IC-7760
Technical Report

~ Profile ~

200 W operation will change your operation style.
~ Switch to a Smarter Operating Style

Icom's 200 W radio began with the IC-775DSP released in 1995. In addition to its massive size for storage in a 19-inch rack and presence in a shack, this radio was equipped with a Digital Signal Processor (DSP) which was a trend in digital technology to bring out weak signals buried in noise.

This DSP triggered the digitization of signal processing, which has recently developed into the emergence of software-defined radio (SDR) using Field Programmable Gate Arrays (FPGA) and RF direct sampling technology.

Meanwhile, the explosive spread of the Internet in the late 1990s made personal computers more accessible.

This led to the use of personal computers in amateur radio as well, for log management and data communication, and they have now become indispensable.

The IC-7760, which responds to both of these trends in the latest digital technology and operational style, is a radio that offers not only performance as a radio, but also a new style of amateur radio operation with the added freedom of installation that is not limited by the shack situation.

TRADEMARKS

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- PART 1 -

Our Design Philosophy 01

Visual Design

The visual design concept for the IC-7760 was to allow a clean and stylish shack to be configured as a radio system, and to allow easy replacement or expansion of existing HF radios.

Based on this, the IC-7760 follows the front panel size of the IC-7610 so that it can be installed in a shack with as little modification as possible. In addition, the position of the indicators and knobs also follows that of the IC-7610.

User Interface ~ Operation/Display System

One of the design concepts is that users of our popular radios, the IC-7300 and IC-7610, should be able to perform basic operations without referring to the instruction manual. In addition to the ergonomic design of the knob layout and function assignments, the touch panel also provides intuitive operation of the various settings.

Support for Network Environment

The concept is to make remote operation over a network easier.

Conventional remote control through a network requires remote control software such as RS-BA1, our PC application.

The IC-7760 uses our network device technology to connect the Controller unit to the RF Deck through the network.

This enables remote control without changing the operation feel of the shack. (Details are explained in the "Network Technology" section.)

Electrical Performance

In electrical performance, the design concept is “cleaner transmitted radio waves. SSB transmitted radio waves, especially those with a lot of distortion, not only make it difficult to hear the transmitted voice but also scatter a lot of unwanted components (IMD) in the neighboring frequencies. In some cases, the transmitting operator may not even notice it. Therefore, with the goal of reducing SSB transmission distortion in particular, we decided to thoroughly master DPD technology and deploy this technology not only in the IC-7760, but also in the IC-7610, which is now available through a firmware upgrade.

Total DPD processing has also been achieved even when using the IC-PW2, a 1 kW linear amplifier. Details are explained in the sections “About Digital Pre-Distortion (DPD),” “About the effect of DPD,” and “About DPD linkage when using an IC-PW2.” In addition, improvements in reception performance have also been incorporated, including a review of the number of divisions in the RF-BPF and the operation of the DIGI-SEL and preamplifier. These are explained in the “Bandpass Filter (BPF)” and “DIGI-SEL (Digital Selector) circuit” sections.

DESIGN CONCEPT

- PART 2 -

Inherited Technology 02

The technology developed in our flag-ship model IC-780, released in 1988, has been continuously improved since then. The following features have been retained to improve the performance and functionality of not only the top-end model, but also other popular Icom models.

➡ Dualwatch®
➡ Spectrum Scope
➡ Large display
➡ High power (200 W) / Built-in power supply

Dualwatch®

The Dualwatch® function is fully independent and completely identical in both Main and Sub band performance which has been provided since the IC-7800, and they are also inherited by the IC-7760. DIGI-SEL and interference rejection functions which have become indispensable in recent radios, also operate completely independently in the Main and Sub bands.

In addition to those features, the IC-7760 is one the first amateur radios to incorporate two speakers for the Main and Sub band, each of which outputs independent audio.

Spectrum scope

IC-780 spectrum scope screen
The display was a monochrome CRT.

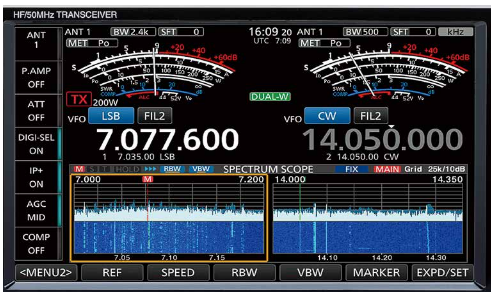
The spectrum scope, first introduced in Icom's flagship IC-780 has continued to evolve in subsequent Icom radios. In the meantime, the IC-7300 and other popular models were also equipped with the spectrum scope, and it has become an indispensable feature.

The spectrum scope not only supported Dualwatch® with the IC-7850/IC-7851, but also dramatically improves the image depiction speed and resolution with the ultra-high speed PLL for the scope and the Fourier Transform (FFT) method.

In the IC-7760, the RF signal captured by the A/D converter is digitally processed by the FPGA/DSP, and the signal data within the set band obtained by these processes is output as an image by the CPU.

In other words, by integrating RF direct sampling technology, physical dedicated circuits are eliminated.

Large display



The display is a 7-inch wide Full VGA TFT color LCD touch screen. The high-definition LCD contributes to the high-precision spectrum scope and waterfall depiction. Furthermore, touch operation is supported, which enables quick, intuitive operation according to the situation in contests and other events.

In addition, the parameters of the needle-type analog meter displayed on the LCD were reviewed to reproduce the movement of the needle like an analog meter, even though it is a digital display.

A 200 W high-power radio with a built-in AC power supply

The final amplifier uses a high-efficiency, high-voltage (Vds = 65 V) Laterally Diffused MOS FET (LDMOS) final transistor to achieve a stable, continuous 200 W output. The power supply for this final amplifier is also a high-efficiency unit designed to save energy. As a result, AC current consumption while transmitting 200 W is also greatly reduced.

	IC-7850/IC-7851	IC-7760
AC power consumption	700 W	470 W*

NOTE: The values in the table are typical values.
AC power consumption varies depending on the measurement conditions.
*This figure is the sum of power consumed by the Controller and RF deck.

Figure 02-1. Built-in AC power supply

RF direct sampling

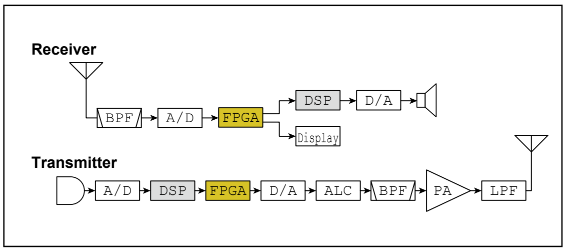


Figure 02-2. Block diagram of the IC-7760

As shown in Figure 02-2, RF direct sampling is a method of digitally converting received RF signals and batch processing them in a Field Programmable Gate Array (FPGA).

Except for the FPGA portion, the flow is similar to that of capturing signals with an Analog-to-Digital (A/D) converter and outputting signals from a Digital-to-Analog (D/A) converter.

However, digital signal processing is also greatly affected by the quality of the analog signal. One of them is the purity of the sampling signal input into the A/D and D/A converters.

The details are explained in "Generator circuit for sampling clock signals."

So, why is digital signal processing in radio equipment becoming more advanced? Space saving, power saving, multifunctionality... There are many reasons, but Icom's idea of digitization is high performance. For example, flip-flop circuits, which are also the basis of logic circuits, used to consist of many transistors. Just as this was replaced by a single-chip IC to save space, the crystal filter (bandpass filter) that was common in the IF stage was replaced by a DSP (Digital Signal Processor) which not only saves space but also enables the operator to adjust the filter characteristics to his/her preference.

Figure 02-3. Crystal filter; one of the analog components

Figure 02-4. Analog components for adjustments

In addition to these factors, it also improves product quality. Specifically, individual components have variations in performance and accuracy. Even if the variation of a single component is small, the total variation of the hundreds or thousands of components used in a radio may reach a level that interferes with performance and product quality.

In order to suppress this variation, adjustments have so far been made using analog components such as variable resistors, variable capacitors, variable coils, and so on. These adjustable analog components are used in the radio equipment.

Although these analog components for adjustment suppress variations and provide the best performance at the time of the adjustment, it is inevitable that performance and quality will change over time due to changes caused by heat, vibration, and other factors.

On the other hand, if these analog components for adjustment are digitized and adjusted by electric signals, there is no change over time due to heat, vibration, or other factors.

Continued on the next page…

In other words, if a radio that uses analog components for adjustment is operated for many years, there is concern about deterioration in performance, such as transmitting output and receiving sensitivity, and quality, such as distortion of the transmitted sound, but with a digital radio, there is no deterioration in performance or quality due to aging.

◆ Transition of the receiving configuration block diagram

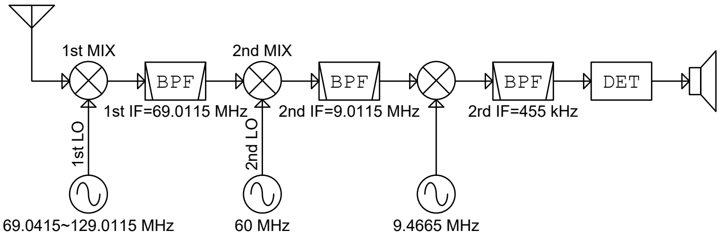


Figure 02-5. Receiver configurations of previous analog type radios

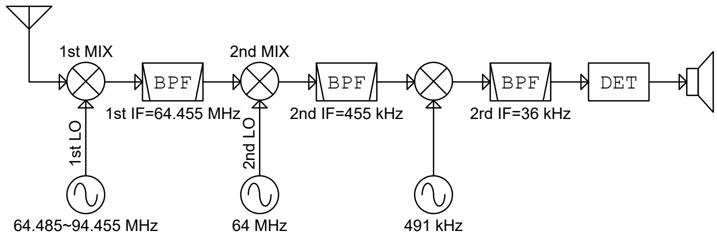


Figure 02-6. Receiver configuration of the early DSP radios

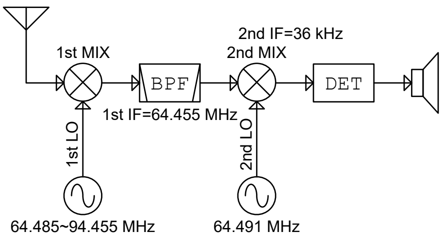


Figure 02-7. Receiver configuration of the IC-7700, IC-7800, and IC-7850/IC-7851

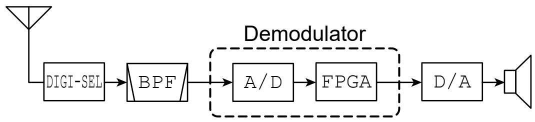


Figure 02-8. Receiver configuration of the Direct sampling radios

Low distortion RF circuit

In "RF direct sampling" on the previous page, we explained that the quality of the analog signal affects the processing of digital signals, and that one of the effects is the purity of the sampling signal input into the A/D converter.

However, the A/D converter also has an RF signal input. Therefore, the RF signal received at the antenna must be input into the A/D converter as a faithful signal without distortion inside the radio.

For this reason, the switching circuit between the antenna connector and the BPF (Bandpass Filter) uses a mechanical relay that does not generate distortion, instead of a semiconductor switching circuit.

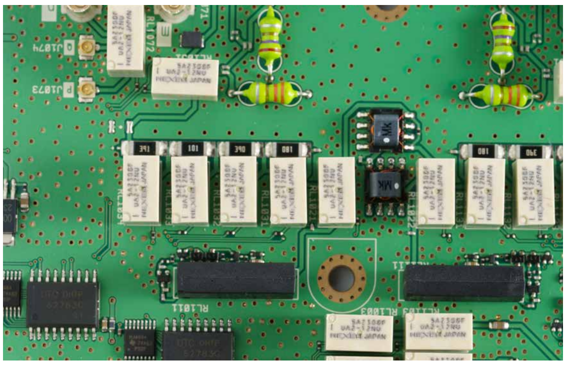


Figure 02-9. RF-B Board
(Attenuator switching circuit)

Improved the RF bandpass filter

In order to suppress the influence of strong international broadcast band signals adjacent to the amateur radio band, the BPF in the RF stage that was divided into 13 bands in the IC-7850/IC-7851 and IC-7610 is further subdivided into 15 bands in the IC-7760. In the HF band in particular, the BPF is subdivided into 11 bands instead of 9 bands.

At the same time, the cutoff frequency of each filter has been redesigned to reduce the influence of signals in the international broadcast bands, as well as adjacent bands on the amateur band signals.

In conventional DIGI-SEL-equipped radios, the preamplifier could not be used when DIGI-SEL was in use.

This is because:

➥ DIGI-SEL should be placed closer to the antenna connector than to the BPF, as it is necessary to eliminate unwanted signals as close to the antenna as possible in order to suppress distortion signal generated by non-linear components, such as switching diodes in the BPF.

➥ The preamplifier is inevitably placed after the DIGI-SEL circuit since it was always considered a matter of course to prevent unwanted frequency signals from being input into the preamplifier.

Operating the preamplifier in this arrangement would also amplify the noise component generated by the DIGI-SEL-derived gain compensation amplifier. This will not improve reception sensitivity, even though the gain is increased, so the preamplifier was forcibly turned OFF when DIGI-SEL was used in conventional radios.

Therefore, we re-examined whether it is really possible to place DIGI-SEL in the rear stage of the preamplifier and determined that the required sensitivity can be obtained.

So, DIGI-SEL can be placed either in the front or rear stage of the preamplifier through a switching circuit.

This switching circuit allows the user to select the appropriate setting according to the operational situation.

Settings	IMD Characteristic	Receiver Sensitivity	Overflow Resistance
DIGI-SEL: OFF PREAMP: ON	★★ (Fine)	★★★ (Superb)	★ (Good enough)
DIGI-SEL: ON PREAMP: OFF	★★★ (Superb)	★★ (Fine)	★★★ (Superb)
DIGI-SEL: ON PREAMP: ON	★★ (Fine)	★★★ (Superb)	★★★ (Superb)

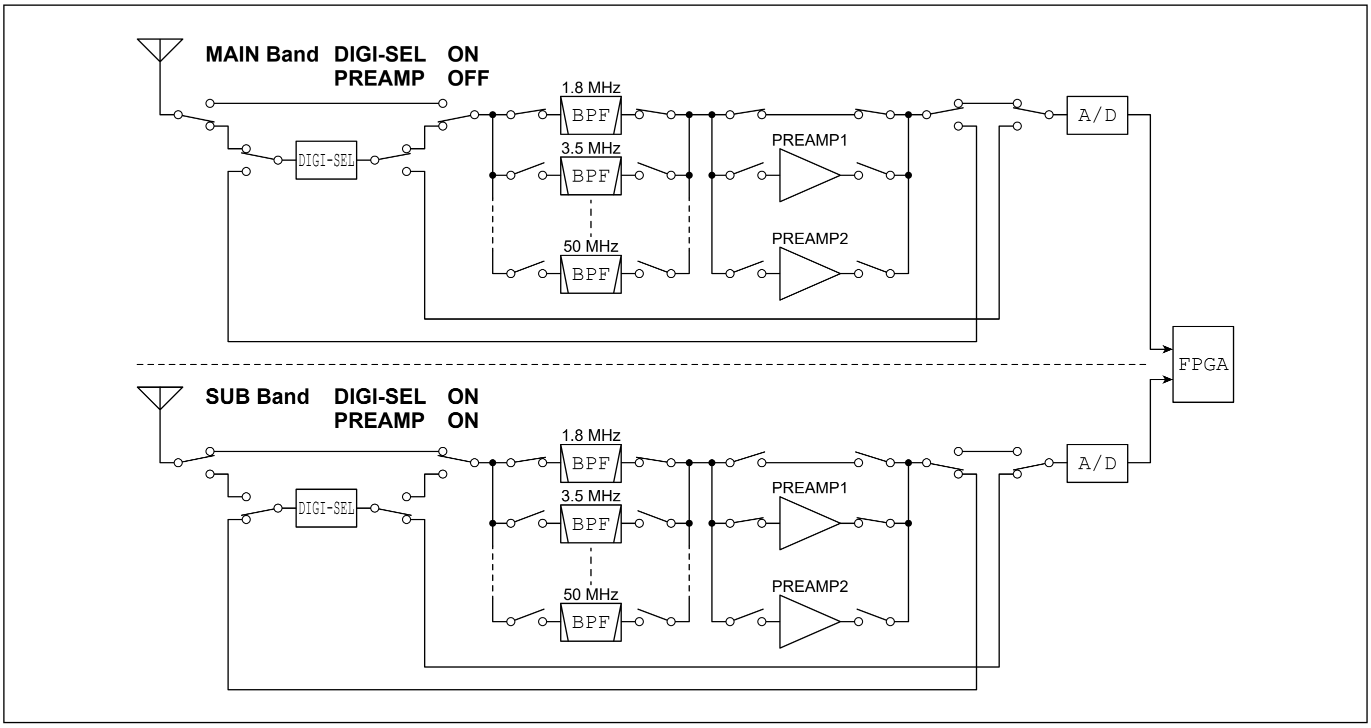


Figure 02-10. Block diagram of the circuit from antenna to FPGA

- PART 3 -

New Initiative 03

What is DPD?

DPD stands for Digital Pre-Distortion. It is a method of inputting a correction signal to reduce the output distortion component caused by the non-linear characteristics of amplifiers. Especially in power amplifiers, where non-linear characteristics have a large impact, the non-linear input/output characteristics are analyzed and learned inside the IC-7760, and correction signals are generated and input to improve the distortion characteristics.

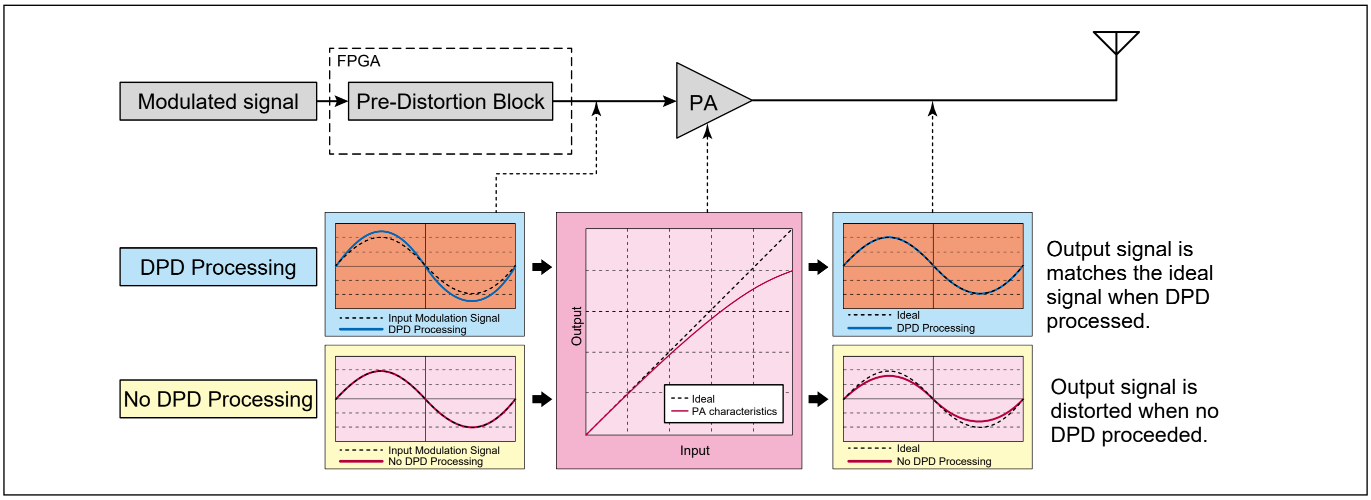


Figure 03-1. Principal of DPD Processing.

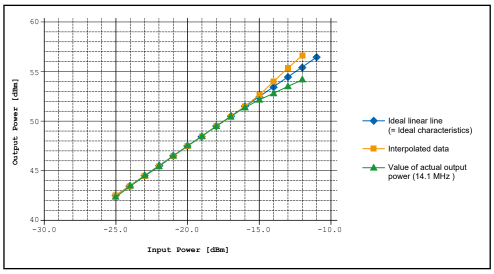


Figure 03-2. Linearity characteristics of the power amplifier

As you can see from the graph to the left, the actual output (—▲—) of the power amplifier is below the ideal linear line (—◆—) as the output increases, resulting in a non-linear characteristic. Distortion occurs in this characteristic area. By correcting the input level to the power amplifier (output level of the D/A converter) to be equal to the ideal straight line for this lower characteristic part, distortion is prevented.

The DPD leads to improved transmit IMD characteristics and reduced influence levels on adjacent bands. Details are explained in the “Commitment to transmission performance” section.

Remote controller

The IC-7760 system has a completely separate controller which operates the radio, and the RF Deck which processes the signals. The Controller and RF Deck can also be connected through a user supplied LAN cable (CAT5e or higher grade). For example, this enables the Controller to be installed on the shack desk and the RF Deck to be stored in a rack or other location for a neat and tidy shack configuration. If the LAN cable is used to directly connect the Controller and RF Deck, it can be up to 100 meters long.

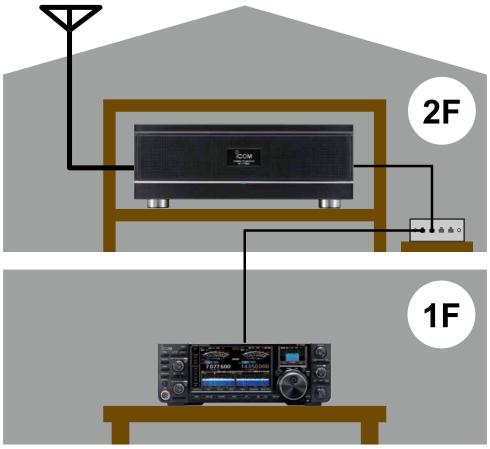
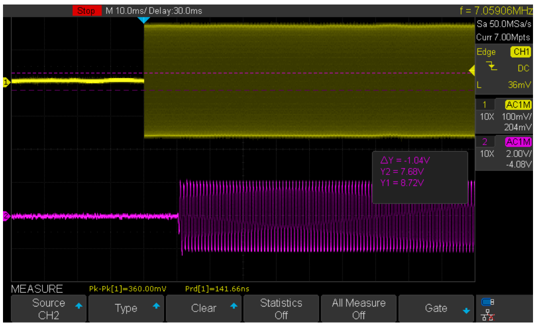
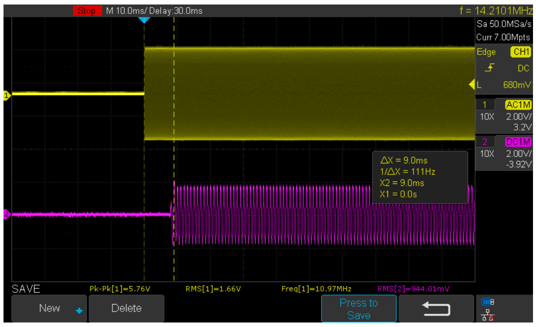


Figure 03-3. Example connection through a network switch



IC-7760: Approximately 10 msec. delay



IC-7610: Approximately 9 msec. delay under the same test conditions to the left

Figure 03-4. Delay of speaker output signal relative to IC-7610 antenna input signal

Sub screen

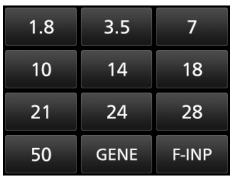
The IC-7760 is equipped with a Sub screen that supports touch operation. This Sub screen displays the following function keys and statuses to assist operation.

◆ Band stacking register switch

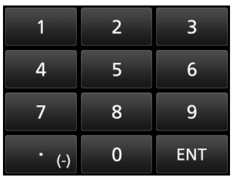
Operates as a band switch/number keypad, similar to those on conventional units.

◆ Band key/number keypad

Displays the band keys corresponding to the band stacking register as on conventional units. Also functions as a numeric keypad for frequency input. Refer to Controller section in Section 6 for additional information.



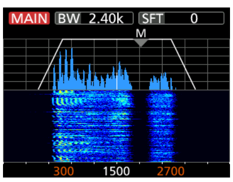
Band key



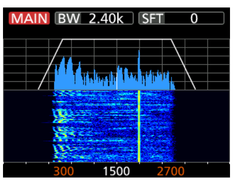
Number keypad

◆ Filter effect display

Filter effects, which in previous models were displayed large when the setting screen was selected, and small near the frequency display during operation, can now be displayed on the Sub screen at all times.



NOTCH ON

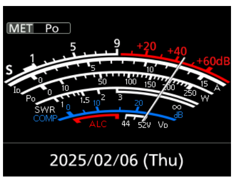


NOTCH OFF

◆ Multi-function meter

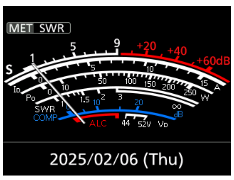
The IC-7760 can also display* a multi-function meter on the Sub screen, which was conventionally located near the operational frequency display. By displaying the multi-function meter on the Sub screen, while keeping the spectrum scope and other function screens on the Main screen, the status of the radio can be constantly monitored.

*The meters are normally displayed on the Main band, and on the Sub band while transmitting in the Split mode.

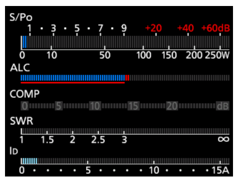


Transmit meter

The meter type can be changed with this screen



SWR meter indication



Multi-function meter

Power amplifier LDMOS FET for high breakdown voltage performance

The newly adopted PA device is an LDMOS FET for high breakdown voltage (Vds = 65 V). This device consists of two elements in a push-pull configuration in a single package with excellent balance.

In addition to low distortion and high efficiency, this device has excellent heat dissipation characteristics. As shown above, this device has a high breakdown voltage, a characteristic that makes it difficult to break even in the event of an anomaly such as high SWR in the antenna load.

Table03-1. Comparison of PA devices

Model Device name	IC-7760 ART450	FTDX101 VRF150	IC-7850 SD2931	Advantages of IC-7760
Vds (BR)	208 V	180 V	125 V	Difficult to destroy by high SWR
FET Structure	LDMOS	VDMOS	VDMOS	High efficiency for RF
Structure as RF amplifier	2in1	2 pcs. needed	2 pcs. needed	Well-balanced Good IMD characteristics
Heat resistance	0.2°C/W	0.6°C/W	0.45°C/W	Hard to destroy by heat

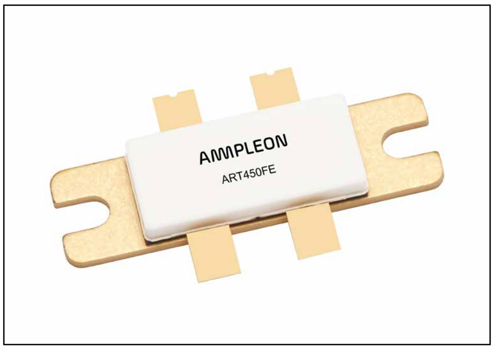


Figure 03-5. ART450 used in the IC-7760

- PART 4 -

04 Reception Blocks

Explanation of direct sampling

◆ What is the direct sampling?

RF direct sampling is used in the IC-7300 and later HF radios. What is "RF Direct Sampling?" Briefly, as described in the "Inherited Technology" section, it is a method that converts the received RF signal into a digital signal and processes it all together, including filtering and demodulation, in a Field Programmable Gate Array (FPGA).

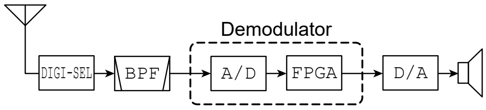


Figure 04-1. Conceptual diagram of direct sampling

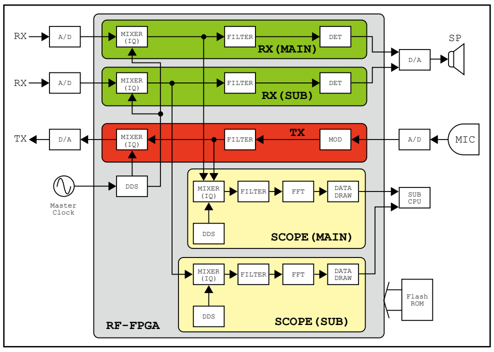


Figure 04-2. Block diagram of inside the FPGA

How are the signals converted into digital signals by the A/D converter processed inside the FPGA? As shown in Figure 04-2, the signals are converted by the IQ mixer inside the FPGA and processed up to filtering and demodulation. Therefore, our direct sampling method is called the direct sampling superheterodyne method.

We often hear of direct conversion methods in telecommunications equipment. Although the name "direct conversion" is similar, they are different. Direct conversion is a method in which the desired RF signal is converted to 0 Hz IF, or low frequency, before demodulation and other processes are performed. Actually, there is no frequency called 0 Hz.

In other words, 0 Hz can be regarded as direct current (DC). The RF signal is converted directly into an audio frequency, so it is called a direct conversion method.

This technique can be configured using analog circuits, but it requires injecting the same frequency component as the received frequency into the mixer as a Local Oscillator (LO) signal, making it difficult to filter out the LO component leaking from the mixer.

For this reason, only a small percentage of commercially available communication devices used direct conversion with analog circuits, and most of them were made by amateur radio operators on an experimental basis. However, recent advances in digital technology have led to the development of many ICs dedicated to direct conversion, especially for cell phones, and this direct conversion method has become a common configuration in recent years.

Continued on the next page…

Why do we use a superheterodyne system with direct sampling instead of direct conversion in our radios? One of the major weaknesses of direct conversion is the DC offset. As mentioned earlier, the direct conversion circuit converts an RF signal to a 0 Hz IF signal, but the 0 Hz component can also be referred to as the DC component, and this DC component causes saturation in the amplifier, which in turn tends to cause signal distortion.

To remove this 0 Hz component, an HPF (High-Pass Filter) can be placed at the rear stage of the mixer, but the HPF's characteristic cuts off the AF (Audio Frequency) component. In other words, the AF signal with AF components is also cut off, making the direct sampling method unsuitable for processing amplitude modulated signal such as SSB or AM.

Figure 04-3 is an example of the frequency response of received audio. As you can see, frequency components below 100 Hz are also included in the received audio. Although the graph does not show signal levels below 100 Hz, it can be predicted from the characteristic graph that signals below 100 Hz will also appear at some level.

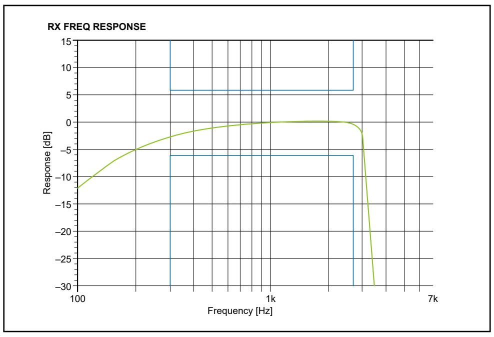


Figure 04-3. Characteristics of HPF for audio frequency

On the other hand, the direct sampling method uses an Intelligent Quotient (IQ) mixer to convert the RF signal to the IF frequency, allowing the necessary BPF to be configured at the IF frequency. Therefore, it is possible to demodulate components in the low modulation frequency range in SSB. By using this IF frequency component in the spectrum scope circuit, a wide-band spectrum scope is realized.

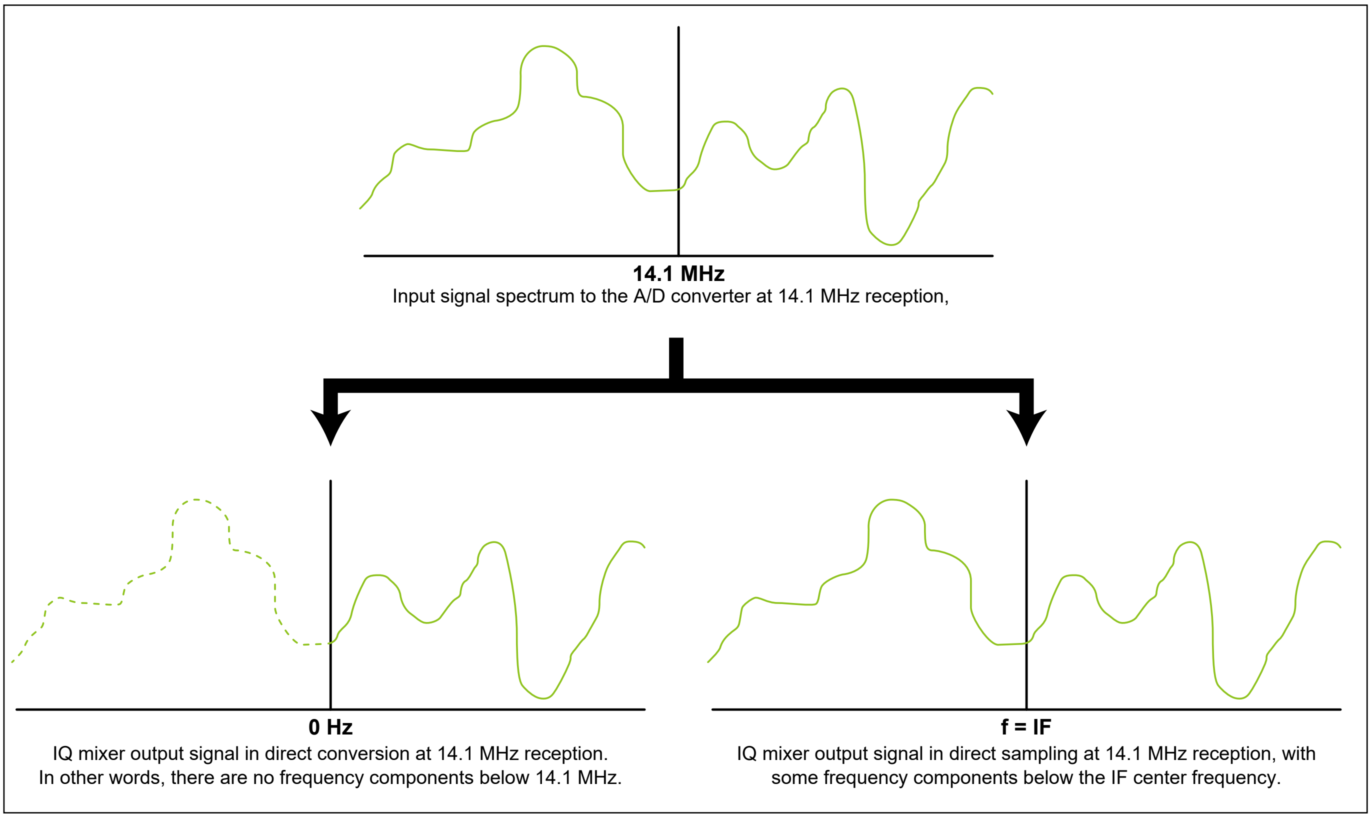


Figure 04-4. Difference between direct conversion and direct sampling

A/D conversion

Signals entering from the antenna are converted to digital signal by an A/D converter after the target signal is extracted by the DIGI-SEL circuit and a Bandpass Filter (BPF). So, how is an analog signal converted into a digital signal? Here is a brief explanation of the principle.

First, as shown in Figure 04-5, the analog signal is divided into intervals of a fixed time (t seconds). Then, the value at each fixed time is read. (Figure 04-6) This is called sampling. The sampled values are then converted to integers for processing with digital signals. This is called quantization. Here, the decimal point is rounded down to the nearest whole number. The quantized value is then converted to a binary number. (Figure 04-7) This is called encoding.

As a result, the analog signal shown in Figure 04-05 is divided into t-second cycles and 16 steps, and when digitally converted in 4-bit, it is encoded into “1000 1110 1111 1001 0010 0100 1011 1001 0100 1001 1010 0010 0010 1000 1110 1101.”

In general, digitization closer to an analog signal can be achieved by reducing the unit time for sampling and increasing the number of steps for quantization. On the other hand, the amount of data increases, so a device capable of processing a considerable amount of data is required.

The unit of measurement generally used to indicate sampling is the hertz (Hz). Music CDs use 44.1 kHz, which means that one second of sound is sampled by dividing it into 44,100 segments.

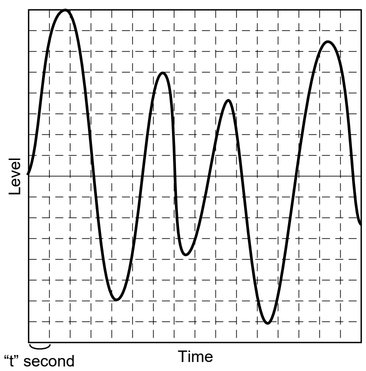


Figure 04-5.

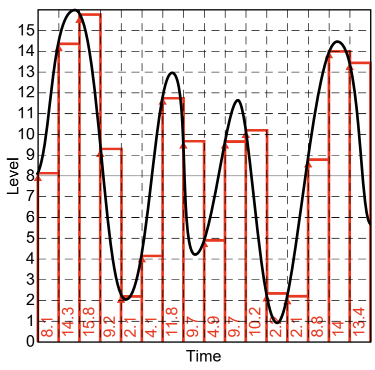


Figure 04-6.

