Operating Manual
for the
IMD Meter by kk7uq

Stand Alone IMD Measurements
for
PSK Modes

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1.0 Introduction

This manual describes operation of the ***IMD Meter by kk7uq***. This is a stand alone instrument. It picks up the locally transmitted RF signal on a small antenna built into the meter; amplifies the signal with an AGC controlled, wide band RF amplifier; uses a diode detector to convert the received RF wave form to a continuous low frequency function; and then feeds this function to the A/D converter of a micro controller. The micro controller analyzes the signal wave form and provides a digital display of the equivalent IMD of the signal being transmitted.

1.1 Intended Use - The IMD Meter design has been created for the amateur radio community to encourage more hams to enjoy the pleasures of sound card digital modes. The IMD Meter is an instrument used to measure the signal quality of BPSK and QPSK transmissions, allowing optimum setting of the audio drive level to the transceiver during operations in these modes. It is ideal for use by ham clubs to aid their members in setting up their equipment for PSK, and for the individual ham who wants to set optimum power levels consistent with excellent signal quality.

1.2 Scope - This manual describes operation of the IMD Meter. Included in this manual are description of controls and displays, initial setup, and daily operation techniques of PSK stations equipped with the IMD Meter.

1.3 Features - Features of the IMD Meter are:

- Measures the IMD of your PSK signal while you are transmitting.
- Used for BPSK31, QPSK31, and BPSK63 operating modes.
- Stand alone device, does not require a connection to your PC for operation.
- Gives equivalent IMD reading when transmit is in Idle mode (no typing, empty buffer), or while transmitting data (typing).
- Operates from 160 meters to 10 meters, no band select required.
- Wide dynamic range, measures signals at QRP to high power levels.
- Accurate to ± 1db of IMD for measurements -23dB and higher (less negative). At -24 and lower, reading accuracy is from 0 to 5 dB of actual. Readings are intentionally set to give conservative readings in this “good” range. IMD readings displayed will be in the range of -10 dB to -34 dB.

Features - continued

- Three digit, Red LED display used to display the equivalent IMD or of relative signal field strength, depending upon mode.
- Two LED, Green and Red, provide a summary view of Good or Bad signal quality.
- An audio tone generator sends four dots (Morse "H") when the IMD goes above -20dB. When the signal has been adjusted and drops below -24 dB, it sends two dots (Morse "I"). The Morse "H" signal is sent once every 100 samples if it remains above the -20 dB threshold. The Morse "I" signal is sent once, when it returns below -24 dB.
- A mode control switch to select one of three modes: UP - measures IMD when transmitting in BPSK63 mode. CENTER - measures IMD when transmitting in either BPSK31 or QPSK31 mode. DOWN - measures relative field strength to aid in selecting best setting of whip antenna, and meter placement.
- Built in whip antenna, adjustable from 6" to 20".
- Wide band RF amplifier, AGC controlled. 50 dB max. gain, AGC attenuation 0 to -40 dB.
- Built in self test verifies operation of control panel display and mode functions.
- An external power unit is supplied with the IMD Meter. It provides 14 VDC at 100 ma. It also provides isolation from system power to enhance accuracy of the unit.

1.4 Applicable Documents - Other documents related to the IMD meter are available for download from the Discovery Bay website, **http://kk7uq.com/**

- Design and Construction Manual - IMD Meter by kk7uq
- Design and Construction Manual - kk7uq interface, Model II

1.5 Sales and Service – for the *IMD Meter by kk7uq* is provided by

Rig Technologies - www.rigexpert.com
Tech support line: 410-272-9110
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2 Controls and Displays

The front panel of the IMD Meter is shown in the photo below.

Power Switch - the right hand switch controls power to the meter. The center position is OFF, the up position selects the External +12.5 to +16 volt supply. The down position, marked Aux, is not used for normal operations, but may be used for short term battery operation of the meter. Battery connector is not supplied with the unit.

