Receiver Shopping List

A Test Report Special
September 1998

Kneisner + Doering KWZ 30

communications receiver

by Willem Bos

Summary

Year Introduced	1997
Power	12 VDC, 2.5 amperes maximum current draw.
Size (WHD)	305 x 105 x 210 mm
Weight	KWZ 30: 4 kg; Power supply unit: 2 kg
Price	DM 3485, including VAT, within the European Union. Outside the EU, DM 3005 (about US$1710) plus import duties.
Coverage	50 kHz to 30 MHz

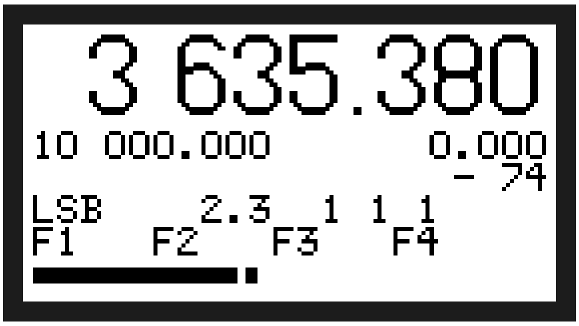
Value Rating[1]	★★★★★

The KWZ 30 has proven to be a remarkable digital signal processing (DSP) receiver that deserves more attention from shortwave listeners around the world.

A number of years ago Lowe, followed by AKD, AOR UK and Fairhaven started to produce high quality receivers at affordable prices. In 1997 Kneisner + Doering from Germany joined the select group of European-based manufacturers with the introduction of the KWZ 30.

The communications receiver tunes the 50 kHz - 30 MHz frequency range. Reception with slightly reduced specifications is possible from upwards of 6 kHz! The receiver is housed in a very sturdy metal cabinet, 305 mm wide, 105 mm high and 210 mm deep, or 12 inches wide, 4 inches high and 8 inches deep. The set itself weighs 4 kg, about 9 pounds.

The receiver operates at 12 Volts DC and draws a maximum current of 2.5 Amps so it can be operated from almost any decent 12 Volts regulated power supply or a car battery. A power supply cable is supplied with a plug that fits the cigarette lighter in a car. Also included is a heavy-duty stabilised power supply for 230 V AC mains operation. This power supply is equipped with a jack for the cigarette lighter plug for the 12 Volts supply voltage. The power supply is an additional 2 kg, about 4 and a half pounds. The web site lists only the 230 V AC supply. Unless Kneisner + Doering changes the power supply input voltage or modifies its power supply to handle multiple input voltages, listeners in North America and elsewhere will have to buy a regulated power supply with a mains input voltage of 110-117 V AC.



The front panel of the KWZ 30 is extremely simple. In the centre, a large (70 x 37 mm, about 2 3/4 x 1 1/2 inches) back-lighted green-coloured LCD display shows the frequency to which the receiver is tuned, accurate to within 1 Hz. It also shows the frequency of the 2nd VFO, S-meter, mode, bandwidth of the selected filter and several other functions. We found it can be viewed under most reasonable angles, but there is no dimmer. You can program the menus to display one of three languages: German, English or French.

For tuning there is a large and heavy tuning knob with finger hole and a 20 key pushbutton field which controls the whole receiver. The pushbuttons are relatively small and if you have thick fingers you might have to operate them with your nails. The volume control knob on the front panel is combined with the on-off power switch. There is a headphone output jack. Use of the headphone switches off the internal loudspeaker. The loudspeaker is a high quality type capable of handling 8 Watts, so even with high volume levels the speaker doesn't produce extra distortion. The speaker is placed behind the front panel. We like this because if you sit in front of the receiver the sound comes straight at you. This gives a clearer sound (especially treble response) than when the speaker is mounted in the top cover or on a plate underneath the set.

The backside of the set is as simple as the front panel. There are jacks for the 12 Volts DC supply, an external speaker, an audio-line output for a tape recorder, a mute control, a 9-pin D-connector for the RS 232 computer control, a ground screw, and an antenna connector.

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★★★★★	**excellent**
★★★★	**good**
★★★	**average**
★★	**poor**
★	**give this receiver a miss.**

Unfortunately the antenna jack is a low-loss BNC connector. The PL-259 connector is more common on most antenna kits, and for some users it may be easier to purchase a SO-239-to-BNC adapter than to change out the PL-259 connector on the antenna cable.

Back to the front panel now: The receiver can be tuned directly by the keypad, an optional remote control, computer control, a tuning knob or the 250 memories that store frequency, mode, bandwidth, and nine additional settings. Two of those settings are digital squelch value and the time constant for auto-scanning, options that we have not seen in other receivers (that we have seen only in a few other receivers). The tuning step-size can be programmed with any value between 1 Hz and 50 kHz, not only including the 5, 9 and 10 kHz spacing on the MW and SW bands but the 8.333 kHz steps used on the aircraft bands. Further, you can adjust the tuning rate to move between 1 Hz and 20 MHz per one revolution of the tuning knob. The bottom line is a virtually infinite number of choices to choose when using the tuning knob.

Memories lead to scanning, and there are many options and variations here. Suffice it to say, scanning intervals, memory lockouts and the setting of the precise digital squelch (compared to a not-so-precise analogue squelch) will keep you busy programming the memories. But there are no "banks" or other facilities to scan just a group of frequencies. If you want to change the number of memories to be scanned, then each memory has to be programmed with a "skip" flag, or the time constant has to be set on zero. If you have stored a lot of frequencies and you want to scan just a few of them, then a lot of (re)programing is necessary. This is all rather time consuming, and computer control is a solution here.

Modes and filters can be selected from the front panel.

The KWZ 30 demodulation modes are USB, LSB, CW1, CW2, CW 3, AM, Narrow-band FM and Digital. All demodulation is done in the DSP unit, so there are no standard analogue AM or product detectors. In all modes, the display shows the actual receiving frequency, i.e. the suppressed carrier in SSB or the carrier in AM and FM. This is particularly useful for those who tune digital signals — there is no need to calculate receiver offsets between the displayed frequency and the received frequency.

The KWZ 30 has 14 "filter settings" with the following bandwidths: 50 Hz, 200 Hz, 300 Hz, 500 Hz, 1 kHz, 1.8 kHz, 2 kHz, 2.3 kHz, 2.6 kHz, 3 kHz, 3.6 kHz, 4.8 kHz, 6 kHz, and 9 kHz. That's more than sufficient for CW, SSB and digital modes, but a little bit restricted for AM broadcast listeners. For AM broadcast stations only the 4.8 kHz, the 6 kHz and 9 kHz filters are relevant. We'd like to see more steps between 3.6 and 9 kHz in a future edition of the radio.