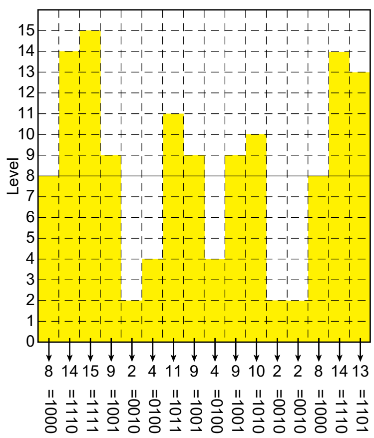


Figure 04-7.

A/D conversion of RF signal

A/D conversion of an RF signal requires a high-speed A/D converter that can sample at a frequency more than twice that of the RF signal to be converted. This is stated in the sampling theorem.

What is the sampling theorem?

If the maximum frequency component of the signal band to be converted is f Hz, a signal sampled at a frequency fs Hz higher than twice that 2f (Hz) can completely restore the original signal by removing the high frequency component with a Low−Pass Filter (LPF).

In the past, high-speed A/D converters capable of sampling RF signal were not practical. However, with the recent proliferation of smartphones and wireless PC networks, devices capable of sampling at higher frequencies have become widespread in the market. As a result, A/D converters that can sample RF signals have also become practical, and RF direct sampling has been realized.

The upper limit of frequencies that can be operated with the IC-7760 is 60 MHz, so in order to sample RF signal, an A/D converter capable of sampling at 120 MHz or higher is required. Therefore, the IC-7760's A/D converter uses a device capable of sampling at 130 MHz

FPGA internal signal processing

The signal digitally converted by the A/D converter is processed inside the FPGA, as shown below.

- ➥ Conversion to IQ signal
- ➥ Detection
- ➥ Signal processing such as noise reduction, noise blanker, NOTCH, PBT®
- ➥ Scope signal generation
- ➥ Squelch control

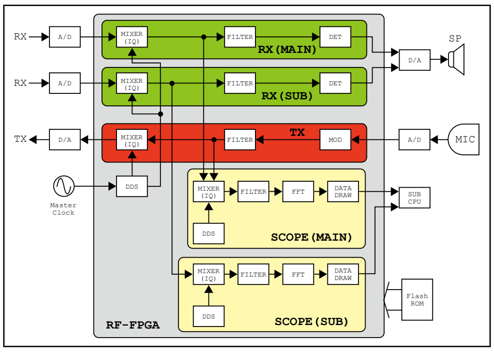


Figure 04-8. Block diagram of inside the FPGA

◆ IQ Signal Conversion and Detection

RF signals digitally converted by the A/D converter are converted to IQ signal by the IQ mixer, and the converted IQ signal are filtered and detected in the FPGA according to the selected operating mode.

For voice modes (SSB, AM, FM), the signal is converted to analog using an external D/A converter, then passed through a voice amplification circuit and output through speakers or headphones.

For data modes such as RTTY or PSK, the data is decoded and displayed on the IC-7760's display or output from the USB port on the rear panel, depending on the selected mode. The demodulated sound is also output through speakers or headphones in the same way as the voice system.

The IQ signal can also be output from the USB port on the rear panel.

◆ Scope Signal Generation

The A/D-converted receive signal is simultaneously processed in the FPGA by FFT processing, which is necessary for display on the spectrum scope, and the FFT-processed signal is sent to the CPU for display.

◆ Various Signal Processing

Signal processing, such as noise reduction (NR), noise blanker (NB), NOTCH, and PBT®, which have been processed by IF-DSP, are also incorporated in the FPGA.

Signal processing from the antenna connectors to the A/D converter

In the direct sampling method of the IC-7760, there are essentially no nonlinear circuits in the receiving section after the A/D converter.

The analog circuits between the antenna and the A/D converter are important factors in the reception distortion characteristics of the unit. Therefore, distortion generation in these analog circuits must be kept as low as possible.

Also, the signals coming from the antenna have various levels, and the dynamic range of those levels is quite large.

Those signals will be input to the A/D converter as a sum of power, so even if each individual radio signal is below the allowable level of the A/D converter, the mixing of many radio signals can cause the input level of the A/D converter to exceed the allowable level. To eliminate this condition, filter and attenuator circuits are incorporated. Each circuit block is explained in turn.

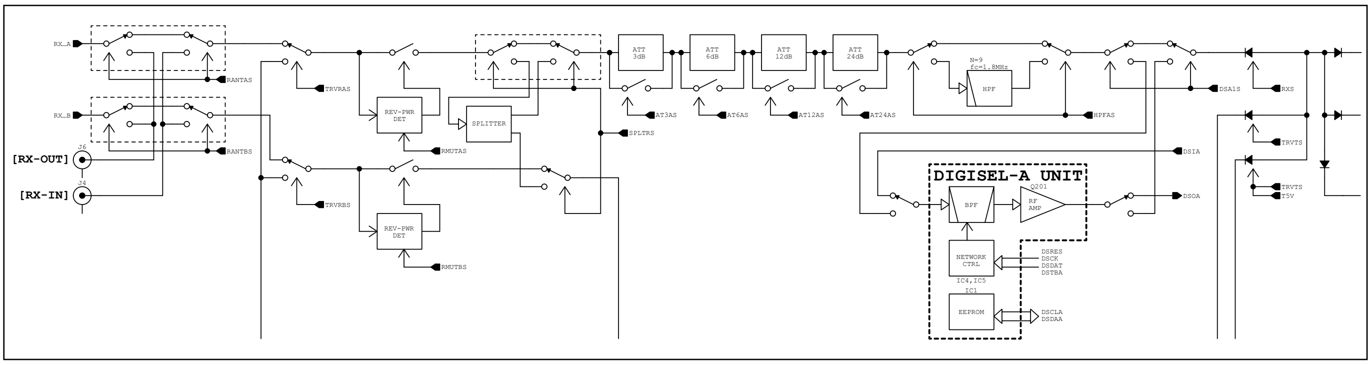


Figure 04-9. Block diagram of receiver circuits

The RF signal input from the antenna is routed to the BPF through the antenna connector switching circuit, the splitter circuit for splitting the received RF signal during Dualwatch®, and one of four levels of attenuation (3/6/12/24 dB), if selected. The signal continues through the HPF for removing strong mid-wave broadcast signals during HF band reception, and through the DIGI-SEL circuit, a narrow band variable BPF, which leads to the BPF.

Mechanical relays are used for all switching described above. This eliminates distortion caused by semiconductor switching circuits, and at the same time enables reception with minimal loss, even at very weak signal levels.

Splitter circuit

The splitter circuit is an important circuit required for Dualwatch® operation with a single antenna.

Figure 04-10 shows ANT1 selected for the Main band, and ANT2 selected for the Sub band. When ANT1 is selected for split and Dualwatch® operation, even on the Sub band, a relay switches the received signal to a route that directs it to the splitter circuit. (See Figure 04-11) When the splitter circuit is activated, the signal loss caused by the splitting of the signal is compensated for by a high dynamic range correction amplifier in the Subsequent stage.

Note that ANT2 to ANT4 can also be used in both Main and Sub bands.

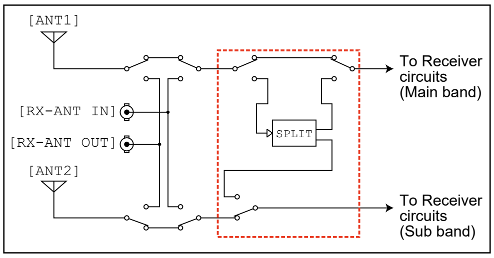


Figure 04-10. Block diagram of the splitter circuit

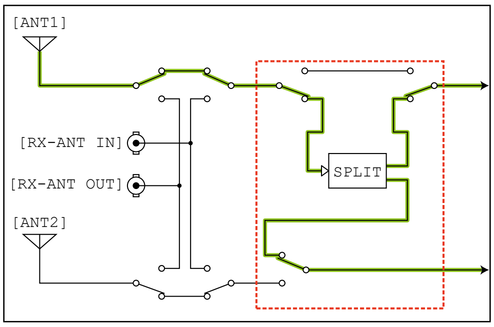


Figure 04-11. Signal route when ANT1 is used in both bands

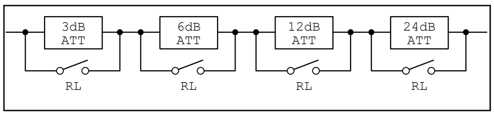


Figure 04-12. Block diagram of receive attenuators

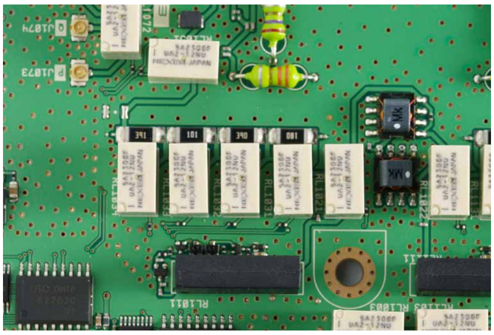


Figure 04-13. Receive attenuator circuit

Receive attenuator circuit

The independent 3, 6, 12, and 24 dB attenuators can be turned ON and OFF by relays, and by combining these attenuators, the attenuation can be set from 3 to 45 dB in 3 dB steps.

Switching with a relay eliminates distortion and minimizes loss when the attenuator is turned OFF. This is especially useful for removing very strong interference that cannot be eliminated by a BPF or DIGI-SEL circuit.

DIGI-SEL (Digital Selector) circuit

In the IC-7760, a DIGI-SEL unit that operates in conjunction with the operating frequency in the amateur bands from 1.8 to 28 MHz is installed in the front stage of the BPF for the Main band and the Sub band. As described in the “Inherited Technologies” section, the connection point between the BPF and the preamplifier can be switched in the latter stage, so that the preamplifier is enabled even when DIGI-SEL is turned ON.

The Digital Selector circuit has a sharp peak characteristic to eliminate as many of the unwanted signals as possible and operates as a pre-selector for the operating frequency. This attenuates strong signals adjacent to the target signal and suppresses the generation of third-order distortion caused by those signals. In exchange for this sharp peak characteristic, there is a slight insertion loss, but this loss is compensated for by placing a post-amplifier immediately after the filter. This post-amplifier is a high dynamic range design with minimal gain and current feedback, so that the receiver’s strong input characteristics are not affected by this amplifier.

The Digital Selector circuits are a simple filter group consisting of coils with high Q using a toroidal core, which do not easily cause magnetic saturation, and low dielectric constant capacitors, which do not easily change its capacitance even at high signal input levels. The center frequency of the filter automatically changes according to the operating frequency. The Digital Selector circuits are covered with a shield case to provide sufficient isolation and are mounted for the Main and Sub bands.

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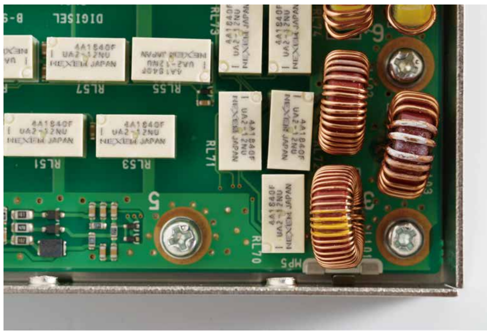
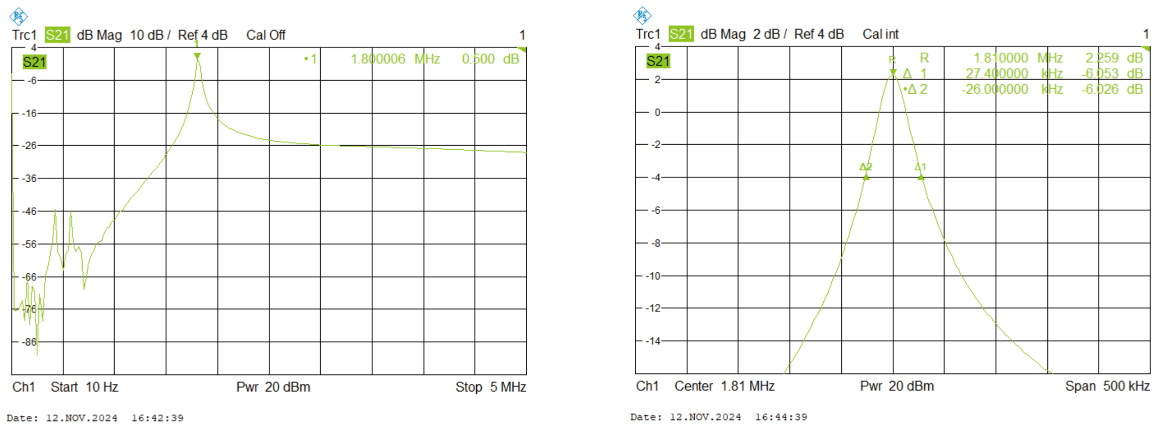
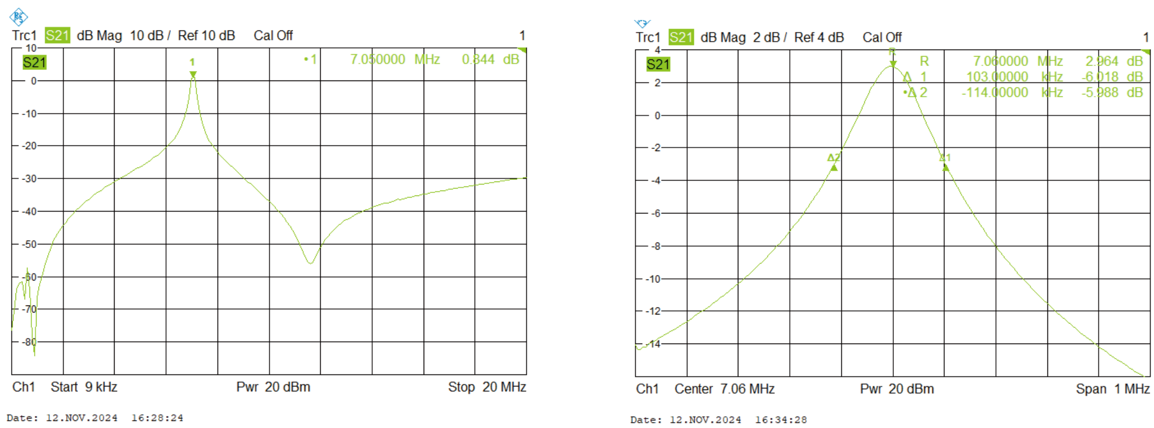


Figure 04-14. High Q coils used in DIGI-SEL with toroidal cores



Passband characteristics of DIGI-SEL at 1.81 MHz
Bandwidth at 6 dB attenuation is approximately 53 kHz



Passband characteristics of DIGI-SEL at 7.06 MHz
Bandwidth at 6 dB attenuation is approximately 220 kHz

Figure 04-15. Passband characteristics of DIGI-SEL

Figure 04-16 shows the basic circuit of the preselector used in this unit, which incorporates several capacitors and coils of different values for C1 to C5 and L1 positions, respectively. Each capacitor or coil can be switched by relays to create 4 different values for C1 and C5, 16 different values for C2 and C4, 2,048 different values for C3, and 7 different values for L1.

From among these different combinations, the relay instantly selects the best combination for the receive frequency and sets the optimum preselector circuit. The LC combination for each receive frequency is adjusted at the factory and stored in memory in the Digital Selector unit. There are approximately 380 memory points in the 1.8 MHz to 28 MHz band. The combination of these LC's will vary, depending on the band in which they are operated, but in the HF low band, the characteristics of this preselector will vary a minimum of 2 kHz steps.

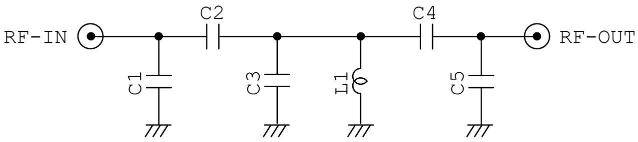


Figure 04-16. Basic preselector circuit

Bandpass Filter (BPF)

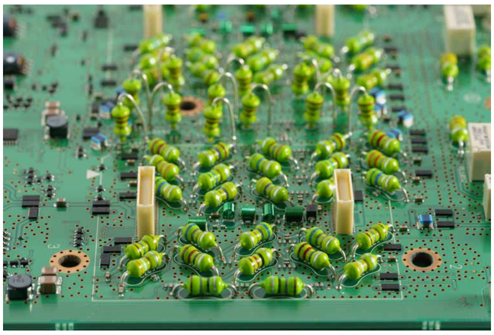


Figure 04-17. BPF circuit in the RF-B unit

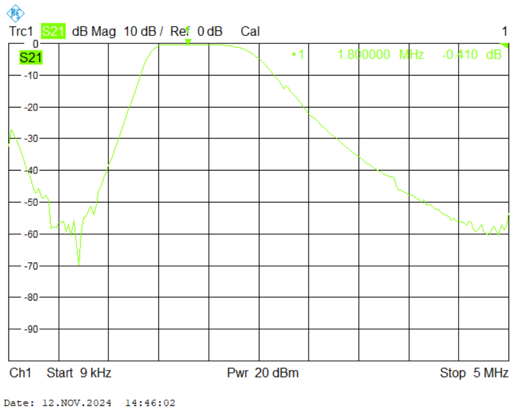
The HF amateur band is adjacent to the international broadcast bands, which transmit powerful signals that are one of the causes of distortion in the radio. The IC-7760 has a revised BPF configuration to minimize these effects. In the past, the HF band was divided into 9 bands, and a BPF was built into each band.

The IC-7760 not only divides the HF band into 11 bands but also changes the cutoff frequency of each BPF to reduce the influence of the international broadcast band and adjacent commercial radios on the amateur bands. For example, the bandwidth of the 7 MHz band BPF, which is also noted in the table below, was narrowed to 6.5~7.8 MHz in the IC-7760 from 6.0~8.0 MHz in the previous model, so that it is not affected by international broadcasting in the 5.9~6.2 MHz and 9.4~9.9 MHz bands.

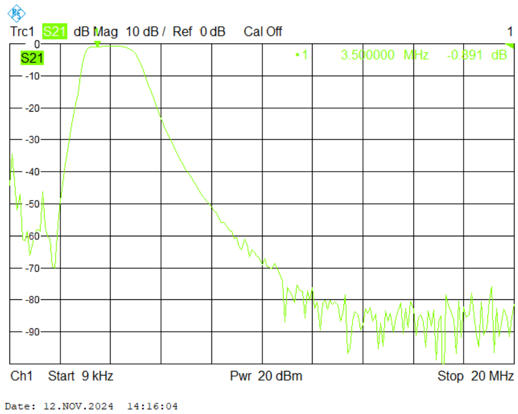
Table04-1. Comparison of passband of BPF

IC-7610/IC-7850/IC-7851	Amateur band		IC-7760
1.600000 ~ 1.999999 MHz	1.8 MHz		1.800000 ~ 1.999999 MHz
2.000000 ~ 2.999999 MHz	–		2.000000 ~ 3.390000 MHz
3.000000 ~ 3.999999 MHz	3.5/3.8 MHz		3.400000 ~ 4.099999 MHz
4.000000 ~ 5.999999 MHz	5 MHz		4.100000 ~ 6.499999 MHz
6.000000 ~ 7.999999 MHz	7 MHz		6.500000 ~ 7.799999 MHz
– – –	–		7.800000 ~ 10.099999 MHz
8.000000 ~ 10.999999 MHz	10 MHz		10.100000 ~ 12.999999 MHz
11.000000 ~ 14.999999 MHz	14 MHz		13.000000 ~ 15.899999 MHz
15.000000 ~ 21.999999 MHz	18 MHz/21 MHz	18 MHz	15.900000 ~ 19.999999 MHz
		21 MHz	20.000000 ~ 23.099999 MHz
22.000000 ~ 30.000000 MHz	24 MHz/28 MHz		23.100000 ~ 30.000000 MHz
50.000000 ~ 54.000000 MHz	50 MHz		50.000000 ~ 54.000000 MHz

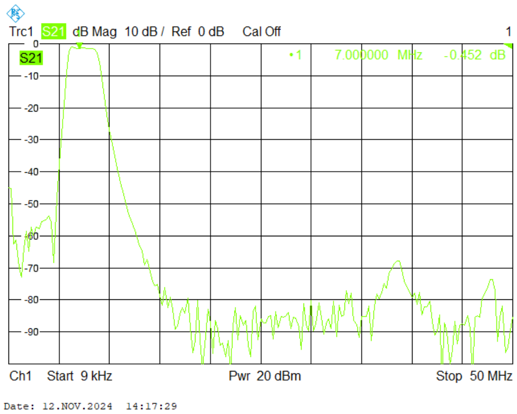
◆ BPF passband width characteristics



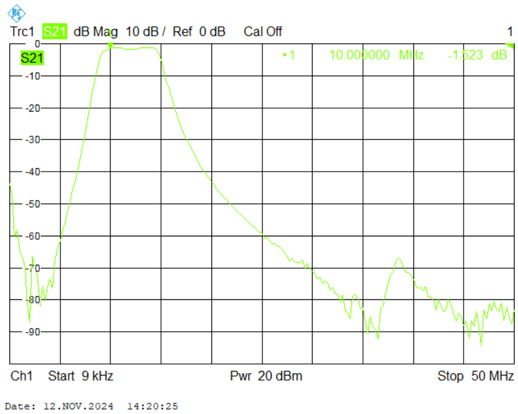
1.8 MHz Band



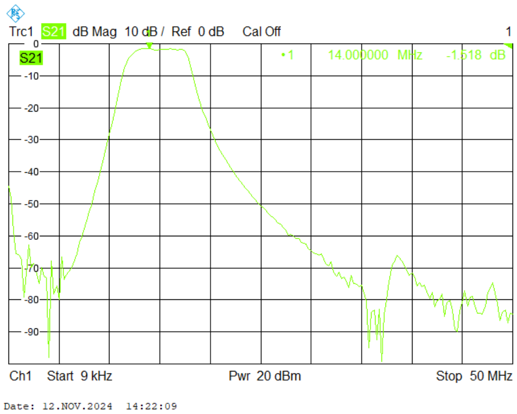
3.5 MHz Band



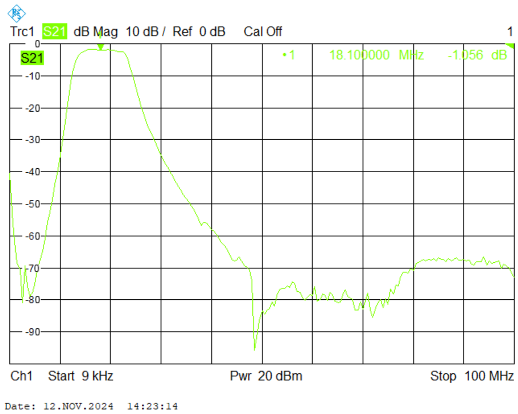
7 MHz Band



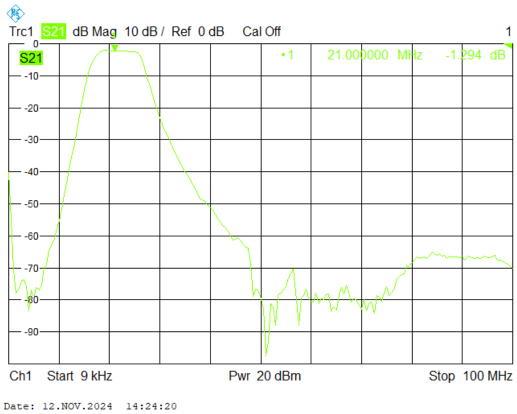
10 MHz Band



14 MHz Band



18 MHz Band



21 MHz Band

Preamplifier 1 with low distortion

Two types of preamplifiers, Preamplifier 1 and Preamplifier 2, are placed after the BPF.

Preamplifier 1, which focuses on dynamic range, consists of a push-pull noiseless feedback (NLFB) amplifier with an excellent noise figure (NF). The preamplifier is designed for operation in environments where electric field strength is relatively strong and has features that make it resistant to distortion of the received signal.

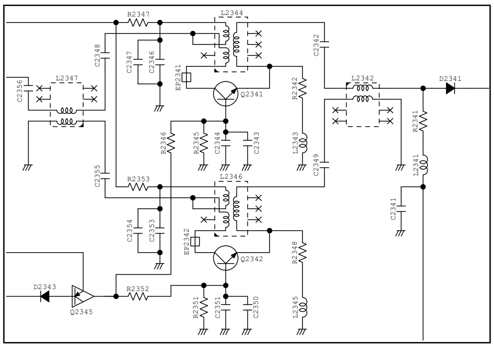


Figure 04-18. Circuit of Preamplifier 1

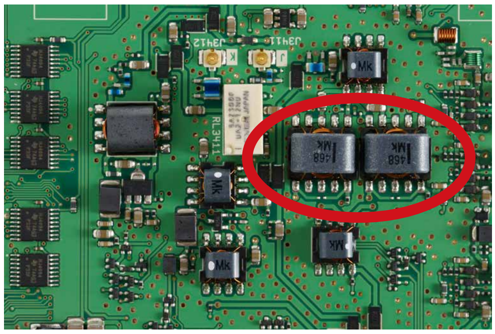


Figure 04-19. Feedback transformers

Preamplifier 2 with sensitivity-oriented and high gain/low noise figure

Preamplifier 2 is a sensitivity-oriented preamplifier that employs a high gain, low noise figure device for operating in environments where the electric field strength is relatively low.

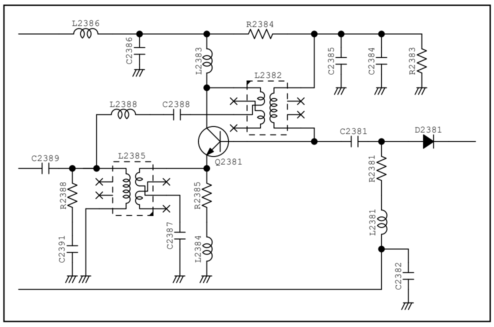


Figure 04-20. Circuit of Preamplifier 2

A/D Converter

For A/D conversion of an RF signal, A/D converters capable of sampling at up to 130 MHz based on the sampling theorem are used for each of the Main and Sub bands. Digitized RF signal is batch processed by FPGA, analog converted by D/A converters, and output from the speakers as an audio signal. The A/D and D/A converters employed in the IC-7760 are described here. It was explained that the choice of A/D converter device is based on the sampling theorem. However, the sampling theorem is for the conversion speed (=sampling rate) required for digital conversion.

Even A/D or D/A converters are largely analog elements, except for the blocks that handle digital signal. Therefore, these converters require the same considerations as analog devices, such as transistors and FETs. Therefore, as key points in device selection, we focused on Signal-to-Noise Ratio (SNR) and Spurious Free Dynamic Range (SFDR), which affect dynamic range in addition to sampling rate, and compared and examined each device.

In general, the performance of A/D converters tends to focus on the number of bits, but SNR and SFDR are important factors for receivers with direct sampling methods. SNR is synonymous with Signal-to-Noise ratio or S/N. The units are usually expressed in 'dB,' but 'dBFS' is used when the reference signal is a full-scale value.

Even A/D converters contain noise (quantization noise) in the output signal. This quantization noise is affected by the resolution, or number of bits (N), and can be expressed as SNR=6.02N+1.76 (dB)* as a theoretical value, but in reality, it is less than the theoretical value.

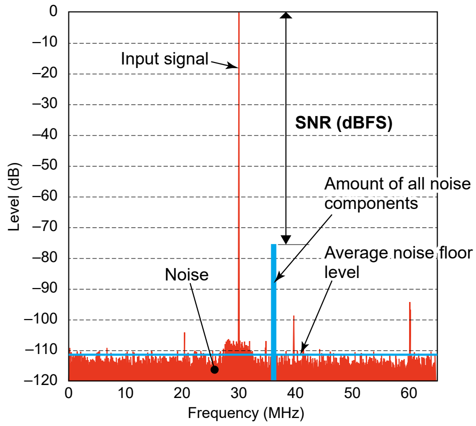


Figure 04-21. Basic idea of Signal-to-Noise Ratio (S/N).

*Calculation formula for the case where there is no noise other than quantization noise and a sinusoidal signal is input.

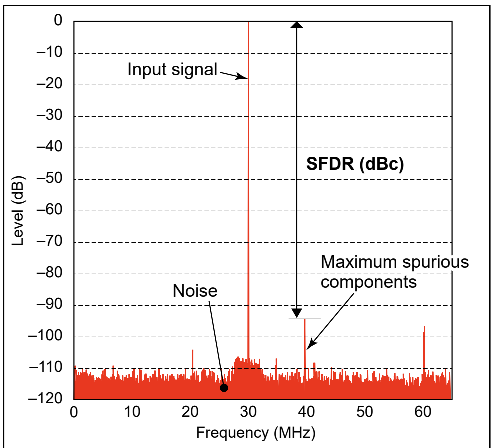


Figure 04-22. Basic idea of spurious free dynamic range

As mentioned above, SFDR stands for Spurious Free Dynamic Range: distortion (spurious components) due to their non-linearity, which also occurs in A/D converters. The SFDR value of an A/D converter is expressed as the ratio of the carrier level to the largest component of the distortion component produced when the carrier is input. The value is generally expressed using 'dBc' because it is a logarithmic ratio with reference to the carrier (= carrier), but it may also be expressed simply in 'dB' by taking the logarithm alone.

After comparing and verifying various A/D converters, the IC-7760 uses an LTC2208 for the 16-bit A/D converter with priority on SNR (Signal to Noise Ratio) performance, and an ISL5961 for the 14-bit D/A converter with total balance of SFDR and SNR. There are two types of those converters. One is for consumer use and the other for industrial use, and the IC-7760 uses the more reliable and higher quality industrial converter. However, a question arises here; A/D converters are 16-bit while D/A converters are 14-bit, which is a difference in resolution. One might think that using a 16-bit D/A converter would improve performance.

As a conclusion, in the IC-7760, SNR and SFDR are prioritized over the number of bits. Specifically, there were devices with better SNR and SFDR performance than 16-bit devices, even if they are 14-bit devices. SNR and SFDR are also important for A/D and D/A converter performance. As shown in the performance comparison in Figure 04-21, the most balanced device was selected based on factors other than number of bit count. It should be noted that there are devices with lower performance, including SNR and SFDR, than 10 and 12-bit devices, even if they are the same 14 or 16-bit devices, as a fact discovered in the process of comparison and examination.

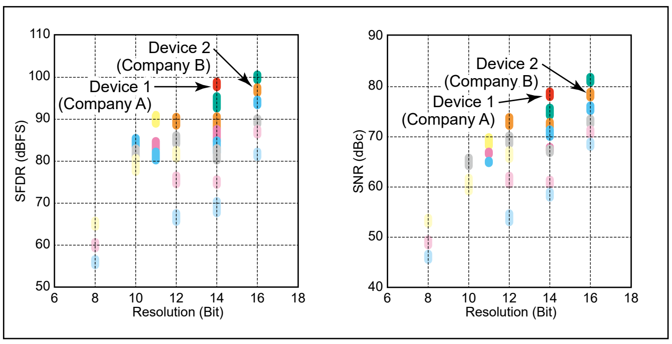


Figure 04-23. Comparison chart between SFDR and SNR

About FPGA and DSP

A Field Programmable Gate Array (FPGA) is a device that can be programmed to change the structure of a digital circuit. Even if an oscillator is normally configured with digital circuits, it can be changed to a filter or mixer configuration by changing the program, or even the same oscillator can be changed in terms of oscillation frequency, or in the case of a filter, the center frequency, bandwidth, and characteristics. It is a multi-purpose device. It can be said to be a collection of digital circuits. The program that operates the FPGA is stored in an external Flash ROM.

The IC-7760 uses an FPGA consisting of about 150,000 logic circuits to process the signals shown below.

- ➥ Conversion of received RF signals to IF signals
- ➥ Filtering at the IF stage to determine the receive bandwidth
- ➥ Receive demodulation
- ➥ Transmit modulation
- ➥ Conversion of transmit IF signals to RF signals

A DSP is a processor specialized for high-speed arithmetic processing, and unlike a CPU, it is good at signal processing, as the name “Signal Processor” implies. Therefore, the FPGA is equipped with a processor that supports floating-point processing at up to 375 MHz.

The DSP mainly processes the following operations.

- ➥ Signal processing after reception and demodulation
- ➥ Signal generation such as sidetone/beep
- ➥ DPD processing after transmit modulation
- ➥ Scope signal drawing processing

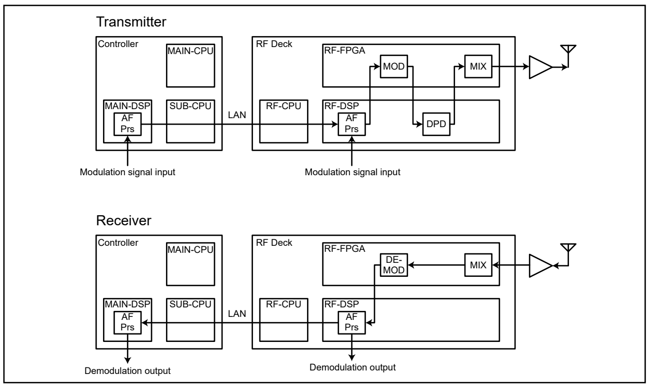


Figure 04-24. Block diagram of FPGA and DSP

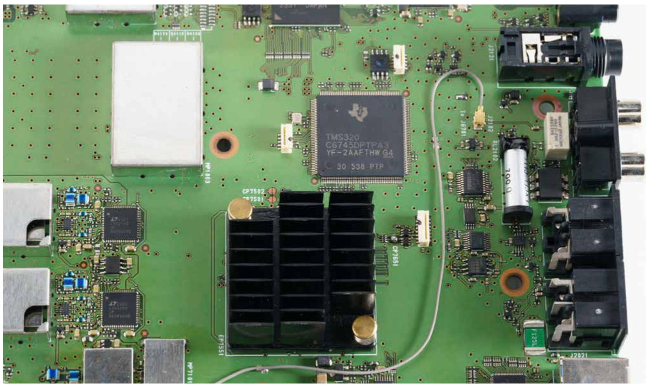


Figure 04-25. FPGA and DSP

AF amplifier

AF signals such as receive signals, key operation beeps, and sidetone output from the D/A converter are amplified by independent AF amplifiers for speakers and headphones. For speakers, the LM4952 AF stereo amplifier is used, which has a low distortion rate of 0.08% even at 2 W output and 78 dB of channel-to-channel isolation.

For headphones, the MAX97220 stereo type headphone amplifier is used. The speaker and headphone volume levels are adjusted by the DSP between the FPGA and the D/A converter, thus eliminating the need for circuits such as a Voltage Controlled Amplifier (VCA), which reduces noise level and achieves a high S/N ratio.

Figure 04-26. Main and Sub speakers are located on the top panel

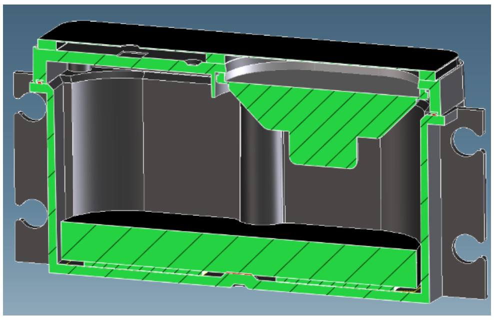


Figure 04-27. Cross-sectional view of the speaker box

Built-in speakers

In the IC-7760, from the RF stage to the AF amplifier, low noise and low distortion have been carefully considered in the design. In addition, the speaker, which converts the received signal into audio has also been carefully designed. High-end models from the IC-7800 onward used a structure in which the speaker was built into a dedicated speaker cabinet.

In the IC-7760, dedicated speaker enclosures are separately installed for each of the Main and Sub bands. This enables clear reception by outputting the Main and Sub band received audio from separate independent speakers during Dualwatch® operation.

This arrangement makes it easy to distinguish between two speaker audio outputs, and also provides fatigue-free sound quality, even during contests and other long hours of operation.

- PART 5 -

Transmission Blocks 05

Commitment to transmission performance

◆ What is transmitting performance?

Is it the transmitting performance that provides sufficient RF power? Spurious level and transmission bandwidth as defined by the Radio Law are also important items that indicate transmission performance.

Regarding reception performance, a decade ago, it was taken for granted that "you cannot communicate with a signal that cannot be heard. However, there was a rare phenomenon in which "signal that should be inaudible were audible. In recent years, this point has been the focus of attention, and specifications such as 3rd Intercept Point (IP3) and Reciprocal Mixing Dynamic Range (RMDR) have come to be considered important. At the same time, in addition to the importance placed on bench test figures, there is also an excessive focus on phenomena that do not occur frequently in actual operation.

On the other hand, in terms of reception performance, our policy was "less susceptibility to interference from signal emitted by other stations," but in the IC-7760, we have adopted the policies of "no interference to other stations" and "clean and clear transmission signals" in terms of transmission and we worked on Digital Pre-Distortion (DPD) to reduce transmission phase noise and to improve transmission Intermodulation Distortion (IMD).