Mode Switch - the left hand switch selects the mode. The **down** position selects the FS (Field Strength) mode, where you measure signal strength being picked up by the meter. If the switch is in this position when power is turned on, the self test is run before the FS mode is performed.

The **up** position, PSK63, measures IMD when transmitting in BPSK63 mode. IMD will be measured when the rig is transmitting either Data (typing) or is in Idle.

The **center** position, PSK31, measures IMD when transmitting in either BPSK31 or QPSK31 mode. IMD will be measured when the rig is transmitting either Data (typing) or is in Idle.

Digit Display - this is a three digit, red LED segment display. It represents the IMD when the Mode switch is in either the **up** or **center** position. A minus sign is displayed in the left digit position, the right two digits represent the IMD. If the display is blank, then signal is being received, but it has not been decoded as a BPSK or QPSK signal.

Digit Display Idle - If the dash (-) is shown in the center digit at half intensity, it means that no signal is being received by the meter. This indication is provided to show that the unit is powered on, but idle.

When the mode switch is in the **down** (FS) position, the digit display represents the AGC level being applied to the meter. Numbers in the range of 000 to 063 will be seen. The higher the number, the higher the attenuation being applied to the RF amplifier - hence the stronger the signal being received.

LED Display - one Green LED, and one Red LED are provided to signal the IMD in a "summary" sense. The Green LED means that the signal being received has an IMD of -20 dB or less. The Red LED means that the signal being received has an IMD of -23 dB or greater. So you will see:

Green LED only - IMD is -24 dB or less (Good)
Red LED only - IMD is -19 or greater (Bad)
Green and Red together –
IMD is between -20 dB and -23 dB inclusive (Marginal)
No LED on - no BPSK or QPSK signal is being received.

Antenna - the antenna for the unit is on the left side. It can be extended by pulling out on the top section. Set up your system with the minimum antenna length consistent with good signal strength. See the Setup section.

Power Receptacle - The DC power receptacle is located on the right side of the meter. It is designed to mate with a **2.1mm x 5.5mm, center positive** power plug. A DC power supply is supplied with the meter. This unit supplies +14VDC at 100 ma. to the meter. It is recommended that this power supply be used with the meter since it provides isolation of the meter from the local ground system. Accuracy of readings are enhanced when using this power unit.

3.0 Setup

3.1 Power supply - a DC power supply is supplied for use with the IMD Meter. Plug the DC power connector into the receptacle in the side of the meter. Then plug the power supply into the AC power system.

3.2 Location - Place the IMD Meter where it is convenient for you to see the display while operating PSK modes, but keep it away from RF generating sources such as the CRT monitor of your PC. About a foot or so of separation is all that is required. You can check if stray RF is being picked up by using the IMD Meter itself. You will determine the proper antenna length, and whether any stray RF is being picked up during the first operation of the meter, described below.

3.3 First Operation - Plug in the power supply to the IMD Meter. Put the Mode switch in the down position - marked "FS". Then turn the power switch to the up position marked "Ext". The meter will perform a self test. This test will be run when power is turned on if the Mode switch is in the "FS". The test will not be run if the mode switch is in any other position. A short beep will sound in all modes when power is turned on.

3.3.1 Self Test - the self test is used to verify that the CPU is running, that the audio transducer functions, and that the digit display and the LED are all functioning. You will see the following sequence:

- Short beep and a brief pulse on the red LED.
- Number sequencing on the digit display. The sequence starts with 000 and then increases the right hand digit from 001 - 009
- Number sequencing of the center digit 000, then 010 to 090
- Number sequencing of the left hand digit 000, then 100 to 900
- Turns off the digit display
- Pulses the Green and Red LED alternately 5 times
- Displays a three digit number representing the firmware version number e.g. "104"
- A Morse "FB" is sent on the audio transducer, the Red LED will pulse during the tones
- All displays off, signaling the end of the self test

Self test - continued

- The meter with then start flashing numbers, typically 000 on the display - this is the beginning of the normal Field Strength (FS) function of the meter

3.3.2 Field Strength Measurement - the FS mode is provided to determine the level of the signal received by the meter when you are transmitting. It is also used to check if there is any stray RF being picked up by the meter from other sources such as CRT displays of the computer.