A second very important specification for filters is the shape factor. This is the ratio between the bandwidth at the -6 dB and the -60 dB attenuation points. A filter that is 6 kHz wide at the -6 dB attenuation point and 12 kHz wide at -60 dB attenuation has a "shape factor" of 2. A better filter, also 6 kHz wide at the -6dB points, but with a bandwidth of 9 kHz at the -60 dB points, has a shape factor of 9:6 which equals 1.5. So the smaller the shape factor figure, the better. The ideal of course is a shape factor of 1. The filter is then as wide at the -60 dB points as the -6 dB points. This is not achievable in practice, but the DSP filters come close. The shape factor of the filters in the KWZ 30 is 1.15, much better than conventional crystal- or ceramic filters. This means that the 6 kHz filter is only 6.9 kHz wide at the -60 dB points. The pass-band ripple of the DSP filters is just 0.2 dB.

The receiver digital signal processing (DSP) works well. The KWZ 30 is a dual conversion receiver, and the DSP functions in the Intermediate Frequency, or IF, chain. The signal is first fed through an 8-pole 15 kHz-wide crystal filter at 75 MHz, the first IF. The second IF at 456 kHz has an AGC circuit to prevent overloading of the DSP circuit. There's a lot of analogue-to-digital processing power in the KWZ 30.

There is a limit to DSP filtering, however. The 16-bit processor limits the dynamic range to 90 dB. That's good, but not as good as high-quality crystal or mechanical filters. The KWZ 30's crystal filter helps. But what the receiver industry is really waiting for are low-cost 24-bit processors. In 1998, the cost is prohibitive.

As with all modern receivers nowadays, the receiver has good numbers on the sensitivity and stability measurements as well.

Additionally the DSP circuitry handles noise reduction. There are 100 steps to best adjust the noise reduction to the signal. As with any DSP receiver, apply too much noise reduction and the receiver sees part of the desired audio signal as noise. This results in severe audio distortion.

Experience is the best teacher here. Learning how to use the noise reduction control to maximum advantage is well worth the time spent.

So how does the receiver operate?

The appearance of the KWZ 30 is very basic indeed. The receiver is operated almost entirely by the keypad via menus. As we have noted in other receiver tests, this type of operation takes some getting used to. In this case of the KWZ-30, we do not like the menu structure. For instance, if you want to change the mode from AM to USB, you have first to push on the menu button. The main menu appears on the display. Then you have to choose the mode function. All the different modes are displayed. Than you have to push the number for USB, and enter your choice. If you want to go back to the AM mode, the whole cycle has to be repeated. All other functions on the set, such as filter bandwidth, are controlled the same way. To be fair, four function buttons on the front panel can be programmed with a function of your own choice. You can program the buttons for instance with AM, USB, LSB and an extra bandwidth position. These functions are then directly accessible with a single push on that button. But in practice 4 functions are not enough to overcome the problem of wading through the menus.

We'd prefer fewer menus and more buttons to directly access the most-used functions, but we recognise the trade-off here. The start-up costs to tool a cabinet and front panel are expensive. Whereas the Far East manufacturers can share tools and dies for large production runs to cover large numbers of shortwave and amateur radio units, the smaller European manufacturers have smaller production runs of perhaps 100, 500 or 1000 units. Software control is less expensive than hardware control, affording the European manufacturers to produce a competitively priced set.

What about computer control?

The KWZ 30's German and English language manuals was lacking information on the computer control. The KWZ 30 ships with a trial version of a software control program called "Radio Manager". You can use the software 20 times free to try it out. But "Radio Manager" is a multi-receiver control program and does not control every function of the KWZ 30. We'd like to see a full-featured software control program, perhaps with an informative interface such as the one provided for the ICOM IC-PCR1000.

But what about listening to the receiver?

Measurements producing numbers don't tell the whole story. Listening to DSP receivers is a new experience. They just sound "different" than a good analogue receiver but it is difficult to give a clear description as to WHY.

The KWZ 30 sounds incredibly "precise". We do not have a better description: it's clean, a little bit "hard" and very open. This kind of description is very subjective of course, but there is no measuring method to specify these sound impressions in figures. But we find it a pleasure to listen to the KWZ 30.

We know that these impressions have a lot to do with the very good shape factor of the filters, the constant group delay of the filters, the low intermodulation distortion within the passband of the filters and detector, the low detector distortion, combined with a very good signal to noise ratio in the detector- and the audio chain. But there is no international agreement on how to measure these differences.

The shape factor of the KWZ 30 filters is very good, and an adjacent station that does not splatter is suppressed completely unless the signal is extremely strong. In other analogue receivers, in some situations, such as a very strong signal at several kHz distance while listening to a weak station, the better attenuation of the crystal filters for larger frequency could be clearly heard.

The KWZ 30 does not have any front-end selectivity. Although the intercept points are very high, we were eager to learn if intermodulation products could be heard. During the early evening hours we listened in the 14.2 - 14.7 MHz band in AM. In that band 2nd and 3rd order IM products appear from the short wave broadcast bands. Don't forget that the broadcast stations are very strong during twilight: we measured with the MK 4 longwire antenna many stations with a level of - 20 dBm (22 mV) and even a few with - 10 dBm (71 milliVolt!) levels. With these strong stations, a few IM products were noticed, but on a very low level. . A 6 dB attenuate between the antenna and antenna input of the KWZ 30 solved this problem. Intermodulation products were not noticed at other times of the day. That is good, but we'd like to see a step attenuate in the front-end of the receiver, for instance with 6, 10 and 20 dB attenuation.

Conclusions: The KWZ 30 receiver costs 3485 DM, including VAT, in Germany and the European Union (EU). Outside the EU, the price is 3005 DM. That translates to about 1710 US dollars, plus whatever import duties are applicable. It is a lot of money, but to our knowledge there is no other receiver on the amateur market that has better specifications and more possibilities.

The AOR AR 7030 performs, from an RF specification point of view, roughly equal to the KWZ 30 and is lower in cost. But by the time you add expensive Collins filters for various bandwidths and the audio DSP processing to the AR 7030, the latter is more expensive than the KWZ 30.

The KWZ 30 probably isn't the receiver of choice for a beginner or a strictly program listener, but for those intermediate-to-advanced shortwave listeners who enjoy an advanced technology receiver this receiver is a beauty. We give it 5 stars on our 1-to-5 rating scale.

