely fragile despite the solid shell of the connector. The main cause for damage is the core has been waggled and this cannot be seen from outside. For choosing adapters, the these principles should be followed.

(1) It's not recommended to alter SMA to a larger connector. For instance, soft connecting cable between SMA connector and N connector is preferred when N type is desired, instead of SMA/N adapter.

(2) When connecting between SMA sockets or connecting to a smaller socket, short adapater whose length is shorter than 50mm is preferred. Soft cables can serve as a replacement if such adapter is not available. Long adapters will drastically multiply the torque applied on the socket, which would consequently damage the socket.

(3) Straight adapters are preferred over curved adapters. Since curved adapters would possibly stretch outside the dimensions of the machine, and once the machine tilts accidentally, enormous torque would be applied to the socket and damage it.

(4) Use 50Ω SMA adapters or 2.92mm connector. 3.5mm connectors from certain providers could possibly damage the core.

(5) Chose high quality product. Rotate the rotating shell of the connecting part but not the entire body while installation. Press the main body of the socket and tighten the screw to make the surface connect seamlessly. The connector must be rotated until tightened before usage, as any shaking could damage the core, even loosening the connection between the socket and the motherboard. Additional attention should be paid to the quality and physical stability of the antenna when an antenna is directly connected. Antennas with poor quality, though steady and still as it seems, their core pins tend to exert torque on the core when the antenna bends, which would definitely threat the reliability of the connector.

4.3 Antenna

4.3.1 Outdoor Antenna

The robustness of the antennas against thunder and static electricity should be taken into consideration when choosing the outdoor antennas. A DC grounded antenna is relatively safer. Before connecting a large size short wave antenna, the static electricity must be discharged first, especially in a windy weather.

In circumstances with complicated environment, narrow-band antennas should be preferred. In city environment, the total RF power of outdoor wide-band antennas can reach as high as 0dBm above. In this situation, the background noise would rise drastically due to the pre-stage jamming. The useful-signal ratio drops as well. To solve this problem, use can increase the reference level to activate the attenuator, and the amplifier would be disabled automatically. Also, user can enable the attenuator and disable the amplifier manually. The anti-interference ability of port 2, which is on the right side, outperforms port1, which is on left side. Thus port 2 should be preferred.

If necessary, consider putting suitable filters in series between KC908 and outdoor antenna.

4.3.2 Hand-held Antenna

For hand-held antennas that are to be used in a mobile manner, select those with desired frequency and gain. Besides, the distance between the antenna and KC908 as well as the force exerted on the RF port should be taken into account.

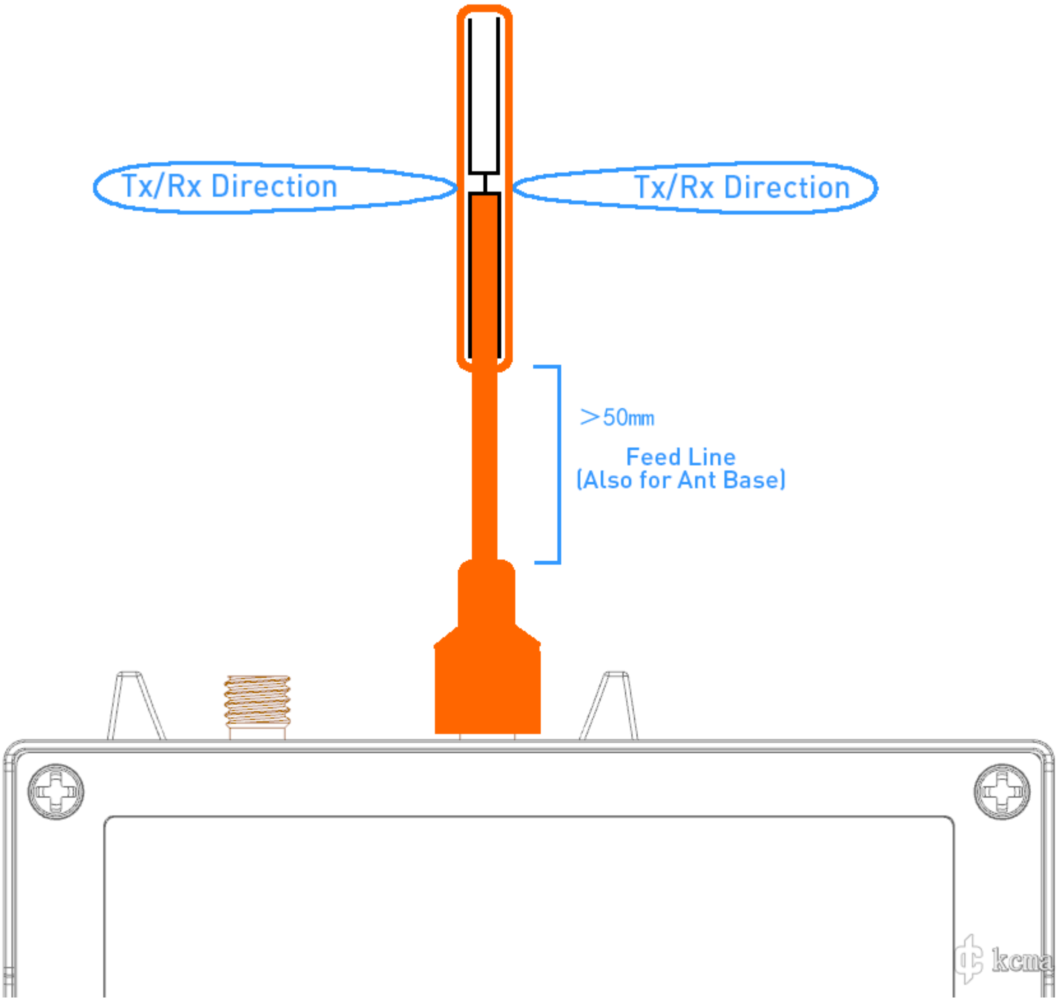
To improve power efficiency as well as to shrink the size, multiple high performance switches have been used in KC908. Despite measures like dithering and shielding, there is still a small amount of high frequency radiation. More importantly, although those high frequency radiation is much weaker than the EMI standard, it's way stronger than KC908's sensitivity. In other words, KC908 would be interfered by its own EMI if the antenna points to itself.

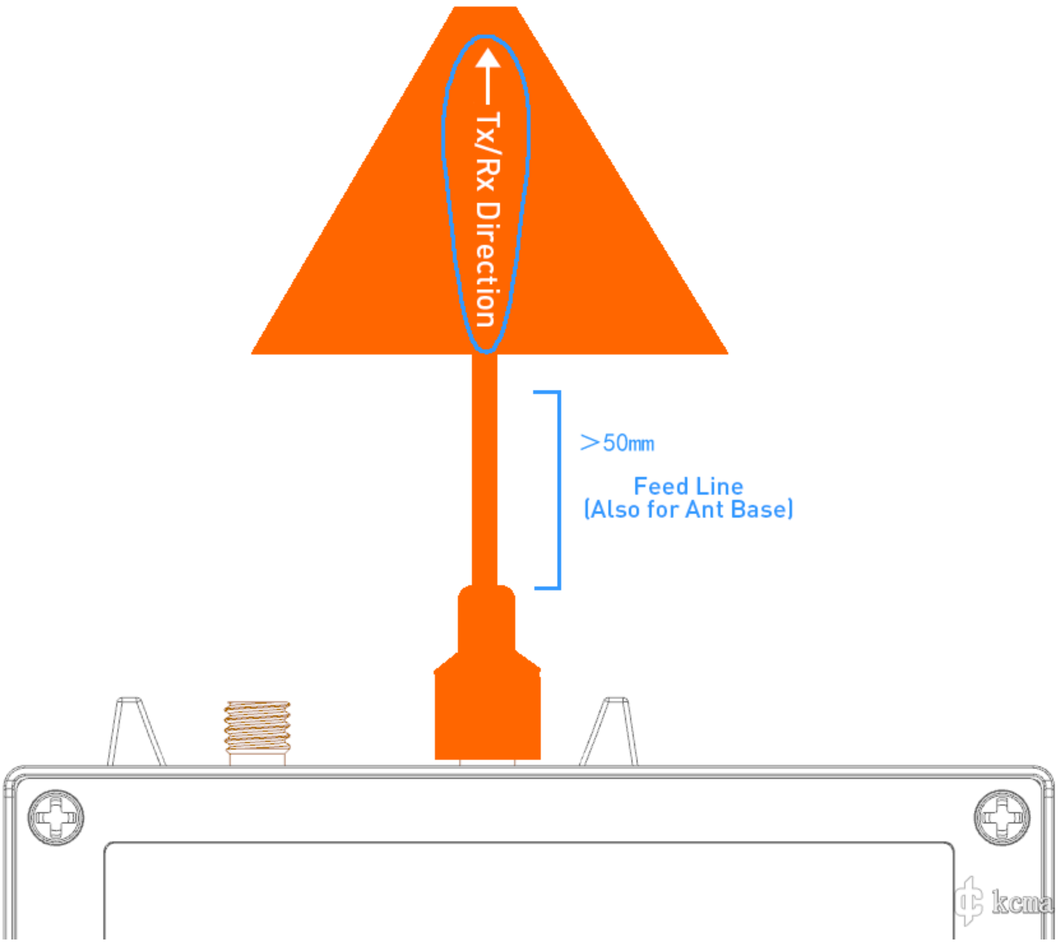
In stead of propagating inside the apparatus, most of the radiation leaks outsides and then turn into interference through the antenna. In a situation where the antenna is not connected, only relatively minor remnant response would appear on the spectrum. And power source interference would not appear. Consequently, the major method to lower the interference is perfecting the isolation for the antenna.