Right after the self test performed above, the digit display will start flashing a number. Typically it will flash 000. If some other number is being flashed, it means that some RF is being picked up by the meter. Move the meter around a bit to see if the number changes. If you move it close to the screen of the monitor, you should see the number go up, moving it away reduces the number back to zero. The meter can be used as a "sniffer" to locate any RF source being picked up. If the number being displayed is low, 002 or less, the meter will still work, but try to get it to 000.

The number displayed represents the level of AGC signal being sent to the RF amplifier stage of the meter. The higher the number, the more attenuation is being applied to the RF amplifier - hence a stronger signal is being received. The numbers will range from 000 to 063. The FS reading is not calibrated, but is approximately 1 dB when the numbers displayed are in the range of 20 to 50.

Now, transmit a signal from your transceiver. The tuning function of your transceiver is convenient, or you can use your PSK software to generate an Idle signal, although it does not have to be a PSK signal to check RF level. If you use your PSK software, listen on the band, and pick a frequency that is not in use. Put the word "TEST" in the call field of your software, and then click on the CALL macro of the software. This will transmit something like "TEST TEST TEST DE YOURCALL" to let other stations know who you are and that you are performing tests. Now, click on the TX button on the screen, which generates an Idle signal. Adjust the power output for your normal operating power. You should see the number on the meter display go up to something in the range of 010 to 055. When you return to RX mode, the number should drop back to 000. If the number is at the low end of the range, pull out the antenna a bit, the number will go up. Try to find a point where the field strength is around 30 - 45. You can

operate at higher numbers or lower numbers, but should try to get it below 55.

At this point you have located the meter in an "RF quiet" place, and adjusted the antenna length to optimize signal reception. The meter is now ready for daily operation.

4 Daily Operations

4.1 Basic Operation with an IMD Meter - Basic operation of your station with an IMD Meter is straightforward. When you transmit a PSK signal, observe both the IMD Meter reading and the power output from your rig. If possible, use a peak reading power meter although an average reading meter can be used. The object is to run your station at your desired power level, consistent with a "good" PSK signal. Good is defined as being an IMD of -24 dB or less (more negative). This means that any distortion products will be 24 dB or more down from your main signal.

You control the power output by adjusting the ***audio*** drive level going to your transceiver. As you increase the audio drive level, you will see the power output go up. As you increase it toward maximum, you will see the IMD numbers increase, say from -30 dB to -18 dB (increase means a less negative number being displayed). If the IMD goes above -24 dB (-23 or above), you have gone too far. Reduce the audio drive level until it comes back.

You can adjust the audio drive level in three ways. First, if you use an interface such as the KK7UQ Model II Interface, with a potentiometer & knob that controls audio drive level, use that control for your audio adjustments - it is the most convenient method. If your interface doesn't have a knob controlled audio drive, then use the PC sound card volume control panel, which you can invoke from your PSK software. The WAVE slider is the one that controls output level. The Master Volume control works in conjunction with the WAVE control for overall level. Slide the control up to increase level, lower it to decrease it. Or if you prefer, you can use the mic gain control on your transceiver to adjust audio level.

4.2 Typical Operating Procedures - Summary - the typical PSK operating procedure is described below. Further discussion of particular operating techniques is provided in the section 5, FAQ.