More Information

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Specifications as Supplied by K+D

Frequency range	50 kHz to 30 MHz, below 50 kHz with reduced sensitivity
Tuning Resolution	1 Hz, tuning and display, tuning resolution selectable
Input impedance	50 Ohm
Intercept 3. Order	+30 dBm
Sensitivity	0,5 uV for 10 dB S/N at 2,3 kHz bandwidth
Modes	AM, USB, LSB, FM, CW, DIG
Demodulation	digital, for AM without selective fading
Filter Bandwidths	50 / 200 / 300 / 500 Hz 1,0 / 1,8 / 2,0 / 2,3 / 2,6 / 3,0 kHz 3,6 / 4,8 / 6,0 / 9,0 kHz
Shape Factor and Pass-band Ripple	S = 1,15 for 6/60 dB, R = 0,2 dB
Adjacent Channel Attenuation	better than 80 dB
Pass-band tuning	+/- 2,8 kHz
BFO	+/- 2,8 kHz tuneable
AGC Range	>100 dB
AGC Time Constants	attack-, hold- and decay- times adjustable attack time min. 20 ms
Outputs	external speaker Headphones (Frontpanel) line/tape recorder RS-232 interface
Inputs	antenna mute power supply 12 V =
Loudspeaker	8 Watts, mounted on the front panel audio amplifier 2 Watt
Display	LCD-Graphic 70 * 37 mm, backlit by LED (green/yellow)
Control Elements	1 main tuning knob, 1 knob audio volume and On/Off, keyboard with 20 keys
Power Requirement	12 V dc, 1.5A, max 2.5 A depending on audio volume, Umin = 10V, Umax = 15V, 220 V AC power supply external
Dimensions	W * H * D = 305 x 105 x 210 mm (12 x 4 x 8 inches)
Weight	KWZ 30: 4 kg (9 lbs), Power supply unit: 2 kg (4.5 lbs)

Full Review

Introduction

A number of years ago, most communication receivers were made in Japan or the USA. Later British manufacturers such as Lowe, followed by AKD, AOR UK and Fairhaven start to produce high quality receivers at an affordable price. In 1997, another small European manufacturer, Kneisner + Doering from Germany joined this select club of European receiver manufacturers. They produce the KWZ 30, a highly sophisticated DSP communications receiver for the 50 kHz - 30 MHz frequency range. The Media Network team at Radio Netherlands has had the opportunity to measure and use this receiver for several months. It turns out to be a remarkable receiver and deserves more attention from short-wave listeners all over the world.

Production Costs and Appearance

Before we start with this extensive test report, here's a short explanation about receiver design and production costs. From the e-mails you send us, it is clear that short-wave listeners often do not understand why there is so much difference in the appearance of European receivers compared to Japanese products.

If we ignore the design costs for a moment, the price of a receiver is mainly determined by two factors: parts and production time.

Mass Production Costs

The parts can be subdivided into two fields: electronic- and mechanical components. Electronic components are less costly than mechanical components. In addition mechanical components, such as switches on a front panel, require printed circuits boards on which the switches are mounted, cables and wires to interconnect these boards and so on. This is very costly, especially when specially designed parts are used. The price is strongly influenced by production quantities. Take for instance the cabinet. The cabinets of receivers and transceivers from large manufacturers such as Kenwood, JRC, ICOM and YAESU are all specially made and look beautiful.

The start-up costs to make such a cabinet are enormous. Special moulds have to be made and special computer aided design machines have to be programmed. Start-up costs of US$ 100,000 and more are not uncommon. These costs are justified though, because these well known manufacturers sell their products all over the world. They are specialised in mass production; runs in excess of 10,000 are the norm. This means that the start-up costs for the cabinet add around US$10 to the final price of the radio. Specially shaped push buttons and the like can be incorporated too without adding excessive costs

The same holds true for the production costs. When a set is mass-produced, it makes sense to invest in very expensive pick-and-place machines in the factory. These robots are used to mount the components on the printed circuit boards, solder the back of the board and perform simple tests. With no personnel involved the production costs are lower.

The smaller European manufacturers do not produce receivers in such large quantities. Although some regard this kind of information as confidential, we know from industry sources that production runs of 100, 250 or at most 1000 are usually the norm. This means that such manufacturers cannot afford to spend that much money on specialised industrial tools for the production of cabinets or specially made push buttons for the front panel. In addition, apart from the larger consumer electronics companies such as Philips, Thomson and Nokia, Europe no longer has the facilities for the mass production of electronic equipment. The receiver manufacturers don't have mass production equipment themselves, and there are not many companies left which can do this type of work at an affordable market price. That's the reason that most European receivers have simple cabinets, fewer push buttons on the front panel, standard displays and so on. By using software control (the menu-tree structure) as opposed to hardware control with switches Europeans are still able to compete with the Japanese products.

Consumers: Mainly Interested in the Bottom Line

As a customer, you're probably not too interested in the challenges facing the manufacturer. You want the best quality receiver with as many features as possible for the lowest price. Why should you buy equipment from these smaller European manufacturers if there are no advantages compared to what's coming out of the Far East. Well, our studies at Radio

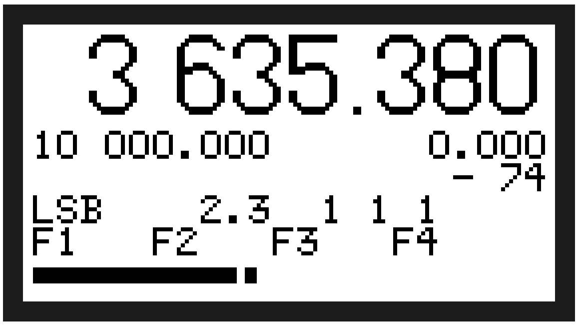
Netherlands show that the European manufacturers have found their own niche in the market place. They either produce low cost equipment with well above average specifications, such as the Lowe HF 150, or very high specification receivers at a moderate price such as the AOR 7030 and the KWZ 30. In both cases the price-performance ratio is extremely good and that's the power of European manufacturers. In North America and the Pacific, the prices of European equipment are higher due to transportation and import-duty costs. Still, these sets are worth a second look.•

As a customer you have to realise that you can't have it both ways. If all the functions of the KWZ 30 in this test were accessible by a set of special push buttons on the front panel, then the receiver would have cost twice as much. That would make it very difficult to market. But the final choice is up to you!