In addition, to cope with high loads on the transmitting power amplifier for RTTY or CW, our design policy is to ensure stable transmitting performance even in an environment of continuous long period of transmission. This section describes these transmission performances step by step.

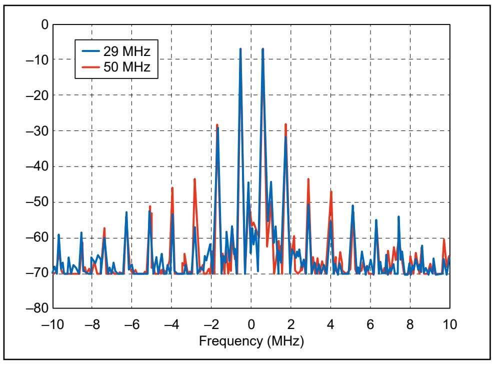


Figure 05-1. Transmit IMD characteristics

Digital Pre-Distortion (DPD) initiatives

First, let us explain what a bad transmit IMD signal looks like. The transmission bandwidth of Single Side Band (SSB) is considered to be 3 kHz or less. This means that the modulation component (voice) between 0 and 3000 Hz is emitted as a signal. However, in transmitters with poor transmit IMD, unwanted frequency components are generated by the various frequencies in the band, distorting the signal and generating signal outside the 3 kHz bandwidth.

The graph shown in Figure 05-1 is an example of the transmitted IMD data from our past HF equipment. The red and blue data are for the 50 MHz and 29 MHz bands, respectively. This examination was done according to the American Radio Relay League (ARRL) measurement method. Input a 700 Hz and a 1900 Hz audio signal to the microphone connector and measure the spectrum of the transmitted output. We can see a spectrum that is a component of distortion every 1200 Hz, which is the difference frequency component between 1900 Hz and 700 Hz.

Continued on the next page…

The third-order distortion (=3rd IMD) components which in this data are 700–1200=–500 Hz and 1900+1200=3100 Hz, extend to the left and right of the center frequency and are the largest distorted components. These are about 30 dB below the rated output, but not at a level that has no effect on nearby frequencies. Next are the measurement results of the IC-7760 (with DPD OFF) which does not operate DPD, but has an analog circuit with thorough distortion countermeasures, so the distortion components are greatly reduced compared to the previous model.

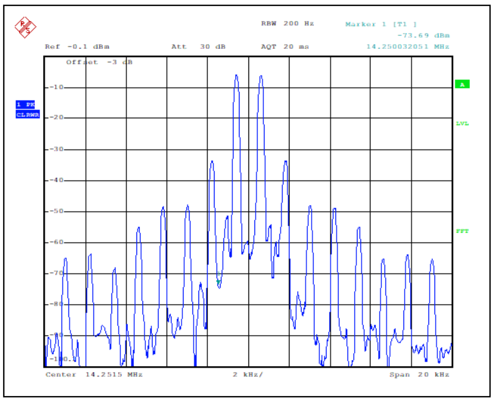


Figure 05-2. IC-7760 transmit IMD characteristics with DPD OFF

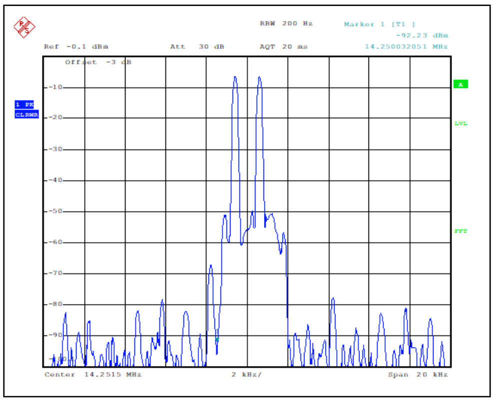


Figure 05-3. Transmit IMD characteristics with DPD ON

The measurement results when DPD is operated are shown in Figure 05-3. DPD reduces the third-order distortion component level by about 20 dB and the fifth-order distortion component by nearly 30 dB.

The results so far are the measurement of transmitted IMD with 2 tones according to the ARRL measurement method. It would not be possible to confirm this with an actual signal. Therefore, the spectrum scope screen below shows the transmission spectrum measured with a modulation close to the actual voice signal using a pseudo voice signal. The out-of-band radiation level is clearly reduced. This is the improved performance of transmitted IMD due to the DPD function.

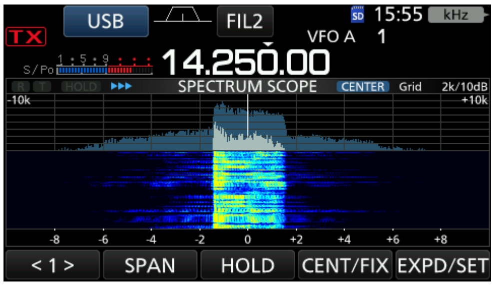


Figure 05-4. Receive signal spectrum when DPD is OFF

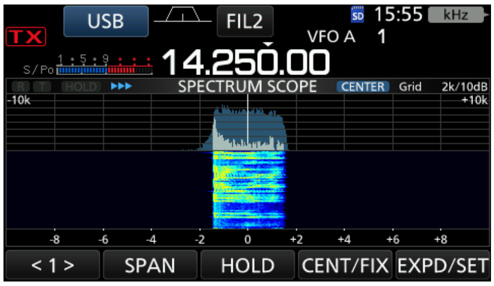


Figure 05-5. Receive signal spectrum when DPD is ON

Transmission phase noise

The improvement of transmit IMD is an effort related to the transmit signal at the time of modulation, but another important item is the signal purity of the carrier itself, or how to reduce phase noise.

This data is the spectrum of transmitted signal when keyed down in CW. In CW operation, other stations may be transmitting on frequencies several hundred Hz apart, depending on the band. If the transmitted signal contains a lot of phase noise, it can cause interference to adjacent frequencies. The IC-7760 reduces phase noise associated with transmitted signal by thoroughly improving the signal purity of the master clock used in signal generation blocks such as FPGAs and D/A converters.

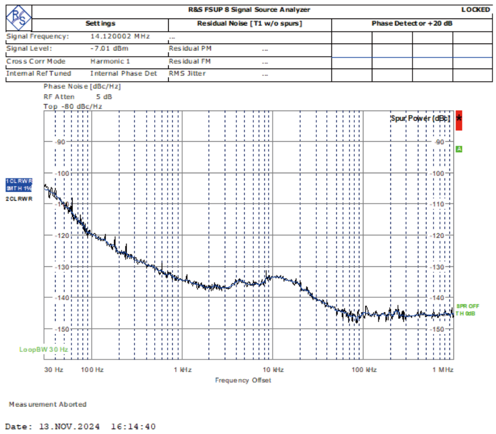


Figure 05-6. IC-7760 transmit Carrier to Noise Ratio (C/N) characteristics

Performance in continuous transmission

The IC-7760 was designed to operate stably, even at 200 W continuous transmission. In particular, there is no degradation in transmit power or frequency drift, even in contest operations such as frequent continuous carrier transmissions in RTTY and other applications. Of course, there is no deterioration of transmit IMD or phase noise characteristics, as mentioned above.

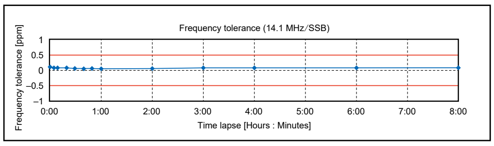


Figure 05-7. Frequency tolerance on SSB at 14.1 MHz

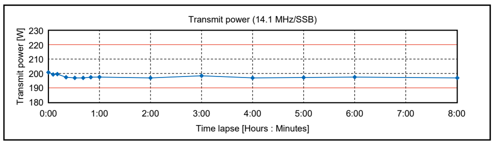


Figure 05-8. Transmission power variation over time on SSB at 14.1 MHz

Transmit PA unit

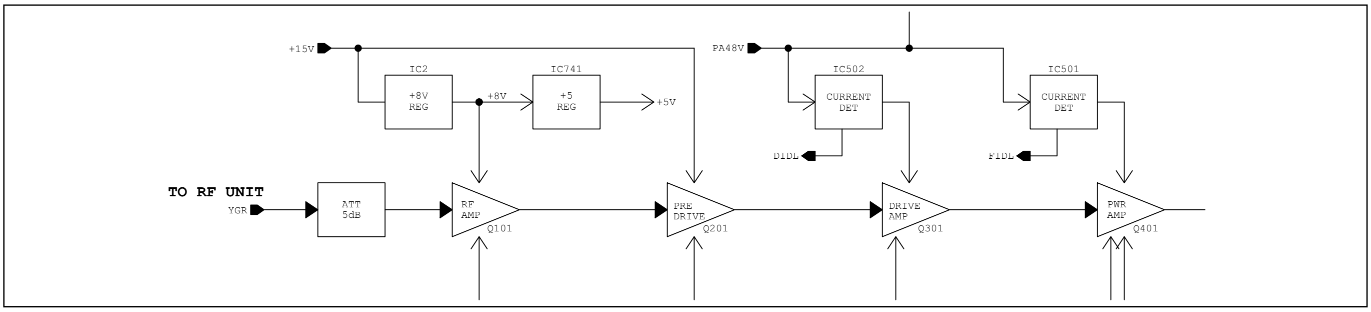


Figure 05-9. Block diagram of the PA unit

The PA unit consists of four stages, as shown in Figure 05-9 above, and amplifies an input signal of approximately 0 dBm (= 1 mW) to 200 W. The attenuator in the PA input stage is intended to stabilize the input impedance close to 50 Ω, as well as to adjust the gain. Each stage from the RF AMP to the PWR AMP uses the devices shown below.

Table05-1. List of devices used.

Stage	Device	Test Frequency	Maximum Power Consumption	Type of transistor	Vd	Remarks
RF AMP	RD01MUS	520 MHz	1 W	VDMOS	8 V	–
PRE DRIVE	PD55003	500 MHz	3 W	LDMOS	15 V	–
DRIVE	BLP15H9S30	1400 MHz	40 W	LDMOS	48 V	–
PWR AMP	ART450	225 MHz	450 W	LDMOS	48 V	Push-Pull

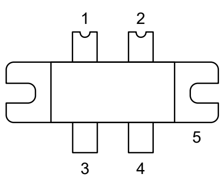
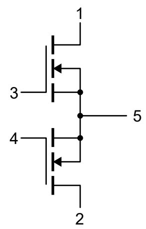
Figure 05-10. PA unit of the IC-7760

As you can see in Table 05-1, LDMOS devices are used in all stages after PRE DRIVE, and a detailed explanation of the LDMOS is given in the About the power amplifier devices section.

About the power amplifier device

The ART450 power amplifier device used in the IC-7760 consists of two LDMOS elements in a single package.

Table05-2. ART450 device information

Pin No.	Description	Outline view	Internal circuit
1	Drain-1		
2	Drain-2		
3	Gate-1		
4	Gate-2		
5	Source		

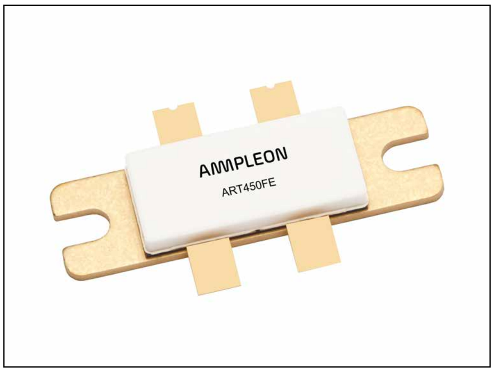


Figure 05-11. Appearance of ART450 LDMOS

◆ Features of the LDMOS - High gain and high efficiency

The LDMOS used in the IC-7760 power amplifier has a high Vds withstand voltage (VDSS) of 208 V, making it particularly resistant to breakdown due to load impedance changes. In addition, thermal resistance is as low as 0.2°C/W, a characteristic that makes thermal breakdown unlikely to occur. It is a power amplifier device with excellent heat dissipation. Combined with the molded heat sink and large cooling fan described below, the configuration can withstand continuous transmission for long periods of time.

For your reference

The VRF150, a Vertical Double-diffused MOS (VDMOS) device used in many HF 200 W devices to date, has a Vds withstand voltage of 170 V DC and a thermal resistance of 0.6°C/W.

◆ Power Amplifier Characteristics

Another characteristic of LDMOS is its high efficiency. When an LDMOS is operated at a high drain voltage, the ON-resistance between the drain and source becomes extremely low. The lower loss due to this ON-resistance results in higher efficiency. This low ON-resistance indicates low heat generation at the rated output of the device.

As shown in Table 05-1, the drain voltage of the IC-7760 power amplifier is as high as 48 V DC. This means that the drain-source resistance is also low and highly efficient. In addition to excellent heat dissipation, heat generation itself is low, enabling continuous transmission for long periods of time.

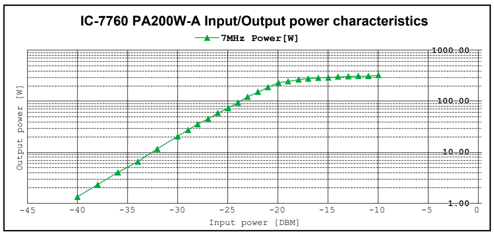


Figure 05-12. PA input/output characteristics of the IC-7760

Next, the input/output characteristics of the IC-7760 power amplifier unit are explained using a typical example in the 7 MHz band.

All amplification elements including power amplifiers have saturation power, and although the rated output of the IC-7760 is 200 W, the verification of the power amplifier unit showed that the saturation power was about 300 W. In other words, it is designed with a margin of about 2/3 of the rated output saturation level. This margin also contributes to improved transmit distortion characteristics.

Heat dissipation design

The blocks that generate heat in the RF Deck of the IC-7760 are the following four blocks.

- RF power amplifier
- AC-DC power supply
- LPF for transmitter circuit
- Antenna tuner

The block that generates the most heat is the RF power amplifier. A special aluminum heat sink is used to dissipate heat from this power amplifier unit. This heat sink is made by extrusion molding.

This extrusion molding heat sink has the following advantages over die casting molding.

- Materials with high thermal conductivity can be used.
- Longer heat dissipating fins can be molded at close intervals.
- Less likely to contain air bubbles or other “nests” during the molding process.
- A molding method for heat sinks that can dissipate heat more easily.

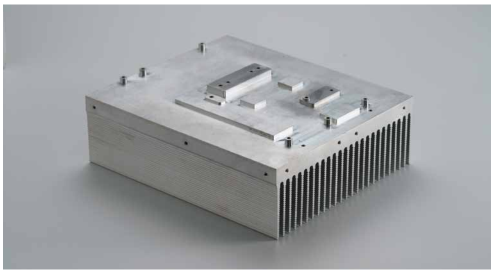


Figure 05-13. The heat sink used in the IC-7760

Figure 05-14. Cooling air flow

Figure 05-15. Two large cooling fans are installed on the PA unit

In addition to the highly efficient heat sinks, the front of the RF Deck is equipped with two large 120 mm square cooling fans that draw air in from outside, and two 80 mm square fans on the rear panel that draw air out from inside. These four fans are used to efficiently cool the heatsinks and internal units. Both fans are rated at 12 V DC, but the IC-7760 drives them at 7 to 10 V DC, depending on the temperature inside the RF Deck. The drive voltage is directly related to the rotation speed of the cooling fan. However, the power amplifier devices used in the IC-7760 generate little heat and have high heat dissipation efficiency. Because they are combined with heat sinks with even higher heat dissipation efficiency, they can be cooled sufficiently even at low cooling fan speeds. By reducing the rotating speed of this cooling fan, noise such as wind noise from the cooling fan is reduced.

About the Antenna Tuner

The antenna tuner built into the IC-7760 is not a variable capacitor-type matching circuit as used in our previous 200 W models, the IC-7700 and IC-7850/IC-7851. The IC-7760 antenna tuner is a relay-type matching circuit that combines a number of coils and capacitors using mechanical relays.

The advantages of relay-type matching circuits are listed below.

- The matched matching circuit state (LC combination) can be memorized, so switching to a tuned frequency is quick.
- The transmitting power required for tuning can be suppressed to about 10 W, which reduces interference to other stations during tuning.
- Reduced interference and interference to other stations
- Reduced number of parts with mechanical life such as motors used in variable capacitor control systems.
- No variation due to assembly accuracy.

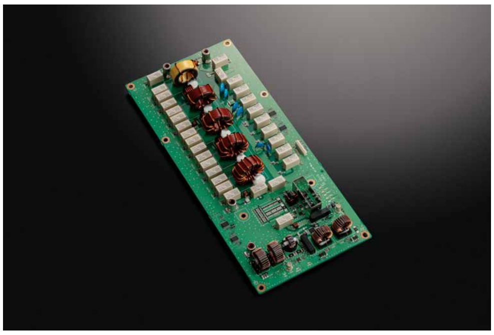


Figure 05-16. Antenna Tuner Unit

As mentioned earlier, once tuned with the same antenna at the same frequency, tuning time is almost negligible because the system memorizes the matching state of the internal coil and capacitor combinations. Furthermore, even if it is the first time tuning a frequency and antenna combination, tuning is completed in 2 to 3 seconds in most cases, and within 15 seconds at the most. The tunable load range is 16.7 to 150 Ω (SWR = 3.0 or less), and the matching accuracy is SWR = 1.5 or less.

When using an antenna with a high impedance, such as a long wire antenna, use our AH-730 External antenna tuner. The transmitter output power of the IC-7760 is 200 W, which exceeds the 150 W of rated input power of the AH-730. The 150 W rated input power of the AH-730 is the peak power, so when using the AH-730 in a mode such as a continuous carrier, it should be used at 100 W for safety. Therefore, when the AH-730 is connected to the [TUNER] connector on the rear panel of the RF Deck, the IC-7760 automatically limits the transmit power to 100 W to protect the AH-730 from damage due to excessive input.

Figure 05-17. [TUNER] connector for the AH-730

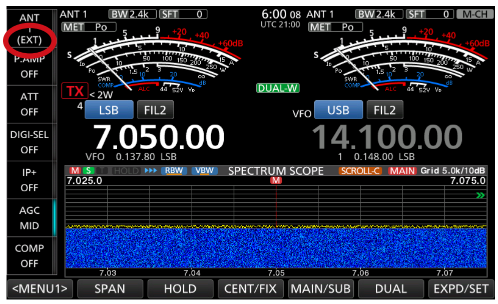


Figure 05-18. "EXT" displays when the AH-730 is connected

When the AH-730 is connected, "EXT" is simultaneously displayed on the [ANT 1] display portion of the multi-function key, as shown in Figure 05-18. The external antenna tuner is initially assigned to ANT 1, but the antenna connector can be set arbitrarily from ANT 1 to ANT 4 in the antenna Set mode.

Continued on the next page…

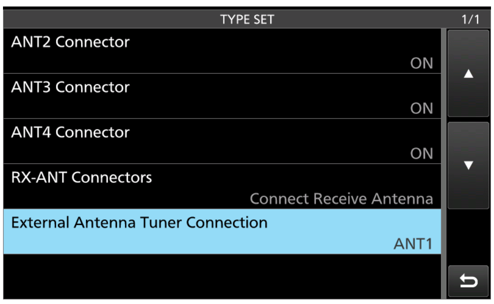


Figure 05-19. Screen of the antenna Set mode

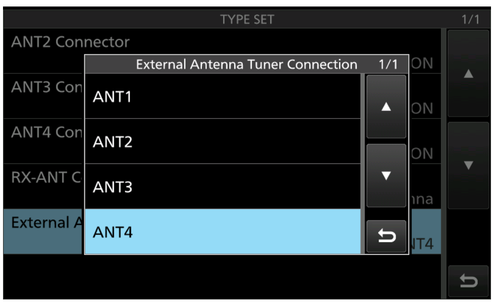


Figure 05-20. Screen of the external antenna tuner Set mode

The basic matching circuit operation of the antenna tuner built into the IC-7760 is an L-type matching circuit.

When the antenna impedance is higher than 50 Ω, a capacitor (C) is placed on the antenna side, and when the impedance is lower than 50 Ω, a capacitor is placed on the power amplifier side to ensure a wide matching range. By making combinations with many coils and capacitors, the wide matching range is made in small steps.

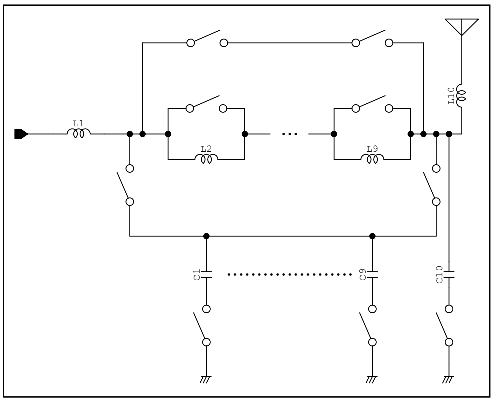


Figure 05-21. Basic L-type matching network

About the Low-pass Filter (LPF)

The output signal of a transmitting power amplifier inevitably contains integer harmonic components. Since each stage in the PA unit of the IC-7760 employs devices that can provide gain up to the VHF band or higher, sufficient care must be taken to suppress harmonics generated in each stage.

As shown in the block diagram Figure 05-23 below, the IC-7760 covers the 1.8 to 54 MHz range with LPFs of eight different cutoff frequencies. In particular, the LPF coils used for frequencies below 21 MHz are designed with multiple large toroidal cores stacked on top of each other, to avoid characteristic degradation due to heat generation.

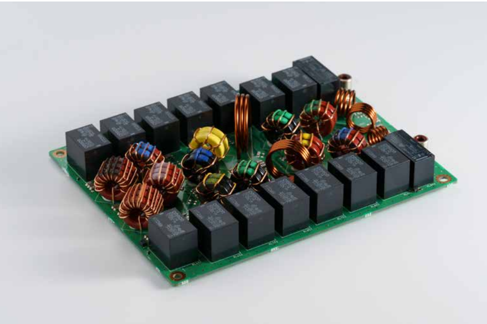


Figure 05-22. Filter unit with LPF mounted

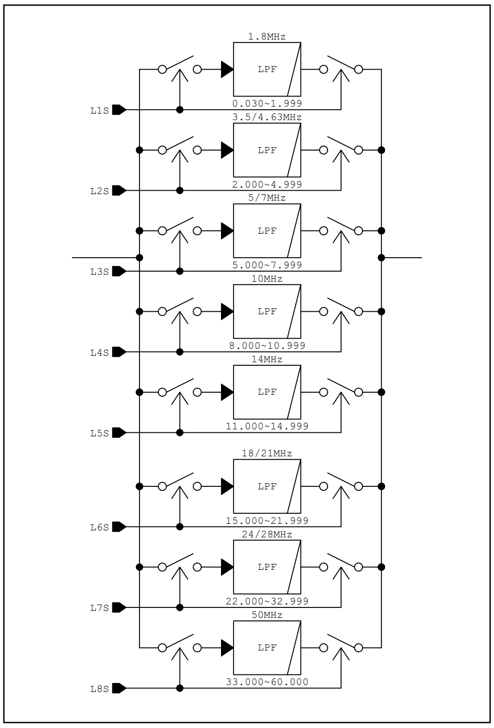


Figure 05-23. Block diagram of LPF

About Digital Pre-Distortion (DPD)

◆ About the circuit configuration

As mentioned in "New Initiatives," the DPD in the IC-7760 analyzes and learns the distortion characteristics (green line) of the power amplifier inside the IC-7760 and improves the distortion characteristics by applying a signal (orange line) to the power amplifier that cancels out the distortion (blue line).

◆ Distortion characteristic measurement

Distortion characteristics vary from individual to individual due to variations in the devices used in power amplifiers and the components used in peripheral circuits. Therefore, distortion characteristics are analyzed during production.

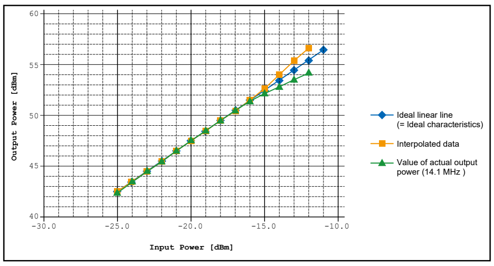


Figure 05-24. Input/Output characteristics of the IC-7760 RF power amplifier

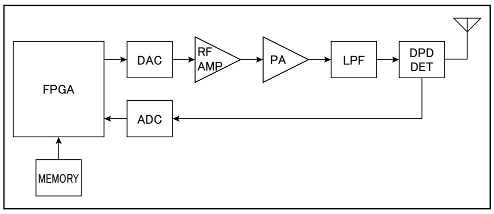


Figure 05-25. Block diagram of the DPD control circuit

While varying the RF output level of the D/A converter shown in the block diagram, the output level of the LPF in the latter stage of the power amplifier is detected and analyzed by the DPD detector. When DPD is used, the D/A converter outputs RF signals with distortion compensation characteristics based on these stored values. This characteristic data is analyzed for each amateur band and distortion correction is applied according to the transmitted frequency.

About the effect of DPD

The DPD function improves the distortion characteristics of transmitted signal. As a result, it reduces signals that may cause interference to other stations and improves the readability of the other station during reception. The most commonly observed data is the transmit Inter-Modulation Distortion (IMD). Generally, the 3rd IMD of a class-AB push-pull amplifier is about 40 dB in the best case, and about 30 dB in the worst case.

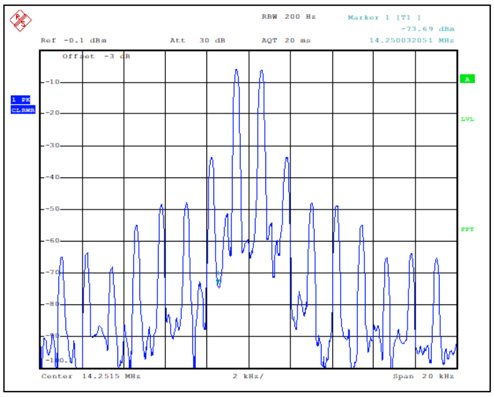


Figure 05-26. Transmit IMD characteristics when DPD is OFF

Figure 05-26 shows the measurement result of the IMD characteristic at the transmitting output of IC-7760. This level is not a problem for a general amateur radio. However, a higher-order distortion appears in the spectrum outside the SSB band (BW = 3 kHz). This frequency component may affect the operation of other adjacent stations.

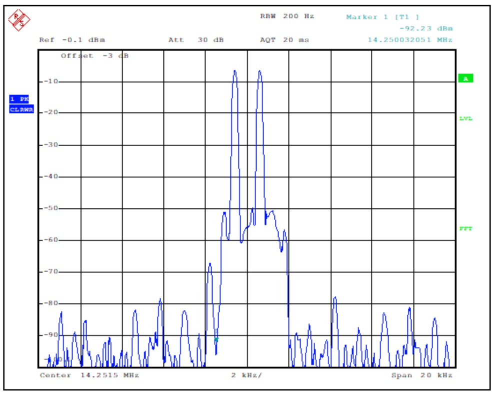


Figure 05-27. Transmit IMD characteristics when DPD is activated

The graph Figure 05-27 to the right shows the IMD characteristics when the DPD function of the IC-7760 is activated. The distortion component is significantly reduced compared to Figure 05-26, showing an improvement of more than 30 dB. In actual operation, interference and jamming from other stations located more than 3 kHz away may not be eliminated, even if the IF filter is narrowed. This can be attributed to poor IMD characteristics.

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Figure 05-28 shows the transmitted signal when modulated with a pseudo-audio signal (a signal similar to white noise) that is close to the actual modulated signal. Although the specifications required by law are fully satisfied, about 60 dB of influence remains at a point 4 kHz away from the center frequency.

As can be seen from this measurement, turning ON the DPD function clearly results in a significant reduction in unwanted emissions on adjacent frequencies. The data shows an improvement of more than 15 dB at a point 4 kHz away from the center frequency.

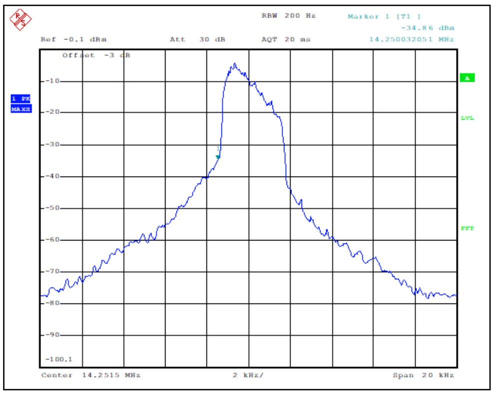


Figure 05-28. IC-7760 pseudo audio spectrum/DPD is OFF

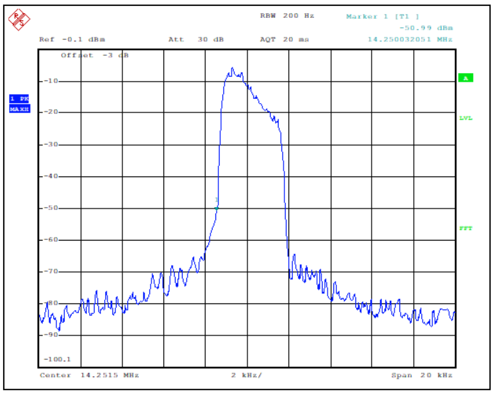


Figure 05-29. IC-7760 pseudo voice spectrum/DPD is activated (ON)

Figure 05-30 and 05-31 show a transmitted signal from one IC-7760 received by another IC-7760. The upper and lower images show signals received with the DPD function OFF and ON, respectively. The settings other than the DPD function are the same in both cases. This shows that there are fewer unwanted frequency components that would cause distortion occurring in the upper and lower regions of the band.

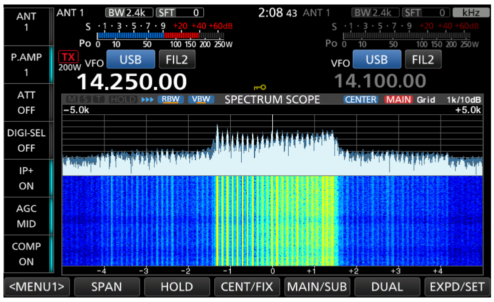


Figure 05-30. Scope with a pseudo audio spectrum (DPD function = OFF)

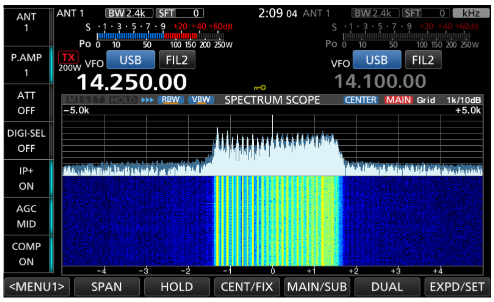


Figure 05-31. Scope with a pseudo audio spectrum (DPD function = ON)

About DPD linkage when using an IC-PW2

We have already explained that the transmission distortion characteristics of the IC-7760 have been greatly improved by the DPD function, but many operators of IC-7760 class radios connect linear amplifiers and use output power on the order of a kilowatt. No matter how small the transmitting distortion of the radio unit itself is, if the distortion characteristics of the linear amplifier connected in the subsequent stage are poor, the characteristics of the linear amplifier will ultimately appear in the output signal. As a result, there is a possibility of interference to stations operating on adjacent frequencies.

With Icom's IC-PW2, there is no need to worry because it is designed to work with our DPD-compatible HF radios, including the IC-7760. The [ALC 1]/[ALC 2] jacks on the rear panel of the IC-PW2 can output a feedback signal for DPD which can be connected to the [ALC] jack on the IC-7760 RF Deck to enable it to analyze and learn the IC-PW2 distortion characteristics. In this case, normal ALC control is performed by pin 5 of the ACC connector.

When using the DPD function in conjunction with an IC-7760 and an IC-PW2, customers will need to make their own DPD adjustments after installation and connection. This is due to the individual differences in the distortion characteristics of the IC-PW2, as mentioned above. Let the IC-7760 analyze and learn the distortion characteristics specific to your IC-PW2 before operation. For details on DPD adjustment, refer to the IC-7760 and IC-PW2 instruction manuals.

Below are graphs of distortion improvement by DPD when an IC-7760 and an IC-PW2 are combined. The DPD function has led to an improvement clearly in the quality of transmitted signal.

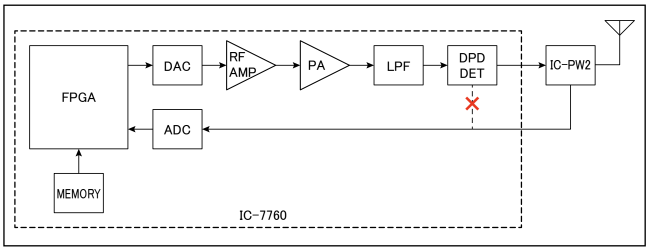
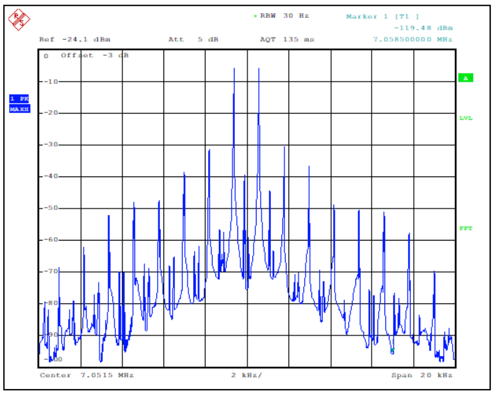
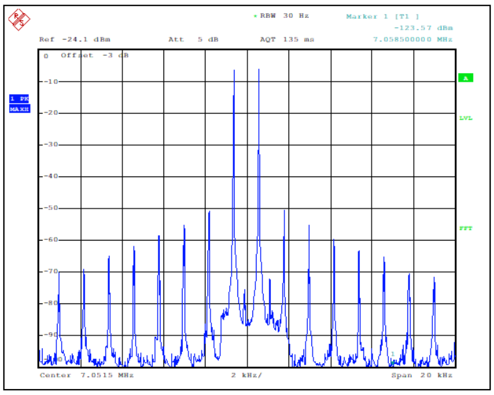


Figure 05-32. The DPD control configuration when an IC-PW2 is connected

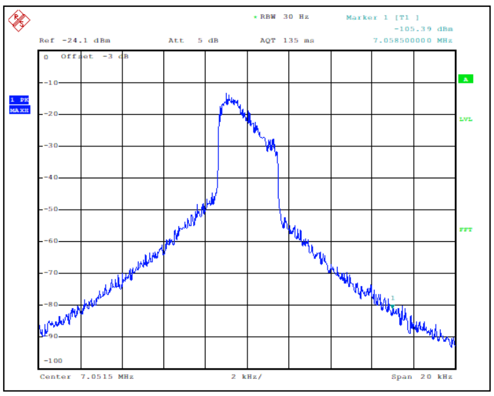


DPD=OFF/3rd IMD≈30dBc

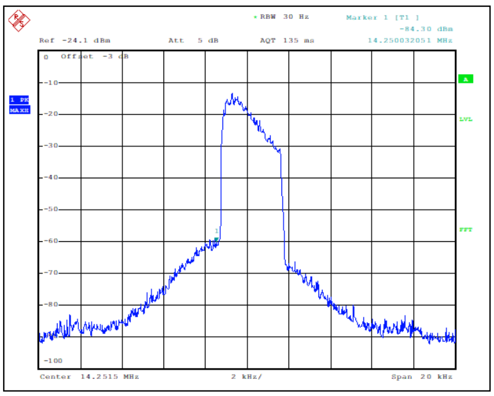


DPD=ON/3rd IMD is 50 dBc or less
≈20 dB improved compared with DPD=OFF

Figure 05-33. Transmit IMD characteristics when applying 2-tone modulation signal



DPD=OFF



DPD=ON/Noise levels in the out-of-band region are reduced by 10 dB or more

Figure 05-34. Comparison of transmit IMD characteristics with a pseudo audio signal

About the D/A converter

The transmitter circuits of the IC-7760, like the receiver circuits, do not employ the heterodyne method using an analog mixer and local oscillator. The FPGA generates the transmit signal and the D/A converter converts them into analog RF signal. Therefore, the RF signal components generated by this method do not have spurious effects caused by heterodyning.

Details of the transmit D/A converter used in the IC-7760 are as follows.

An ISL5961, which has a proven track record in the IC-7610, is used.

Sampling clock: 122.88 MHz
SFDR: Approximately 86 dBc

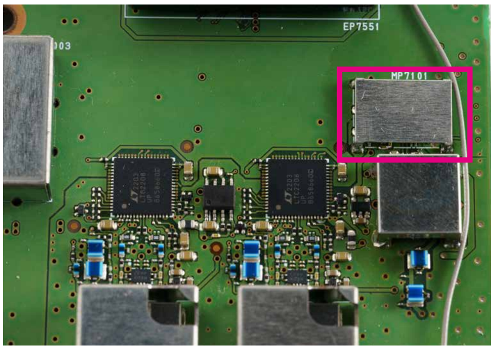


Figure 05-35. Transmit D/A converter
(Inside the shield case shown in the red frame.)