4.2.1 Changing bands

- First tune up on the new band and minimize SWR.
- Set the IMD Meter mode to either PSK31 or PSK63, as appropriate
- If your power output meter can be set to "Peak Reading", select this. You will be monitoring the Peak output when transmitting PSK signals. If your output meter only reads "Average Power", then use that, and realize that you are seeing about 60% of Peak output being reported when transmitting Idle signals. When you type, you will also see power level vary, since the duty cycle of the transmitted PSK signal varies with data content.
- Next, do a short transmission in Idle, in PSK. Check the power level and the IMD level. Adjust the audio drive to produce the desired power level with an IMD of -24 dB or better.
- Periodically identify yourself when testing. An easy way is to put TEST in the call field of the software and do a "Call". This will put out a TEST TEST TEST DE YOURCALL kind of sequence. Or make a test macro to do it.
- When using an IMD Meter to monitor signal quality, you can set a maximum power output to be used by adjusting the "power output" control on your *transceiver*, since you have a way of checking the quality of your signal. **Note**: do NOT do this if you are not using an IMD Meter since you can easily over drive the audio level, but not see any change in output power because it is being pegged by the transceiver. Over driving the audio causes bad IMD and wide signals on the band!

4.2.2 Operating inside the waterfall

- Stay within the ***transmit*** *pass band* of your transceiver. Typically from 500 to 2200 Hz offset from your transmitter frequency.
- Check your transmitting IMD on your IMD Meter and check the power level when ever you change frequencies within the waterfall. Adjust the audio drive level for desired output power and good signal quality.

5 FAQ - Frequently Asked Questions

Why does my output power vary all over the place for a given audio drive level? - It is a characteristic of modern transceivers, that the audio drive level required to produce a given power output may vary several dB from band to band. In fact, the drive level will even vary a few dB within the 2200 Hz transmit pass band at a particular frequency setting.

The reality is that operation in the PSK modes is anything but a set it and forget kind of operation. You need to pay attention to the audio drive level and the subsequent power output that is produced whenever you switch bands, or change your frequency within a single waterfall screen.

Why do I have to stay within the transmit audio pass band of my rig? - You also need to remember that you must stay within the audio pass band of your transceiver when operating, since most transceivers operated in USB (or LSB) mode, are set up for voice operation, and have good filtering to contain the signal within a few kHz. Typically about 2200 Hz or less. When you view a waterfall display in PSK, you are looking at the audio spectrum of the receiver output from 0 to 3000 Hz or more. The receive filtering is different that the transmit filtering, and often wider, so you may see reasonable signal strength at audio frequencies well above those that you can transmit.

As an example, if you see a PSK CQ signal at 3000 Hz on the waterfall, it may look strong. If you click on the signal, and then try to call him, you are operating above the transmit filter cut off frequency. What you see is that your output power is reduced significantly. If you then increase the audio drive level, you may see your power output increase somewhat, but what you don't see is that you are now overdriving the audio, and clipping your signal - causing significant distortion and unwanted side bands. If your IMD meter is in operation, your displayed IMD increases, and the meter sends out a Morse "H" code to indicate that you have gone too far.

The same thing will happen if you try to operate too low on the waterfall. The transmit filter has a sharp cut off at the low end, starting around 500 Hz and really dropping off at 200 Hz.

Be conservative, operate within the pass band limits, typically from 500 to 2200 Hz. Move your transmitter base frequency if you need to operate outside of this area.

How do I adjust the audio drive level into my rig? - Good PSK operating practice means being aware of your power output, your signal IMD level, and having a way to adjust the audio drive level easily to maintain a particular power level consistent with an acceptable IMD. If you have a KK7UQ interface you have an external potentiometer with a knob on it that lets you easily and quickly adjust the output level. If you use other interfaces, you can use the PC output level control slider to adjust the WAVE setting. Or you may be able to use the mic gain control to control the audio drive level on your transceiver.

What output power levels can I run? - Another thing to consider in PSK operations is power output of your transceiver. The PSK signal has a duty cycle of 50% to about 70%, depending upon the data being sent. In Idle (no typing, empty output buffer) the duty cycle is 50%. When you are typing it can run upwards of 70%. Other sound card modes, such as RTTY, MFSK, and Olivia run at 100% duty cycles. So if you monitor your power output with a peak reading meter, you will see that the peak stays constant in PSK. If your meter reads average power output, you will see the needle moving up and down as you type.