General Product Description

The Kneisner + Doering KWZ 30 is a communications receiver for the 50 kHz - 30 MHz frequency range. Reception with slightly reduced specifications is possible from upwards of 6 kHz! The receiver is housed in a very sturdy metal cabinet, 305 mm wide, 105 mm high and 210 mm deep. The set itself weighs 4 kg. The receiver operates at 12 Volts DC and draws a current of 2.5 Amps maximum (1.5 A at moderate volume), so it can be operated from a car battery. A power supply cable is supplied with a plug that fits the cigarette lighter in a car. Also included is a heavy-duty stabilised power supply for 230 V AC mains operation. This power supply is equipped with a jack for the cigarette lighter plug for the 12 Volts supply voltage. The power supply is an additional 4 kg.

The front panel of the KWZ 30 is extremely simple. In the centre, a large (70 x 37 mm) back-lighted LCD display shows the frequency to which the receiver is tuned, accurate to within 1 Hz. It also shows the frequency of the 2nd VFO, S-meter, mode, bandwidth of the selected filter and several other functions. The display is bright and light green in colour. We found it can be viewed under most reasonable angles, but there is no dimmer. Note that you can be program the menus to use one of three languages. The KWZ 30 uses German, English or French on the display.



For tuning there is a large and heavy tuning knob with finger hole and a 20 key push buttonbutton field which controls the whole receiver. The push buttonbuttons are relatively small and if you have thick fingers you might have to operate them with your nails. The volume control knob on the front panel is combined with the on-off power switch. There is a 6.3 mm headphone output jack. Use of the headphone switches off the internal loudspeaker. The loudspeaker is a high quality type capable of handling 8 Watts, so even with high volume levels the speaker doesn't produce extra distortion. The speaker is placed behind the front panel. We like this because if you sit in front of the receiver the sound comes straight at you. This gives a clearer sound (especially treble response) than when the speaker is mounted in the top cover or on a plate underneath the set.

The backside of the set is as simple as the front panel. Here's the list: there is a 2.1 mm DC jack for the 12 Volts supply, a 3.5 mm telephone jack for an external loudspeaker, a cinch jack as audio-line output with constant signal strength for connection of a tape recorder, decoder or other equipment, a cinch jack to mute the receiver when it is used in combination with a transmitter, a 9 pole D jack for RS 232 computer control and a screw for the connection of ground.

A BNC type connector is used for the antenna-input connector. We don't like this for short-wave receivers. Although from an impedance point of view, the BNC is better than the well known SO 239 to match the PL 259 plug, we know that many short-wave listeners have great problems mounting a BNC connector on the end of an antenna cable. In practice, most users buys a SO 239 to BNC adapter and uses a PL 259 plug on the cable. We think that the BNC connector should be replaced by a good quality SO 239 jack.

The appearance of the KWZ 30 is very basic indeed. The receiver is operated almost entirely by the keypad via menus. As we have noted in other receiver tests, this type of operation takes some getting used to. In this case of the KWZ-30, we do not like the menu structure. For instance, if you want to change the mode from AM to USB, you have first to push button on the menu button. The main menu appears on the display. Then you have to choose the mode function. All the different modes are displayed. Than you have to push button the number for USB, and enter your choice. If you want to go back to the AM mode, the whole cycle has to be repeated. All other functions on the set, such as filter bandwidth, are controlled the same way. To be fair, four function buttons on the front panel can be programmed with a function of your own choice. You can program the buttons for instance with AM, USB, LSB and an extra bandwidth position. These functions are then directly accessible with a single push button on that button. But in practice 4 functions are not enough to overcome the problem of wading through the menus.

As said in the beginning of this test: if a push button was used for every function on this set, the price would have to be doubled. But in our personal opinion, it would have been better to pay a little more for a few more push buttons (say 8, 10, or 12) so that the most used functions are directly accessible. Seldom used functions such as attack-, hold- and decay times of the AGC can then still be adjusted via menus. Maybe such a compromise is an idea for a future model.

Although operation of all functions is somewhat time consuming, the KWZ 30 offers an incredible number of control functions. As far as we can tell, no receiver on the market today has so many options and functions. It's great that the receiver can be adapted to meet all your needs. On the other hand, only the experienced user should fiddle with the factory settings on the KWZ 30. You must know, for instance, how things like attack-, hold- and decay times of the AGC affect reception. These settings change depending on which mode you're using. For the less experienced listener, Kneisner + Doering has given all functions default values and we agree with the settings they have chosen.

Circuit Concept

The KWZ 30 is a receiver with Digital Signal Processing (DSP) in the Intermediate Frequency (IF) chain. An explanation about DSP is available elsewhere in the Real Radio part of the website. The DSP in the KWZ 30 is quite complicated and very advanced.

The high quality of the DSP unit can be only properly exploited if all other parts of the receiver also have excellent specifications. To achieve this, the KWZ 30 is a dual conversion receiver. The antenna input is protected against static build-up and followed by a relay-driven 40 dB attenuator. Note that this attenuator is part of the automatic protection mechanism for the delicate input circuitry of the set. It only triggers when the level of the input signal reach values above 1 Volt. With normal signals from the antenna, it does not function. There are no other attenuators, amplifiers or bandpass filters.

The antenna signal is directly fed to the first mixer via a 32 MHz lowpass filter which rejects mirror frequencies. This mixer is a new type of switching mixer with D-MOS switches. This type of mixer has excellent specifications. The manufacturer gives a 3rd order intercept point of + 30 dBm. The mixer is then followed by an 8 pole (!) crystal filter at 75 MHz, the first IF frequency. This filter has a bandwidth of 15 kHz.

The second mixer is a conventional diode ring mixer which converts the first IF to the second IF of 456 kHz. This second IF has no extra filters, but uses an AGC circuit to prevent overload of the DSP unit. This means that the AGC of this set is derived from the signals that pass through the 15 kHz wide roofing filter after the first mixer. *Read more about this in the DSP article on our website*. Directly after the second IF, the KWZ 30 switches over to DSP. That's remarkable, because many other manufacturers use a third IF stage around 20 kHz and then start DSP. The use of a third IF stage is a disadvantage, because every mixer beyond the traditional dual conversion designs reduces the overall performance of the receiver.

To make DSP possible at 456 kHz, Kneisner + Doering use quite a bit of processing power. Here's another list: they have a high speed 16 bits A/D converter for the RF signal, a 8 bits A/D converter to be able to process the AGC voltage to the S-meter, constant volume control and digital squelch, no less than two high speed (56 MHz!) DSP processor chips for filtering, demodulation, noise reduction and notch filter functions, plus a high speed D/A converter which reconverts the processed signal back into audio. DSP processing can produce very good shape factors in the filters, but this can be spoiled if the oscillator signals have too much sideband noise. The KWZ 30 therefore uses a DDS-PLL synthesizer which generates all oscillator signals within an accuracy of 1 Hz and very low sideband noise. The synthesizer uses a TCXO (Temperature Compensated X-tal Oscillator) as a source, and we noted that the receiver is extremely stable. Another micro-processor controls all the other parts such as the LCD display, memories, etc.