(1) Prefer balanced antennas if possible. Non-balanced antennas could possibly make the shell involved in the transmitting/receiving process, consequently worsening the interference.

(2) Avoid the utilization of loaded antenna, especially those with inductance at the root of the antenna. Loaded coil's extra sensitivity towards magnetic field would worsen the interference. The effect reveals itself most while using radial helical antennas (spring anatennas).

(3) DO NOT point the transmitting/receiving direction of the antenna towards the apparatus. Instead, this direction should be paralleled to KC908, or just keep a distance between the antenna and the apparatus. As the pics shown below.





(4) The root of the handle of the antenna should be firm. Otherwise the core pin would tend to waggle, consequently damaging the RF port.

(5) A soft feeder line should be used to connect the hand–held antenna while direction finding. Always avoid winding the antenna with user's body, as it may hurt the user while the user is running and damage the connector.

(6) To measure the field strength, prepare an antenna whose gain is already known, and input its gain to KC908.

Warning: Most whip antennas are not DC grounded, and the metal oscillator connected to the core pin is even exposed outsides (such as telescopic antennas). In this situation, static electricity on human body or other object can be conducted into the instrument or into the ground, which could easily damage the circuit. For this reason, user should avoid using whip antennas whose metal part is exposed.

4.4 Holding and Carrying

KC908 is designed to be operated with both hands. Hold the machine with both hands and use thumbs to operate the keyboard. To operate the rotary knob, hold the right part of the machine with right hand and rotate the knob with lefr thumb. With baldric attached, it's possible to opearate with single hand.

There are mounting points at both top and bottom part of the apparatus to mount the baldric. Each mounting point, with a maximum bearable force of 100N, is design to withstand the weight of the whole machine. The breaking force of the new baldric is 550N, which is tested in real–world scenario.

The mounting point is narrow, while the baldric is quite thick. While installation, gadgets like tweezer could be used for assistance. Also, user can shape the leading part of the baldric using fingers, to make it easier for the baldric to cross the mounting point.

It is advised to use those two lower mounting points, to place the apparatus in a upside–down position. As for operation position, simply hang the baldric behind the neck and put the machine in front of stomach with its screen facing outside. If the machine is picked up in this position, the panel would face the user.

With those two upper mounting points being used, the screen should be faced inside towards the stomach. However, in this position, user's body would probably get stabbed by the connected antenna if the user falls, thus this position is not recommended. The upper mounting points are just meant for those users accustomed to hand–held and sling–across–shoulder positions.

For running situations, we recommend using the lower mounting points as well as adopting a sling–across–shoulder position.

KC908 comes with **ZERO** ability of water–proof. What's more, even with a silicon case, the situation can barely be improved. In water–related scenarios, the apparatus must be sealed with dedicated water–proof plastic bag in advance. Note that the functions of the two knobs can be completely achieved by simply using the keyboard, so the knobs do not need to be left outside the bag. If the apparatus is exposed to water inadvertently, it must be shut down immediately and place the machine vertically with the left side panel (the knob side) facing down. Once the water goes inside the machine, user should swing it with the left panel facing outside at once, to hopefully get rid of the water inside. Subsequently, place the machine in a safe position to drain the water inside. Attention should be paid to the possibility of battery explosion. If the machine fails to boot, uninstall the battery as soon as possible referring to those steps in chapter 2.4, then send the machine without battery back to factory for repairing.

The screws on the coverplate must be complete in number and tightened. On the other hand, the baldric could possibly loosen itself over time, so it should be checked routinely. During operation on an elevated altitude, strong baldric should be inserted across at least two mounting points to mount the machine firmly, to prevent it from falling.

4.5 Get to Know the Tested Object, Prevent Potential Damage

Make assumption of the tested object, take measures to control the input within safe interval to avoid damaging KC908.

(1) Ensure the insulation between the antenna and the tested object, keep the antenna from touching the tested object.

(2) Pay attention to low-frequency electromagnetic induction when a relatively long antenna is installed, particularly a short wave antenna. The resistant power of KC908 drops when the frequency is below 1MHz, above 0dBm input is strong enough to possibly cause damage at 100KHz.

(3) DO NOT get too close to the transmitter. A power of 1W can be inducted with a transmitter transmitting right next to the antenna. The apparatus can still possibly be damaged with a distance of dozens of centimeters.

(4) Make adequate assumption for DC voltage, signal magnitude, noise level and the static electricity problem before a closed circuit test. Despite the fact that the ports are capable of withstanding a 15V DC voltage, frequent switching caused by poor contact or DC voltage instability (equivalent to AC) could possibly damage the pre-stage of the apparatus.

For different REF, the power resistance of the apparatus varies. With a relatively low REF, 13dBm is enough to cause damage (this value should be considered as 0dBm below 1MHz). Note that this value is total power level, not just the observed signal.

(5) Under circumstances where there is risk or the risk is unclear, protection measures like DC blocking, attenuation and filtering should be adopted. Last but not least, set the attenuator to maximum (30dB) before connecting the circuit that is to be tested.

5.Operation Manual

KC908 can be described as versatile. And the design principle for the menu is to be clear in steps and logic, but not the simpler the better. To live up to this principle, our designers have optimized the human-computer interaction logic with the aim of making it possible for the users to educate themselves following intuition solely. It would typically take half an hour for a person with basic RF knowledge to get the hang of KC908.

One thing we take for granted is that KC908's users are all professional, thus the main focus is the counter-intuitive part. As for the menu structure, the more concise way is operating in person.

5.1 Boot and Shutdown

The POWER button on the lower left part of the keyboard is used to boot/shutdown, while the RB button is used for hard-reboot.

The POWER button would only be functional after being pressed for more than half a second.

Parameters would be stored before each shutdown and restored after each boot.

After RB button is pressed, the power of the machine will be cut completely. The power will recover and the machine will boot up after RB button is released. Since the power is directly cut, the unsaved parameters will be lost, while the saved ones will survive. The RB button on the keyboard is not designed to reset the machine to factory default. For this function, navigate to the FUNC menu and proceed.

The machine comes with a scheduled shutdown capability, and it can be set in FUNC menu.

FUNC→system settings→scheduled shutdown

For example, if this setting is set to 30min, then a 30–min time period without any operation would shut the machine down. Any operation interrupting the countdown would restart the countdown.

To disable this function, input "0" or shorten the time parameter using the knob until "off" is displayed on the screen.

All settings will be saved before executing scheduled shutdown.

5.2 Typical Operations

5.2.1 Primary Functions

KC908 comes with 3 major operating logic other than RUN/STOP buttons.

(1) Menu–select–input(or setting)–confirm(or cancel)

Take setting the central frequency as an example. Press RF/CF button first and the frequency setting menu shows. There are 3 options, central frequency, scanning width and resolution bandwidth. Press and select central frequency option, input the desired frequency and press ENTER to activate.

(2) Menu–switch (on/off)

Example: Switch squelching on. Press AF, select squelch–level squelch, and press on/off button at this time.

(3) Menu–execute

Example: decreasing frequency stepping. In frequency–related settings menu, press ÷10 button, the stepping becomes one tenth. Press again and the stepping becomes tenth of a tenth.

5.2.2 Secondary Functions

The operating logic of secondary functions, which are summoned using SHIFT+buttons, comes as two types.