Input from D/A converter to PA (Power Amplifier) unit

Transmit frequency control and modulation processing are performed inside the FPGA. The digital RF signal output from the FPGA is converted into an analog RF signal by the D/A converter, as already explained. Therefore, the analog circuit from the D/A converter to the antenna connector is designed to ensure the linearity of the amplification circuit, level control, and the removal of unwanted frequency components.

The LPF immediately after the D/A converter is a Nyquist filter that removes the folded component of the master clock of the D/A converter. Therefore, this LPF removes frequency components above 61.44 MHz, which is half the frequency of the master clock.

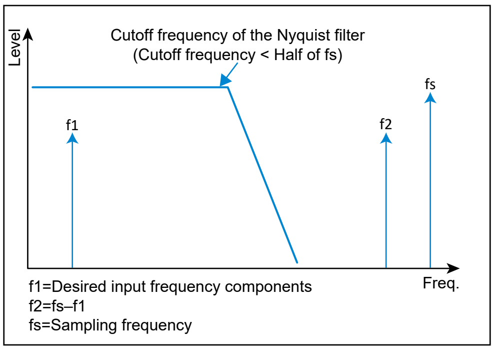


Figure 05-36. Concept of Nyquist filter

What is a Nyquist filter?

A Nyquist filter is a filter that removes unnecessary frequency components in order to extract only the necessary frequency components among the frequency components generated during signal sampling.

In the ideal sampling shown in the figure below, when two different frequencies, f1 and f2, are input to the A/D converter, the D/A converter outputs a signal as shown in the graph.

The filter that removes the f2 component is called the Nyquist filter.

f1=desired output frequency component
f2=fs–f1
fs=sampling frequency

[In the case of the A/D converter]
When the desired frequency component (f1) signal is sampled (digitized) at the sampling frequency (fs), the f2 component (fs–f1) such as a strong signal from broadcasting stations or internal spurious signal may be input into the A/D converter. If this happens, this f2 component is also processed the same signal as f1. Therefore, a Nyquist filter that removes the f2 component is required at the input of the A/D converter.

[In the case of the D/A converter]
When the desired frequency component (f1) is obtained from the D/A converter, the f2 component (fs–f1) is simultaneously output. Therefore, a Nyquist filter to remove the f2 component is required at the D/A converter output.

Continued on the next page…

The next stage of the LPF is an ALC (Automatic Level Control) circuit consisting of a variable attenuator using PIN (P-Intrinsic-N) diodes and an amplifier. This circuit detects the transmit output level just before the antenna connector and feeds back the detection result (DC voltage) to this ALC circuit to limit the transmit output to the level set in the radio itself. Distortion caused by the ALC control is suppressed by using a PIN diode, and by controlling with an appropriate time constant according to the operation mode.

At the rear of the ALC circuit is a BPF that is shared with the receiver circuit. This BPF reduces transmit spurious by attenuating frequency components outside the amateur bands.

The transmit signal that has passed through the BPF is further amplified in the next stage amplifier to the level required by the PA unit in the subsequent stage.

This amplifier and its peripheral circuits are designed to minimize distortion in this stage by using analog circuits with high saturation characteristics.

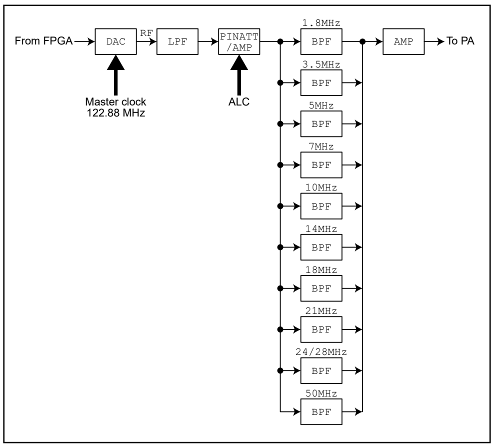


Figure 05-37. Transmit block diagram after the stage of the D/A converter

Keying waveform and signal purity in CW transmission

In designing the IC-7760, it was explained earlier that the major goal was to generate a clean transmit signal by suppressing unwanted components generated in the vicinity of the transmit frequency. It was also explained that the transmitter circuitry in SSB mode thoroughly suppresses distortion and DPD technology is used to reduce splatter and other unwanted components generated at adjacent frequencies.

The following two items are also important for CW transmit signal.

➥ Phase noise must be low.
➥ Low key clicks.

About phase noise

Phase noise refers to noise generated in the frequency range adjacent to the target frequency signal when a Phase Locked Loop (PLL) circuit is used to generate the signal. In the PLL circuit, the oscillation frequency is compared with a reference frequency by a phase comparator, and the signal generated by the comparison is fed back into the loop as a control signal to keep the oscillation frequency constant. The fluctuating component of the frequency during this control becomes phase noise. In a typical radio configuration, phase noise is reduced by varying the frequency oscillated by the PLL in order to cover a wide range of transmit and receive frequencies.

Therefore, it is susceptible to phase noise depending on the frequency at which it is oscillated.

The IC-7760 has only a PLL circuit that oscillates a fixed frequency of 122.88 MHz, the master clock for the FPGA, A/D and D/A converters, and is not affected by phase noise associated with variable frequency. The details of the circuit are described in the "Generator circuit for sampling clock signals."

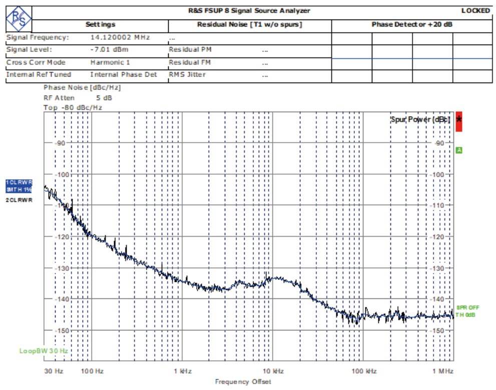


Figure 05-38. Transmit phase noise characteristics on the 14 MHz band

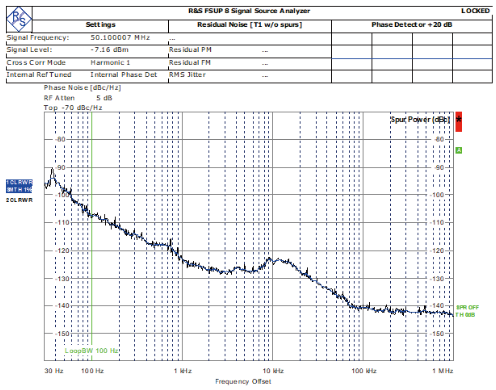


Figure 05-39. Transmit phase noise characteristics on the 50 MHz band

About key clicks

CW stands for Continuous Wave, which transmits information by intermittent radio waves. In other words, the repetition of emitting and stopping radio waves is performed in the transmitter circuit.

Therefore, the rise and fall of the radio wave becomes pulse modulation, and the Fourier-transformed modulation component spreads in the vicinity of the target signal. This is the cause of the phenomenon known as key clicks.

To reduce key clicks, the CW transmission waveform, for example, the rise and fall of the radio wave, should not be a steep rise and fall waveform like a square wave, but should have an envelope to the extent possible.

In that case, care should be taken because a loose slope of the envelope will cause the radio wave to fall off before the set sufficient transmission power can be obtained when the keying speed is increased. In the IC-7760, this waveform forming time (envelope slope) can be varied in the Set mode.

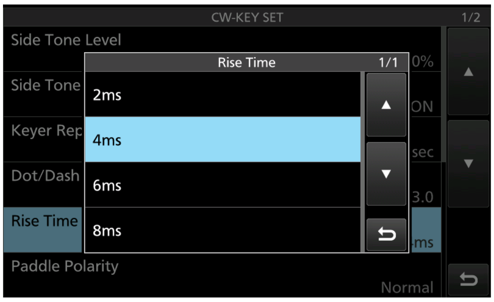
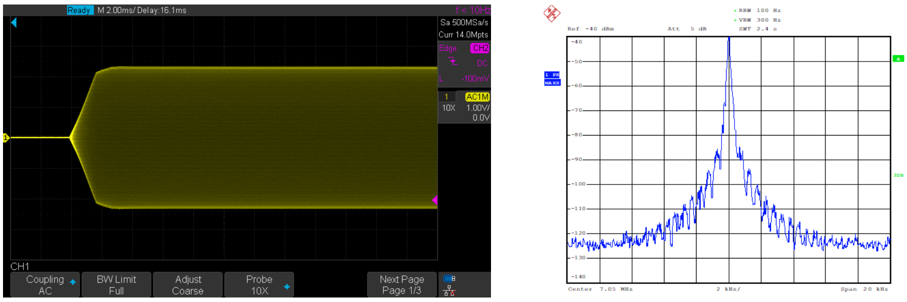
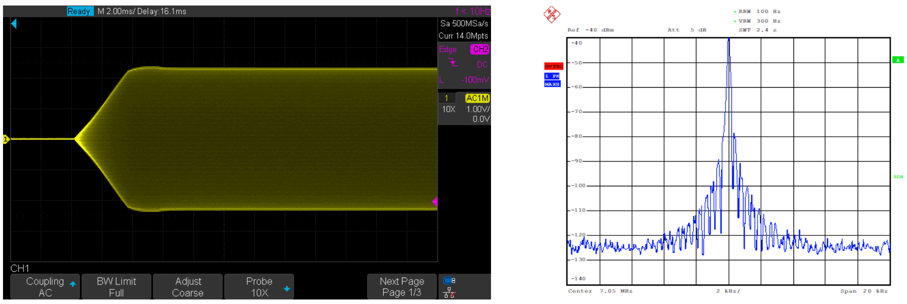


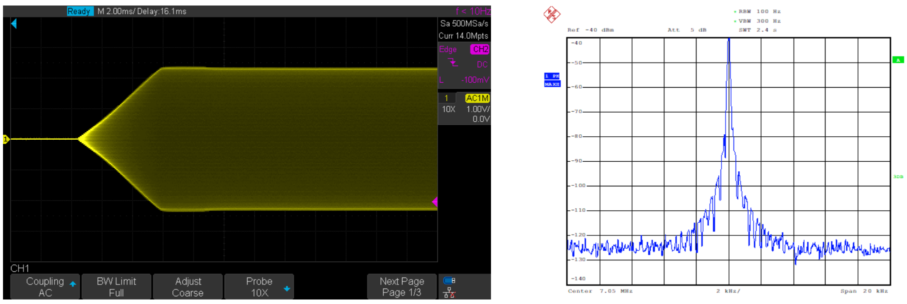
Figure 05-40. Setting screen for selecting CW rise time on the key down



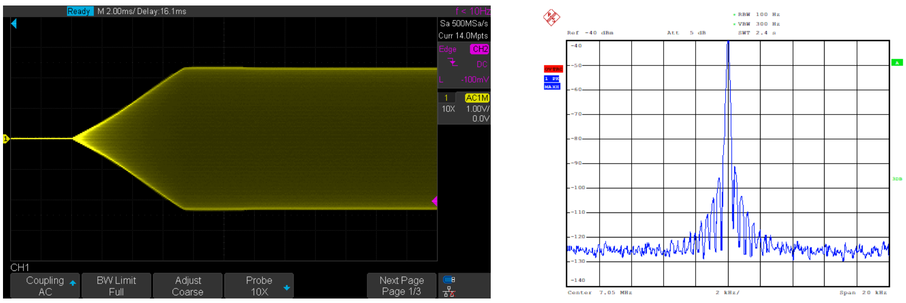
Rise time=2 ms.



Rise time=4 ms.



Rise time=6 ms.



Rise time=8 ms.

Figure 05-41. Envelope waveform versus transmit signal at each rise time

Signal processing from the microphone to the D/A converter

◆ Signal processing from the microphone to the Controller output

The Controller unit described here is the RC-7760, and the main unit of the radio is the RF Deck. Audio signal from the microphone connected to the Controller is input to the A/D converter after passing through the microphone amplifier.

Audio signal digitally converted by the A/D converter is input to the CPU after level adjustment, waveform shaping, and other signal processing by the DSP, where they are converted to I2S packets and sent through the HUB to the RF Deck.

CW keying signal is sent through the HUB to the RF Deck after ELEC-KEY operation and timing are controlled by a dedicated CPU.

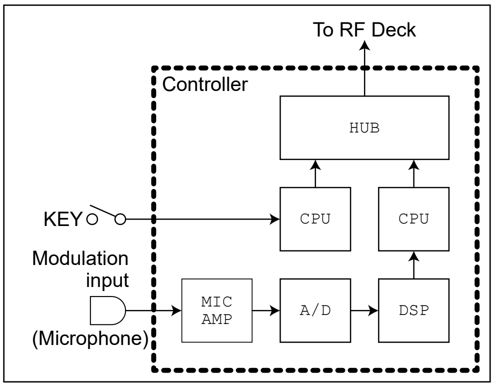


Figure 05-42. Block diagram of the internal Controller unit

◆ Signal processing until the signal input to the RF Deck is converted to an RF signal

I2S packets input from the Controller to the RF Deck are sent to the CPU. I2S packets for audio signals are sent to the FPGA through the DSP, and I2S packets for keying signals are sent directly to the FPGA. The I2S packets are sent to the FPGA for signal processing, such as modulation waveform shaping, filtering, and compressing before being sent to the D/A converter, where they are converted to an analog RF signal at the operational frequency and sent to the transmit amplifier circuit.

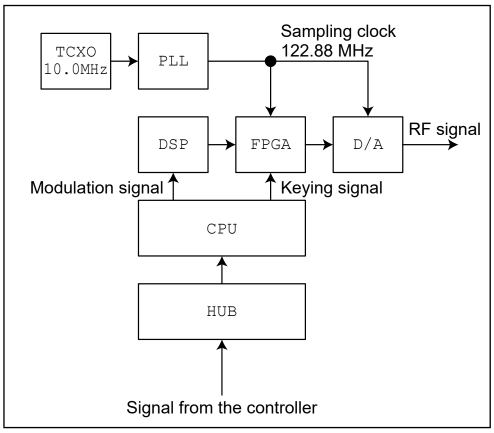


Figure 05-43. Signal processing from the input of the RF Deck to the D/A converter

- PART 6 -

06 Common circuits

AC-DC power supply unit

The AC-DC power supply unit is an important block for the IC-7760 to operate stably as a 200 W radio. The performance required of the power supply unit is to provide the voltage and current that will enable the transmitting power amplifier to output a stable 200 W output.

The LDMOS power amplifier device used in the IC-7760 power amplifier is designed to be powered by 48 V DC. In order to get the full performance out of the power amplifier, it is important that the power supply unit has a generous current capacity.

For this reason, a power supply unit with a continuous 600 W output capacity is used to ensure that the transmitter output of 200 W is stable. The AC input of the power supply unit is compatible not only with 120 V AC in North America, but also with 220~240 AC used in Europe and Australia.

Figure 06-1. Power supply unit

Power supply unit specifications ~Outline

Manufacturer:	Nipron Co., Ltd. (Japanese company)
Power supply unit:	UZP-600 type
Input voltage:	100 V AC to 240 V AC
Efficiency (at rating):	
At 115 V AC	93% typ.
At 200 V AC	95%
Output current:	16.7 A DC continuous (under forced air cooling)
Peak output current:	25 A DC

Therefore, there is no need to modify the power supply or switch troublesome input voltages when the input voltage changes, as the power supply is designed for universal input from 100 to 240 V AC. In addition, each circuit in the RF Deck that requires a voltage other than 48 V DC is supplied after converting this 48 V DC to the required voltage in the respective DC-DC converter circuits. Switching noise emitted from these DC-DC converter circuits can be effectively suppressed by using a clock signal that generates a common switching frequency for all DC-DC converters, thereby suppressing the type of noise generated.

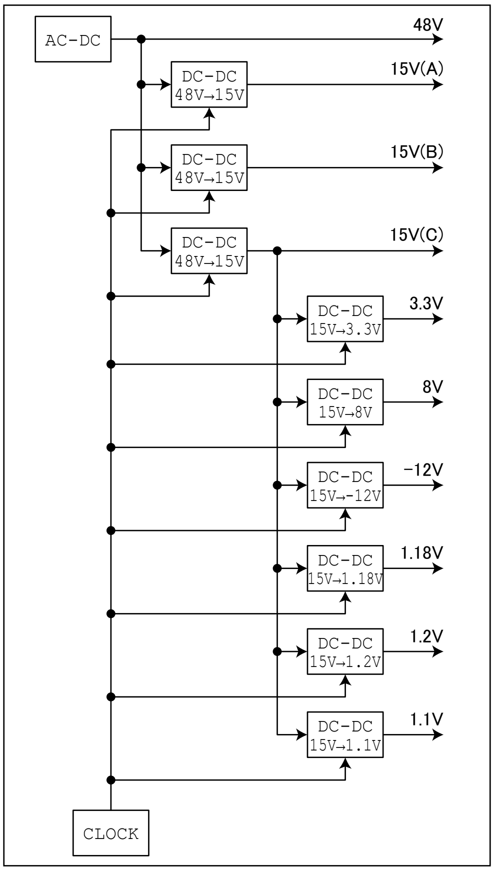


Figure 06-2. Block diagram of the Power supply unit

Antenna switching circuit

The IC-7760 is equipped with four antenna connectors. These antenna connectors are controlled by the antenna switching circuit used in the Icom flagship models from the IC-7800 onward, for preferred antenna switching in split or cross-band operation, as well as the regular operating frequency.

Figure 06-3. ANT-SW unit

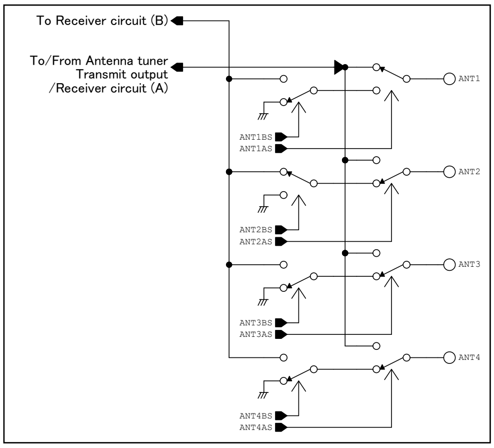


Figure 06-4. Block diagram of the antenna switching circuit

Figure 06-4 is the block diagram of the antenna switching circuit.

Antennas that are not used for transmitting or receiving are disconnected from the internal circuit by two relays and connected to GND. This prevents damage to the radio due to strong external signal input or electrostatic charging of the antenna. By switching the antenna connection destination, one antenna can be assigned to transmit and receive on the Main band, while the other antenna can be assigned to receive only on the Sub band. This enables fully independent Dualwatch® operation.

Antenna switching combinations can be stored in the antenna Set mode. This is very convenient for one-touch operation, even when frequently switching combinations.

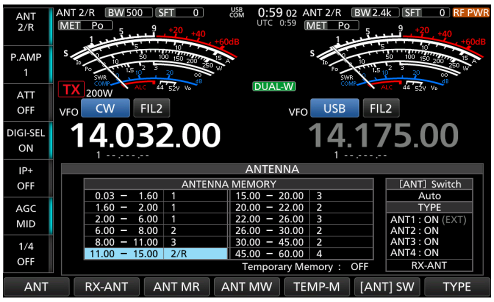


Figure 06-5. Antenna settings per band

Figure 06-6. Four antenna connectors on the rear panel of the RF Deck

Generator circuit for sampling clock signals

As explained in each of the previous sections, the basic circuitry for transmission and reception in the IC-7760 is that all signals are digitally processed by digital circuitry.

Digital Signal Processing (DSP) requires a sampling clock signal. This sampling clock signal enables conversion from analog to digital and vice versa.

In other words, all transmitted and received signals follow the sampling clock signal. Therefore, the accuracy and quality of the sampling clock signal directly affects the performance of the radio. This section describes the circuit that generates the sampling clock signal.

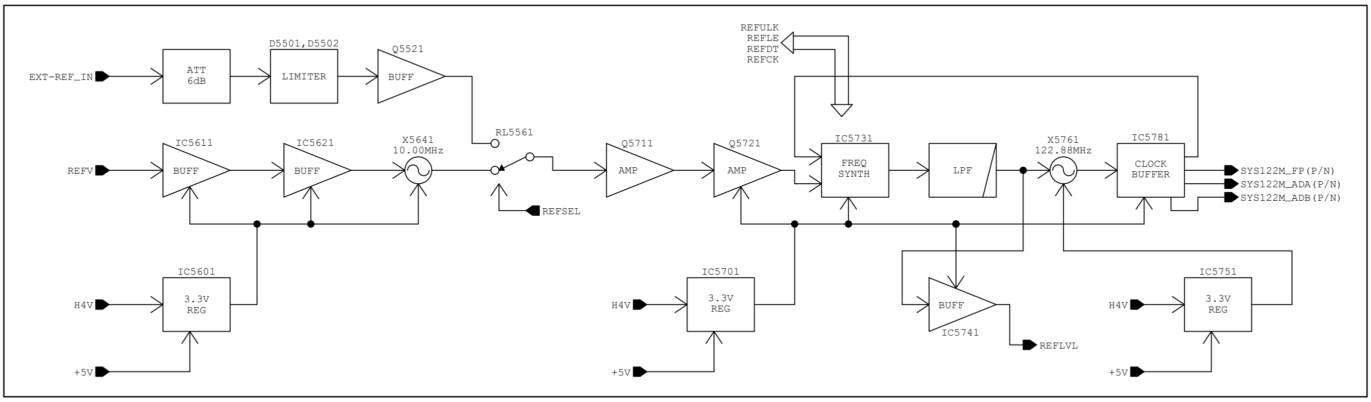


Figure 06-7. Block diagram of the sampling clock generator

The X5761 shown in Figure 06-7 is a VCXO (Voltage Controlled X'tal* Oscillator) oscillating at 122.88 MHz. The output of this oscillator is used as the master clock for each digital signal processing circuit.

Although it is a VCXO, it is still a crystal oscillator, so its oscillation frequency fluctuates, depending on external disturbances such as temperature. To stabilize the oscillation frequency, the PLL is controlled by using an X5641, a 10 MHz highly stable Temperature Controlled X'tal* Oscillator (TCXO) with ±0.5 ppm from –30 to +85°C, as a reference signal. The PLL IC internally compares the 122.88 MHz signal with the 10 MHz reference signal, and uses the result of that comparison to control the X5761 so that the 122.88 MHz signal is stable and does not deviate.

*X'tal=Crystal

Control noise and PLL noise generated in the control process can cause phase noise appearing in the output signal. For this reason, the sampling clock generation circuit of the IC-7760 undergoes thorough consideration at the phase comparison frequency selection stage. In addition, since the VCXO is composed of a crystal oscillator as mentioned above, it also operates as a High-Q filter. As a result, phase noise and other unwanted components in the PLL output are greatly suppressed.

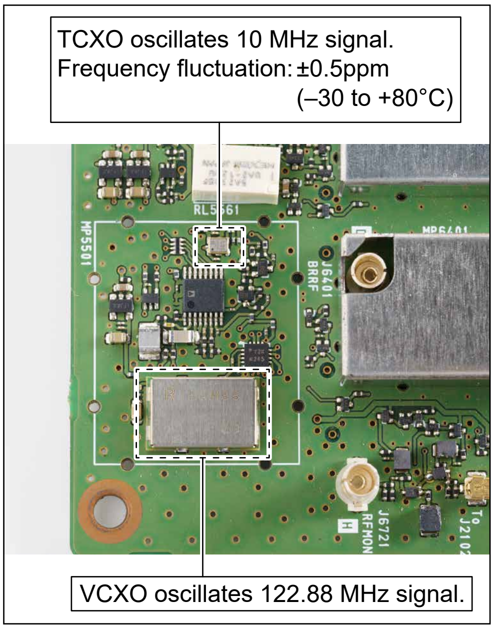


Figure 06-8. TCXO and VCXO installed in the IC-7760

Figure 06-9. [EXT-REF] connector

The rear panel of the IC-7760 has an [EXT-REF] connector. By externally inputting a very accurate and stable 10 MHz (–10 dBm) reference frequency signal to this connector, the frequency can be made even more accurate and stable. If you have a radio that is capable of outputting a 10 MHz high-stability reference frequency signal, such as an IC-7850/IC-7851, you can input the radio's reference frequency signal output to the IC-7760 to obtain the same frequency accuracy and stability as your IC-7850/IC-7851.

Relationship between signal purity and RMDR

As mentioned above, the master clock is the basis of the IC-7760's transmitting and receiving performance. If the purity of the master clock is low, phase noise will be superimposed on the received signal and transmitted radio wave, resulting in poor performance. This section explains the relationship between the purity of the master clock and the Reciprocal Mixing Dynamic Range (RMDR), which is used as an indicator of reception performance.

What is RMDR?

RMDR is one of the reception performance indicators that expresses the level ratio of proximity disturbance to the target signal and indicates how much the reception sensitivity deteriorates due to blocking from strong input signal in close proximity. Simply said, the higher the value of RMDR, the stronger the resistance to a proximity jamming signal.

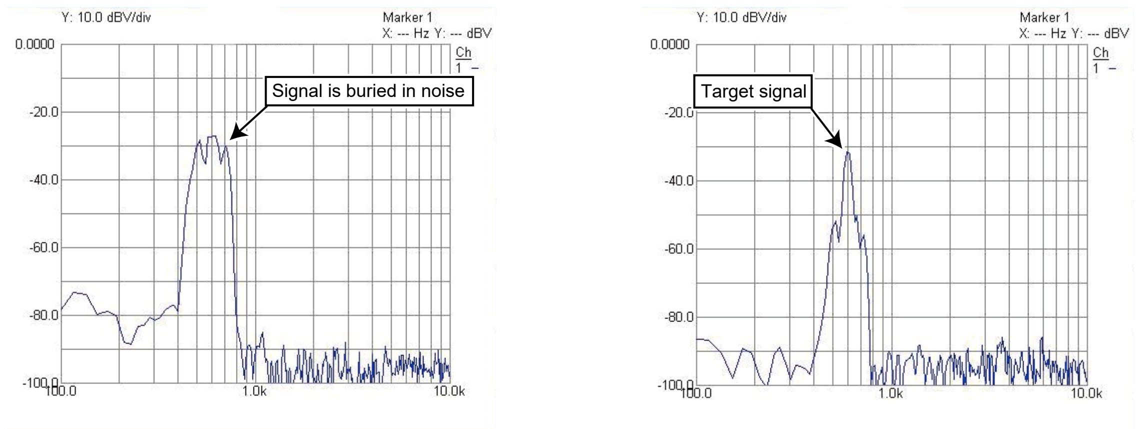
Why evaluate receiver performance with RMDR?

Conventionally, receiver performance has been expressed in terms of 3rd Intercept Point (IP3). However, when receivers with superior IP3 performance are compared with each other, there is a difference in actual operation, even if their IP3 values are the same. In the course of investigating and researching this difference, we focused on RMDR, which is cited by various organizations as one of the items for evaluating receiver performance.

At the same time, it was widely argued that RMDR performance is more important for high-performance receivers with a certain level of IP3 performance. Therefore, in the IC-7850/IC-7851 released in 2014, we also promoted reception performance in RMDR. On the other hand, for receivers employing the RF direct sampling method, IP3 as a measure of performance does not make much sense because, as mentioned earlier, they do not have an analog mixer circuit. For these reasons, Icom has positioned RMDR as an alternative to IP3 as an indicator of reception performance.

A case study to experience RMDR

If you are participating in a contest on a neighboring frequency to a local station transmitting a strong signal, you may have experienced that the local station's transmission drowns out the weak signal that you are barely receiving. A receiver with excellent RMDR characteristics can free or mitigate such occurrences. Figure 06-10 shows an FFT scope analysis of the audio output with and without the interference.



For receives with low RMDR, if the local station signal appears near the target signal, the target signal will be buried by the local station signal.

For receive with a high RMDR, the target signal can be received clearly without being buried by the local station signal, even when the local station appears near the target signal.

Figure 06-10. FFT analysis image of received audio output

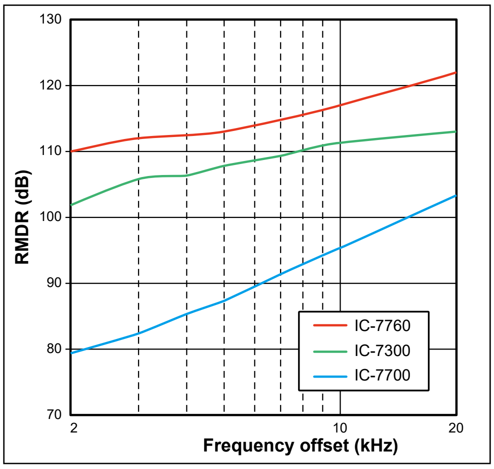


Figure 06-11. Comparison chart of RMDR

Comparison of RMDR

The RMDR of the conventional IC-7700 was approximately 80 dB. The RMDR specifications of the IC-7760 is approximately 110 dB*. In contrast, an astounding improvement of approximately 30 dB. This value is equivalent to our flagship IC-7850/IC-7851 and the IC-7610 in the practical equipment class. In other words, all of Icom's HF/50 MHz all-mode radios in the practical class have an RMDR of approximately 110 dB*. This shows the tremendous benefit that the high purity of the reference signal and RF direct sampling have on the RMDR.

*Representative values
(2 kHz separation, received frequency: 14.200 MHz, mode: CW, BW: 500 Hz)

Controller section

The most significant feature of the IC-7760 in terms of operation, installation, and operation is the complete separation of the Controller, which performs the operations of the main body of the radio. The main body of the radio is called the RF Deck. A Local Area Network (LAN) connection can be made between the Controller and the RF Deck. Details of this LAN connection are explained in the “Network Technology” section.

As a new approach, the Controller’s display is equipped with a Sub screen, which simultaneously displays a variety of information different from that of the Main screen.

- ➥ 7-inch wide
- ➥ 800 × 480 pixel
- ➥ 24-bit color (1,677,216 colors)

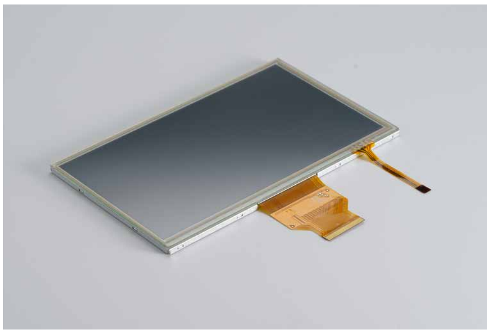


Figure 06-12. Main screen LCD module

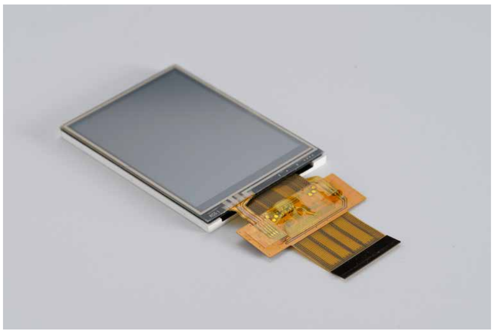


Figure 06-13. Sub screen LCD module

The Sub screen uses an LCD with the following specifications.

- ➥ 2.4-inch
- ➥ 240 × 320 pixel
- ➥ 18-bit color (262,144 colors)

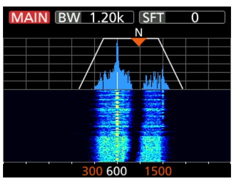
Main and Sub screens use long-life backlight LEDs.

◆ Front panel side

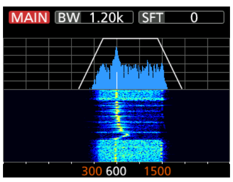
In addition to the circuit related to the LAN connection, the Controller naturally has the same functions and circuit as the front panel section as a regular transceiver. One of the major differences from previous models is the Sub screen, which supports touch operation. The following information is selectable on the Sub screen.

<Filter Effects Display>

The Sub screen shows the IF filter selection, bandwidth setting by PBT®, and manual notch frequency setting, superimposed on the demodulated received audio spectrum. This makes the operation quicker and easier by adding a visual “guide” to interference elimination, which used to rely on auditory information and experience.



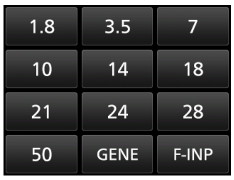
NOTCH ON



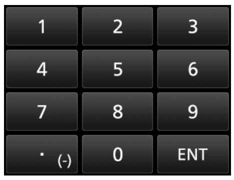
NOTCH OFF

<Keypad screen>

The same functions corresponding to the frequency input and band stacking register as the band key/number keypad provided on the front panel of conventional models such as the IC-7700, IC-7850/IC-7851 can be performed by touching the display keys.



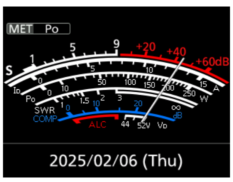
Band keypad



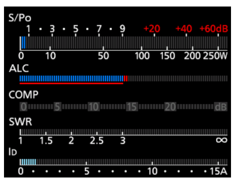
Number keypad

<Meter Screen>

The meter functions displayed near the frequency display on the Main screen can be displayed on the Sub screen. In particular, with the spectrum scope and various setting screens displayed on the Main screen, the multimeter and needle display meter can be displayed on the Sub screen to improve the visibility of meter information.



Normal meter



Multi-function meter

Continued on the next page…

◆ Rear panel side

CW keys, external keypads, external monitor screen, speaker, and USB devices are often placed on the radio shack desk close to the Controller. For this reason, the connectors needed to connect devices are conveniently located on the rear panel of the Controller. However, the antenna connector, ALC terminal, and AC power connector required for the RF power amplifier section are on the rear panel of the RF Deck. Note that the Controller requires the connection of the supplied AC adapter to power the Controller. The use of the AC adapter to supply DC power was taken into consideration to allow easy remote LAN operation in another location in the house.

Figure 06-14. Rear panel of the Controller

Spectrum Scope

Since the IC-780 flagship radio, released by Icom in 1988, high-grade models have always been equipped with a spectrum scope. With the evolution of spectrum scope technology, it has now become commonplace to say that Icom's all-mode models are equipped with a spectrum scope. In recent years, our competitor's radios have also incorporated spectrum scopes, but we are proud to say that our spectrum scopes are superior to the competitors in terms of the ease of viewing the signals on the scope screen and the level of detail. Details of the spectrum scope are described in the following sections.

Dual Spectrum Scope with amazing dynamic range

Since the IC-780, released in 1988, Icom has always equipped its high-end models with spectrum scopes. The high-spec spectrum scope has been incorporated into the recent flagship model IC-7851, and the know-how has been introduced into popular models such as IC-7300 and IC-7610. In recent years, our competitors have also introduced spectrum scopes, but we are proud to say that our spectrum scope is "outstanding" in terms of the ease of viewing signals on the scope screen and the level of detail. Here we explain about spectrum scopes.

This dual spectrum scope was put to practical use in the flagship model IC-7851 and was later incorporated in the popular models IC-7300 and IC-7610. This spectrum scope has been further brushed up and incorporated in the IC-7760.

The dynamic range of the scope display has reached an astonishing 100 dB, thanks to the cooperative processing of FPGA and CPU software. Of course, the sweep speed and resolution have also reached the realm of a flagship model. The spectrum scope operates even during Dualwatch® operation, displaying Main and Sub band conditions with the same performance as single-band reception.

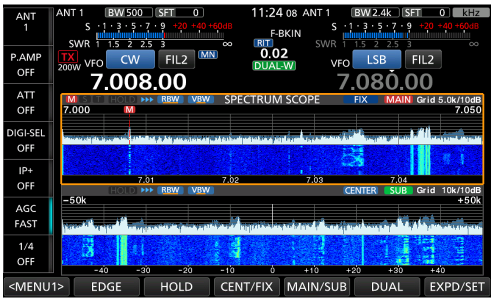


Figure 06-15. The Dual Spectrum Scope

High-resolution waterfall display

The waterfall display enables you to check the history of received signals in chronological order and to see faint signals that are difficult to distinguish with a spectrum scope alone. Since it is displayed at the same time as the Spectrum Scope, you can get a detailed understanding of the band status and available frequency information.

In addition, by switching to the extended display, a longer history can be displayed in the waterfall.

The waterfall display is one of the items that maximizes the IC-7760's reception performance and increases the possibility of communication without missing faint DX station signals.

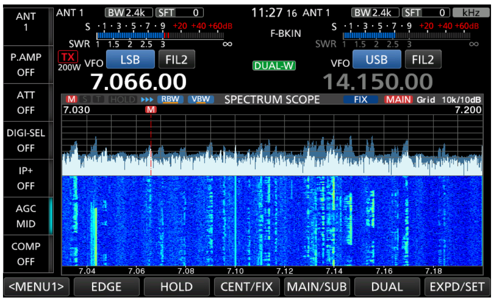


Figure 06-16. The Waterfall screen

Evolution of spectrum scope technology

The evolution of spectrum scope technology that began with the IC-780 can be summarized as follows.