Tuning

The receiver can be tuned in several ways: direct entry via the keypad, via an optional remote control, via the RS 232 computer port, with the manual tuning knob, or via the memories. With keypad tuning the required frequency can be directly tapped in. There is no MHz or kHz option: the tuning frequency has to be given in kHz, followed by enter. That's at least the default value, because this can be changed from 1 Hz to 10 kHz as last figure. The last figure is indicated on the display by an arrow that can be moved over the frequency display.

The tuned frequency of the receiver can also be adjusted with the tuning knob. The stepsize can be programmed: any value between 1 Hz to 50 kHz per step. So not only can you program the 5, 9 or 10 kHz steps which are useful for broadcast stations, but also the new 8.333 kHz steps used on the aircraft bands. But that's not all. The optical encoder on the tuning knob has 400 steps per revolution. That's nice if you have programmed 1 Hz per step, because a complete revolution of the knob changes the tuning frequency just 400 Hz. But, if this is too fine, you can also use the broadcast setting 5 kHz per step. In fact you can program the number of steps per revolution from 1 to 400. There is complete freedom, so in combination with the step-size, you can programme the tuning knob to move between 1 Hz and 20 MHz per revolution. If that's not enough, you can also program the tuning progression. Normally the frequency step is independent of the rotation speed of the knob. With tuning progression, the step size increases when the knob is turned faster. Apart from the fixed step size, three rates of progression can be selected.

Computer Control

The KWZ 30 can be controlled via the RS 232 port. The receiver comes with a CD ROM with a trial version of a control programme "Radio-Manager" from Switzerland. You can use the software 20 times for free to try it out. This program contains a database with 40.000 recent entries from broadcast- and utility stations and has driver programmes for decoders and several receivers, including the KWZ 30. Radio Manager is, however, not specifically designed to control every function on the KWZ 30. We noted that neither the English or German language manual delivered with the KWZ 30 gives information about the RS 232 control port. As of publication on the web in August 1998, a computer control programme for all the functions of the KWZ 30 is not available yet.

A remote control for the KWZ 30 is available as an optional extra. This is, however, a duplicate of the keyboard in the front panel, connected by 2 m length of cable to the RS 232 port. It offers the same possibilities as the built-in keyboard. But because the volume control cannot be operated with this control, plus the fact that you need to see the display while you're tuning, we cannot see much use for this wired remote control.

Memories

The KWZ 30 is equipped with 250 memories. Each memory position can store the following data: Frequency, mode, bandwidth, AGC time constants, noise reduction settings, notch filter (ON-OFF), digital squelch value, tuning speed, pass-band tuning, BFO frequency, skip-flag on/off and the time constant for autoscanning. Fortunately you don't have to program all these values by hand each time: you tune to the desired frequency and all settings are stored in the memory with a few key push buttones. The storage of the frequency and other settings is also possible via the RS 232 port.

Tricks with Scanning

Once you select a memory channel, the receiver continues to operate in the settings that have been stored in that memory. This can be very handy. Let's illustrate this with an example: In the first memory you program a frequency in the middle of a short-wave broadcast band. You use the settings normal for broadcast listening: AM mode, 6 kHz wide bandwidth filter, 5 kHz frequency step and so on. Now, the second memory channel can be set to tune a channel middle in an aircraft band with all the appropriate setting; 8.333 kHz steps, USB mode and AGC time constants suitable for single sideband. The third memory contains the right values for the 80 m amateur radio band: 20 Hz step size, LSB, etc.

So if you want to change from broadcast to aircraft reception, you simply jump to the memory dedicated to that type of listening. You can tune across that particular band with all the right settings, which saves a lot of time fiddling with the main software menus. The second variable frequency oscillator (VFO) in the KWZ 30 is in fact also such a memory channel, with the addition that the stored frequency in this extra memory is shown on the LCD display.

The 250 memories can be recalled with the tuning knob or by directly keying the number entry into the keyboard. The memory position is shown on the display. The memories can also be scanned, by entering a time constant (0 to 20 seconds) in the memory. As soon as 2 or more time constants are entered, you can scan those memories. So you can set the receiver to switch every few seconds from the main frequency to another frequency (and mode if required) and back again.

On scanners this is known as priority channel. You can monitor a particular channel for activity (say you're waiting for a station to sign on) while tuning around another part of the dial looking for other stations. The variable time constant for each channel is a nice touch, but for real scanning the problem is that you have to enter the time constant for each channel before scanning is possible. In that way, all the channels with a time constant are scanned. But there are no "banks" or other facilities to scan just a group of frequencies. If you want to change the number of memories to be scanned, then each memory has to be programmed with a "skip" flag, or the time constant has to be set on zero. If you have stored a lot of frequencies and you want to scan just a few of them, then a lot of (re)programming is necessary. This is all rather time consuming.

Modes and Pass-band Tuning

The KWZ 30 has the following demodulation modes: USB, LSB, CW1, CW2, CW 3, AM, Narrow-band FM and Digital. All demodulation is done in the Digital signal processing unit, so there are no standard analogue AM or product detectors. In all modes, the display shows the actual receiving frequency, i.e. the suppressed carrier in SSB or the carrier in AM and FM. In both single sideband modes, the BFO frequency generates a lowest audio frequency of 300 Hz and a highest frequency of 300 Hz + the bandwidth. The modes CW 1 -3 and Digital are in fact the same. They are intended for the reception of Morse telegraphy (CW) and digital modulation systems such as PACTOR or RTTY. Four different modes are implemented so that they can be pre-set with the right settings for each type of modulation (bandwidth and BFO frequency). The BFO frequency range covers + or - 2800 Hz, so every tone can be generated, even with narrow bandwidths.

The AM demodulator is unique. The DSP unit generates both sidebands of the AM signal. The values of each sideband are processed and then added together. From the sum, the square root is calculated and this is one point of the modulation envelope curve of the audio signal. This is done 12,000 times per second and than processed back into audio. This method of demodulation is great, because the carrier isn't needed for demodulation. The advantage is that the recovered audio is nearly distortion-free, even when the carrier level is low with respect to the sidebands. This can happen during selective fading, as a result of multi-path reflection in the ionosphere. Normal analogue AM detectors generate horrible distortion during selective fading, which can make the signal unreadable.