(1) As a shortcut to other settings, and the subsequent operations resemble primary functions.

Example: SHIFT+LEV to adjust the marker menu swiftly.

(2) Serve as a quick switch between on/off or parameters.

Example: SHIFT+4 to switch the background lighting level. (Press repeatedly to circulate the setting among 10%, 30%, 70% and 100%.)

5.2.3 Mistaken Input

With a mistaken input that involves number, don't press ENTER and reactivate input again, the value would be restored to original setting. When it comes to frequency, press CENT before pressing ENTER would erase the input and restore to original setting.

For setting with relatively long number, a DELETE button would appear on the soft menu. Each time the user presses it, one digit will be erased.

Selective settings take effect instantaneously after being selected. Such as ATT setting, press and select 20, 20dB is set immediately. To correct a mistaken selection, simply select again.

5.2.4 HOME Button

HOME button is used to switch the measuring mode of the machine, and it's constantly used. Whatever the situation is, press the HOME button would show the measuring mode menu or main menu of the current mode. Press the HOME button repeatedly and it would circulate between these two mentioned menus.

5.2.5 FUNC button

To be precise, this button should be CONFIG, as it's meant for system configurations. We call it FUNC simply to respect the custom. After pressing the FUNC button the setting menu appears, to navigate the marker in this menu, use left/right key (+,–key). Press ENTER to select. Menus with resemblance to this one would appear in other functions as well.

5.2.6 Knobs

There are 3 knobs on the left side of the machine. The big one on the front panel is function knob, the same as the small one on the upper left side, while the other one is audio control knob.

Rotating the function knob is equivalent to pressing the +,– key. The knob can be pressed, and pressing it equals to pressing ENTER, normally.

The audio control knob is capable of controlling volume, squelching, level prompt tone central point, etc. The exact function is relevant to settings. For example, in situation where the squelcher hasn't been enabled, this knob cannot be used to adjust squelching. Pressing the knob can switch among those function controls mentioned. Tone will be played after pressing the knob. One beep for volume adjusting, two beeps for squelching, three beeps for level tone central point adjusting. an interval of 5 seconds without input would restore the knob's funtion to volume controlling.

5.2.7 Locking

Press SHIFT+ENTER to lock or unlock the machine to prevent accidental unwanted operation. The locking function comes with multiple configs, which can be specified in FUNC–Local settings.

(1) All. Locks all keys and knobs, leaving only the power button and unlock button effective.

(2) Most. Leaves just the SHIFT key and some level 2 functions effective in addition to power button and unlock button. Those level 2 functions that are still effective are simple on/off, switchings like display brightness, recording on/off. Those complicated settings which need extra key to complete setting are not included.

(3) Locks keyoard and knobs. Part of level 2 functions and audio control are still effective.(This locking config is default out of factory).

(4)Light. Locks the keyboard, leaves the knobs.

(5)Knob. Locks the knobs only.

Rebooting the machine using power buton doesn't change locking config, while rebooting using RB button does.

5.2.8 Custom Parameters

To provide extra convenience, some parameters come with an option of custom value. Take demodulation bandwidth as an example, in addition to those typical options among 150Hz–300KHz, this parameter can potentially be adjusted continuously. Such as a 3.3KHz demodulation bandwidth setting. Whenever there is a "custom" option in the menu, it suggests that this parameter is compatible with custom value setting. To customize, simply select ”custom”, input the value and select desired unit, and that’s it.

The input valued would be saved temporarily. And it would be restored as the default value next time when ”custom” is selected again.

5.3 Complete Operation Procedure

In this episode, several frequently used testing procedures would serve as an example to enlight the users. Hopefully making it possible for the users to educate themselves in other operation procedures.

5.3.1 Demodulating Audio Signal and Measuring Field Intensity

(1) Make it clear what to measure. Like the frequency, bandwidth and modulation method of the tested signal. For example, modulated stereo broadcasting, modulation method is FM and the typical bandwidth is 250kHz.

Different measuring purposes may be corresponding to different sets of parameters. As for modulated broadcasting, nominal bandwidth should be adpoted to ensure the precision of field intensity measurement. Or simply set it according to the testing standards, which typically is 200kHz or 250kHz. A wrong bandwidth selection results in either a smaller-than-actual field strength reading due to the fact that the energy outside the bandwidth hasn’t been detected, or a higher-than-actual field strength reading for taking the unwanted interference into account.

In scenario where monitoring the audio is the main purpose while the field strength is just for a glimpse, bandwidth could be narrowed appropriately, like 120kHz or 150kHz. As for monitoring, the priority is to hear the content clearly. By selecting a minimum bandwidth in which no obvious distortion has occured, noise can be reduced and an ideal monitoring effect can be achieved.

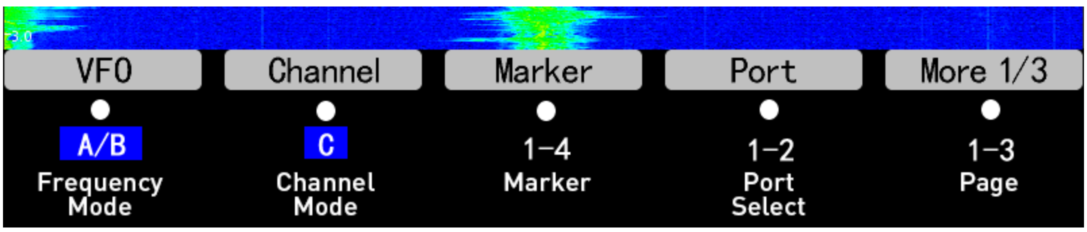
(2) Select desired port and connect the tested antenna. To acquire a precise field strength, an antenna with known gain must be used. As for direction finding, the utilized antenna should come with either a distinct directionality, or a sharp null point. Lastly, if the user just wants to monitor the audio, just select the antenna following heart.

There are 2 ports on the machine with different performance and **the right port is normally meant for receiving.** The pic below shows the pre-selectors of the left/right port.

Connect the antenna to the desired port.

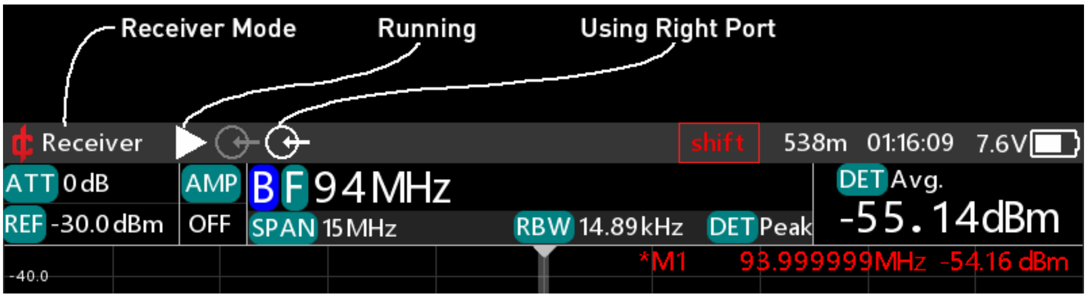
(3) Press and hold **POWER** button for half a second, KC908 beeps and boots. Next, press **HOME** button to switch the machine into **Receiver Mode**.

(4) Check whether the port being used is the desired one. (Right port in this case). If not, select **PORT** on the soft menu on the screen and set it to right port. If the **PORT** option is not present, press **MODE** button repeatedly until mode main menu appears, then press **More** to navigate to the second page. The selected port would shine with a lamp, there will be notification on the upper part of the screen as well.



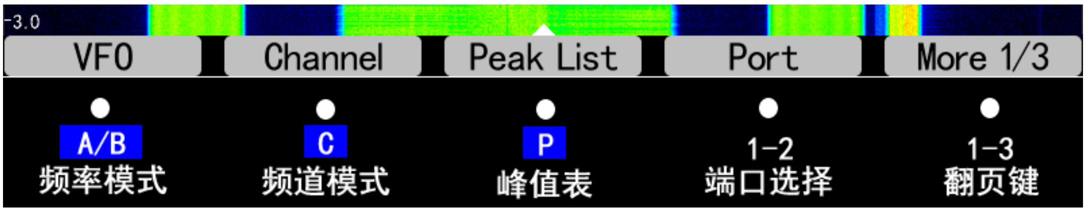
(5) If the apparatus is not running yet, press RUN/STOP button to initiate when desire.

The three conditions displayed on the upper part of the screen should be adjusted to be exact the same as the pic below.