The general rule of thumb is to operate your transceiver at peak power levels about 50% of the rated CW power of the rig. If you have a 100 watt transceiver, you would operate at about 50 watts peak. This will translate to about 30 watts average in Idle mode. When you operate at these levels, two things happen. First, your finals run cooler, and operating life is extended. Second, you pretty much guarantee that you are operating in a linear part of the audio system. This is the secret to clean signals using PSK.

Can I use the power control of my transceiver to adjust power level when operating PSK? - Before the advent of signal quality measuring devices like the IMD Meter it was not good practice to limit your output power on your rig using the rig power control. The reason was that the relationship between output power and audio drive level was not evident - the output power was pegged by the transceiver.

Normally you set the power control to maximum, or maybe 75%, but not close to your desired level.

Now, with the IMD Meter you have a way to keep track of your signal quality. You can safely set the maximum power level desired with your transceiver, and adjust the audio to a level that produces a clean signal.

How do I safely boost power in special circumstances? - There are times that you may want to increase power to help break the pile up for that rare DX station on the band, or to finish a QSO in a fading band. Under these conditions, you keep your transmissions short, so heat build up on the heat sink is not a problem. Keep an eye on the IMD meter when you do this, so that you are still putting out a clean signal even at your increased power level. You will find that many rigs will operate at about 90% of maximum (peak) and still put out a clean signal. But, heat in the finals is another story entirely. You may want to provide additional air flow with an external fan to the heat sink if you do this very often. Check your transceiver manual or your manufacturer to determine the power level you can safely run. The rating for RTTY is a good guide, since it is a 100% duty cycle mode.

What is a Good IMD? - you should shoot for an IMD of -24 dB or lower. IMD on modern rigs, properly set up will produce signals with IMD readings in the mid -30s.

Why do I see readings on the IMD Meter when operating in other modes? If you operate in other modes, you may see what look like valid IMD readings on the IMD meter. These numbers have no meaning in those modes. The internal firmware is set up to analyze BPSK and QPSK signal, either at 31.25 baud or 62.50 baud only. You should either turn off the meter when operating in other modes, or else put the mode switch in the FS position so that you are displaying relative Field Strength of the peak signal being transmitted.

How do I give an IMD report to other hams?

- You will often be asked for an IMD report by other hams. Your operating software will have a display of the received IMD of a signal. In your operating software, you only get accurate IMD reading in receive when the station is transmitting in Idle. (Note: using the IMD Meter, you get accurate measurements of your signal in Idle, and when you are typing.)

How do I give an IMD report to other hams? (continued)

- The accuracy of the IMD measured is only as good as the S/N of the signal being received. If the signal is weak, say 10 dB above the local noise level, the best IMD reported will be -10 dB even if the signal is clean. If you use software like MixW, you have a spectrum display which shows you the signal level relative to the noise floor. MixW has calibrated reference lines 10 dB apart to give you a visual guide.

- The signal can be too strong also. If the station is very strong, it is likely the one controlling the AGC on your transceiver. This means that the signal may be clipped inside the receiver. This clipping will give false IMD reports. On strong signals, use your RF gain to reduce the signal level. You will see the IMD improve significantly, and any side bars disappear from the waterfall. Another clue is that the signal is RED on the waterfall, indicating that it is at the maximum level the A/D converter can handle. Use the RF gain to bring it back into the bright yellow area.

- Be sure that the *input* level set on your PC audio control is not too high. If you overdrive the sound card A/D converter, it will start clipping, producing side bars and harmonics on the display. This is produced in the PC, not in your receiver or by the transmitting station. The optimum setting on the input control is one that produces a waterfall that is blue, or speckled light blue in the areas where there is no signal.

Notes