Table06-1. Comparison chart of spectrum scope performance

	IC-780	IC-7700/IC-7800	IC-7850/IC-7851	IC-7760
Signal processing way	Analog	DSP	DSP	FPGA
Sweep method	VXO	PLL	PLL	DDS (FPGA)
Sweep speed	4 times/sec.	0.8 ~ 4 times/sec.	4 ~ 29 times/sec.	30 time/sec.
Sensitivity	–10 dBμ or less	–15 dBμ or less	–30 dBμ or less	–30 dBμ or less
Dynamic range	60 dB	80 dB	100 dB	100 dB
Maximum span range	200 kHz	500 kHz	1000 kHz	1000 kHz
RBW	800 Hz	0.2/0.5/1/2 kHz	29 Hz minimum	17.8 Hz minimum

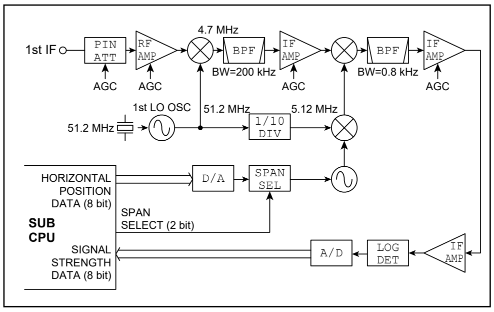


Figure 06-17. Block diagram of the IC-780 Spectrum Scope

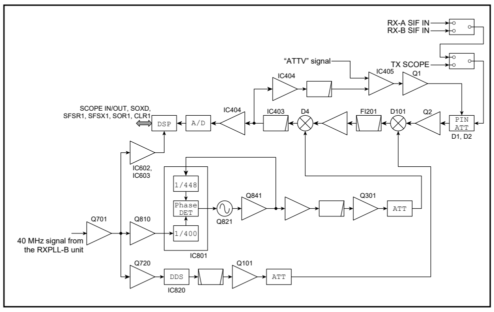


Figure 06-18. Block diagram of the IC-7700/ IC-7800 Spectrum Scope

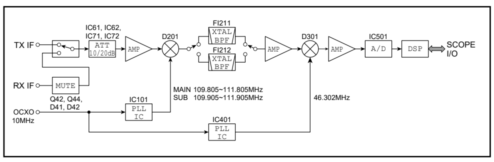


Figure 06-19. Block diagram of the IC-7850/7851 Spectrum Scope

The first model with a spectrum scope, the IC-780, used a fully analog process using a ceramic filter and a sweep method with a VXO. In the next models, the IC-7700/IC-7800, the filtering process was carried out by Digital Signal Processing (DSP), enables Resolution Band Width (RBW) switching and evolving to a sweep method using a PLL.

Continued on the next page…

Later, the IC-7850/IC-7851 spectrum scopes not only support Dualwatch®, but also dramatically improve image depiction speed and resolution by adopting ultra-high-speed PLL for scopes and the Fast Fourier transform (FFT) method.

The IC-7760 also uses the FFT method in the FPGA for the RBW filter for the scope. The sweep also uses the Direct Digital Synthesizer (DDS) embedded in the FPGA to achieve a high sweep speed of about 30 times/second and high resolution.

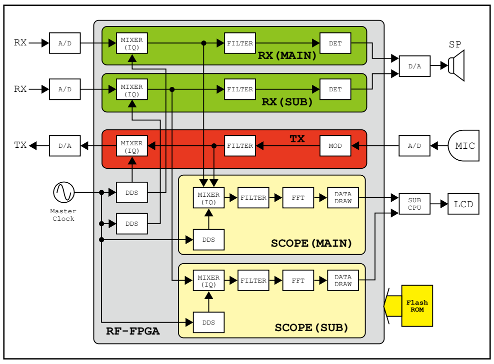


Figure 06-20. Scope block diagram for the IC-7760

In products before the IC-7850/IC-7851, when RBW is set lower, the sweep speed goes slower and is a disadvantage. The IC-7760, however, incorporates signal processing into the FPGA to achieve the fastest sweep speed of approximately 30 times per second at all times, independent of the RBW.

- PART 7 -

Impressions 07

My Impressions After Using the IC-7760

JR9TUG, Muneaki (Aki) MATSUHIRA

Introduction

The IC-7760 was announced at the Ham Fair 2024 in August 2024 held in Tokyo and has been on sale at the end of August 2024. I had the opportunity to operate an IC-7760 and report on my impressions of its use.

The Controller, PC, microphone, and CW paddle in front of the RF Deck

The Controller with the stand and the RF Deck.

Unpacking and making connections

The IC-7760 is divided into a Controller unit that performs operations and an RF Deck that operates as the radio. The size of the Controller is W340 x H118 x D103.5 mm, and its weight is about 2.3 kg (according to its brochure). This design is unique to the IC-7760. The RF Deck weighs approximately 15.8 kg (according to the brochure) and measures W425 x H149 x D442 mm.

The included accessories are as follows:

- Desktop stand (attached to tilt the Controller.)
- BC-267 (Power adapter) for the Controller
- AC power cable for the RF Deck (some versions have no AC cable included)
- Controller cable (3-meter long, connects between the Controller and RF Deck)
- Various other plugs

The connection of cables was quite simple. The control cable is used to connect the Controller to the RF Deck, the AC power cable is connected to the RF Deck, and the AC adapter is connected to the Controller. Up to four antenna coaxial cables can be connected to ANT1 ~ ANT4.

Continued on the next page…

For Controller cable

For Power adapter

Figure 07-1. Connection points of the Controller rear panel (red circled)

Figure 07-2. Rear panel of the RF Deck

For Controller cable from the controller

For AC power cable

Figure 07-3. Connection points of the RF Deck rear panel (red circled)

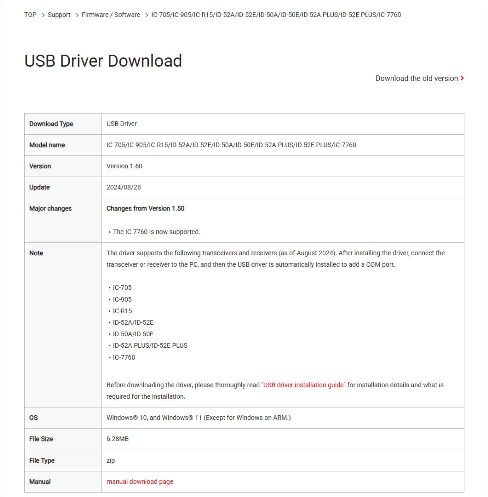
After the Controller and RF Deck are connected, pairing between them is automatically done when the power is turned ON for the first time. Therefore, any changes to the network connection, such as connecting to a LAN, must be made after pairing.

Connecting to my PC

A connection between a radio and a PC has become a necessity. I connected my PC after installing the USB driver and the WSJT-X 2.6.1 application, which is often used in FT8 operations.

◆ USB driver installation

I downloaded the latest version of the USB driver from the IC-7760 product page on Icom website and installed it on my PC.



TOP > Support > Firmware / Software > IC-705/IC-905/IC-R15/ID-52A/ID-52E/ID-50A/ID-50E/ID-52A PLUS/ID-52E PLUS/IC-7760

USB Driver Download

Download the old version >

Download Type	USB Driver
Model name	IC-705/IC-905/IC-R15/ID-52A/ID-52E/ID-50A/ID-50E/ID-52A PLUS/ID-52E PLUS/IC-7760
Version	Version 1.60
Update	2024/08/28
Major changes	**Changes from Version 1.50** • The IC-7760 is now supported.
Note	The driver supports the following transceivers and receivers (as of August 2024). After installing the driver, connect the transceiver or receiver to the PC, and then the USB driver is automatically installed to add a COM port. • IC-705 • IC-905 • IC-R15 • ID-52A/ID-52E • ID-50A/ID-50E • ID-52A PLUS/ID-52E PLUS • IC-7760 Before downloading the driver, please thoroughly read "USB driver installation guide" for installation details and what is required for the installation.
OS	Windows® 10, and Windows® 11 (Except for Windows on ARM.)
File Size	6.28MB
File Type	zip
Manual	manual download page

Figure 07-4. USB driver download page on the ICOM's web site

Download and install the corresponded USB driver for IC-7760.

Connecting my IC-7760 and my PC

A commercially available USB-B to USB-A cable was used to connect the IC-7760 Controller to the PC. I used a USB cable with a ferrite EMI filter to prevent RF feedback effects.

Figure 07-5. USB cable with a ferrite EMI filter example

Figure 07-6. Connect a USB cable to the USB port on the controller's rear panel (red squared)

USB (B) Function (Default: RTTY/PSK Decode)

The transceiver has 2 virtual COM ports, A and B.
In this item, sets the function to be assigned to virtual COM port B.
ⓘ Virtual COM port A is used for CI-V operation.
ⓘ When connecting the [USB B] port on the controller's rear panel to your PC, the ports are virtually named "IC-7760 Serial Port A (CI-V)" and "IC-7760 Serial Port B."

- RTTY/PSK Decode:
  Outputs the decoded data of the RTTY or PSK signal.
- CI-V: Inputs or outputs CI-V commands.

Figure 07-7. Descriptions for the USB (B) function (from the instruction manual)

Once the connection was made, I turned ON the IC-7760 first. The connection was made properly, and my PC recognized the IC-7760. I checked the number assigned to the COM port. You should be sure to remember the COM port number for later use in setting up the application. In my case, COM3 was assigned to USB (A) (for CI-V) and COM4 was assigned to USB (B). The function of USB (B) is to output RTTY/FSK decoded data in the initial state, but it can be switched to the CI-V function. Both USB (A) and USB (B) can also be used for USB SEND and CW/RTTY keying.

The assignment of these functions depends on the PC environment, but the device manager will indicate which of the two COM ports is for CI-V.

I checked the CI-V address assigned to the IC-7760 by touching [MENU] > [SET] > [External Terminal] > [CI-V] > [CI-V Address].

Figure 07-8. IC-7760 CI-V address

Connections with WSJT-X software

The following explanation is based on my using WSJT-X version 2.6.1 (hereafter WSJT-X) installed on my PC. First, I started up the WSJT-X software.

I clicked on tabs [File]-[Settings] to proceed from the menu bar.

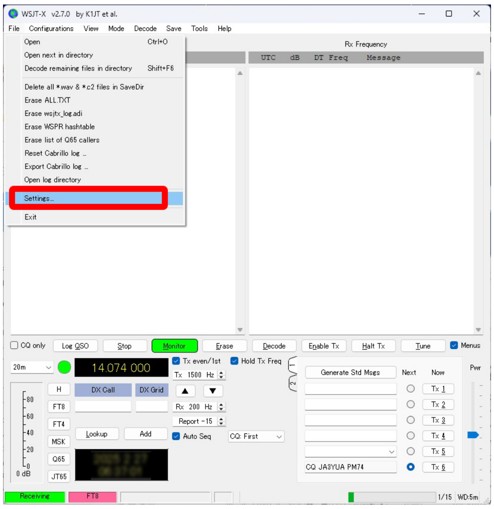


Figure 07-9. [File]-[Settings]

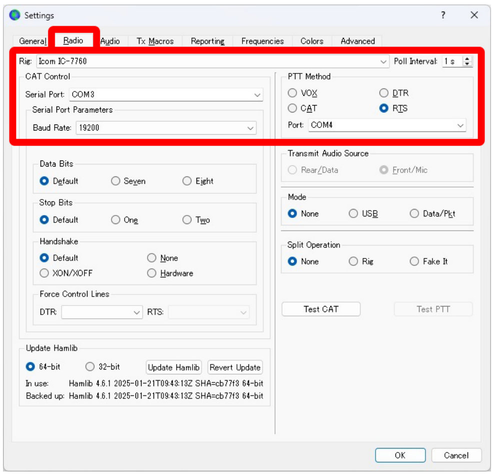


Figure 07-10. [File]-[Settings]-[Radio]

On the settings screen, I went to the "Radio" tab and set "Radio: Icom IC-7760," "COM3" as the serial port for CAT control, and "19200" as the baud rate. Also, I set the PTT method to "RTS" and the PTT port to "COM4." Check the manual to see how to do this.

The FT8 PRESET icon in the IC-7760 menu made it easy to set up for FT8.

Figure 07-11. MENU screen
PRESET button is displayed

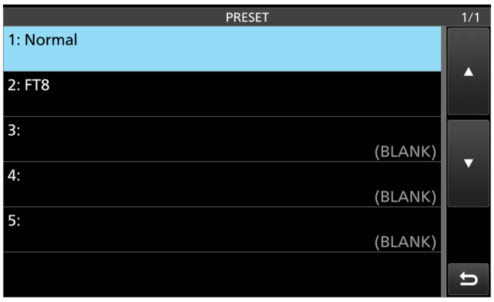


Figure 07-12. PRESET screen

Operating

My PC was connected to the IC-7760 and the WSJT-X software described earlier was installed on the PC. With that software up and running, I began operating FT8.

The Sub screen can show three types of information: meters, band keys, and filter effects. I decided to display the new filter effects screen that is very useful to check the filter effects on the received signal. The Filter Effect screen can also display the bandwidth of the filter being used. This was especially useful when operating CW with a filter selected, as it allowed me to display a narrower bandwidth than that of the spectrum scope displayed on the Main screen. For example, I used the Main screen to display a wide bandwidth centered on the operating frequency, while I checked the received signal within the filter bandwidth on the Sub screen.

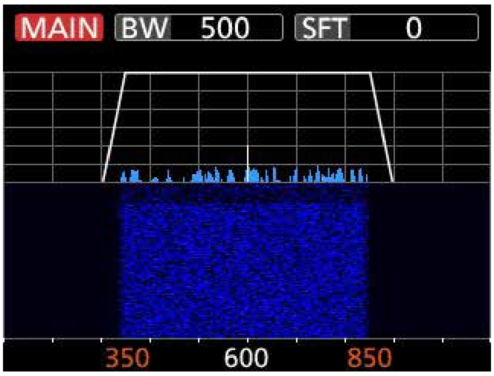


Figure 07-13. Filter effect state on the Sub screen (in CW mode)

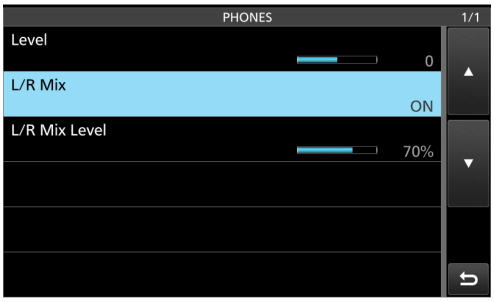


Figure 07-14. Phones setting screen

In an SSB QSO, I did not say that I was using an Icom SM-30 microphone, but I received many reports of "good audio quality." When I told them that I had DPD turned ON, I was pleased to hear their compliments, saying, "It's a good signal."

My operating location was a very quiet environment with no urban noise. The RF Deck was placed about 1.5 meters away from the location of the operation. The fan in the RF Deck was operating, but at that distance the fan wind noise was barely audible. It would have been even quieter if the RF Deck had been installed farther apart.

The speakers are mounted on the left and right sides of the Controller's top, so that I could hear the Main and Sub audio at the same time. This made it clear which band was being heard, the Main or the Sub band, even when Dualwatch® reception was used. When listening with headphones connected, I could also listen to the Main and Sub band audio separately, the same as with speakers, or I could set up a mix of Main/Sub band audio so I could hear in both ears.

The antenna used in this project had an input power rating of 200 W or higher, so operating the IC-7760 at its full 200 W output did not require any reduction in transmit power. For those hams who may not be able to operate the IC-7760 at 200 W due to the input power limit of their antennas, the IC-7760 enables you to set the transmit power limit for each band in DATA and other modes. Note that the DATA mode here refers to LSB-D, USB-D, AM-D, and FM-D, and is not reflected in RTTY or PSK.

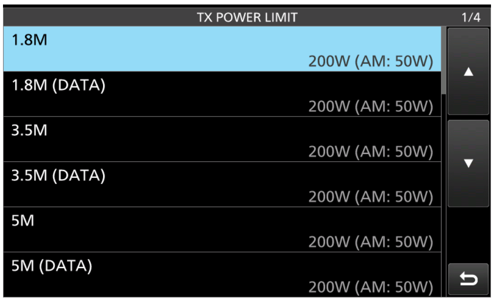


Figure 07-15. Transmit output power limit setting screen

There is a Transmit Power Limit function that enables you to set the required output power when the gain or allowable input power varies by the band, when using external devices such as linear amplifiers.

Continued on the next page…

The IC-7760 has a slightly different receiver circuit configuration than previous receivers that have the DIGI-SEL function installed. In the IC-7760, DIGI-SEL operates on the antenna side when the preamplifier is OFF, as in previous models, and when the preamplifier is ON, the DIGI-SEL operates in a stage after the preamplifier. This made it possible for me to turn ON DIGI-SEL and a preamplifier at the same time. This improved the reception sensitivity while preventing interference and suppression by unwanted strong out-of-band signals.

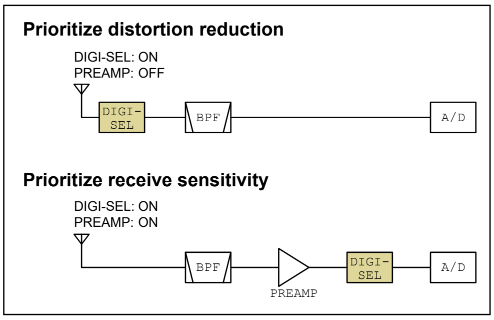
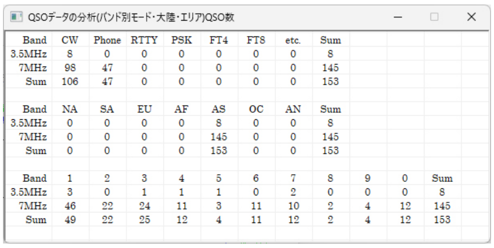


Figure 07-16. DIGI-SEL and PREAMP composition



QSOデータの分析(バンド別モード・大陸・エリア)QSO数

Band	CW	Phone	RTTY	PSK	FT4	FT8	etc.	Sum
3.5MHz	8	0	0	0	0	0	0	8
7MHz	98	47	0	0	0	0	0	145
Sum	106	47	0	0	0	0	0	153

Band	NA	SA	EU	AF	AS	OC	AN	Sum
3.5MHz	0	0	0	0	8	0	0	8
7MHz	0	0	0	0	145	0	0	145
Sum	0	0	0	0	153	0	0	153

Band	1	2	3	4	5	6	7	8	9	0	Sum
3.5MHz	3	0	1	1	1	0	2	0	0	0	8
7MHz	46	22	24	11	3	11	10	2	4	12	145
Sum	49	22	25	12	4	11	12	2	4	12	153

Figure 07-17. SSB/CW QSO result using a software (Japanese only)

Figure 07-17 to the left summarizes the results of my QSOs. Even though I operated mainly during the daytime on weekdays, I was able to make QSOs with amateur operators from all over Japan. In addition, I also made QSOs with 18 stations on FT8.

Connection with the AH-730 Antenna Tuner

The IC-7760 is a 200 W output radio, but an optional automatic antenna tuner, AH-730 with a peak input power (PEP) of 150 W is available. This may not be enough to withstand the input power, but I checked what happens when the optional AH-730 is actually connected.

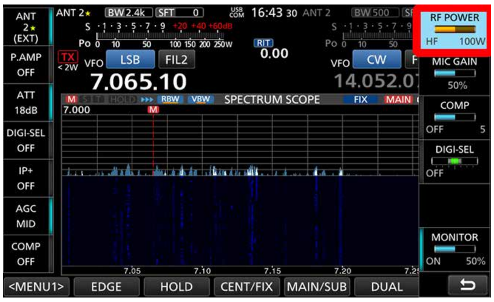


Figure 07-18. In this example, an AH-730 is connected to ANT2, so the maximum power output is automatically limited to 100 W

The previous 200 W Icom radios did not have a control terminal for connecting an external automatic antenna tuner because the company did not have an automatic 200 W antenna tuner. However, the IC-7760 can be connected to the AH-730 as if it were a 100 W radio. This is because it has a function that automatically limits the radio's output power to a maximum of 100 W when an AH-730 is connected. This function prevents damage to the tuner. Furthermore, in conventional radios, the antenna connector to which the AH-730 auto antenna tuner can be connected is fixed to the ANT1 connector. In the IC-7760, an external automatic antenna tuner can be connected to any antenna connector from ANT1 to ANT4.

Summary

The IC-7760 Controller and RF Deck are separate, and the layout in your shack can be made more flexible. The IC-PW2 linear amplifier has a separate control panel that can be detached, so that when both models are combined for 1 kilowatt operation, only the Controllers can be installed on the desk to create a neat and quiet shack, with no wind noise from the air cooling fans.

I could customize the audio quality of transmission and reception, the type of meter, the color of the scope waveform, and more to meet my preferences. I could save these settings on an SD card or USB memory. This can enable you to quickly change settings during operator shifts in multi-operation scenarios, making the IC-7760 useful in various situations.

Furthermore, the ability to change the bandwidth and filter shape while viewing the actual received signal and filter effect on the Sub screen is a very nice feature that enabled smooth and error-free operation. Another improvement is that the CW KEY setting is now displayed on the SET screen, so I could set it in any operation mode.

The IC-7760 has the potential for a new form of shack construction in which the Controller can be used anywhere in the home.

About the author, JR9TUG / Muneaki (Aki) MATSUHIRA

Born in September 1974 in Takaoka City, Toyama Prefecture, Japan. JR9TUG opened his amateur radio station in 1991. He is a first class amateur radio operator. His main operation modes are CW and RTTY, and he operates while traveling around Japan by car. His favorite radio is an Icom IC-7610M with a wire antenna through an AH-730 auto antenna tuner. He makes approximately 5,000 QSOs per year and has participated in domestic contests, winning many of them.

- PART 8 -

08 Network Technology

Network technology

The IC-7760 uses LAN technology to connect the RF Deck to the Controller. The circuit configuration for stable operation is shown in Figure 08-1.

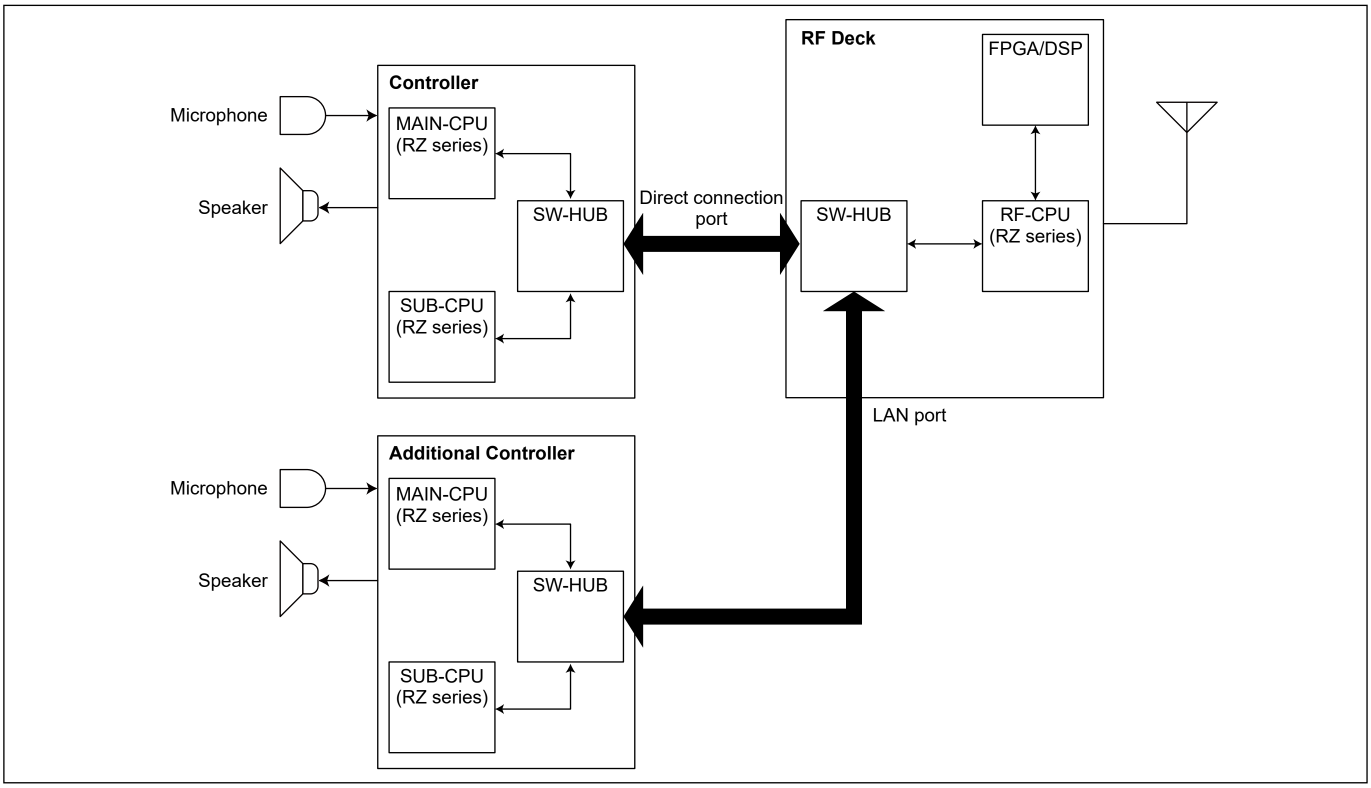


Figure 08-1. Network block between Controller and RF Deck

The received demodulated signal is digitized by the FPGA/DSP in the RF Deck and then sent to the RF-CPU. The digitized signal is converted by the RFCPU into a data format that can be handled within the LAN. The received audio signal is transmitted to the Controller through the SW-HUB.

The transmit audio signal from the microphone is digitized by the Controller's A/D converter, processed by the MAIN-DSP, and then converted to a data format that can be handled within the LAN by the SUB-CPU. The converted transmit audio signal is transmitted to the RF Deck as a transmit modulation signal.

This LAN signal also includes control signal and scope data.

Continued on the next page…

The SW-HUB circuit of the RF Deck has two system ports, [CONTROLLER] and [LAN]. [CONTROLLER] is a port for direct connection to the Controller, and [LAN] is used for remote operation through a home network (LAN). When connecting the Controller directly to the RF Deck (not through a switch), use the supplied Controller cable to connect to the port marked [CONTROLLER].

Figure 08-2. Rear panel of the RF Deck

When connecting the Controller through a home LAN (through a network switch), use a commercially available LAN cable (Gigabit compatible: CAT5e or higher grade) to connect from a switch to the port marked [LAN].

The IC-7760 has a completely separate Controller based on the concept of a new style of operation. The challenge effects of this design have been verified and addressed in the design phase. The challenge is "delay." As mentioned above, until the received signal becomes an audio signal and the microphone audio signal is transmitted as radio waves, there are delays in A/D and D/A conversion, various signal processing by DSP, demodulation, and modulation processing by the FPGA. The delay is caused by data transmission over a long control cable, which can be significantly different from that of an integrated radio.

◆ Controller ↔ RF Deck direct connection

Voice signal response at a level comparable to operation with conventional integrated HF radios such as the IC-7851 and IC-7610. The response is comparable to that of integrated radios, not only for voice communications, but also for high-speed full break-in operation in CW. The response time of the spectrum scope and the response time of the function operation are also comparable to that of an integrated radio.

◆ LAN connection

Although the IC-7760 is a separate "separated" HF/50MHz radio, the Controller and RF Deck can be connected through LAN in your home by using commercially available gigabit-compatible LAN cables (CAT5e or higher grade) and a switch.

In addition, the ability to connect through a LAN enables remote operation of up to 100 meters between switches. In other words, the Controller can be installed in one room of the house and the RF Deck in a separate room location. Even during such remote operation, audio and other delays are comparable to those of a direct connection. Note that if the Controller and RF Deck are paired, the RF Deck is automatically recognized, even when the Controller is moved to another room and the LAN cable is reconnected. Therefore, there are no extra settings to be made before being able to operate the system. For more information on pairing, refer to "Pairing at the time of purchase or after an all-reset" in the instruction manual.

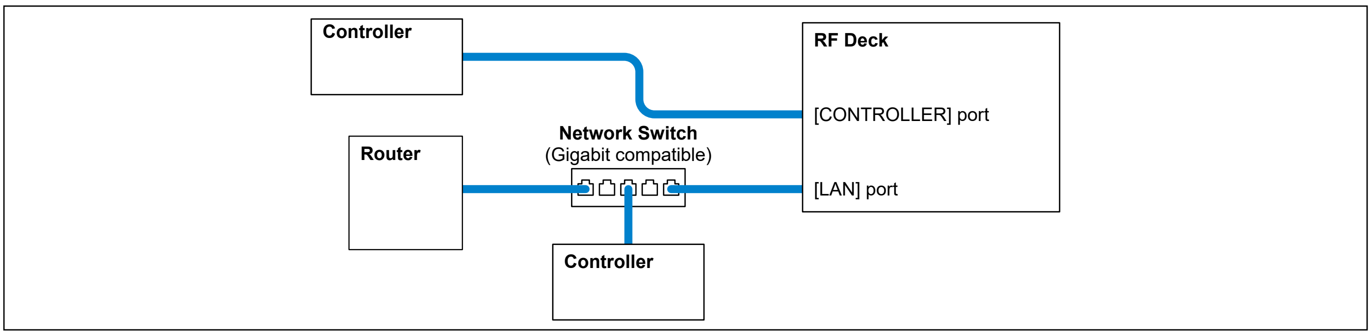


Figure 08-3. Direct connection and a connection through a LAN

About an optional Controller

An IC-7760 with firmware version 1.10 or later can be connected to up to four RC-7760 Controllers, which will be sold separately, in addition to the included Controller. (A total of five Controllers can be connected.)

This makes it possible to permanently install a Controller in different locations. In that case, both the network switch and LAN cable must be Gigabit-compatible to connect the RF Deck and the Controllers. Furthermore, connection to another segment through a network router is also supported.

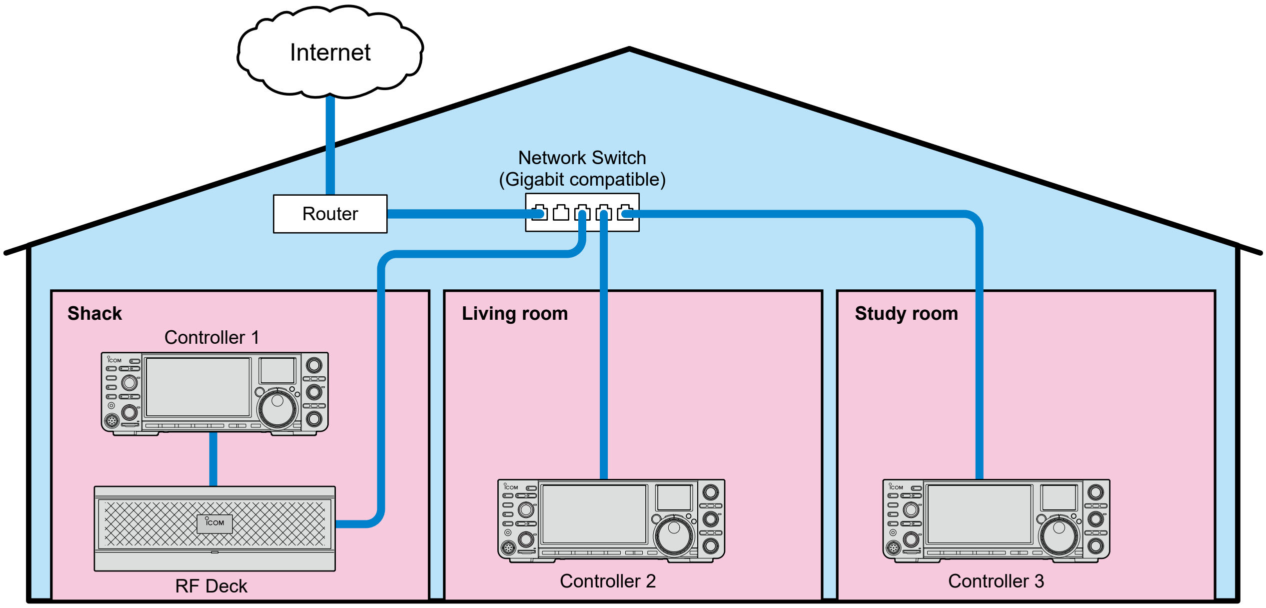


Figure 08-4. Connections with multiple Controllers through a switch (1)

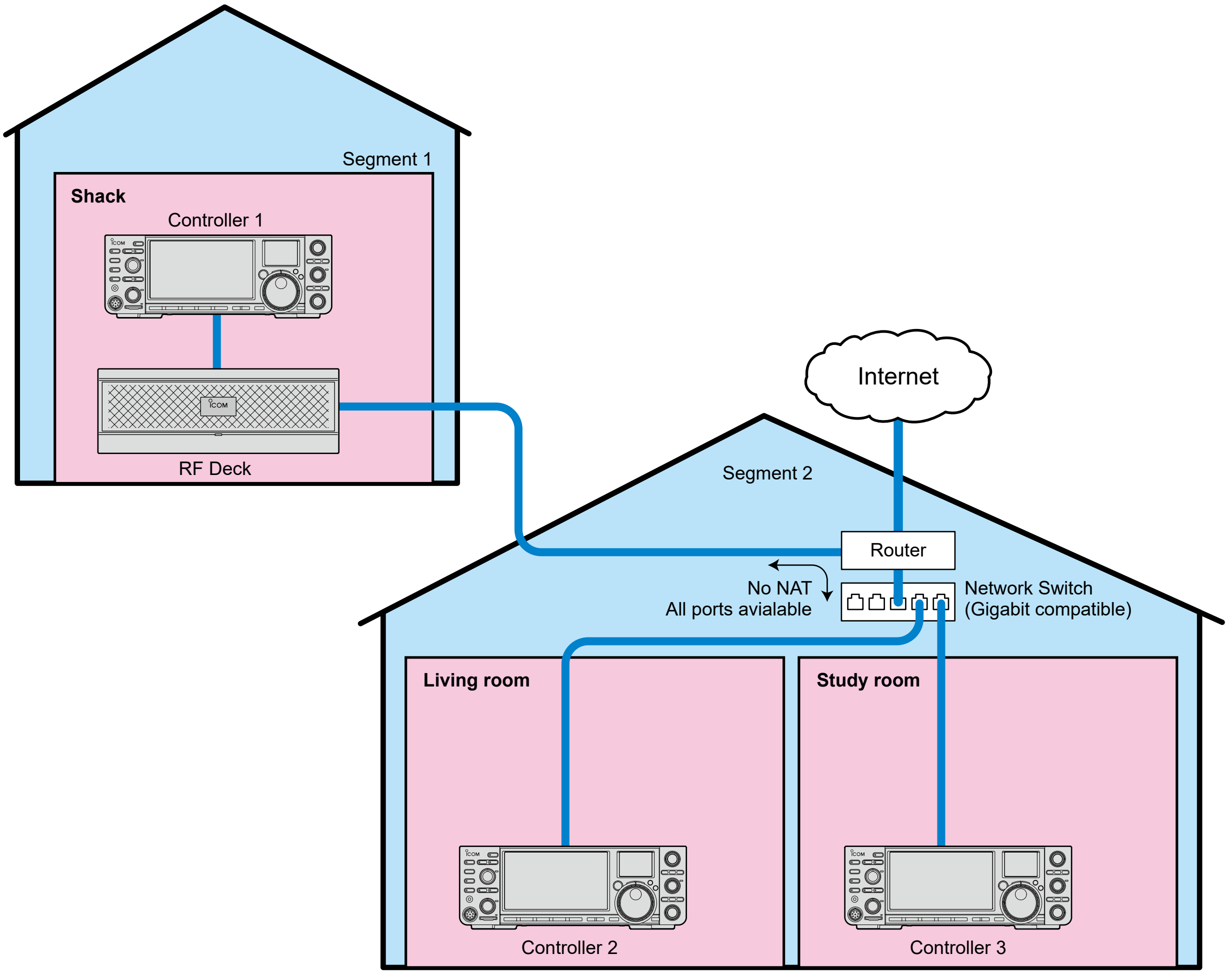


Figure 08-5. Connections with multiple Controllers in separate LAN segments (2)

Audio buffering in communication between Controller and RF Deck

Audio information, including voice and CW/RTTY keying signals, is constantly passed back and forth between the Controller and the RF Deck. If the Controller and RF Deck are directly connected with a controller cable, there is no audio interruption due to lost signals because these signals are transmitted with a constant delay of the signal processing time in the respective internal circuits.

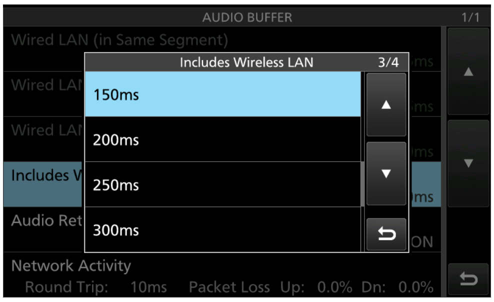


Figure 08-6. Pre-buffering time setting screen

However, especially when the Controller and the RF Deck are connected through a wireless LAN or the Internet speed, the delay time may increase, depending on the connection conditions (usage conditions). With increased delay, some signals such as received audio, transmitted modulated audio, keying signals, and scope information may be lost, resulting in audio interruption and disturbance in spectrum depiction.