(6) Check the frequency. (F, settings that could be adjusted often displayed as white over a cyan background). Set it to whatever frequency the user needs.

If the frequency to be tested has been stored as a channel, that channel can be accessed by pressing **CHANNEL** on main menu. Following this operation, C channel will be displayed on the screen.



If the peak list is stored in spectrometer mode in advance, receiver mode can directly access those data by selecting Peak List in the pic above, just like the pic below shows.

No matter where the frequency comes from, channel or peak list, **user should push it to VFO** if user wants to adjust the parameters temporarily.

Otherwise, check whether it's using A or B channel. If not, press **VFO** on the menu and select VFOA or VFOB, whichever the user needs. We choose **VFOB** here. The settings of channel A and B are different from each other. The user can specify them in advance and switch instantaneously between two channels.

In VFO mode, user can press CENT button, input the desired frequency through keyboard, like 94, and select MHz unit. Directly clicking the **ENTER** button would attach a MHz as well, since it's default unit.

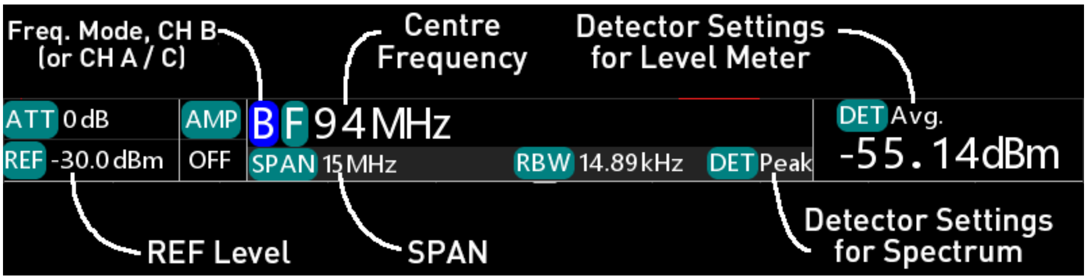
(7) Observe the position of the curve on the screen, if its upper part exceeds the top of the screen, simply increase **REF**. If the curve is miles away from the top of the screen, or its bottom part exceeds the screen bottom, the **REF** should be decreased. If the gain is set to be relevant to the reference, the lower the reference level, the higher the receiving sensitivity, and the weaker the anti-interference ability.

Reference level and other settings that are relevant to signal intensity are all in **LEVEL** menu. To modify these settings, press **LEV** button, input digits, and select unit on the soft menu and press **ENTER** to confirm. Knobs and left/right key (+,-) can also be used.

In circumstance where the curve is well within the screen, yet the background noise is high and the shape of the signal is obviously abnormal, it's possible that the receiver is jammed by a strong interference. Moreover, the interference could be outside the spectrum and thus cannot be directly observed on the screen. To cope with it, manually increase attenuation (ATT) or reduce gain (AMP) would help. These settings are all included in **LEV** menu.

(8) Set **SPAN** appropriately by pressing **SPAN** button. The narrower the width, the higher the resolution, the lower the background noise, and slightly better the anti-interference ability. Vice versa. With other demands satisfied, the narrower the better. Nonetheless, extremely low background noise in a narrow spectrum exposes the residual responses of the apparatus (also known as dots), even making them dazzling.

(9) Normally the spectrum adopts peak detector, and the setting entrance locates in the second page of the mode main menu. This parameter does not worth attention unless the user is paticular with spectrum, like reading number using the marker.

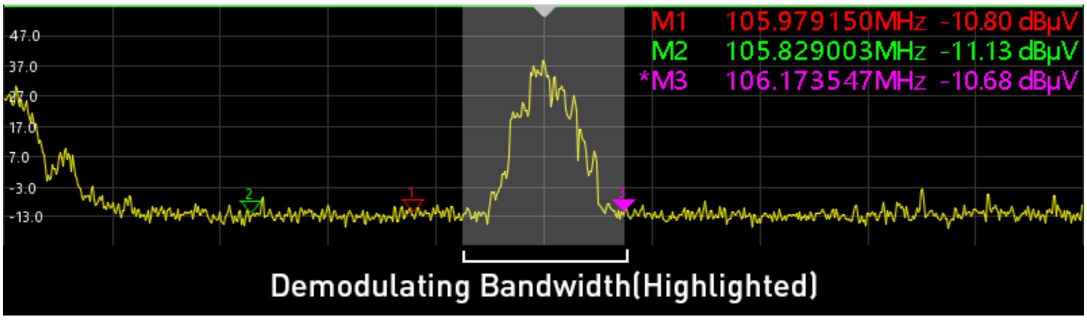


(10) Press **MODU** button to enter demodulation setting menu. Level measurements parameters are also in here.

Firstly, set demodulation. In **MODU** menu, select **DEMOD** option and adjust it using knobs or left/right key. For example, set to FM for measuring modulated broadcating.

Secondly, set demodulating bandwidth, which is 250kHz in this example. Select **DEMOD BW** and adjust using knobs or left/right key. Additionally, it can be specified using **CUSTOM** option. **Demodulating bandwidth is the detection bandwidth of the level meter as well.**

The highlighted area of the spectrum represents the demodulating bandwidth. This highlight function can be switched on/off in setting. The demodulating bandwidth can be adjusted if the tested signal is much wider/narrower than the highlighted area.



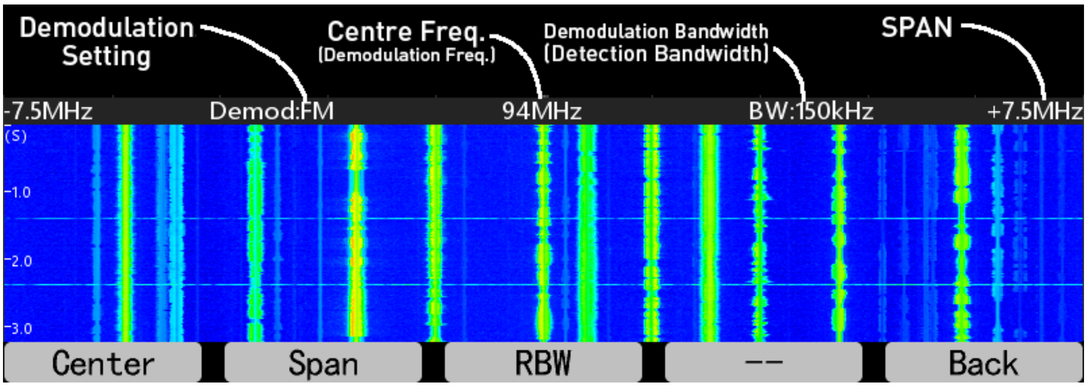
In **MODU** menu, **DETECTOR** defines the way level meter detects the signals. This setting can be neglected if the user just want to take a glance of the level/field strength. Whereas a precise field strength measurement demands the **DETECTOR** parameter properly set accroding to different modulating methods of the signal, or accroding to relevant standards.

(11) Set the data type of Level Meter. Press MODU button and navigate to UNIT option. Simply select the appropriate unit. To directly display field strength, select dBuV/m. In the third page of mode main menu, navigate to ANT GAIN to tell the machine the gain of the antenna, it would calculate the field strength automatically. There is also a unit setting in this page, which is used to determine the unit of the spectrum.

(12) Press **AF** button to enter audio settings. Parameters are volume, squelch, level tone, audio bandwidth, telegram tone, audio auto gain, mute, and so on. Volume can also be adjusted using the knob on the lower left side. Provided that electronic attenuation or

level tone is enabled, by pressing the knob user can specify whose parameter is to be set.

Demodulation parameters are displayed on the information bar on the middle on the screen.



(13) Adjust the antenna , find out the position and direction where field strength maximizes and watch the reading on the screen. For screenshots, press SHIFT+1.

(14) Accumulating function (optional component), which is an optional component, can be used if the standard of the test demands. The entrance locates at mode main menu. The "accumulating method" setting in this function is comprised of peak and average. This detection is executed once again after the detection of the machine itself. For instance, average detecting method has been selected in **MODU** menu, yet peak accumulating method is set in accumulating menu, then the machine will pick the peak value among several average values. The accumulating time can also be set, such as a typical value of 360 seconds in electromagnetic radiation standard.

(15) Provided that these mention settings are freqeuently used, they should be stored as a channel. To do that, press **VFO** in mode main menu, then press **SAVE** and select a number for these settings. By default it would assign the minimum number available.

(16) Lastly, long press **POWER** button to shutdown after the test is done. All the settings will be saved and will be restored after next boot.