That's the reason why more and more analogue receivers are equipped with synchronous detectors, which can also demodulate during selective fading, but can drop out of lock during very deep fades. The DSP AM demodulator in the KWZ 30 cannot fall out of lock, because the carrier is not used. However, it does have the disadvantage that both sidebands are needed. If one sideband is distorted by splatter from an adjacent station, you cannot select between the upper or lower sideband in an effort to reject the splatter. That's a pity for those who are mainly interested in reception of AM broadcast stations. If you want to listen to one sideband only, you have to switch the KWZ 30 into Single Side Band mode, tune the receiver exactly to the carrier of the AM station and than use either USB or LSB. Thanks to the excellent stability and the shape factor of the IF filters, this method works. But we think it is not as handy as a selectable sideband AM synchronous detector that you'll find on cheaper portable sets.

The KWZ 30 also boasts pass-band tuning. With pass-band tuning, the IF filter can be shifted over the received signal, without changing the tuned frequency and the pitch of the recovered audio. This is very handy when you are trying to reject splattering or interfering adjacent stations. The pass-band tuning range of the KWZ 30 is + or - 2800 Hz, but works only in SSB and CW, not in AM!

Filters

The selection of the desired station and the rejection of all other signals coming from the antenna is achieved by bandpass filters. In analogue receivers, crystal-, mechanical or ceramic filters are mostly used. In the KWZ 30 the DSP unit does the filtering. When you examine the quality of filters, four specifications are very important. These are: bandwidth, shape factor, group-delay and maximum attenuation outside the pass-band.

Each station has its own specific bandwidth, depending of the type of modulation and the highest frequency of the modulation. Ideally, the bandwidth set on the receiver should match the bandwidth being transmitted by the station. Analogue receivers have only a few filter options because good quality filters are expensive. On the other hand, the KWZ 30 DSP technology means only the processor has to be reprogrammed to change the desired bandwidth. The KWZ 30 has 14 "filter settings" with the following bandwidths: 50 Hz, 200 Hz, 300 Hz, 500 Hz, 1 kHz, 1.8 kHz, 2 kHz, 2.3 kHz, 2.6 kHz, 3 kHz, 3.6 kHz, 4.8 kHz, 6 kHz, and 9 kHz. That's more than sufficient for CW, SSB and digital modes, but a little bit restricted for AM broadcast listeners. For AM broadcast stations only the 4.8 kHz, the 6 kHz and 9 kHz filters are relevant because the 4.8 kHz filter already limits the frequency response of the recovered audio to 2.4 kHz, just enough to understand speech.

A second very important specification for filters is the shape factor. This is the ratio between the bandwidth at the -6 dB and the -60 dB attenuation points. A filter that is 6 kHz wide at the -6 dB attenuation point and 12 kHz wide at -60 dB attenuation has a "shape factor" of 2. A better filter, also 6 kHz wide at the -6dB points, but with a bandwidth of 9 kHz at the -60 dB points, has a shape factor of 9:6 which equals 1.5. So the smaller the shape factor figure, the better. The ideal of course is a shape factor of 1. The filter is then as wide at the -60 dB points as the -6 dB points. This is not achievable in practice, but the DSP filters come close. The shape factor of the filters in the KWZ 30 is 1.15, much better than conventional crystal- or ceramic filters. This means that the 6 kHz filter is only 6.9 kHz wide at the -60 dB points. The pass-band ripple of the DSP filters is just 0.2 dB.

Group Delay

Most listeners will be not familiar with the term "group delay". Nevertheless this is an important filter specification. Let's use an oversimplified example to explain: It takes time before a signal has travelled through a filter. This is called the group delay. The problem with conventional crystal, ceramic and mechanical filters is that the signals with frequencies that fall within the pass-band of the filter do not travel with the same speed through the filter. The delay is frequency dependent. If the signal that travels through the filter is an AM broadcast station, the signal has a carrier with sidebands. The carrier, in the middle of the signal, has a constant delay. The sidebands have a different delay time with respect to the carrier. This means that there is a difference between the input signal and the output signal. So after travelling through the filter, the phase relationship between the carrier and sidebands has been changed. For an AM broadcast signal the effects are not that serious: the audio may sound a little "muddy" but speech is still intelligible. For other types of modulation such as RTTY or Morse code (CW) the non-constant group delay can be disastrous. A CW signal is a rectangular pulse. The difference in group delay now "stretches" the pulses. They are no longer rectangular and if the repetition rate of the CW or RTTY is high enough, they cannot be heard as separate tone bursts any more. Morse signals that have passed through in a filter in this way are said to suffer from "ringing". The group delay differs the most at the sides of the filter pass-band of the filter. It is greatly influenced by the type and shape factor of the filter. The "ringing effect" is the reason, that very narrow conventional crystal or mechanical filters are not as useful as you might imagine. But the DSP filters used in the KWZ 30 are different. The DSP filters have a constant group delay. This means that they do not "ring" and that an extremely narrow bandwidth filter such as the 50 Hz filter in the KWZ 30, can be used to copy Morse code signals without problems.

What's the Downside to DSP filters?

There are some negative points to mention. Conventional filters have an attenuation factor outside the pass-band that becomes higher at larger frequency distances. That assumes they are properly screened and if the amplifiers before and after the filter are sufficient de-coupled. A good crystal or mechanic filter can reach attenuation values outside the pass-band of 110 dB and more, which is required to suppress adjacent strong stations.

With a DSP filter this is different. The maximum attenuation outside the pass-band depends on the number of bits used to process the filter curve. With a 16-bit processor, as used in the KWZ 30 and most other DSP receivers, the maximum attenuation outside the pass-band can be 90 dB. That's good, but not as good as high quality crystal or mechanic filters. More serious is the fact that with the most common type of DSP filter, the attenuation outside the pass-band does not become larger at greater frequency distances. Without further filters and other measures, the dynamic range of a receiver with DSP filters can only be equal to the maximum attenuation of the filter.

Unfortunately, a dynamic range of 90 dB is not sufficient for today's high performance receivers. In the KWZ 30 an 8-pole crystal filter directly after the first mixer, plus an advanced AGC system, are both used to solve this problem. This filter is 15 kHz wide, so for frequencies at a larger frequency distance than + or - 7.5 kHz the dynamic range is better. But within the pass-band of this filter, the dynamic range is still limited to 90 dB. That is still much better than most table-top receivers, but, *as explained elsewhere on the website,* the industry is waiting for low cost 24 bits processors.