To avoid this, the IC-7760 has a certain amount of buffering time that can be set by the user. In other words, a constant buffering time (= delay) is always set to avoid losing signals.

In an environment where the delay is small, the user can set a shorter time, and in an environment where the delay is expected to be large, a longer time can be set to achieve loss free operation. If the delay is smaller than the set pre-buffering time, the entire transmission/reception audio is shifted without losing signals, as shown in Figure 08-7.

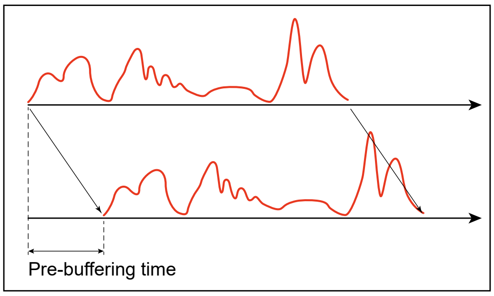


Figure 08-7. Pre-buffering image

Even in CW full break-in operation, with frequent repeated transmission and reception, by setting the pre-buffer time according to the connection used, it is possible to minimize lost transmit signals and received audio, as shown in Figure 08-8.

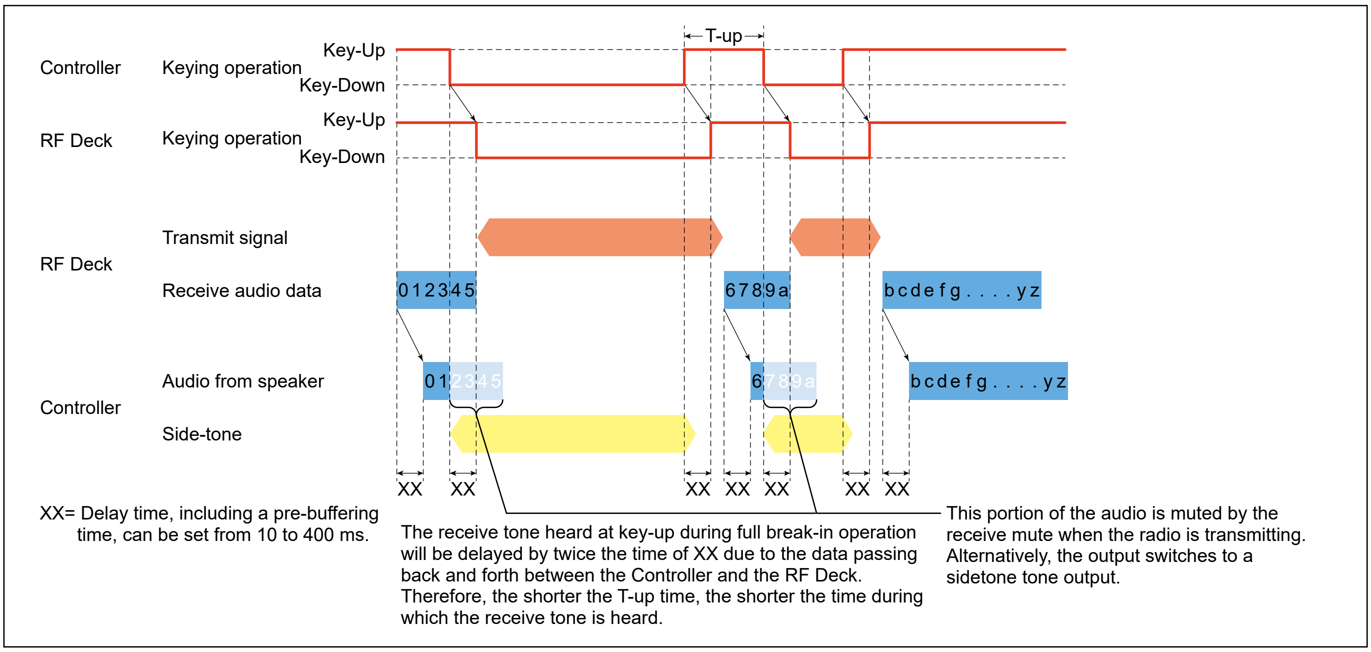


Figure 08-8. Pre-buffering image in CW (full break-in)

09 Remote Control Setting

Connection route

There are three main connection routes between the IC-7760 Controller (RC-7760) and the RF Deck, as shown in the table below.

The connection between the home LAN and the one through the Internet are further subdivided according to the configuration, specifications, and line type of the network equipment you are using.

Connection route	Subdivisions		Outline
Direct connection	–		This is a basic connection that simply connects the Controller's [RF DECK] port and the RF Deck's [CONTROLLER] port directly with the supplied controller cable.
Home LAN connection (Home Network)	Same segment		This is the simplest remote connection where the Controller and the RF Deck are connected through a network switch. In this case, the switch and RF Deck are connected to the [LAN] port using a commercially available LAN cable (CAT5e or higher). Once the Controller and RF Deck are directly connected and paired, the connection can be made without additional configuration. Even if the Controller is moved from the shack to the living room or study, operation is possible by simply connecting the Controller to the network switch that the RF Deck is connected to.
	Separate segment	No port forwarding setting is necessary	This method connects the Controller and the RF Deck to the home LAN through a router (+ network switch). By placing the Controller and the RF Deck on different network segments, communication with PCs, smartphones, tablets, and others connected to the same home LAN can be restricted, and the RF Deck and Controller can be made less visible to those devices.
		Port forwarding settings on the Controller side router are necessary	Even when the IC-7760 is connected to a different segment of the home LAN, depending on the router you are using, it may be necessary to change the communication port on the Controller side of the router or on the RF Deck side.
		Port forwarding settings on the RF Deck side router are necessary	
Internet connection	Port forwarding settings on both the controller and the RF Deck side routers are necessary		This is a configuration for the Controller to be added.
	Port forwarding settings on the Controller side router are necessary		This is the setting for an additional controller.
	L2 VPN/Same Segment		This is a connection through a VPN (Virtual Private Network), even on an Internet network. The same segment settings are used on both the Controller and the RF Deck sides.
	L3 VPN/Separate segment		Connection through a VPN, with different segment settings for the Controller and the RF Deck.
	Static IP Address Direct Assignment		Static IP Address Direct Assignment

When the same firmware version 1.10 or later is installed in both the Controller and the RF Deck, you can connect using a wireless LAN for each connection pattern rather than the "Direct connection to RF Deck."

Image of each connection route

◆ Direct connection

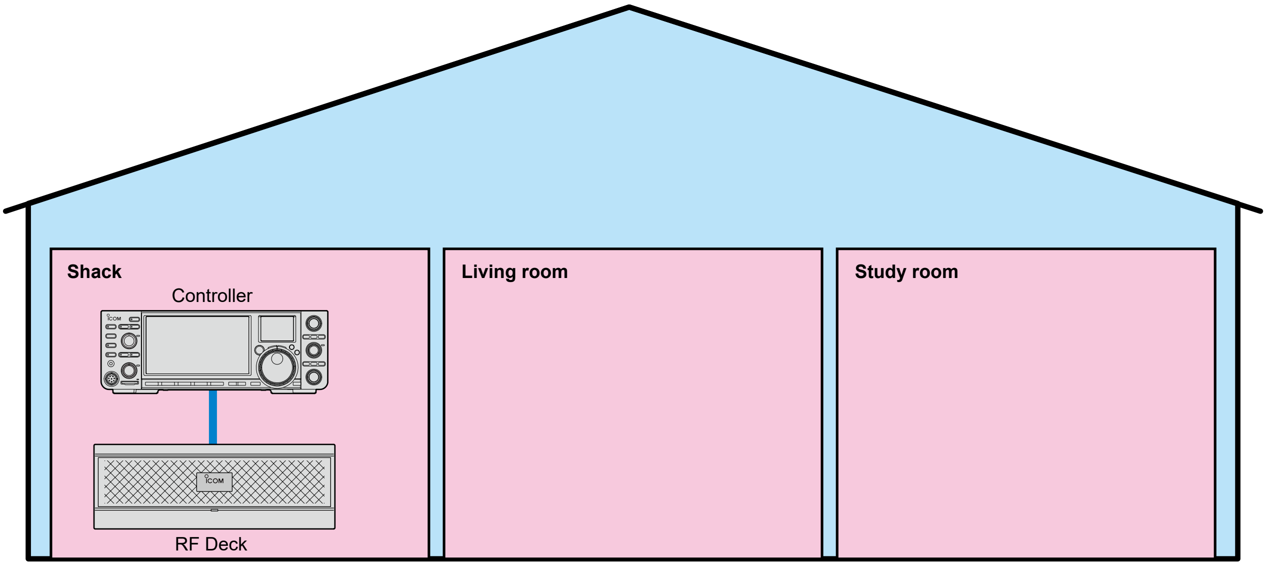


Figure 09-1. Direct connection

◆ Home LAN (home network) connection

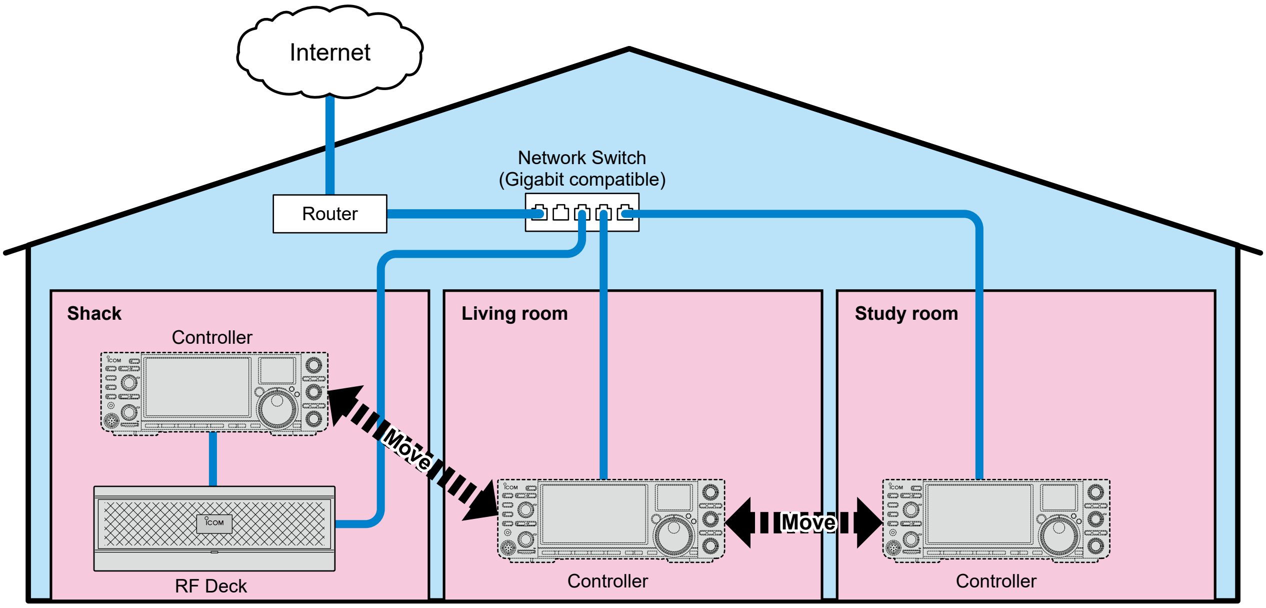


Figure 09-2. Home LAN (home network) connection

Continued on the next page…

◆ Internet connection

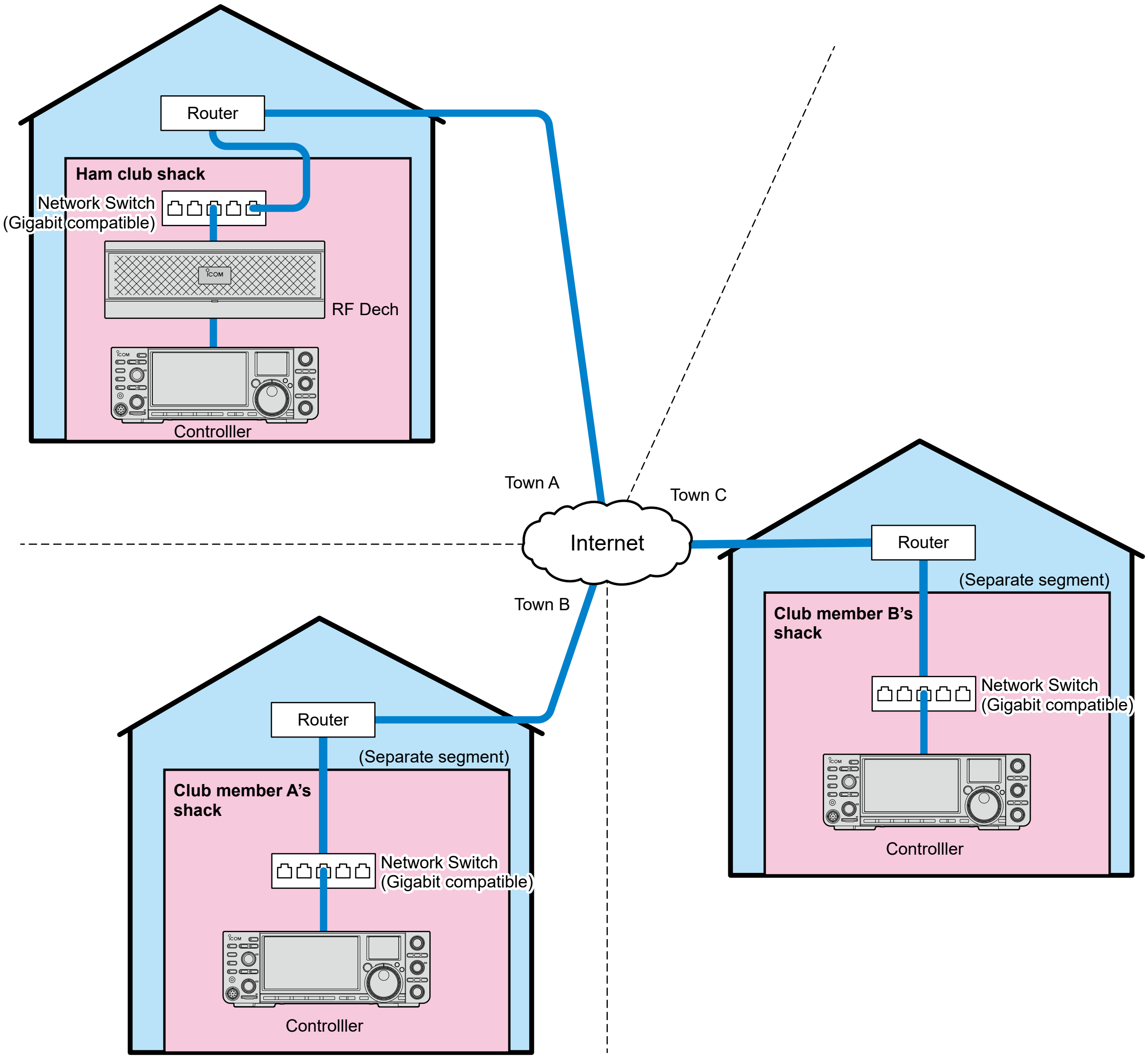


Figure 09-3. Internet connection

◆ VPN connection

For "Internet connections," this method involves connecting using a VPN (Virtual Private Network) service.

The advantages of using a VPN service over a typical Internet connection are that it is highly secure, and network devices on the same VPN can be used as if they were on the same network.

Two types of VPN services are available: L2 (Layer 2) VPN (same segment) and L3 (Layer 3) VPN (separate segment), and it depends on the VPN router to be used.

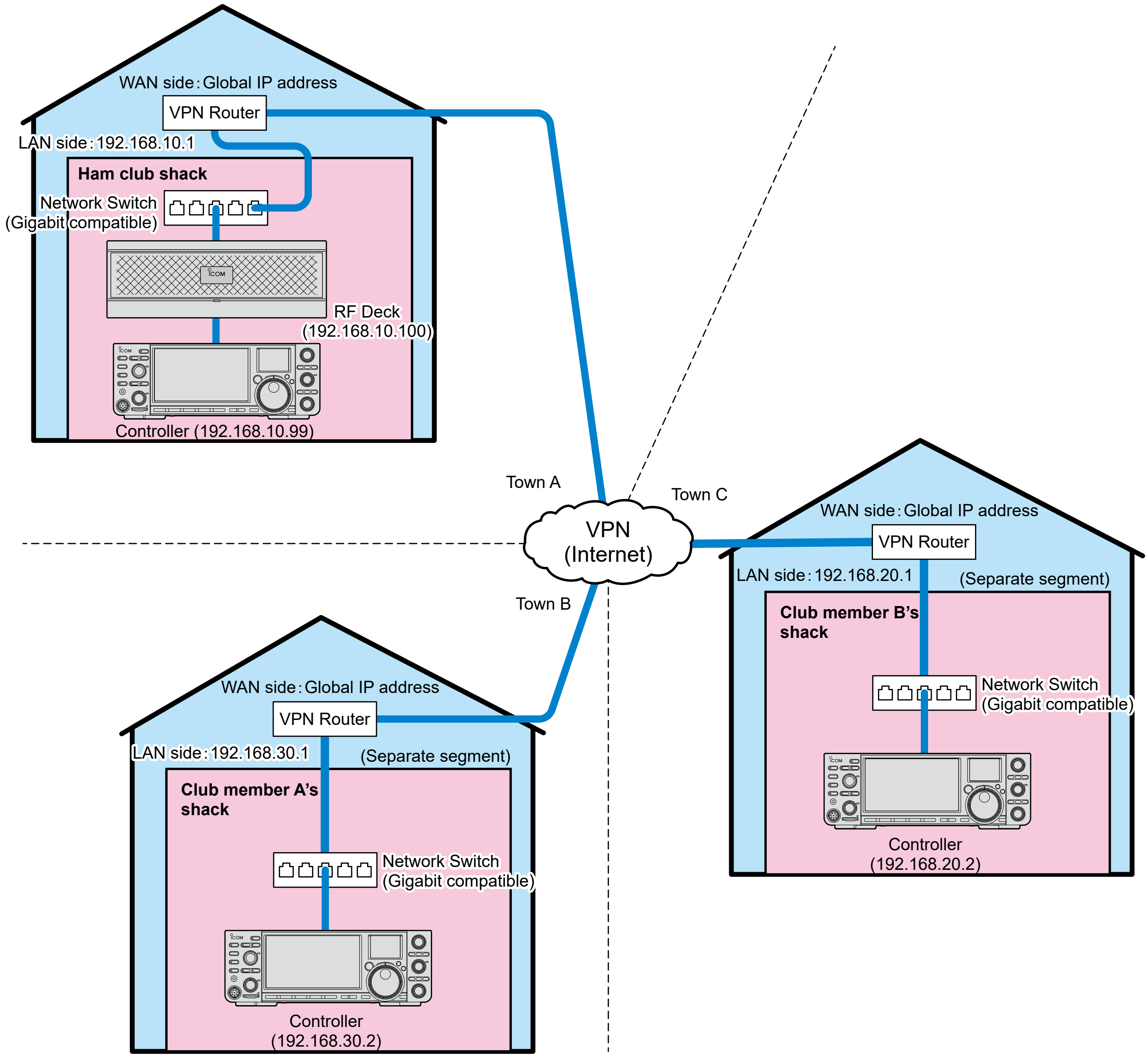


Figure 09-4. VPN connection

◆ Home LAN (home network) connection~ Separate segment

For "Home LAN (Home network) connection," this method connects through a router (+ network switch).

Port forwarding settings on the router are necessary for either side of the controller or the RF Deck, depending on where the router is installed.

*In Figure 09-5, the port forwarding settings on the controller side (Router 2) are necessary.

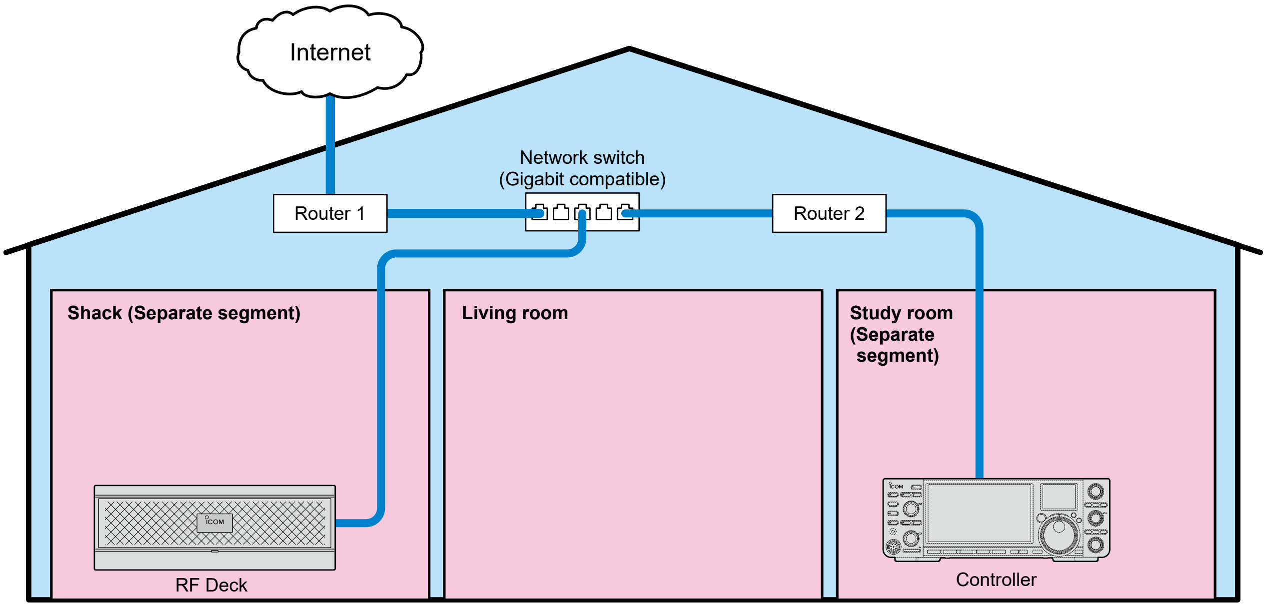


Figure 09-5. Home LAN (home network) connection with separate segment settings

◆ Internet connection with a static IP address

For "Internet connections," static IP (global) addresses assigned by the Internet service provider are used for both the controller and the RF Deck and specified to connect them.

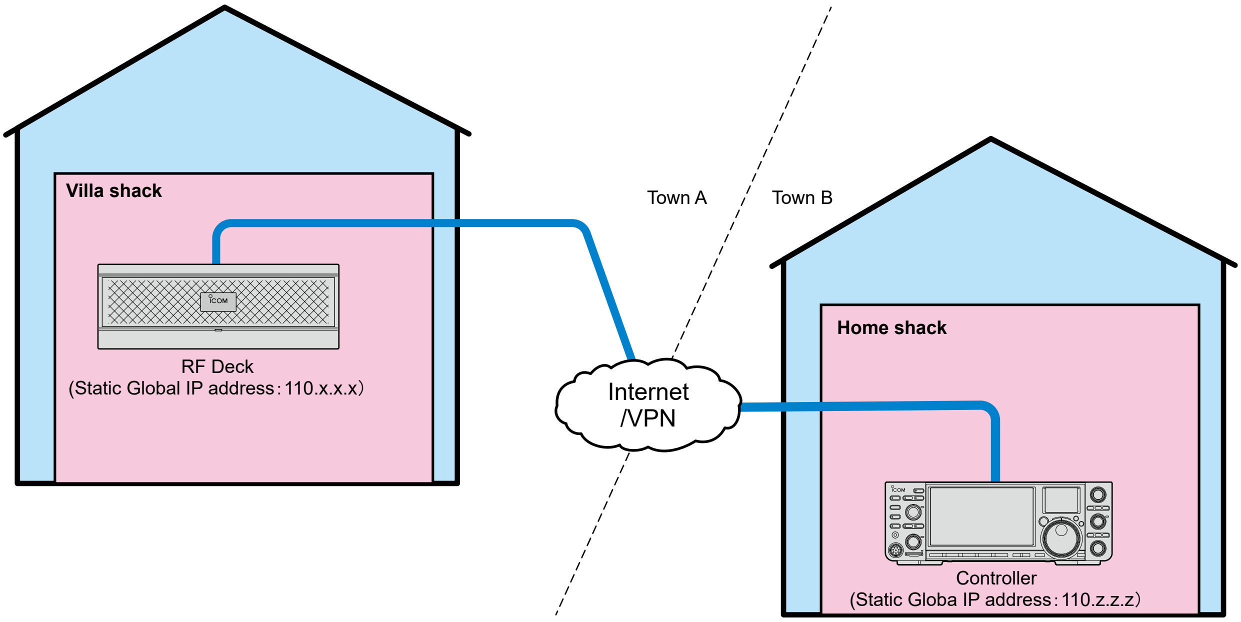


Figure 09-6. Internet connection with a static IP address

About the lines in a home LAN (home network) and Internet connection

The connection between the IC-7760 Controller and the RF Deck requires a Gigabit Ether-compatible network switch and LAN cables (CAT5e or higher grade). This is related to the amount of data transferred between the Controller and the RF Deck, in addition to latency. The data transmitted from the Controller to the RF Deck is primarily the transmit audio and CW keying signal. In contrast, the data transmitted from the RF Deck to the Controller includes data for the spectrum scope, in addition to the received audio.

For these reasons, when connecting to a home LAN (home network) and the Internet, make sure that the line speed shown in Table 09-1 can be obtained stably.

Table09-1. Recommended line speed
(For firmware version 1.12 or later)

	Line speed
Upload (Controller→RF Deck)	2 Mbps
Download (RF Deck→Controller)	One of the USB/LINE-OUT/ACC/LAN output settings is IF: 7 Mbps All of the USB/LINE-OUT/ACC/LAN output settings are AF: 4 Mbps

Note that if the IC-7760 is operated while watching SNS videos or Internet TV, it may be difficult to obtain the above line speeds. Also, in the case of an Internet connection, the line speed may vary, depending on the Internet activity at any neighboring homes that are using the same line.

Wireless LAN connection

When connecting the IC-7760 Controller and the RF Deck through a home LAN (home network) or Internet connection, make sure that your router supports wireless LAN or that you have connected an access point to your home LAN, and at the same time, you have connected a wireless LAN device to the Controller. If you connect a wireless device to the [RF DECK] port on the Controller, you can also connect through wireless LAN instead of a LAN cable.

Setup Procedure

Basic settings

Always pair the Controller and RF Deck first, regardless of whether you are using a home LAN or Internet connection. After pairing is complete, make the necessary settings necessary for each connection type.

Direct connection between Controller and RF Deck

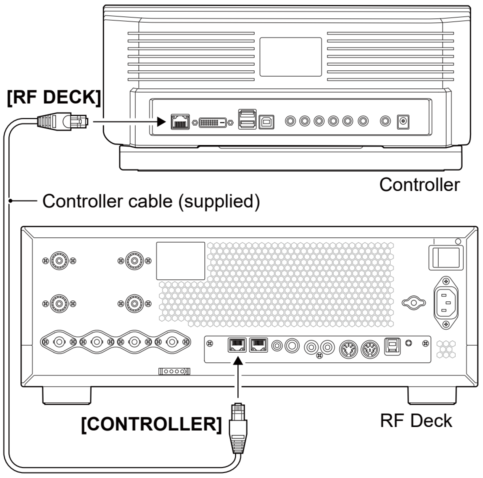


Figure 09-7. Direct connection

1). You must connect the supplied Controller cable as shown in Figure 09-7 before turning ON the power.
   ➥ This is the same as when you turn ON the power for the first time after purchasing this product, or after an All-reset.
2). After connecting and turning ON the Controller, it will be automatically paired and ready to operate the RF Deck from the Controller.

Home LAN (Home network) connection settings

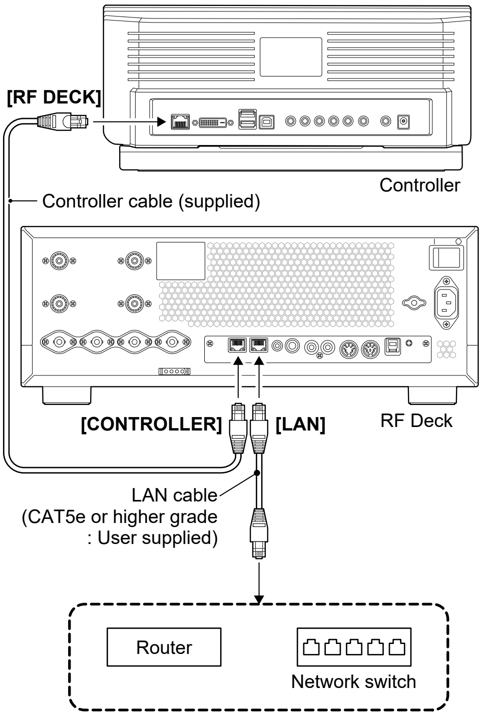


Figure 09-8. Connection to a network switch or router

Follow the same procedure for setting up additional RC-7760 Controllers. When multiple Controllers are connected and operated, the firmware version in both the Controllers and the RF Deck must be the same.

1). Directly connect the Controller and the RF Deck. (See p. 64)

2). Connect the [LAN] port of the RF Deck to your home network switch or router (LAN side) with a commercially available LAN cable (CAT5e or higher grade), as shown in Figure 09-8.

3). Make sure that the “DHCP *” setting in the Set mode is “ON.”
➥ MENU > SET > Network

4). Make sure that the “Connection Route *” setting in Set mode is “LAN (in Same Segment).”
➥ MENU > SET > Network > Controller Connection (via LAN)

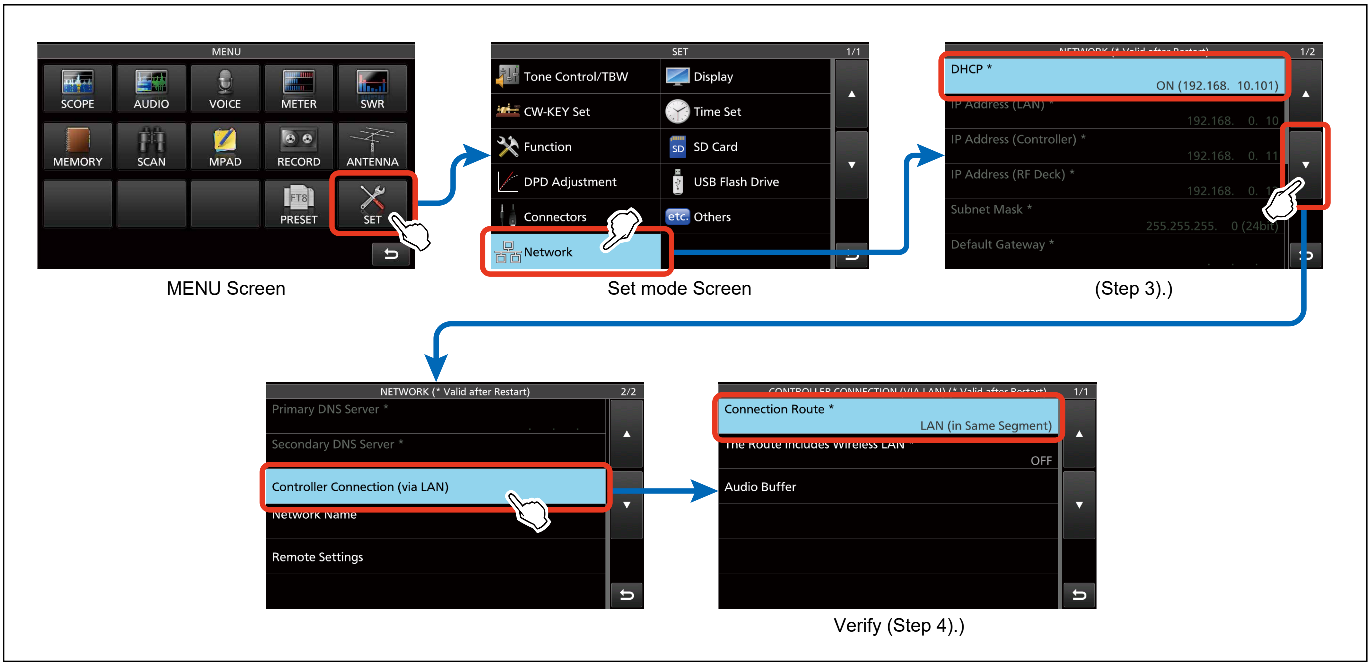


Figure 09-9. Setting Confirmation Process— Home LAN (Home Network) (1)

When using a LAN cable, go to step 5). on the next page. When using a wireless LAN to connect the Controller and the RF Deck, go to step 7). on the next page.

◆ When connecting through a LAN cable

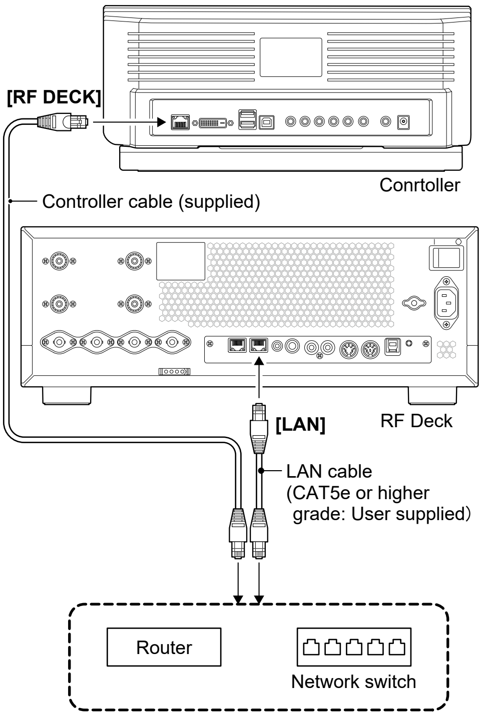


Figure 09-10. Connection in a Home Network

5). Turn OFF the Controller.

6). Connect the [RF DECK] port of the Controller to your home network switch or router (LAN side) with the supplied controller cable. (Figure 09-10)

➥ Turn ON the Controller and it will operate as a connection in the home LAN (home network).

➥ If you hear choppy reception, set the audio buffer as described in "Audio Buffer setting." (See p. 83)

◆ When connecting through a wireless LAN

7). Turn ON "The Route includes Wireless LAN *" in the Set mode.

➥ MENU > SET > Network > Controller Connection (via LAN)

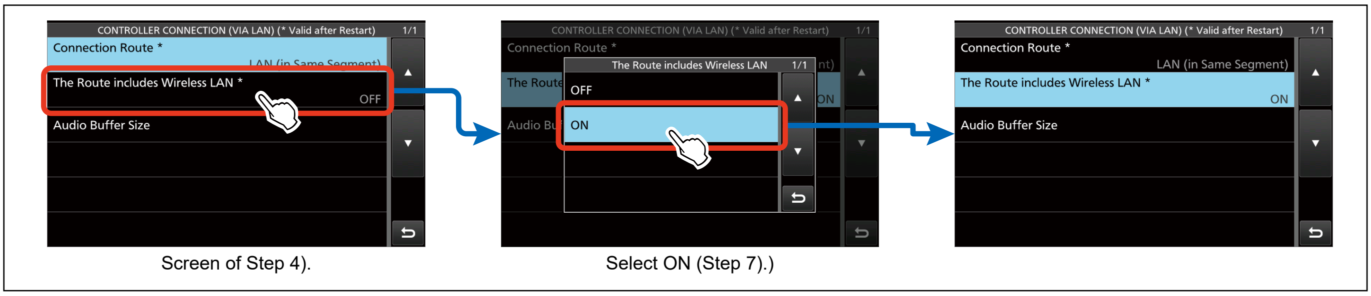


Figure 09-11. Configuration flow for wireless LAN

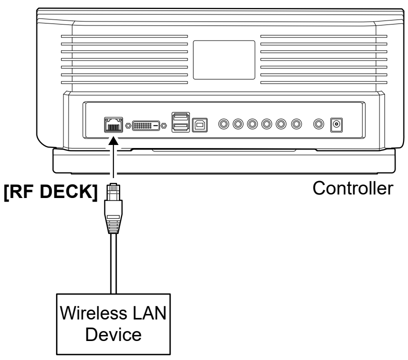


Figure 09-12. Connecting the Wireless LAN Device

8). Turn OFF the Controller.

9). Connect the wireless LAN device to the [RF DECK] port of the Controller.

➥ When the Controller is turned ON, it will operate as a connection in the home network.