5.3.2 Search and Measure Nearby Emissive Source

In technical field, chances are it's clear there is a emissive source nearby and its frequency needs to be measured. For instance, several people is communicating using walkie-talkie in the public. The frequency they are on needs to be found and the content of the conversation needs to be demodulated. Traditionally this mission would be completed by cymometer. Being referred to as "receiver searcher", it's effectively a receiver served by the cymometer. However, the sensitivity of the cymometer is relatively low and it's vulnerable to interference produced by emissive sources out of interest (like mobile phone base station). Fortunately, the spectrum mode of KC908 offers a performance right on the sweet spot of speed, sensitivity, anti-interference ability as well as frequency accuracy, in other words, an ideal comprehensive performance.

(1) Connect the antenna and boot, enter **SPECTRUM** mode in **MODE** menu. Enter frequency setting by pressing **CENT** button. Take the preset scenario above as an instance. Normally walkie-talkie works between 300-500MHz, thus **CENTER** could be set to 400MHz, and **SPAN** set to 200MHz. Use START, STOP option to spcify 300-500MHz also works.

(2) Since it's from neighbourhood, the signal tends to be strong. Lower the sensitivity by pressing **LEV** button and set **REF** to -10dBm or higher.

(3) Use marker function if manual observation is scheduled to find the emission frequency. Press **MODU** into marker menu, press M1 to activate marker M1 and enter its setting. Press **MORE**, select **AUTO Peaking**. Then press **BACK** button to return to M1's function menu.

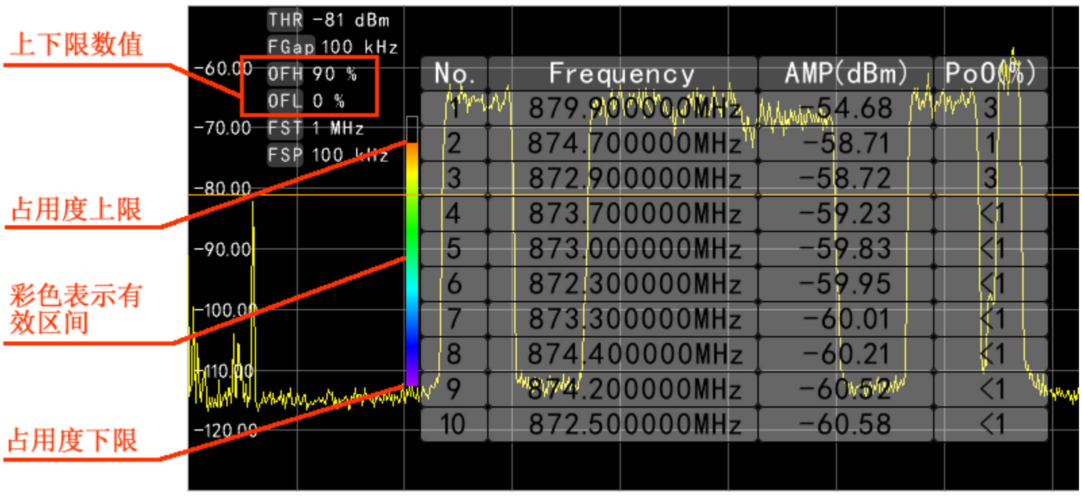
(4) Put a finger on **TO RECEIVER** option and observe the curve. It can be seen that the marker is finding the peak automatically in real-time.

(5) Attributing to the close distance, the emissive source of interest tends to be very strong, reaching -30dBm with a distance of tens of meters. Within such a distance, a signal that is detectable for a cymometer typically reaches stronger than -20dBm. Press **TO RECEIVER** button immediately as soon as such a strong narrow-band signal appears in the spectrum, to set the frequency to receiver. Next, observe the spectrum on the receiver, fine tune the frequency to centralize that signal. Lastly, adjust the settings of the receiver to demodulate that signal.

(6) To log strong signals over a period of time, use **PEAK TABLE** function. Its entrance locates on mode main menu. Press ON/OFF after entering to enable this function, and the list could be seen. Whenever manual observation is preferred, select **HIDDEN** button to temporarily hide this table, whose log would still be running in the background. Press **HIDDEN** again to show the hidden table.

(7) If necessary, parameters such as **FREQ GAP**, **LEV GAP** and **Threshold**, etc, can be set in **SEARCH SET** menu. Tips are, set **FREQ GAP** to half of channel gap like 12.5KHz, set **LEV GAP** to 5dB or above, set **Threshold** to -30dBm. (With a whip antenna of one fourth wavelength, that is equivalent to a 1W walkie-talkie within 50 meters). Frequency gap should be set to less than a half of the channel gap, like 10kHz, while amplitude gap should be set to 10dB or bigger.

Utilise the occupancy filter function properly. To rule out constant emission strong signals, set the upper limit to 90%, and the lower limit to 0%. After that, observe the colorful indicator, the top should be empty and the rest part should be colorful.



(8) After a period of time, check the **PEAK TABLE** and estimate whether the signal of interest is logged. If the answer is yes, press the save button on the soft menu to save the table.

The table will be saved to TF card (if equipped) as well as the VFO temporary frequency list. In Receiver mode, enter VFO and access the list, then use knobs or left/right key to move the frequencies to be selected, which correspond to top 100 strong signals that have just been saved. For frequency of interest, it can be saved to channel list separately.

The data in this temporary frequency list will be refreshed if the **PEAK TABLE** function is used and saved again.

(9) Frequency of interest can also be selected directly on **PEAK TABLE**, and be sent to receiver. This operation sends the frequency to VFOB, the the current B channel frequency will be overwritten, while other settings remain the same. The drawback of this method is that if the frequency needs to be selected again, the user need to re-enter the PEAK TABLE to operate.

(10) If the analogical demodulator is not capable of demodulating the signal, press key combination SHIFT+2 to record the IQ data for future analysis.(a TF card needs to be installed in advance).

6.FAQ

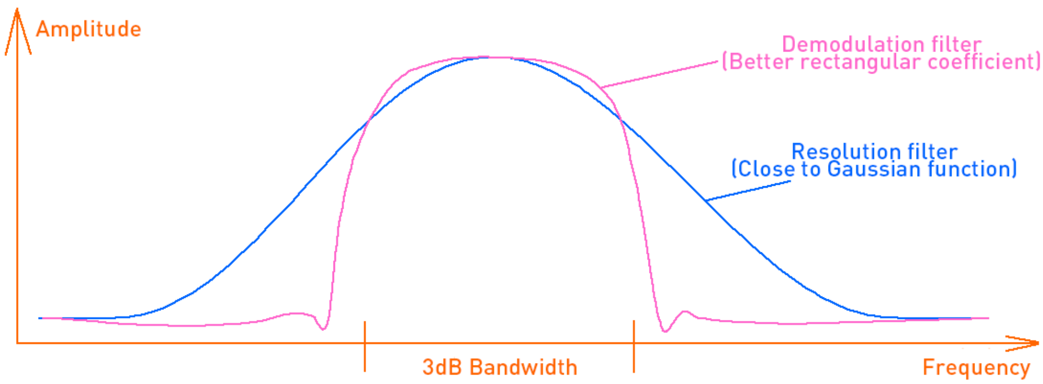
This section mainly answers the questions often asked in normal use, but dosen't include any basic knowledge.

6.1 Why is the reading of the spectrum inconsistent with the field intensity in receiving mode?

For KC908, the value of LEVEL (field intensity) is the total energy within the whole bandwith of demodulation. The SPECTRUM is showing how those energy distributes in the frequency domain. Each point on the spectrum curve represents the energy within the resolution bandwidth(RBW), approximately.

Or we can say, the bandwidth represented by each point on the SPECTRUM may be different from the read out of the detection bandwidth of LEVEL. Different bandwidth, different energy is collected, and the read out must be different.

For narrow-band signal, e.g. unmodulated carriers, the readout from spectrum and level are very close. For wide-band signal, e.g. CDMA signal), these two readout can be very different depending on the bandwidth settings. If the RBW of spectrum and the demodulation bandwidth(DEMODU BW) are set to same value, those two read out should be basically the same. Of course there will be a minor difference since spectrum analyzer uses a Gaussian filter(for meet certain standards) but the demodulation uses a rectangular filer, their passband shapes are not similar.



For wide-band signals, the wider the resolution bandwidth or demodulation bandwidth is set, the larger the readout will be.

Also, the detection method of SPECTRUM and LEVEL can be set separately. If then, the readout will be different.