Noise Reduction

DSP noise reduction has introduced a great step forward in short wave listening. With analogue receivers, the only way to reduce noise is to reduce the bandwidth of the IF filter. This also cuts off the higher tones in the audio. DSP opens new ways of tackling the problem

Noise is a non-coherent signal; that is, the noise signal changes constantly in strength. In the case of white noise, the noise power stays the same irrespective of the frequency. But an audio signal such as a single tone is coherent: the same signal form, for instance a sinewave, is repeated as long as the tone is present. Because the DSP unit converts any signal it gets into a string of numbers, the processor sees this tone as a repeated sequence of numbers, whereas the noise is represented by random numbers.

In order to reduce the background noise on a signal, the program in the DSP processor suppresses random numbers and reconverts only the repeated numbers back into audio. The result is that the background noise practically disappears and only the speech can be heard. There are several types of mathematical programs (the so-called "algorithm") to suppress the noise. Some advanced add-on DSP units employ several methods. The KWZ 30 uses a single adaptive filter algorithm.

With noise reduction technology, the challenge is to recognise the coherent signal in the noise signal. This is easy when the signal is a single tone, such as with Morse code. In that case the noise is suppressed completely, which makes it possible to "dig out" the station even when it is almost totally buried in noise. But for speech or music the problem is that these signals change constantly too. The DSP unit sees than less difference between the noise and the signal. The result is that the noise reduction is less effective with speech and music. To get the best possible results, the noise reduction has to be adjusted to match the signal. With this adjustment you will tell the processor in fact, which signal is to be considered as noise. If you set the level to "heavy", the processor sees parts of the audio signal as noise as well, resulting in a very distorted audio signal. We note that the noise reduction levels have to be adjusted carefully. The KWZ 30 offers an adjustment range in 100 steps, either with the tuning knob or with the keyboard. Again you have to use the menu structure for this function because there is no separate knob. However, the effects of the noise reduction on the signal can be heard during adjustment.

Notch Filter

A notch filter is used to suppress an interfering signal, for instance, a heterodyne tone from an adjacent broadcast station or a CW signal. With conventional analogue receivers, a notch filter can be placed in the IF- or in the audio chain of the receiver. The filter has to be adjusted very carefully and can suppress only one single tone. A disadvantage of analogue filters is that they have a certain bandwidth, so that besides the unwanted tone, part of the audio is also suppressed. Notch filtering in the intermediate frequency stage of the set is more costly than in the audio part, but has the advantage that the AGC of the receiver is no longer influenced by the interfering signal. The principles of DSP notch filtering are the same as with noise reduction. With notch filtering, however, the DSP processor now suppresses the constant signal such as a tone whereas random type signals such as speech or audio are reconverted back into audio.

There are several advantages with DSP notches. The biggest is that the DSP unit recognises the repeated numbers that represent the interfering tone. The DSP notch does not have to be adjusted: it finds the interfering tone automatically and suppresses it. If the pitch of the interfering tone changes fairly slowly, then the processor can still recognise the slowly changing numbers. The DSP notch will follow the tone. Another great advantage is that even if there are several tones, the processor recognises them all. A DSP notch is therefore a multi tone notch filter. There are also disadvantages; as with noise reduction it is a challenge to program the software to recognise the difference between coherent- and non-coherent signals. If you listen to speech or music and the interfering signal is a constant tone, then it is easy. But if the interfering signal is CW or RTTY, than it is much harder to suppress the unwanted signal. The biggest problem occurs if you listen to a CW signal and another CW signal starts interfering. The DSP computer is, unfortunately, not so intelligent that it knows which signal you want to hear. So it suppresses both signals. In such a situation an analogue notch filter is better. In contrast to noise reduction, the notch filtering in the KWZ 30 cannot be adjusted: it's on or off, controlled by a direct key entry on the keyboard.

Digital Squelch.

A squelch can mute the audio if the signal to noise ratio of the received station is insufficient to understand the speech, or if you want to hear only stations with a certain signal strength. The squelch function is required if you want to scan the memories of the receiver. With most analogue receivers, the squelch level is derived from the AGC voltage, i.e. the signal strength of the received station. But here, DSP offers new possibilities. Instead of the AGC voltage, the squelch in the KWZ 30 looks at the syllable rhythm of the speech in the AM and SSB mode. This means that the KWZ 30 squelch actually looks to the type of the received signal: it recognises if it is speech, music or noise! To be able to detect the difference between noise and a desirable signal, the squelch can be adjusted in 100 steps. The receiver continues working during the adjustment, so the result can be heard immediately. We found it useful that the found value is stored until the next adjustment. The squelch mutes the audio two seconds after the signal has disappeared.

It takes time for every squelch to react. With some analogue squelches, it takes so much time, that the first part of the signal is lost. In these cases, the squelch cannot be used during reception of CW or data signals (RTTY, packet, AMTOR, etc.). With the DSP squelch in the KWZ 30 storing the received signal during the attack time of the squelch solves this problem. So if the signal is recovered into audio after the squelch has opened, no part of the information is lost! For FM modulated signals, the KWZ 30 squelch acts differently. If no signal is received in the FM mode, the noise level is very high. As soon as a signal is received, this noise level is reduced strongly. In the FM mode, the squelch monitors this noise level and again switches the audio in as soon the noise level becomes lower than the chosen value. Also this FM squelch level is stored independently from the stored AM/SSB squelch level. In the CW mode, the squelch of the KWZ 30 looks for a changing, but coherent signal. This means that a CW or RTTY signal opens the squelch, but a constant tone (carrier) does not, regardless its signal strength.

The Measurements

We have measured the main specifications of the KWZ 30, according to our usual method that meets international standards. *These methods are described elsewhere on the Radio Netherlands website.* To avoid make this KWZ 30 test report not too long, and it is already very detailed, the measurements methods are not explained separately in this article..

Sensitivity

The sensitivity is specified as the signal strength in microvolts (uV) across the 50 ohms input impedance of the receiver, needed to achieve 10 dB S+N/N ratio at the external loudspeaker output at a level of 100 mW into 8 ohms impedance. This is measured with a true RMS voltmeter fitted with a CCIR psofometric filter. For AM, a 1 kHz tone is used with a modulation depth of 60%, for SSB and CW a noise free carrier is used, with the receiver BFO set to generate a 1 kHz tone. During all measurements, the digital gain of the receiver was set to the default value of 40. The selected bandwidth filter influences the sensitivity of a receiver, but as there is a fixed ratio between the filters, we used the 9 kHz filter for AM signals and the 2.3 kHz filter for SSB.