➥ If you hear choppy reception, set the audio buffer as described in "Audio Buffer setting." (See p. 83)

Internet connection

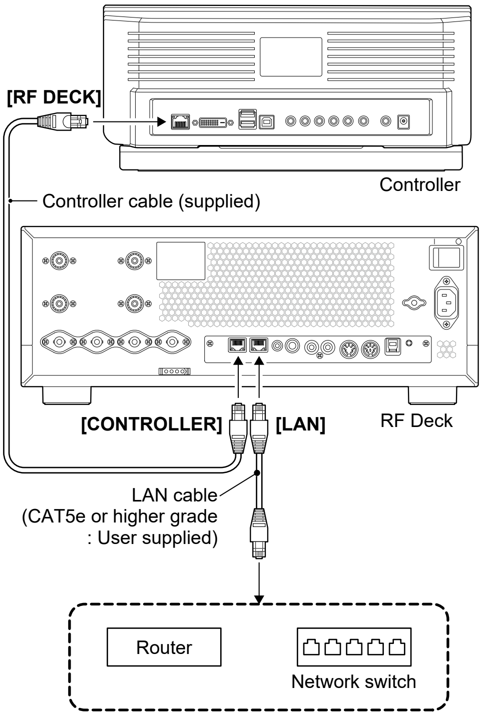


Figure 09-13. Connection with network switch or router (1)

Follow the same procedure for setting up additional RC-7760 Controllers. When multiple Controllers are connected and operated, the firmware version in both the Controllers and the RF Deck must be the same.

1). Directly connect the Controller and the RF Deck. (See p. 64)

2). Connect the [LAN] port of the RF Deck to a network switch or router (LAN side) with the connection in step 1). (Figure 09-13)

3). Make sure that the "DHCP *" setting in the Set mode is "ON."

➥ MENU > SET > Network

4). Change the "Connection Route *" setting in Set mode to "Internet (by on Both sides Port FWD)."

➥ MENU > SET > Network > Controller Connection (via LAN)

➥ "Selecting this option will set the RF deck to a static IP address." dialog appears, then touch "OK."

Continued on the next page…

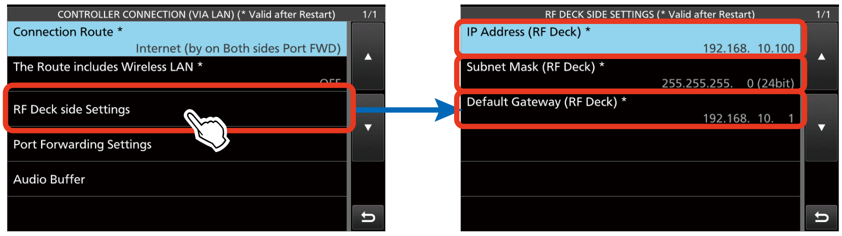
Figure 09-14. Confirmation and setting flow— Internet connection (1)

5). Set each item in the “RF Deck side Settings” screen.

➥ MENU > SET > Network > Controller Connection (via LAN) > RF Deck side Settings

➥ “IP Address (RF Deck) *” is the IP address of the network that the RF Deck is connected to, outside the range of IP addresses assigned by the DHCP server.

➥ “Subnet Mask (RF Deck) *” and “Default Gateway (RF Deck) *” should match the network that the RF Deck is connected to.



Controller Connection (via LAN) screen (step 5.)   RF Deck side Settings screen

Figure 09-15. Confirmation and setting flow— Internet connection (2)

6). Set the port forwarding on the router on the RF Deck side. Set the port information displayed in the “Port Information (RF Deck side)” screen to the router on the RF Deck side.

➥ MENU > SET > Network > Controller Connection (via LAN) > Port Forwarding Settings > Port Information (RF Deck side)

➥ For details on setting port information to your router, refer to your router’s user manual.

7). Turn OFF the power and disconnect the Controller cable from the RF Deck.

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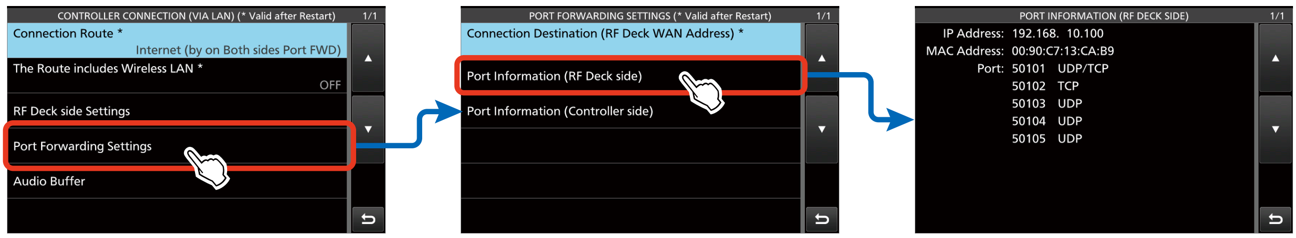

Controller Connection (via LAN) screen (step 6.)   Port Forwarding Settings screen   Port Information (RF Deck side) screen

Figure 09-16. Confirmation and setting flow— Internet connection (3)

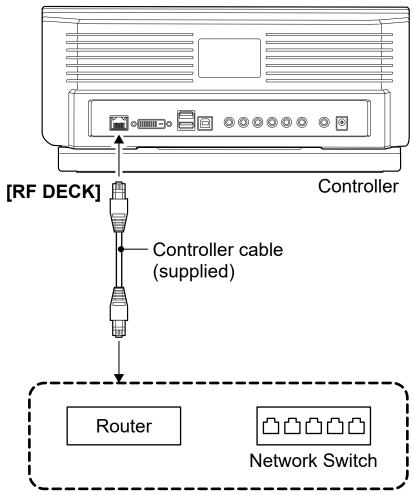

Figure 09-17. Connection with network switch or router (2)

Figure 09-18. Dialog

8). Move the Controller and controller cable to the remote operation location and connect them to the network switch or router (LAN side) at the remote operation location. (Figure 09-17).

9). Turn ON the Controller.

➥ The dialog box will appear "The RF deck is not detected. Check the power of the RF deck and connection, then restart the IC-7760." (Figure 09-18)
Touch "CLOSE" to close the dialog and continue with the configuration.

10). Set the "DHCP *" setting to "OFF" in the Set mode.

➥ MENU > SET > Network > DHCP *

11). Continue with the "IP Address (LAN) *," "IP Address (Controller) *," "Default Gateway *," and "Primary DNS Server *" settings.

➥ "IP Address (LAN) *" and "IP Address (Controller) *" are the IP addresses of the network that the Controller is connected to, outside the range of IP addresses assigned by the DHCP server.

➥ "Subnet Mask *," "Default Gateway *," and "Primary DNS Server *" should match the network that the Controller is connected to.

➥ Do not change any of the settings in the "RF Deck Side Settings" screen (MENU > SET > Network > Controller Connection (via LAN)).
If you have changed them by mistake, start over from step 5).

Continued on the next page…

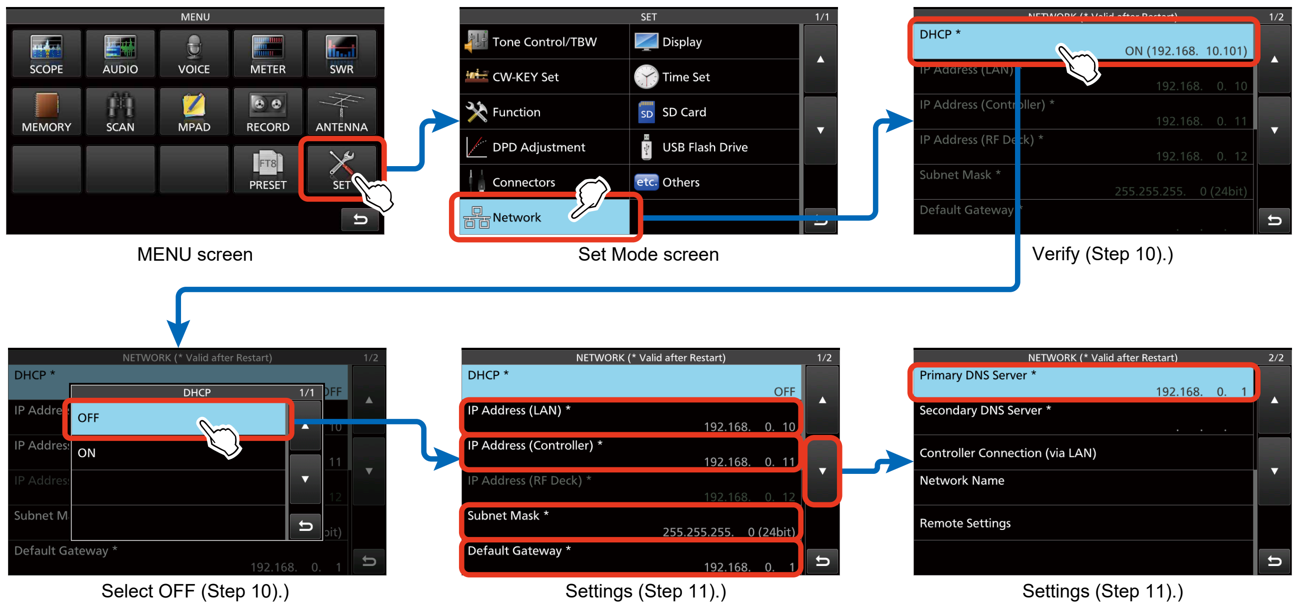

Figure 09-19. Confirmation and setting flow— Internet connection (4)

12). Set the "Connection Destination (RF Deck WAN Address) *" in the Set mode.

- ➥ MENU > SET > Network > Controller Connection (via LAN) > Port Forwarding Settings
- ➥ Set the WAN IP address of the router that the RF Deck is connected to.
- ➥ In addition to entering the IP address directly, you can also specify the name using a dynamic DNS service.
  For more information on dynamic DNS service, refer to "About Dynamic DNS" in "For your reference." (See p. 86)

13). Set the port forwarding of the router on the Controller side according to the SET mode screen.
Set the port information displayed on the "Port Information Used (Controller Side)" screen to the router on the Controller side.

- ➥ MENU > SET > Network > Controller Connection (via LAN) > Port Forwarding Settings > Port Information (Controller side)
- ➥ For details on setting port information to the router, refer to the user's manual of the router you are using.

When using a LAN cable, go to step 14). as below. When using a wireless LAN to connect the Controller and the RF Deck, go to step 15). on the next page.

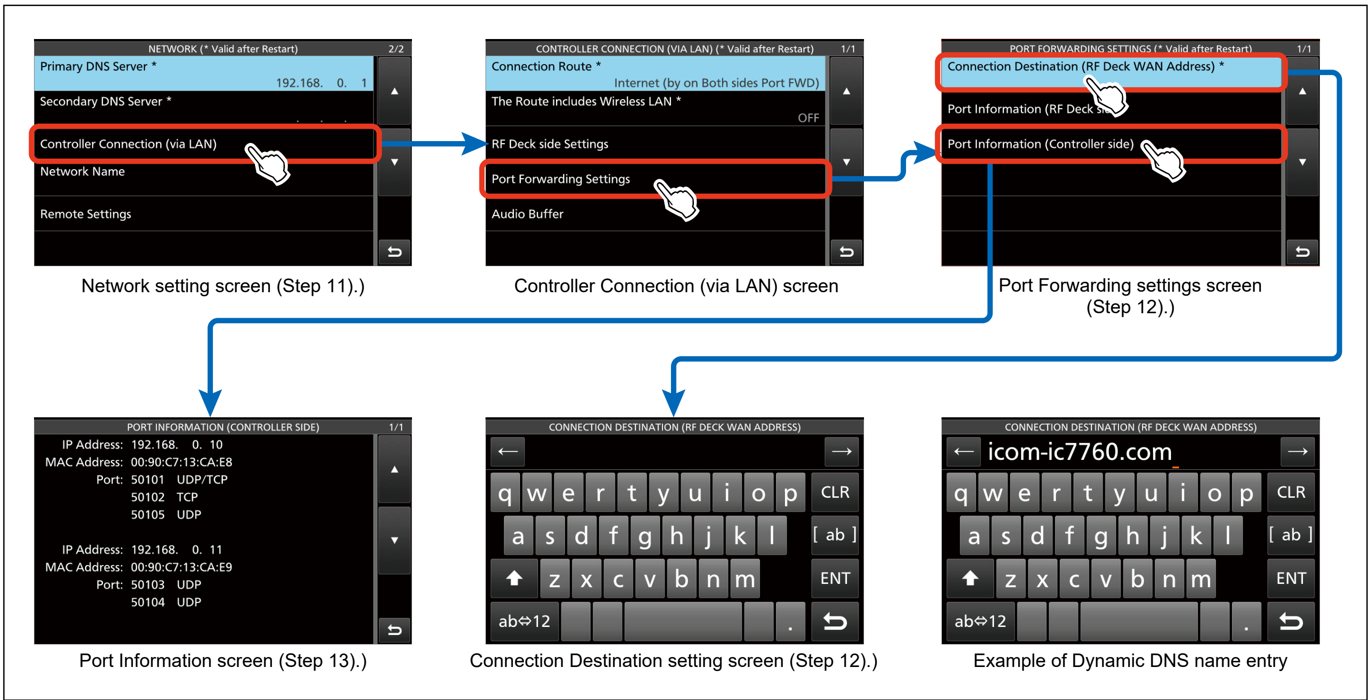

Figure 09-20. Flow of confirmation and setting— Internet connection (5)

◆ When connecting through a LAN cable

14). Reboot the radio and it will connect.

- ➥ If you hear choppy reception, set the audio buffer as described in "Audio Buffer setting." (See p. 83)

◆ When connecting through a wireless LAN

15). Set "The Route includes Wireless LAN *" to "ON" in the Set mode.

➥ MENU > SET > Network > Controller Connection (via LAN)

16). Turn OFF the Controller.

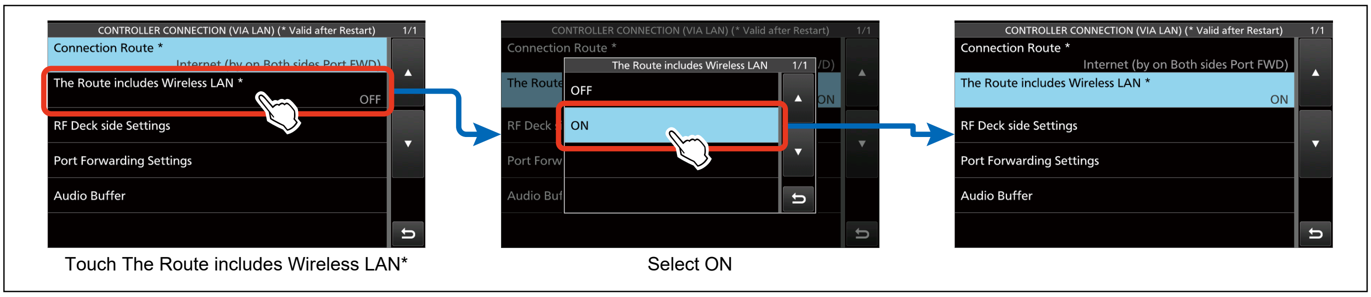

Figure 09-21. Configuration flow regarding wireless LAN

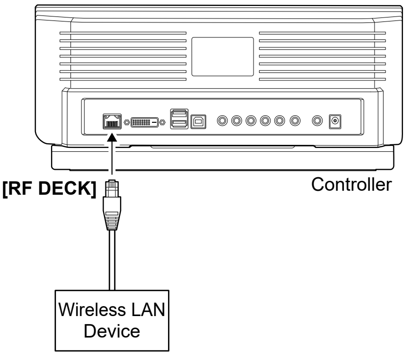

Figure 09-22. Connecting the Wireless LAN device

17). Connect a wireless LAN device to the [RF DECK] port of the Controller. (Figure 09-22)

➥ When the Controller is turned ON, it will operate as a connection in the home LAN (home network).

➥ If you hear choppy reception, set the audio buffer as described in "Audio Buffer setting." (See p. 83)

➥ For the authentication of the connection between the wireless LAN device and the wireless router or access point, refer to the wireless LAN device's user manual.

L3 VPN connections

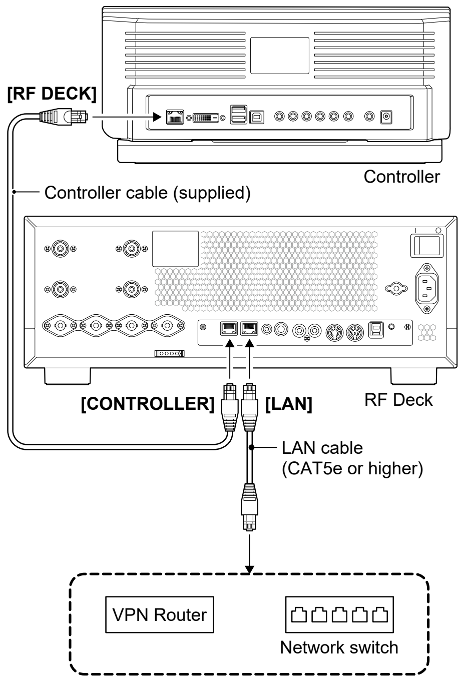

Figure 09-23. Connection with network switch or VPN router (1)

Follow the same procedure for setting up additional RC-7760 Controllers. When multiple Controllers are connected and operated, the firmware version in both the Controllers and the RF Deck must be the same.

It is assumed that communication through VPN has been established between the VPN routers installed at each location.

1). Directly connect the Controller and the RF Deck. (See p. 64)

2). Connect the [LAN] port of the RF Deck to a network switch or router (LAN side) with the connection in step 1). (Figure 09-23)

3). Make sure that the "DHCP *" setting in the Set mode is "ON."
➥ MENU > SET > Network

4). Change the "Connection Route *" setting in Set mode to "Internet (V3 VPN from Diff Segment)."
➥ MENU > SET > Network > Controller Connection (via LAN)
➥ "Selecting this option will set the RF deck to a static IP address." dialog appears, then touch "OK."

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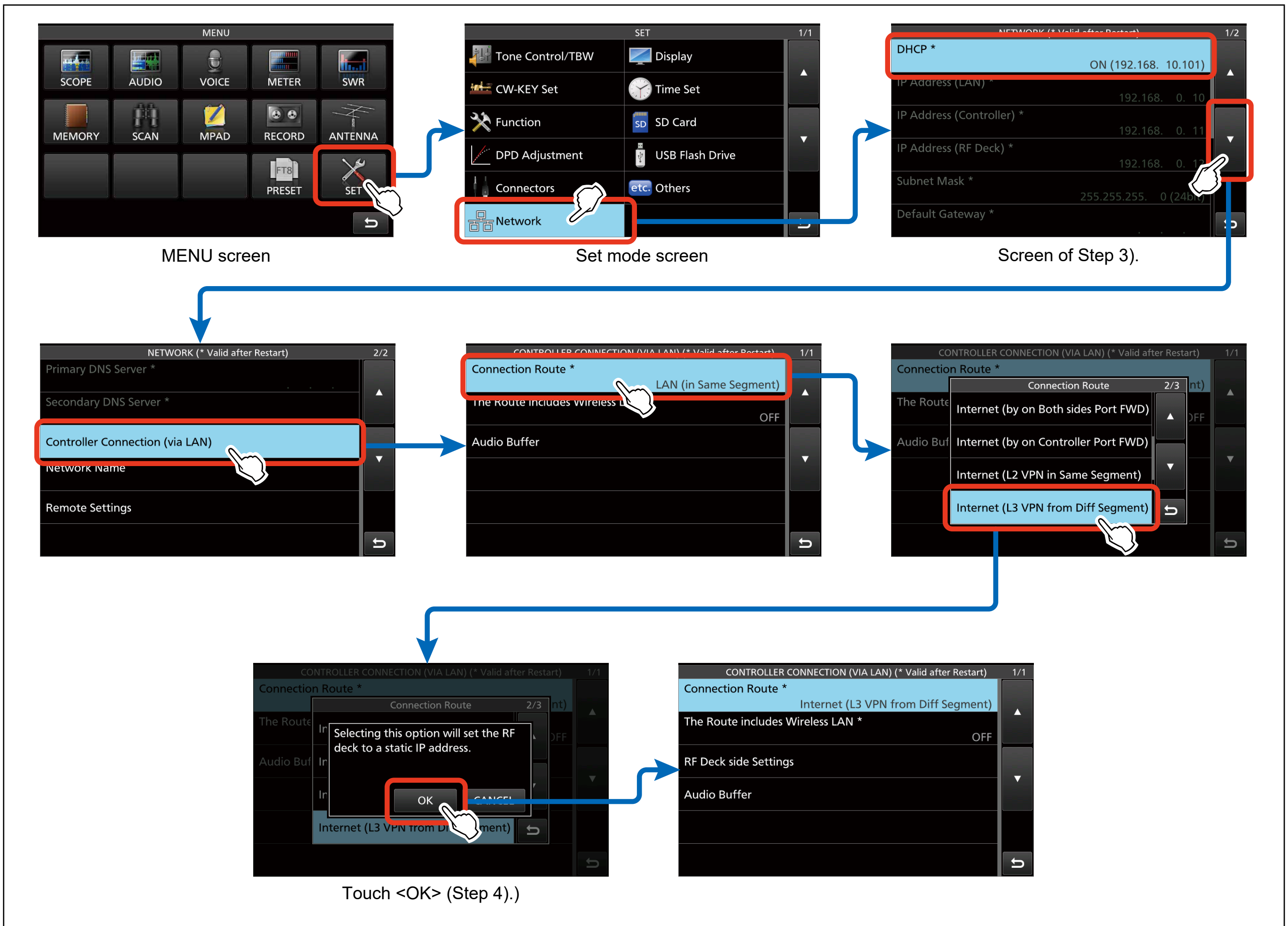
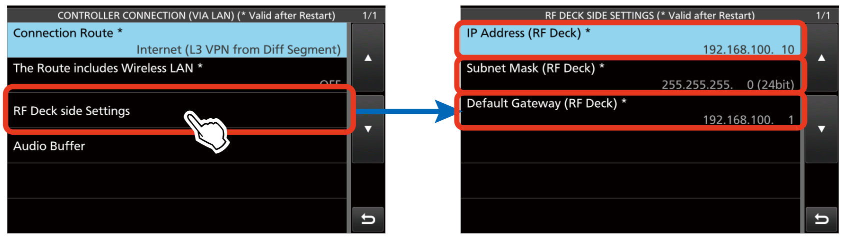


Figure 09-24. Flow of confirmation and setting— L3 VPN connections (1)

5). Set each item in the "RF Deck side Settings" screen.
   ➥ MENU > SET > Network > Controller Connection (via LAN) > RF Deck side Settings
   ➥ "IP Address (RF Deck) *" is the IP address of the network that the RF Deck is connected to, outside the range of IP addresses assigned by the DHCP server.
   ➥ "Subnet Mask (RF Deck) *" and "Default Gateway (RF Deck) *" should match the network that the RF Deck is connected to.

6). Turn OFF the power and disconnect the Controller cable from the RF Deck.

When using a LAN cable, go to step 7). as below. When using a wireless LAN to connect the Controller and the RF Deck, go to step 8). on the next page.



Controller Connection (via LAN) screen (step 5).) RF Deck side Settings screen

Figure 09-25. Flow of confirmation and setting— L3 VPN connections (2)

◆ When connecting through a LAN cable

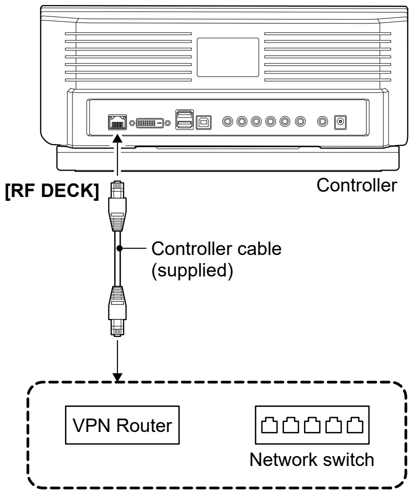


Figure 09-26. Connection with network switch or VPN router (2)

7). Move the Controller and controller cable to the remote operation location and connect them to the network switch or VPN router (LAN side) at the remote operation location. (LAN side) of the remote operation location (Figure 09-26).
   ➥ Turn ON the Controller and it will operate as a connection in the home LAN (home network).
   ➥ If you hear choppy reception, set the audio buffer as described in "Audio Buffer setting." (See p. 83)

◆ When connecting through a wireless LAN

8). Set "The Route includes Wireless LAN *" to "ON" in the Set mode.

➥ MENU > SET > Network > Controller Connection (via LAN)

9). Turn OFF the Controller.

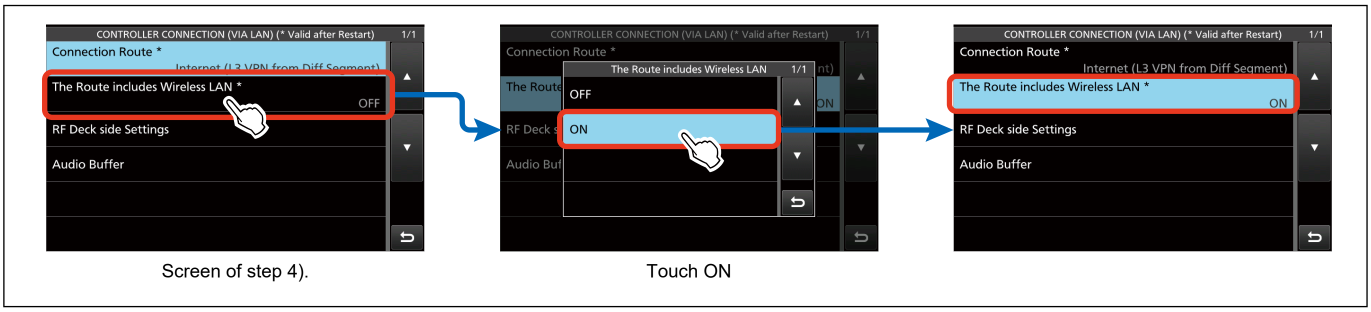


Figure 09-27. Configuration flow regarding wireless LAN

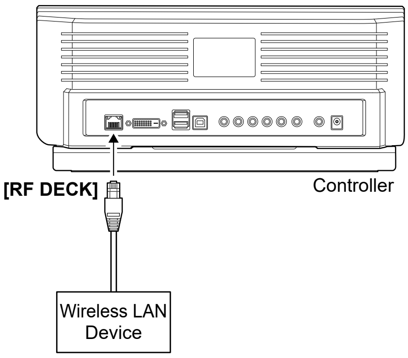


Figure 09-28. Connecting the Wireless LAN device

10). Connect a wireless LAN device to the [RF DECK] port of the Controller. (Figure 09-28)

➥ When the Controller is turned ON, it will operate as a connection in the home LAN (home network).

➥ If you hear choppy reception, set the audio buffer as described in "Audio Buffer setting." (See p. 83)

➥ For the authentication of the connection between the wireless LAN device and the wireless VPN router or access point, refer to the wireless LAN device's user manual.

L2 VPN connections

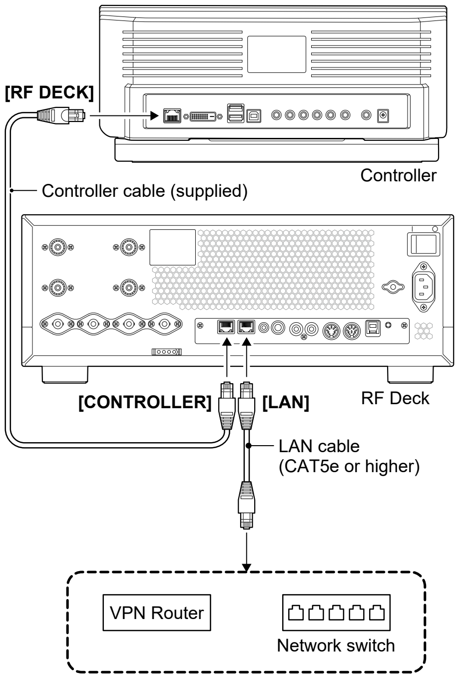


Figure 09-29. Connection with network switch or VPN router (1)

Follow the same procedure for setting up additional RC-7760 Controllers. When multiple Controllers are connected and operated, the firmware version in both the Controllers and the RF Deck must be the same.

It is assumed that communication through VPN has been established between the VPN routers installed at each location.

1). Directly connect the Controller and the RF Deck. (See p. 64)

2). Connect the [LAN] port of the RF Deck to a network switch or router (LAN side) with the connection in step 1). (Figure 09-29)

3). Make sure that the “DHCP *” setting in the Set mode is “ON.”
➥ MENU > SET > Network

4). Change the “Connection Route *” setting in Set mode to “Internet (V2 VPN in Same Segment).”
➥ MENU > SET > Network > Controller Connection (via LAN)

5). Turn OFF the power and disconnect the Controller cable from the RF Deck.

When using a LAN cable, go to step 6). on the next page. When using a wireless LAN to connect the Controller and the RF Deck, go to step 7). on the next page.

Continued on the next page…

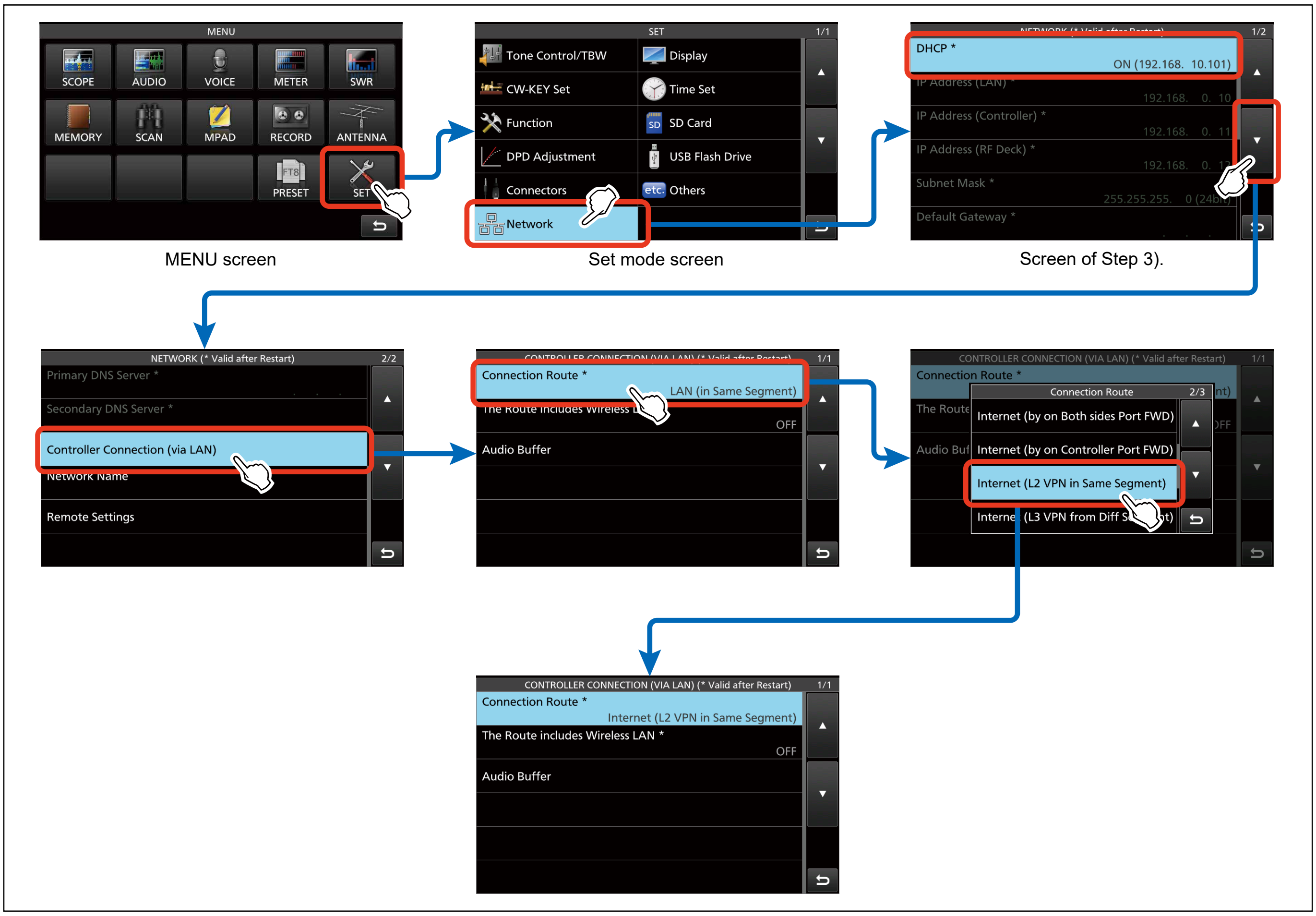


Figure 09-30. Flow of confirmation and setting— L2 VPN connections (1)

◆ When connecting through a LAN cable

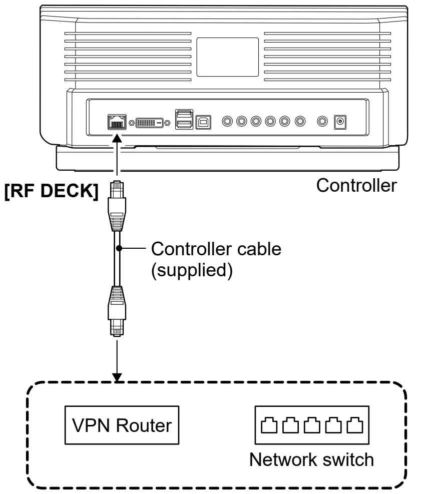


Figure 09-31. Connection with network switch or VPN router (2)

6). Move the Controller and controller cable to the remote operation location and connect them to the network switch or VPN router (LAN side) at the remote operation location. (Figure 09-31).
- ➥ Turn ON the Controller and it will operate as a connection in the home LAN (home network).
- ➥ If you hear choppy reception, set the audio buffer as described in “Audio Buffer setting.” (See p. 83)

◆ When connecting through a wireless LAN

7). Set “The Route includes Wireless LAN *” to “ON” in the Set mode.
- ➥ MENU > SET > Network > Controller Connection (via LAN)

8). Turn OFF the Controller.

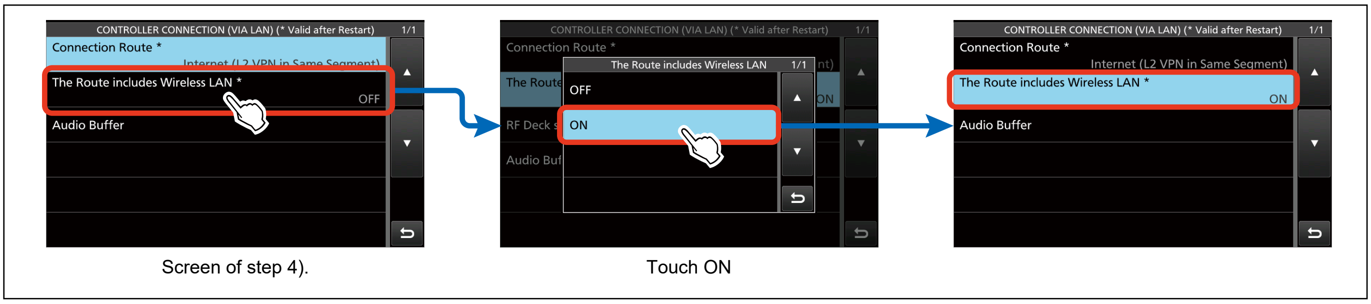


Figure 09-32. Configuration flow regarding wireless LAN

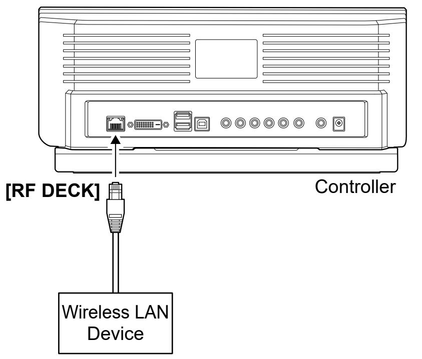


Figure 09-33. Connecting the Wireless LAN device

9). Connect a wireless LAN device to the [RF DECK] port of the Controller. (Figure 09-33)
- ➥ When the Controller is turned ON, it will operate as a connection in the home LAN (home network).
- ➥ For the authentication of the connection between the wireless LAN device and the wireless VPN router or access point, refer to the wireless LAN device’s user manual.
- ➥ If you hear choppy reception, set the audio buffer as described in “Audio Buffer setting.” (See p. 83)

Home LAN (Home network) ~ Separate segment

Follow the same procedure for setting up additional RC-7760 Controllers. When multiple Controllers are connected and operated, the firmware version in both the Controllers and the RF Deck must be the same.