6.2 Why the squelch can be turned on when the frequency spectrum is lower than the threshold of the squelch level?

The reason is the same as 6.1. The basis for level squelch is level(field intensity) readout. Spectral resolution bandwidth is usually narrower than demodulation bandwidth, thus the signal curve will often below the level value.

Since the squelch level line on the screen is drawn by the level of demodulator, the level in demodulator will be higher than RBW value.there will be a situation where the spectrum is lower than the prompt line but the squelch is still turned on.

The wider the demodulation bandwidth, the greater this difference. When setting the squelch level, please pay attention to the level readout.

6.3 Why the refresh rate is slow when SPAN is set to narrow?

The spectral resolution of KC908 is tied to SPAN. The narrower the SPAN, the smaller the resolution(RBW).

For example, when SPAN=1KHz, the resolution is 1Hz. It takes time to measure the frequency of 1 Hz, and the period of the 1 Hz is 1 second. To increse the frequency resolution, either add more sampling points, or narrow the bandwidth, this is the principle of FFT. And more sampling points means more time, in certain amout of sampling point, the narrower the bandwidth, the longer the period, means it'll take longer to collect the same amout of sampling point.

For sacannning spectrum, the narrower the RBW, the narrower the bandwidth of the resolution filter, and the longer it takes for the signal to pass through.

For example, there is a filter with a nominal bandwidth = 1Hz, if a signal can pass through it within 0.5s, then it will pass a signal of 2Hz at least, this is obviously contradicted with the bandwidth. Actually the response time of the filter will be longer. At high resolution, FFT spectrum is way fatster than scanning spectrum.

6.4 Where does the image interference appear?

In the range of 0~750MHz(0–500MHz for left port) and above 6GHz, there may be two kinds of image interference, namely the image interference of the first mixer and the second image interference. For 10.8GHz model, the frequency of the 1st IF is about 2.65 GHz, and the image interference point is about 5.3 GHz away from the observation frequency point. The severity of the image interference depends on the performance of the preselector.

Using a high LO in 0~750MHz, an image signal of 5.3GHz~5.8GHz may appear, which is usually more than 60dB lower than the real signal. Because the performance of low-frequency antennas at high frequencies is often not ideal and can bring in more image suppression, this part of image interference has minor influence.

Above 6GHz, 10.8GHz model and 18.6GHz model adopt different strategies for LO as well as for preselection.

Low LO is used by 10.8GHz model above 6GHz, and the signals within 0–5.5GHz might become an image interference. However this frequency band comes with strict preselector offering at least 50dB image suppression. Thus the major concern for 10.8GHz is spurious response introduced by the second, third LO harmonic wave.

The 18.6GHz model adopts tracking preselector, protecting all its passband from image interference frequencies, thus it can offer at least 50dB image suppression.

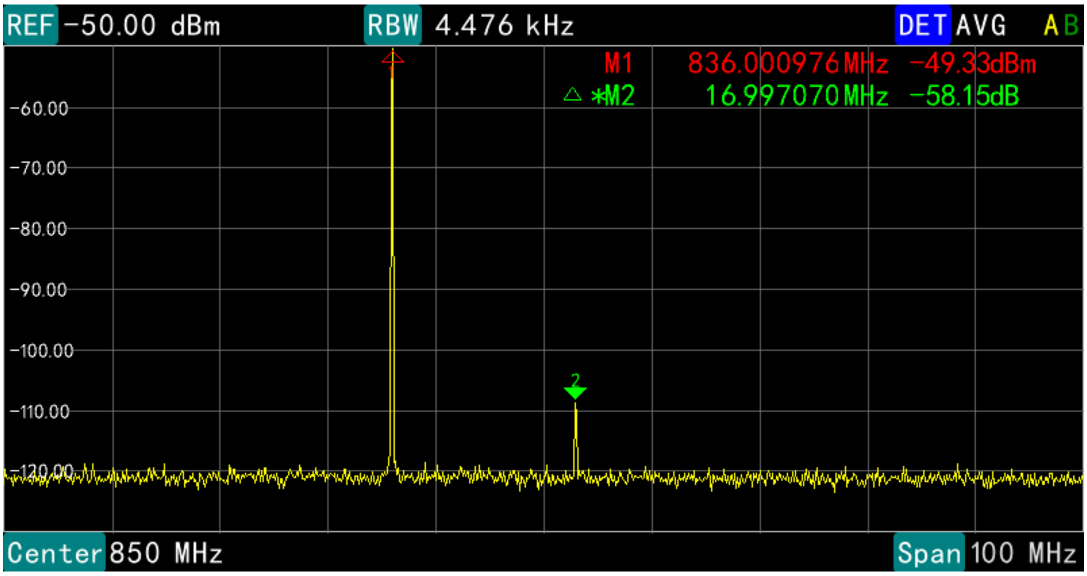
You can pre-determine whether the signal is true or fake by adjusting the center frequency and observe the direction and speed of spectral line movement. For example, if the central frequency is increased, the true signal will move left, while the image signal will move right. The moving speed of the true signal is equal to the speed the center frequency shifts, while the fake response caused by the harmonic wave mixing would have a faster moving speed.

The second image interference is inherent in the zero-IF receiver, and suppression is usually up to 60dB, occasionally drops to 40dB. The second image signal is often very close to the true signal, the typical distance is 6 ~ 31MHz, but with a narrow SPAN, the distance will become closer, can be about 1MHz minimum.

In the range of 750MHz~6GHz, usually only the image interference of the zero-IF receiver occurs, and its characteristics resemble the second image interference's mentioned.

Second image suppression might become obvious after a long period of consistent operation. User could consider pausing or rebooting the machine to re-calibrate the IQ, so as to mitigate the suppression. In addition, decreasing the input signal, lowering IF gain and changing central frequency(CENT) would probably help.

The pic below shows a relative severe situation of second image interference, where the image suppression is approximately 58dB. By shifting central frequency, the interference could be lowered to -65dBc. Since the second image is very close to tested signal, user needs to keep in mind not to confuse it with the spurious divergence. To distinguish them, user can simply shift the central frequency and observe whether it moves with the main wave at the same time.



6.5 What about other interference besides image interference?

Besides image interference, higher-order harmonics, intermodulation and other reason will also produce false responses, usually below -60dBc. However in reality, the working conditions of the preamplifier are not ideal, which probably makes it worse than this value, due to the fact that the total amount of energy entering the receiver is tremendous. User should note that the front low-noise amplifier of the KC908 has been working continuously. Manually turn off the amplification (by press the LEV key, set in the AMP menu) or setting a higher REF only greatly reduces the gain of the front low-noise amplifier, but can not 'turn off' it completely. Therefore, the probability of fake signal is generally greater than traditional spectrum analyzers which the signal directly inputted into the mixer.

The situation is better than a traditional spectrum analyzer with preamplifier turnd on. This is a compromise between high sensitivity and anti-interference ability. For details, see the index of third-order intercept point.

KC908 will generate EMI itself. These radiation will leak into the receiver from the inside of the instrument, just a small amount.The resulting residual response is usually below -100dBm. Most part of radiation will leak into the sky, and those radiation may be received back by its own antenna, especially when the whip antenna is directly connected to instrument port. This interference may cause a large residual response.

The residual response mentioned above will be obvious on KC908. One of the reasons is the instrument will maintain high sensitivity even under a wide span. e.g, the noise floor is still as low as -120dBm(Avg), with 1GHz span. At this time, the residual responses in the entire span are at a glance. On the other side, the noise floor is usually as high as -80dBm with traditional scanning spectrum with 1GHz span, which is enough to cover all the residual responses.

While using a narrower SPAN (such as receiving mode), the noise floor is often as low as -130~-140dBm, and the internal leakage interference will become easy to notice. Considering the size of KC908 is too small to isolate, it is recommended to keep the antenna away from the body of instrument to reduce interference.

What's more, occasionally there will be a relatively large residual response at 9.800GHz,
yet since the residual part is fixed, it's quite easy to notice.

6.6 Why is there an overload occurred even the signal has not exceed REF?

Real-time spectrum analyzers are usually only equipped with wide analog filter. The signal in the entire filter passband will be sent to the post stage, resulting in a quite high total power level. If there are lot of signals in passband, there will be a situation where the peak of the spectrum hasn't overflowed, but the sum of the signals has already overloaded.

In KC908, the analog bandwidth is wider than SPAN, usually around 50MHz. In other words, signals that are not visible on the spectrum can also cause overload. After overload occurs,the instrument usually will displays a prompt, but it is not quite reliable.

Increase REF as much as possible to prevent overload, as long as you are satisfied with sensitivity. In receiver mode preamplifiers should be turned off.(AMP set to 20dB or 0dB)

After overload, the spectrogram will be distorted and clutter will appear. In this case, increase REF, lower the gain and increase attenuation(LEV-GAIN-ATT) until the everyting is back to normal.

The front stage of the instrument may also be overloaded besides the overload of the ADC. It's also called blocking. Strong signals causing block may be far from the set frequency, they can still be relevant as long as they are within the corresponding preselector band(see 2.7). This situation often occurs when there's a base station or a broadcasting station nearby. It should be noted that the anti-blocking capability of this instrument is relatively strong, due to the usage of high compression point amplifiers and mixers. But the cost is power consumption.

The common phenomenon of pre-stage overload is: the signal peak value is reduced, the noise floor is raised by 20~30dB, and a lot of burrs appear on the originally independent signal. User can try changing the antenna orientation, increase REF, or set manual attenuation (LEV-AMP-ATT). It means that an overload has occurred indeed during this process, if the burrs suddenly appears and suddenly be gone, or the background noise suddenly decreases, etc.

In the case of complex electromagnetic environments such as in the middle of city, rooftops, or when using outdoor antennas, you can manually turn the 10-20dB attenuator on and turn off the amplifier to improve the ability to resist overload. Just remember to set it back to auto in normal handheld scenario.

Sometimes the noise floor may rise up to -70dBm indoors. Usually there is real interference, but not overload. You can try turning off the lights, staying away from electrical devices, or going outdoors. Indoor interference is often caused by shoddy LED lights.

6.7 The shell is hot while working, is it normal?

Many high linear power amplifiers and mixers are integrated inside the instrument. High linearity means high current and high energy consumption. Meanwhile, the high-speed digital circuits also needs enormous power resources, these factors would lead to heat generation too. The minimum power consumption of KC908 is about 10 watts, and typical power consumption is 12W, while the peak power consumption is 15W. When charging the battery, an additional 4W power will be dissipated apart from the energy stored in the battery. At this time, the shell will be very hot. The temperature of the shell will increase 20~35℃ with these heat. In summer, the surface temperature can reach 70℃, which may cause burns. In winter, it can be used as a "hand warmer". This situation has been considered during design, also over-temperature protection measures are designed. There's no significant effect to the instrument, so there is no need to worry about. (Of course, there's a slight influence on battery life and measurement performance)

To avoid accidents, do not wrap the instrument with thermal insulation material. If the instrument needs to be installed in a poorly ventilated chasis or anywhere that the ambient temperature exceeds 40°C, there should be some active ventilated means or a heatsink should be added to the surface of the instrument.

7. Parameters

Those max/min in this chapter refers to the extreme values observed in normal situation. Occasional factors or a prolonged period observation might exceed these values.

7.1 Frequency Range

Port	Min	Typical	Max	Note
Spectrometer, receiver				
port 1, left	100kHz		6GHz	effective (note 1)
	0		6GHz	setable
port 2, right	100kHz		10.8/18.6GHz	effective
	0		10.8/18.6GHz	setable
Comparator(note 2)				

Both ports used	1MHz		6GHz	effective
	0		6GHz	setable
Signal source(note 3)				
port 1, left	100kHz		10.8/18.6GHz	effective
	0		10.8/18.6GHz	setable
port 2, right	100MHz		6GHz	effective
	80MHz		6GHz	setable

Note: 1. Effective values are relatively reliable, the exceeding part is just for the experienced engineers' temporary usage. 2. Non-official funtion. Whether or not this function/frequency range is available depends on the model the user purchased.

7.2 Spectrum Width(KC908A/B)

port	min	typical	max	note
spectrometer				
port 1, left	1kHz		5.995GHz	effective
	1kHz		6GHz	setable
port 2, right	1kHz		10.8/18.6GHz	effective
	1kHz		10.8/18.6GHz	setab
receiver				
	1kHz		15MHz	

comparator				
	1kHz		10MHz	

7.3 Bandwidth

7.3.1 Resolution Bandwidth

Resolution bandwidth is relevant to spectrum width(SPAN). The minimum resolution bandwidth after adjusting SPAN is 1Hz, while the maximum value is 2.048MHz(the max adjustable value is 8MHz, not guaranteed). This setting is continuously adjustable with the permitted SPAN range.

7.3.2 Real-time Bandwidth

When displayed locally, the real-time bandwidth is 15MHz. The spectrum of receiver only works in real-time bandwidth's range, and SPAN is continuously adjustable. When spectrometer's SPAN is set to less than 15MHz, it's real-time spectrum, while when SPAN is over 15MHz, it becomes spliced spectrum.

The max real-time bandwidth is around 38MHz and the sample rate is 40M while using IQ data output.

7.3.3 Demodulation Bandwidth

The range is 150Hz-300kHz, it's continuously adjustable under the setting of 3 effective digits. The machine offers commonly used bandwidth list for users to select.

7.3.4 Recording Bandwidth

While recording IQ data to TF card, the sampling rate of IQ data is relevant to demodulation bandwidth, and usually this value is 1.2x-2x of demodulation bandwidth. With demodulation bandwidth under 200kHz, IQ data can be written to TF card instantaneously. The only limitation the capacity of TF card, and there is no max recording time limit. When the demodulation bandwidth is larger than 200kHz, IQ data would be written to DDR memory first, then wriiten to TF card at a relatively low speed, with a max recording time limitation of 90 seconds.

7.3.5 Audio Bandwidth

No matter how the demodulation bandwidth is set, the max audio bandwidth are always 15kHz. Audio bandwidth could be set within a range of 150Hz-15kHz, and it's continuously adjustable with 3 effective digits. The machine offers common bandwidth list for the user to select.

7.4 Frequency Accuracy(note 1)

Item	Condition	Min	Typical	Max
Central uncertainty	25℃		0.5ppm	1ppm
	-20~40℃		1ppm	2ppm
Long-term stability	1a,25℃		0.5ppm	1ppm
Short-term stability(note 2)	1hr,25℃		0.1ppm	0.5ppm
SPAN uncertainty			0.1%	0.2%
Software calibration range		2ppm		

Note: i. Tested after 10-min preheat. all the temperatures are ambient temperature.
ii. The frequency of the machine can be calibrated in FUNC-System Settings, thus short-term stability is more important.

7.5 Amplitude

Item	Min	Typical	Max	Note/Condition
Spectrometer, receiver				
REF range	-100dBm		20dBm(note 1)	effective
	-100dBm		20dBm	setable
damage level			23dBm	ATT>=10dB
			13dBm	ATT=0dB
amplitude uncertainty (note 2)		±1.5dB		1MHz-6GHz
		±2dB		6-10.8GHz

		±2dB		6–18.6GHz
Signal Uncertainty(note 3)				
left port		±2dB(note 4)		1MHz–6GHz
		±3dB(note 4)		6–10.8/18.6GHz
right port		±3dB(note 4)		100MHz–6Ghz
max output level		13dBm		1MHz–6GHz
		0dBm		10.8GHz model
		13dBm		18.6GHz model
		–3dBm		right port

Note: 1. When frequency is above 10MHz. With frequency between 1–10MHz, 10dBm. Frequency <=1MHz, 0dBm.

2. Ambient temperature 25℃, after 10min preheat.
3. Non-official function, just for reference. all tested with CW output.
4. In specific amplitude range. Other amplitude deviation might be bigger.(system warns ”Unlevel”)

7.6 Spectrometer/Receiver SSB Phase Noise

Frequency	Distance	Min dBc/Hz	Typical dBc/Hz	Max dBc/Hz
100MHz	1kHz		–83	–80
	10kHz		–94	–90
	100kHz		–95	–92
	1MHz		–107	–105

749MHz(note 1)	1kHz		–85	–80
	10kHz		–91	–88
	100kHz		–92	–90
	1MHz		–108	–105
751MHz	1kHz		–105	–102
	10kHz		–115	–110
	100kHz		–113	–110
	1MHz		–120	–105

1GHz	1kHz		−100	−95
	10kHz		−110	−103
	100kHz		−107	−105
	1MHz		−117	−113
4GHz	1kHz		−90	−80
	10kHz		−93	−87
	100kHz		−94	−87
	1MHz		−105	−100

10GHz	1kHz		−70	−62
	10kHz		−87	−80
	100kHz		−85	−79
	1MHz		−106	−100

Note: 1. There are 3 frequency changes while working below 750MHz, the local oscillations of the first and second LO frequency change are above 2GHz. For this reason, the phase noise of 749MHz is obviously worse than 751MHz.