1). Directly connect the Controller and the RF Deck. (See p. 64)

2). Connect the [LAN] port of the RF Deck to a network switch or router (LAN side) with the connection in step 1). (Figure 09-34)

3). Make sure that the "DHCP *" setting in the Set mode is "ON."
➥ MENU > SET > Network

4). Change the "Connection Route *" setting in Set mode to "LAN (from Different Segment)."
➥ MENU > SET > Network > Controller Connection (via LAN)

Continued on the next page…

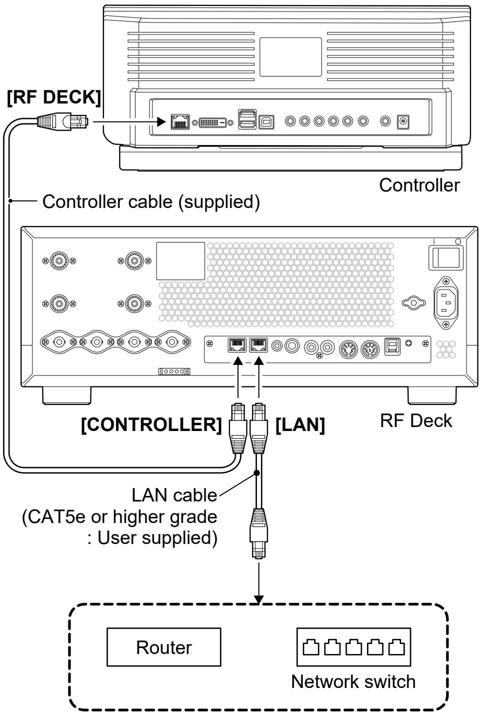


Figure 09-34. Connection with network switch or router (1)

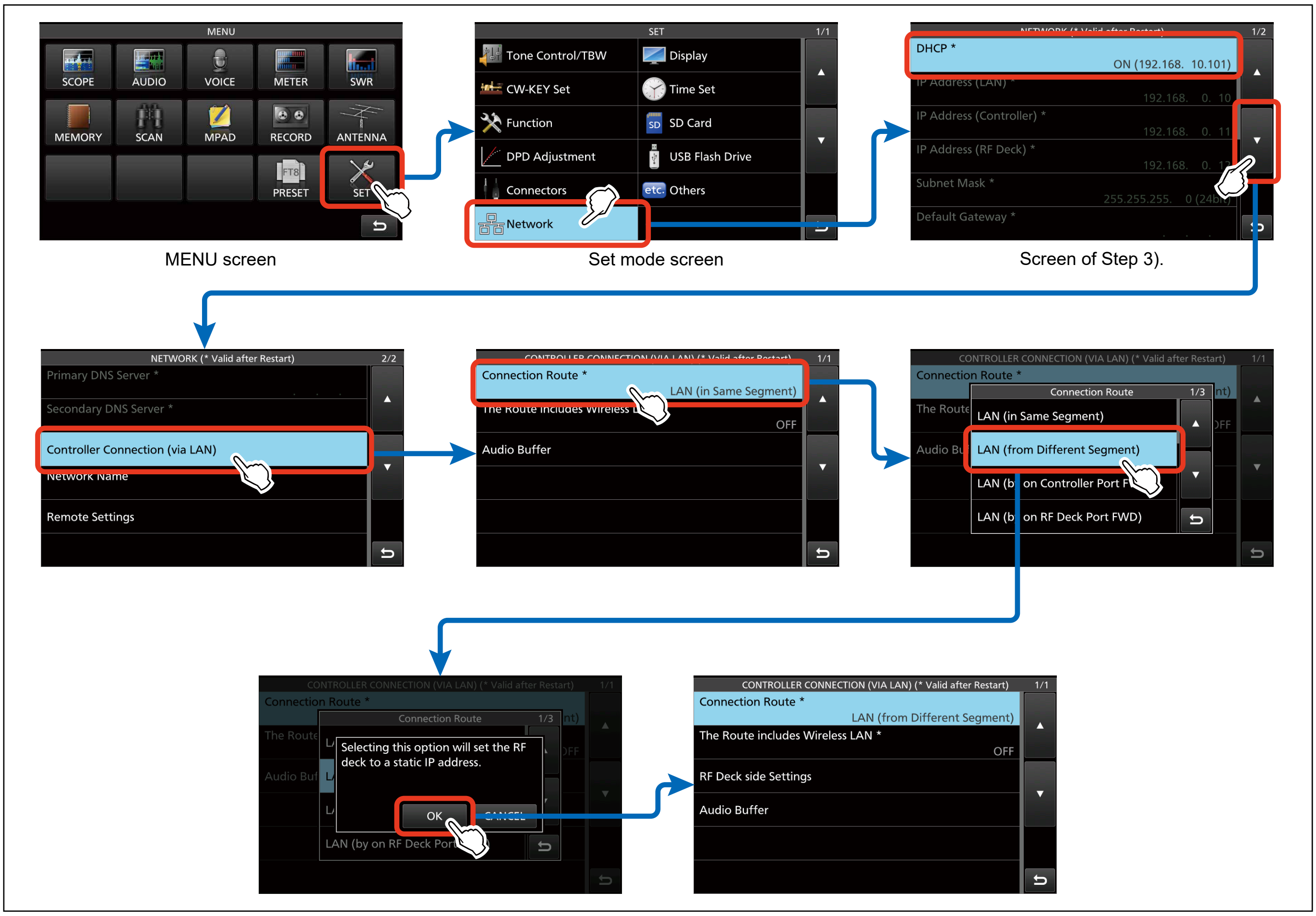
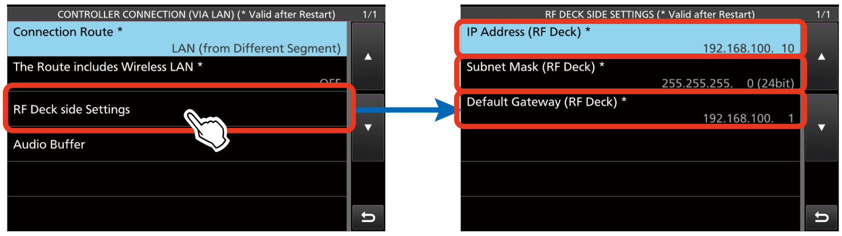


Figure 09-35. Flow of confirmation and setting— Home LAN (separate segment) connections (1)

5). Set each item in the “RF Deck side Settings” screen.
- ➥ MENU > SET > Network > Controller Connection (via LAN) > RF Deck side Settings
- ➥ “IP Address (RF Deck) *” is the IP address of the network that the RF Deck is connected to, outside the range of IP addresses assigned by the DHCP server.
- ➥ “Subnet Mask (RF Deck) *” and “Default Gateway (RF Deck) *” should match the network that the RF Deck is connected to.

6). Turn OFF the power and disconnect the Controller cable from the RF Deck.



Controller Connection (via LAN) screen (step 5).) RF Deck side Settings screen

Figure 09-36. Flow of confirmation and setting— Home LAN (separate segment) connections (2)

When using a LAN cable, go to step 7). as below. When using a wireless LAN to connect the Controller and the RF Deck, go to step 8). on the next page.

◆ When connecting through a LAN cable

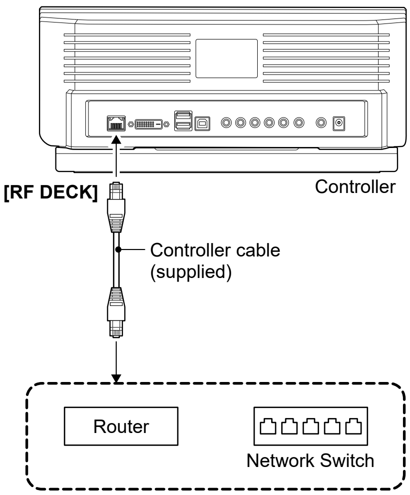


Figure 09-37. Connection with network switch or router (2)

7). Move the Controller and controller cable to the remote operation location (separate segment) and connect them to the network switch or router (LAN side) at the remote operation location (separate segment). (Figure 09-37)
- ➥ Turn ON the Controller and it will operate as a connection in the home LAN (home network).
- ➥ If you hear choppy reception, set the audio buffer as described in “Audio Buffer setting.” (See p. 83)

◆ When connecting through a wireless LAN

8). Set “The Route includes Wireless LAN *” to “ON” in the Set mode.

➥ MENU > SET > Network > Controller Connection (via LAN)

9). Turn OFF the Controller.

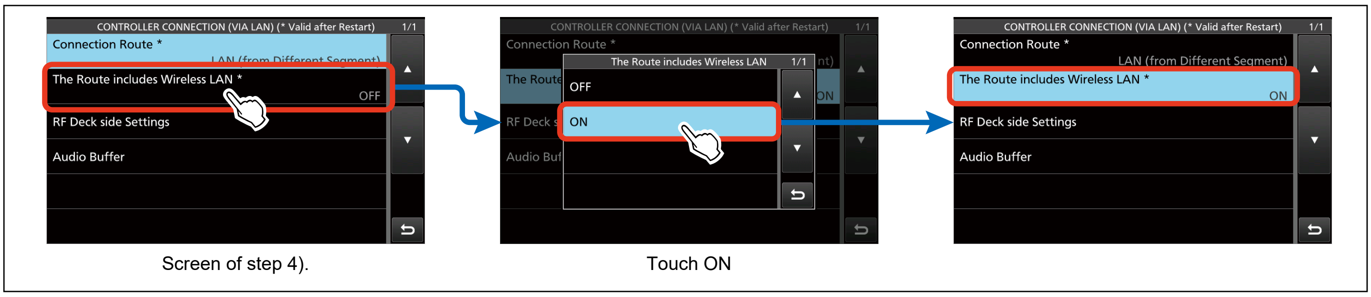


Figure 09-38. Configuration flow regarding wireless LAN

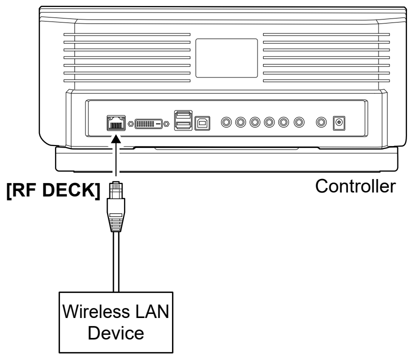


Figure 09-39. Connecting the Wireless LAN device

10). Connect a wireless LAN device to the [RF DECK] port of the Controller. (Figure 09-39)

➥ When the Controller is turned ON, it will operate as a connection in the home LAN (home network).

➥ For the authentication of the connection between the wireless LAN device and the wireless router or access point, refer to the wireless LAN device’s user manual.

➥ If you hear choppy reception, set the audio buffer as described in “Audio Buffer setting.” (See p. 83)

Internet connection ~ specifying static IP addresses

Prepare your Internet service provider's contract for setting up.

1). Directly connect the Controller and the RF Deck. (See p. 64)

2). Connect the [LAN] port of the RF Deck to a network switch or router (LAN side) with the connection in step 1). (Figure 09-40)

3). Change the "Connection Route *" setting in Set mode to "Internet (with Static IP Address)."

➥ MENU > SET > Network > Controller Connection (via LAN)

➥ "Selecting this option will set the RF deck to a static IP address." dialog appears, then touch "OK."

Continued on the next page…

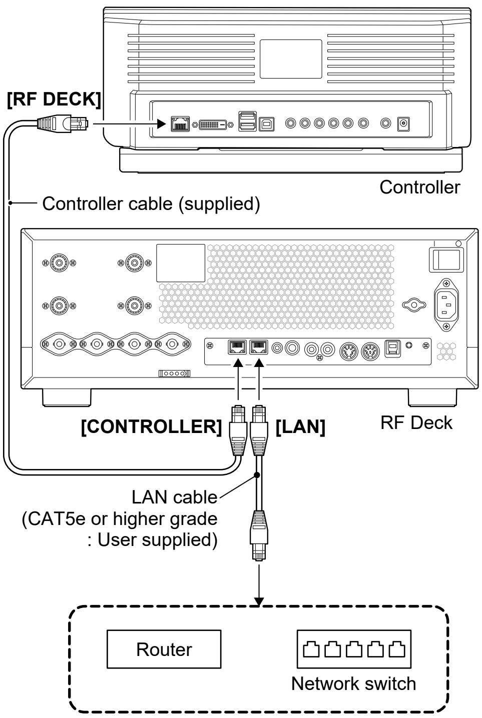


Figure 09-40. Connection with network switch or router (1)

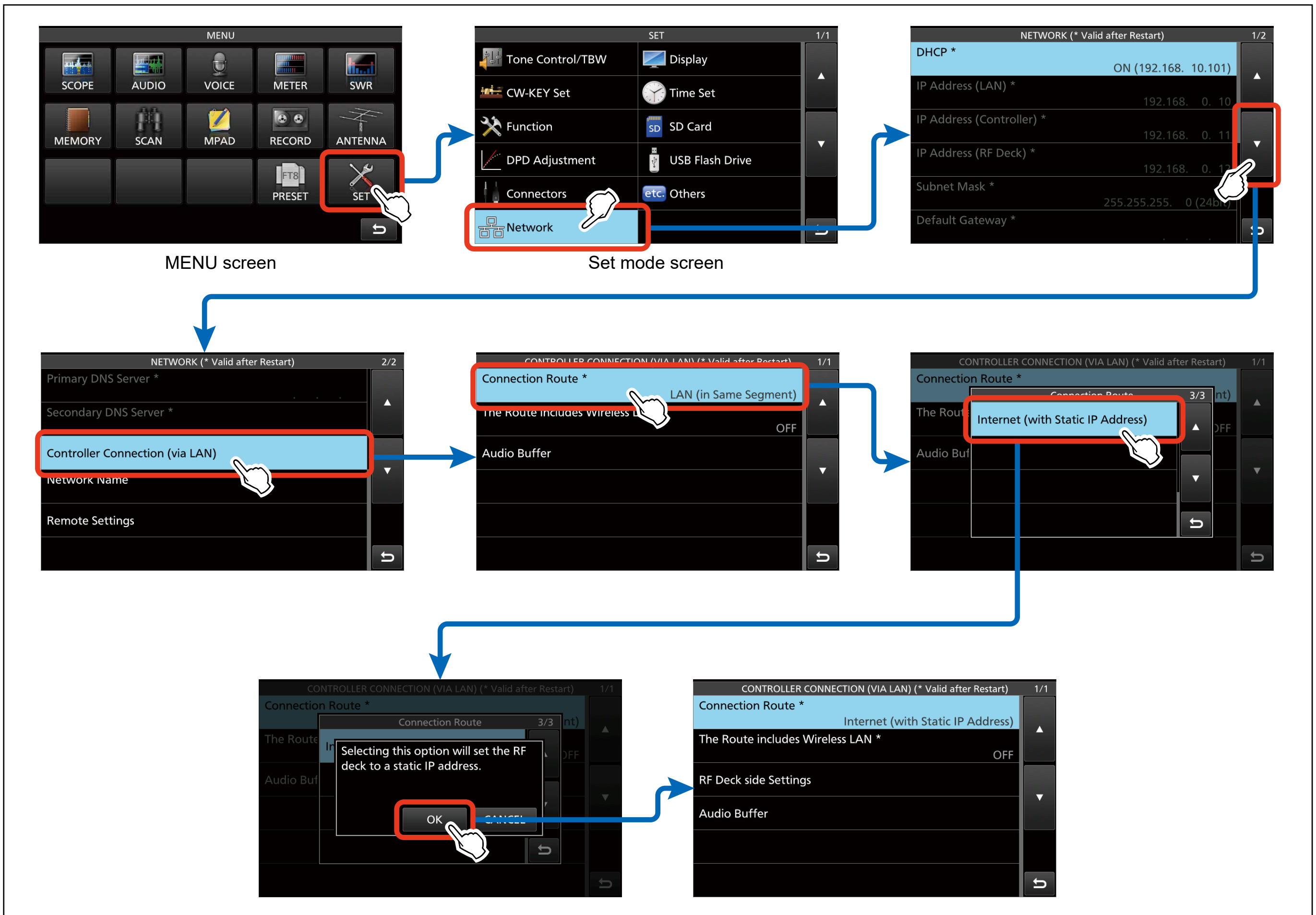
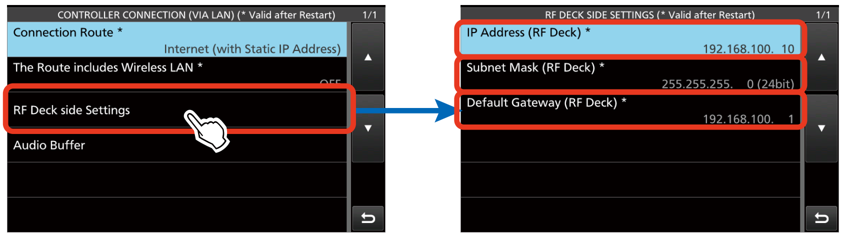


Figure 09-41. Flow of confirmation and setting— Internet connection (specifying static IP address) (1)

4). Set each item in the "RF Deck side Settings" screen.
   ➥ MENU > SET > Network > Controller Connection (via LAN) > RF Deck side Settings
   ➥ Set "IP Address (RF Deck) *", "Subnet Mask (RF Deck) *", and "Default Gateway (RF Deck) *" as specified in the Internet service provider's contract.

5). Turn OFF the power and disconnect the Controller cable from the RF Deck.



Controller Connection (via LAN) screen (step 4).) RF Deck side Settings screen

Figure 09-42. Flow of confirmation and setting— Internet connection (specifying static IP address) (2)

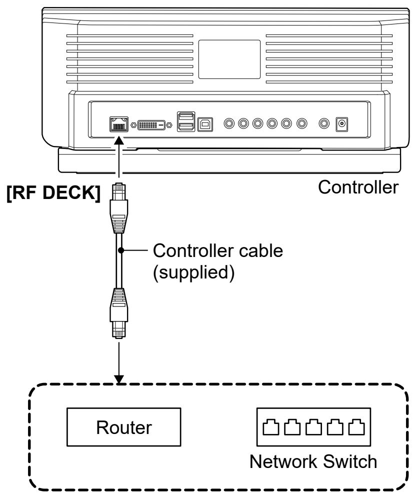


Figure 09-43. Connection to the network switch

Figure 09-44. Dialog

6). Move the Controller and controller cable to the remote operation location (separate segment) and connect them to the network switch or router (LAN side) at the remote operation location (separate segment). (Figure 09-43)

7). Turn ON the Controller.
   ➥ The dialog box will appear "The RF deck is not detected. Check the power of the RF deck and connection, then restart the IC-7760." (Figure 09-44)
   Touch "CLOSE" to close the dialog and continue with the configuration.

Continued on the next page…

8). Set each item in the “Network Screen.”

➥ MENU > SET > Network

➥ Set “IP Address (LAN) *,” “IP Address (Controller) *,” “Subnet Mask *,” “Default Gateway *,” “Primary DNS Server *,” and “Secondary DNS Server *” as specified in the Internet service provider’s contract.

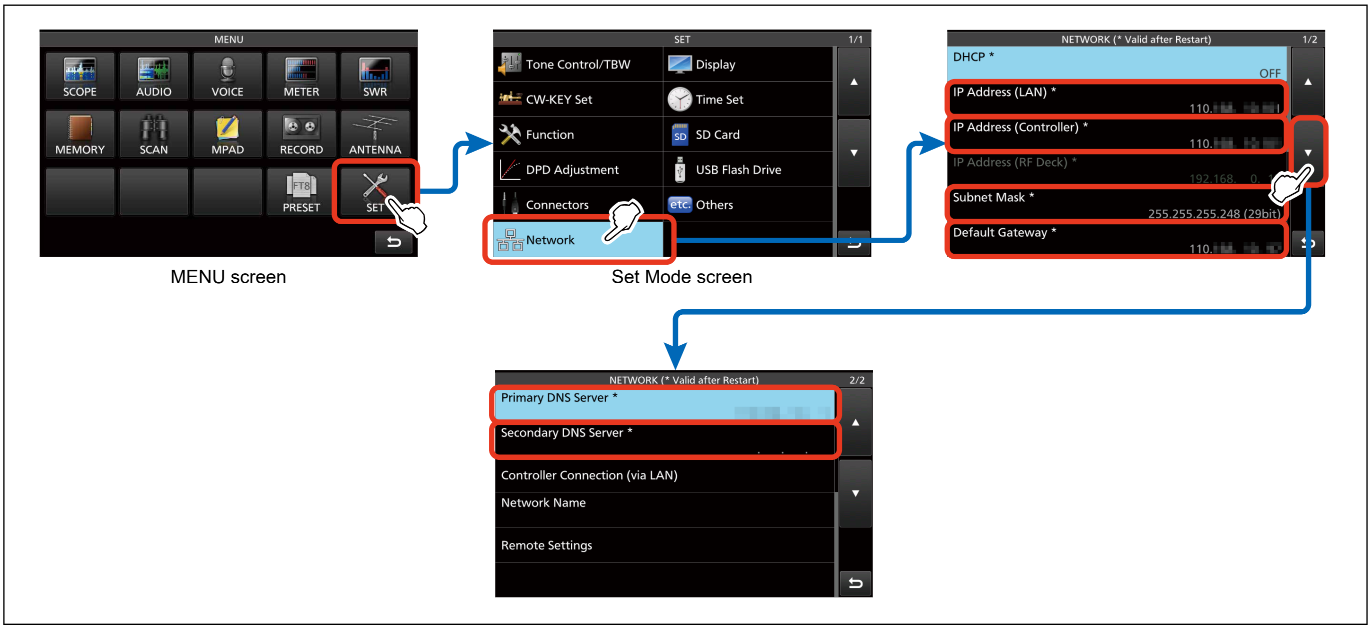


Figure 09-45. Flow of confirmation and setting— Internet connection (specifying static IP address) (3)

9). When a wireless LAN device is connected to either the controller or the RF Deck connected network, set “The Route includes Wireless LAN *” to “ON” in the Set mode.

➥ MENU > SET > Network > Controller Connection (via LAN)

➥ No wireless LAN device is connected to either network, skip this setting and go to step 10).

10). After rebooting the controller, it will be operable.

➥ If you hear choppy reception, set the audio buffer as described in “Audio Buffer setting.” (See p. 83)

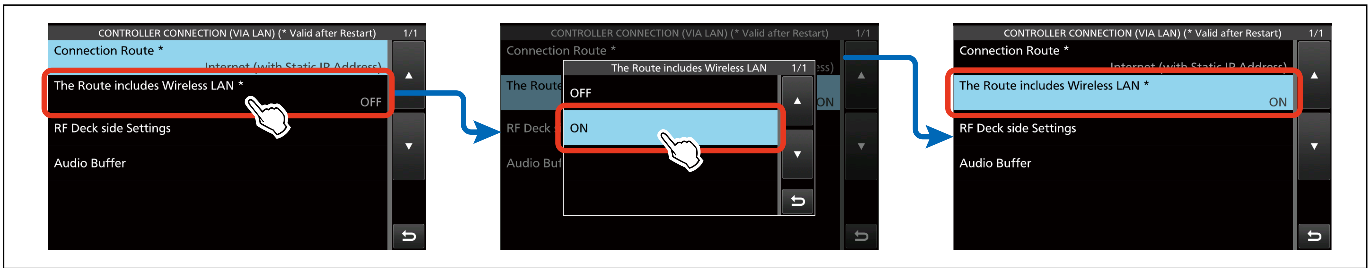


Figure 09-46. Flow of confirmation and setting— Internet connection (specifying static IP address) (4)

Audio Buffer setting

Except for directly connecting the controller and the RF Deck, set the audio buffer as follows if you hear choppy reception.

1). Turn ON the Monitor function.
   ➥ FUNCTION > MONI
2). On the “Audio Buffer” screen, touch the item that corresponds to the connection route and the setting for using wireless LAN.
   ➥ MENU > Network > Controller Connection (via LAN) > Audio Buffer
   ➥ The item that corresponds to the settings for “Connection Route *” and “The Route includes Wireless LAN *” will be displayed brightly (not grayed out).
3). While listening to the received audio, select a value in the displayed dialog.
4). While the monitoring function is used, and if choppy monitoring audio is heard, select a larger value in the dialog.
   ➥ When the monitoring sound is not choppy, keep the value set in step 3).

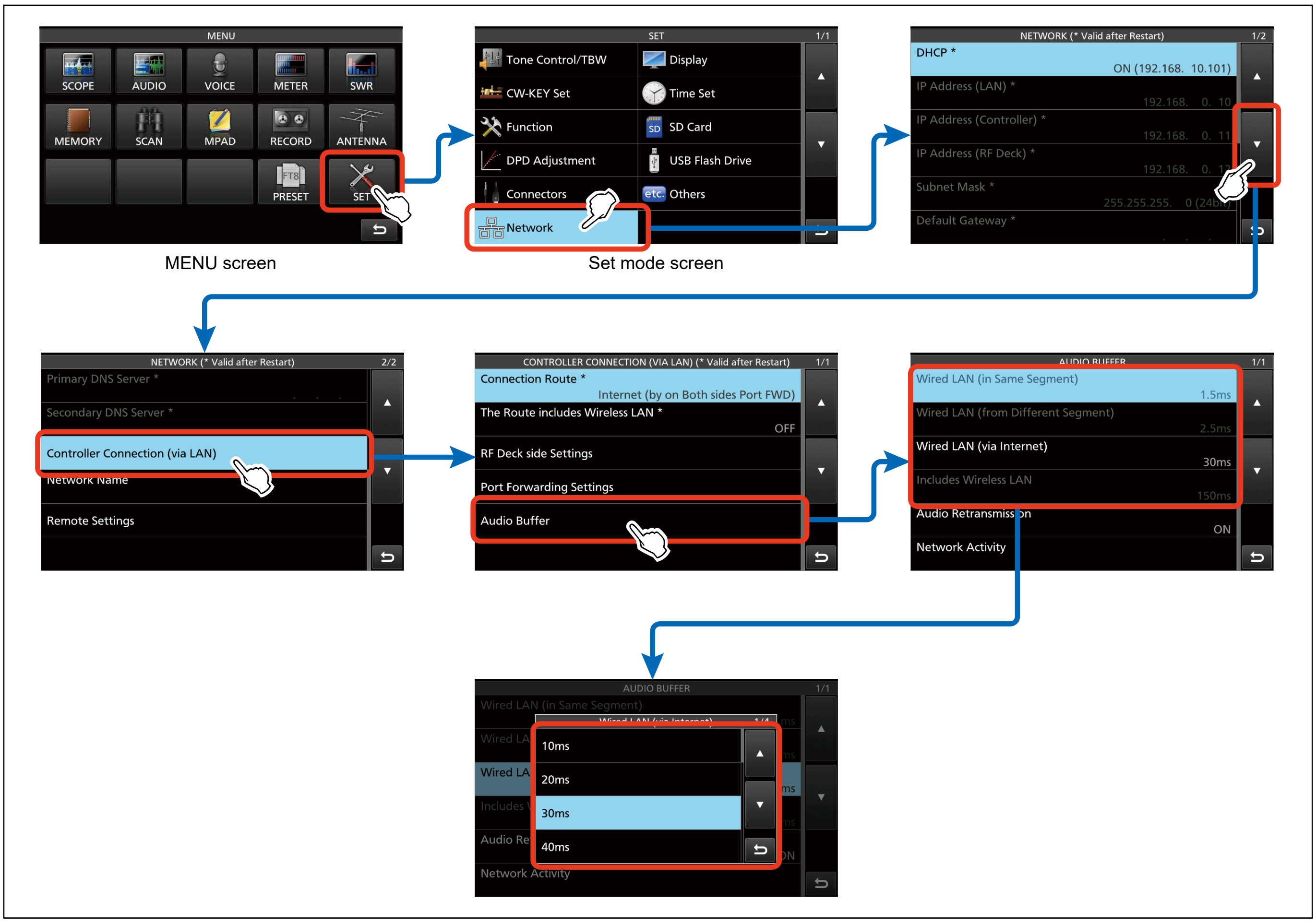


Figure 09-47. Flow of setting the audio buffer

About packet loss (Applicable for Firmware version 1.12 or later)

Packet loss is a phenomenon in which a portion of data (packets) is lost during communication.

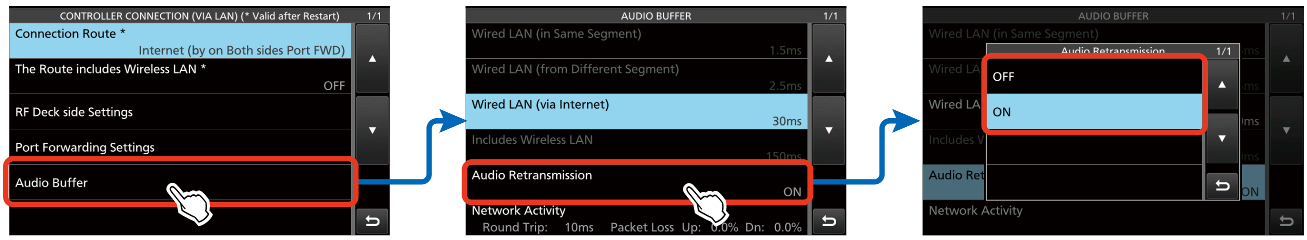
When the controller and RF deck are connected through a network, packet loss can occur depending on the network line usage or network devices, causing choppy audio in transmission and reception.

The IC-7760 has the Audio Retransmission function to compensate for choppy audio in transmission and reception audio caused by packet loss.

Also, IC-7760 can show the network status, including packet loss.

◆ Audio Retransmission function

1). Open the "Audio Buffer" screen.
  ➥ MENU > Network > Controller Connection (via LAN) > Audio Buffer
2). Touch "Audio Retransmission" and turn the function ON/OFF in the displayed dialog. (Default: ON)
  ➥ When the audio retransmission function is used, set the Audio Buffer to a larger value.
  ➥ Note that even when the Audio Retransmission function is used, choppy audio may not be improved depending on the Internet line used, data flowing value, and the Audio Buffer setting.
  ➥ If the choppy audio for transmission and reception due to packet loss does not bother you, network delay can be minimized by turning OFF the Audio Retransmission function.
  ➥ Note that the used Internet line does not have enough bandwidth; the Audio Retransmission function may cause choppy audio because the data flowing value increases.
  ➥ Setting the Audio Retransmission function based not only on choppy audio, but also on "Round Trip" time and "Packet Loss" rate displayed in "Network Activity" on the Audio Buffer setting screen described on the next page is recommended.



Controller Connection setting screen

Figure 09-48. Audio Retransmission function setting flow

◆ Network Activity

1). Open the "Audio Buffer" screen.
➥ MENU > Network > Controller Connection (via LAN) > Audio Buffer

2). The status of the following items is displayed in "Network Activity."

Round Trip: Shows data round-trip time from the controller to the RF Deck and return to the controller. The shorter the time, the smaller the network latency.

Packet Loss: This shows the percentage of packet loss on the upload (Up) and download (Dn) in the network line.

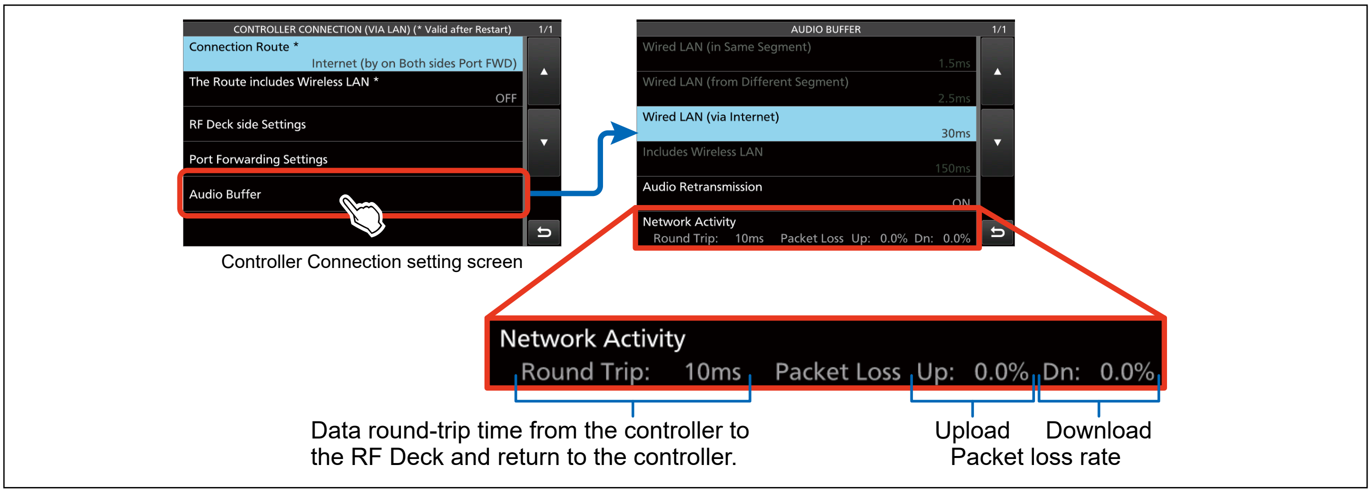


Figure 09-49. Checking the Network Activity

For your reference

◆ About Dynamic DNS

Generally, a dynamic global IP address is assigned by the provider as the WAN address of the router. In other words, the global IP address changes periodically. When operating the IC-7760 remotely through the Internet, the Controller specifies the RF Deck using the global IP address assigned by the provider. But if the WAN address of the RF Deck that you are connecting to is changed frequently, you will not find the destination address set in the Controller.

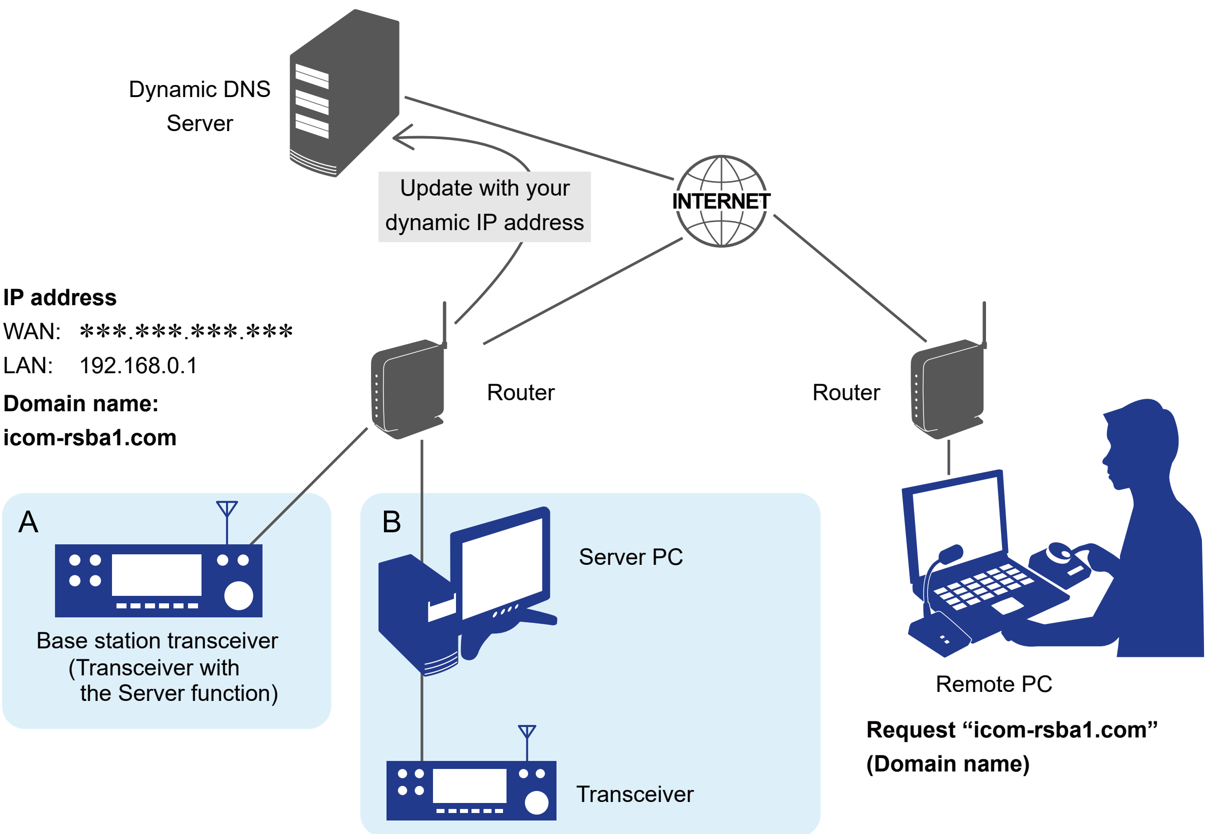
However, if the WAN-side address of the RF Deck (WAN address of the router) is changed periodically, the connection destination set in the Controller will not be found. By using a dynamic DNS service, the domain name can be accessed, even if the global IP address is periodically changed.

Below is an excerpt from the RS-BA1 instruction manual for reference.

◆ To enable PCs connect to the Base station using its domain name

If you set up an account for a Dynamic DNS server, the DNS server resolves the domain name into your dynamic IP address. Using the domain name, PCs can connect to the Base station through the Internet, even if the Base station's public IP address is changed.

ⓘ Check the router's manual about how to configure your router to use the Dynamic DNS services.



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Icom Inc.
1-1-32, Kamiminami, Hirano-ku, Osaka 547-0003, Japan