7.7 Anti-interference Ability

Item	Condition	Typical	Max	Note
Residual Response (port not connected)	100kHz−3MHz	−90dBm		REF=−70dBm, others at auto. Turning off AMP manually would increase the residual response.
	3MHz−35MHz	−110dBm	−100dBm	
	35−750MHz (note1)	−120dBm	−105dBm	
	750MHz−6GHz	−100dBm	−90dBm	
	6−10.8/18.6GHz	−110dBm	−100dBm	
Residual Response(port with 10cm copper wire inserted)	100kHz−35kHz	−90dBm		Tested in the anechoic chamber. REF=−70dBm, other settings at auto.
	35−750MHz	−85dBm		
	750MHz−6GHz	−80dBm		
	6−10.8/18.6GHz	−90dBm		
Harmonic suppression	REF=−40dBm	60dBc	35dBc	Incoming carrier =−43dBm

Spurious Response	REF=–40dBm, incoming carrier=–43dBm	–50dBc	–35dBc	Image, harmonic response not included
Image suppression	100kHz–6GHz, incoming carrier 6dB lower than REF	60dBc	35dBc	Refer to Chapter 6.4

Front–end third–order intercept point	AMP:40, ATT:0	–29dBm		IF part not included. 1MHz–750MHz
	AMP:20, ATT:0	7dBm		
	AMP:20, ATT:30	35dBm		
	AMP:40, ATT:0	–3dBm		IF part not included. 750MHz–6GHz
	AMP:20, ATT:0	18dBm		
	AMP:20, ATT:30	46dBm		
	ATT:0, AMP:20	5dBm		6–10.8/18.6GHz IF part not included.
	ATT:30, AMP:20	32dBm		

Input third–order intercept point with max IF gain	AMP:40, ATT:0	–42dBm		1MHz–750MHz, IF included, REF<–60dBm.
	AMP:20, ATT:0	–14dBm		
	AMP:20, ATT:30	14dBm		
	AMP:40, ATT:0	–40dBm		750MHz–6GHz, IF included REF<–60dBm.
	AMP:20, ATT:0	–18dBm		
	AMP:20, ATT:30	10dBm		
	AMP:0, ATT:20	–16dBm		6–10.8/18.6GHz, REF<–60dBm.
	AMP:30, ATT:20	12dBm		

Remote blocking level	100kHz–35MHz, interference above 55MHz	10dBm		REF=–70dBm (achieved max gain), others at auto (AMP40). Port 2, the interference level making –80dBm signal's level drop 6dB. Port 1 is inferior to port 2.
	35MHz–750MHz, distance 50MHz	–32dBm		
	750MHz–6Ghz, distance 100MHz	–33dBm		
	6–10.8GHz (10.8GHz model), distance 100MHz	–17dBm		
	6–18.6GHz(18.6 model), distance 100MHz	–13dBm		
	1MHz–750MHz, distance 100MHz	higher than 23dBm		REF=20dBm (minimum gain), other settings at auto(AMP0), both ports, interference level making 0dBm signal level drop 6dB.
	750MHz–6GHz, distance 100MHz	higher than 23dBm		
	6–18.6GHz, distance 100MHz	higher than 23dBm		

Proximal blocking level	With only one strong interference, usually at REF+6dB, no blocking happens(signal level drops 6dB). With multiple interference signals, calculate the total power within central frequency ±50MHz or within the range of preselector(whichever is narrower), no more than REF+6dB. For interference outside this range, refer to remote blocking level.			
LO Leakage	<=750MHz or >6Ghz	–40dBm		
	750MHz–6GHz	–100dBm		

Note 1: All 750MHz segment split point in the manual only applies to 10.8GHz model. As for 18.6 model, the point would be 500MHz.

7.8 Speed(note 1)

Item	Condition	Typical	Max	Note
Tuning speed	100kHz–750MHz	2ms/pt	3ms/pt	The gap between switching frequency and obtaining correct data, RBW=5kHz
	750MHz–6GHz	10ms/pt	15ms/pt	
	6–10.8/18.6GHz	2ms/pt	3ms/pt	
Update speed	100kHz–750MHz	5GHz/s	7.5GHz/s	RBW=5kHz
	750MHz–6GHz	2GHz/s	3GHz/s	
	6–10.8/18.6GHz	5GHz/s	7.5GHz/s	
Spectrum refresh rate		20FPS		SPAN=15MHz
Time resolution of waterfall chart		100Lps(10ms)		0.5s/div
reading refresh speed		0.05s		
Capturing time in real-time bandwidth	discover signals	5us		SPAN=15MHz. Smaller the SPAN, longer the capturing time.
	measure accurately		210us	
Booting time	From pressing to operatable	10s		
Shutdown time	From pressing to fully shutdown	2s		
Squelcher shutdown time		10ms		

NOTE: 1. Just for spectrometer and receiver. Comparator not included.

7.9 Sensitivity(KC908A/B/W)(note 1)

Item	Condition	Typical	Max	Note

Normalized noise floor (note 2)	3MHz–750MHz	–162dBm/Hz	–155dBm/Hz	All refer to with max gain. REF=–70dBm, others at auto. Average value detection mode.
	750MHz–6GHz	–163dBm/Hz	–153dBm/Hz	
	6–10.8GHz	–160dBm/Hz	–147dBm/Hz	
	6–18.6GHz	–157dBm/Hz	–143dBm/Hz	
	18.6–32GHz	–153dBm/Hz		
	32–43.5GHz	–157dBm/Hz		
FM demodulation (note 3)	3MHz–750MHz	0.3uV		12kHz BW
AM demodulation (note 3)	1MHz–750MHz	1uV		6kHz BW
SSB demodulation (note 3)	1MHz–750MHz	0.15uV		3kHz BW
CW demodulation (note 3)	1MHz–750MHz	0.1uV		600Hz BW

Note:

1. Ambient temperature 25℃, neglect influence by residual response or other factors.
2. At frequency below 3MHz, noise floor would rise obviously.
3. Sensitivity indicators relevant to demodulation are all refering to the situation in which SINAD is approximately 12dB. The modulating signal is 1kHz single tone, FM modulation frequency deviation is 3kHz, AM modulation 80% depth. CW as non–modulated carrier. PRE AMP, AGC turned on.

Parameter	Min	Typical	Max	Note
Port DC voltage withstand ability	/	/	10V	RF port
External DC power supply	10.5V 4.9V		26V 20V	5.5/2.5 Power Jack TYPE–C port
External DC power current	/ /	2.0A 1.5A	2.5A 3A	5.5/2.5 Power Jack TYPE–C port
Battery Voltage	6.5V	/	8.5V	/
Power Consumption (10% volume, 50% display brightness)	10W 14W /	12W 16W 4W	15W 20W /	Battery only. Running. 12V external power connected. Running. Battery only. Idle.
Shutdown Power				

Power Consumption	/	500uW	1mW	Battery only.
Storage Time with power	1a	2a	/	With initial battery voltage of 7.5V
Speaker Power	/	2W	4W	
Audio LineOut Power	/	1W	1.5W	Impedance of 4Ohm
MIC Input Sensitivity	/	50mV	/	Impedance of 600 Ohm
Internal Barometer Range	300 hPa	/	1100 hPa	
Internal Barometer Uncertainty	/	0.5 hPA	/	Core temperature at 40℃
Internal Inclinometer Uncertainty	/	1 degree	/	After calibration
Internal Magnetic Compass Uncertainty	/	5 degrees	/	After calibration
Ambient Temperature	0℃ -40℃ -40℃ 0℃	/	40℃ 50℃ 70℃ 35℃	Nomal range Permitted range Short-term storage Long-term storage
	The minimum acceptable temperature mentioned above is determined by the minimum usable temperature of the battery.		The core temperature of the machine must be lower than the upper limit of the battery temperature.	
Relative Humidity	0%	/	95%	Runing or short-term storage
Waterproof	/	Level 0		No waterproof ability
Falling Resistance (Damaged appearance yet perfectly functional)	/	30cm 1.2m	/	Without protective case With a protective case
Aseismatic Ability	/	20Hz@5G@30 min, any direction	/	
Size	/	188x110x39 177x102x32	/	Main body only, with stick-out part Without stick-out part

Net Weight	/	908g	/	Main body with battery inside.
Package Weight	/	3kg	/	With stock protective case