The increase in sensitivity when a smaller filter is used is not very large: changing from the 9 kHz filter to the 6 kHz filter increases the sensitivity by 1.75 dB, which is equal to a factor of 1.22. A sensitivity of 1 uV with the 9 kHz filter, becomes 0.82 uV with the 6 kHz filter. As there are no switched bandpass filters or amplifiers in the input circuitry of the KWZ 30, the sensitivity figures are very flat and only influenced by the ripple in the 32 MHz lowpass filter and the increasing conversion loss in the first mixer at higher frequencies. We measured the sensitivity at every 500 kHz, but bearing in mind the flatness we show only a few steps.

Frequency	AM 9 kHz	SSB 2.3 kHz
50 kHz	1.6 uV	0.58 uV
100 kHz	1.5 uV	0.56 uV
500 kHz	1.6 uV	0.58 uV
1.5 MHz	1.5 uV	0.55 uV
2.5 MHz	1.5 uV	0.56 uV
3.5 MHz	1.5 uV	0.56 uV
5.5 MHz	1.5 uV	0.56 uV
7.5 MHz	1.6 uV	0.58 uV
10 MHz	1.6 uV	0.58 uV

14 MHz	1.6 uV	0.58 uV
16 MHz	1.6 uV	0.58 uV
18 MHz	1.7 uV	0.61 uV
21 MHz	2.0 uV	0.72 uV
24 MHz	1.8 uV	0.65 uV
26 MHz	2.1 uV	0.76 uV
28.5 MHz	2.6 uV	0.94 uV
29.9 MHz	2.2 uV	0.79 uV

The KWZ 30 is not extremely sensitive, but there is no need to be. The atmospheric- and man-made noise level on the short-wave bands up to around 15 MHz is so high, that any reasonable antenna brings in a noise floor which considerably exceeds the noise floor of the KWZ-30. Above 20 MHz the sensitivity could be better.

Effects of Noise Reduction on Sensitivity

The sensitivity is measured at a signal to noise ratio of 10 dB. At this value, the speech is just audible above the noise. The noise reduction of the KWZ 30 can be of great help in reducing that noise. This means, that with noise reduction less signal is required to achieve the level of 10 dB S+N/N, resulting in an increased sensitivity figure. We did that test at 9 MHz in SSB. Without noise reduction 0.58 uV was required for 10 dB S+N/N. When we switched in the noise reduction, the noise practically disappeared, but the audio level of the tone dropped 10 dB! Which brings us to a clever trick.

The KWZ 30 has an adjustable digital gain, which brings the signal within the proper working range of the A/D converter. Normally this digital gain has a default value of 40, which is a usable average value. But with these very low signal levels, the A/D converter gets signals which are too low. Increasing the digital gain restores the signal level back into the linear working area of the A/D converter and the original volume level is restored. With the digital gain on 100 and a carefully adjusted noise reduction, only 0.1 uV was required to achieve a signal-to-noise ratio of 10 dB! This is 6 times better than without noise reduction. Don't forget however, that this is an ideal situation: just noise and a single constant tone, ideal for the noise reduction circuitry. In practice, certainly with speech, the effect of the noise reduction circuitry is less. But this test shows clearly the capabilities of the noise reduction.

We have already emphasised that the KWZ 30 is a receiver for the more experienced listener. This point illustrates the point: to get the most out of this receiver, you must choose the right bandwidth, correct the AGC settings and fiddle around with the digital gain and noise reduction knobs (main tuning knob via the menus). But the effort is worth it.

Signal Required for Better Signal to Noise Ratio

The 10 dB S+N/N ratio for sensitivity measurement may look good on paper, but it is not pleasant to listen to: the speech is still very noisy and difficult to follow. We believe that 20 dB S+N/N is a better reference point, for this represent a good intelligible signal. A 30 dB S+N/N signal is even better, regarded as virtually noise free. With analogue receivers, there is often no exact relationship between the required RF signal strength and the signal to noise ratio, caused by the gain distribution, AGC and non-linearities in the detector. The digital receiver is strictly linear, even in AM. With the digital gain set to 40, every 10 dB increase of the RF signal level, causes a corresponding 10 dB increase in signal to noise ratio. For SSB this means that 20 dB S+N/N is reached with an antenna signal of 1.83 uV and 30 dB S+N/N with 5.8 uV. In AM (9 kHz filter) 20 dB S+N/N is reached with 5 uV antenna signal, 30 dB S+N/N with 16 uV and 40 dB S+N/N with 50 uV. These are really excellent figures!

Automatic Gain Control

The task of the automatic gain control (AGC) is to keep the recovered audio from a station at a constant volume level, regardless the incoming signal strength. As described earlier, the AGC of the KWZ 30 is in the second IF chain, mainly to prevent overload of the A/D converter. There is, however, a second kind of AGC in the DSP. This DSP AGC keeps the audio signal strength after the bandpass filtering at constant level. It is however essential that the A/D converter works in linear way at this range so there must be sufficient digital gain. This digital gain is not adjusted automatically; this must be done by hand. For safety's sake, we first checked if the sensitivity was influenced by the digital gain. As the digital gain control shifts the signal into the linear working range of the A/D converter, this should have no influence on the sensitivity. That turns out to be partly correct in practice. An AM modulated signal with a level of 1.5 uV gives 10 dB S+N/N, with digital gain settings from 10 to 50.

With digital gain settings from 50 to 100, the sensitivity decreases slowly from 1.5 uV to 2.2 uV at a setting of 100, caused by the shift of the signal into the upper, non-linear working range of the A/D converter. A good average value of the digital gain setting is 40 and this is the default value. When we measured the influence of both AGC's on the audio level with varying RF input voltages with this default setting, we noticed the following: with a strong signal (50 uV, S9) the volume was adjusted to 100 mW, we called this 0 dB. The volume remains constant at 0 dB down to an antenna signal of 5 uV (S6), giving us 20 dB S+N/N. But with lower antenna signals, the volume of the audio also drops. For instance, with a 1.5 uV antenna signal, which gives 10 dB S+N/N, the audio level is already 6 dB down.

In practice this means that if you tune over the band, weak stations have a considerable lower volume than strong stations. Or, if the received station fades from strong to weak, the audio level changes much more than normal. With lower digital gain settings this effect is even worse: with a digital gain setting of 20 the audio level dropped already to -8 dB with a signal of 5 uV, and even to - 16 dB with 1.5 uV. At a digital gain setting of 60, the audio level of the received station remains constant from 50 uV down to 1.5 uV antenna signal.

Maybe all this detail makes you wonder why the manufacturers didn't simple chose a fixed value of 60 for the digital gain. Remember that most other DSP receivers do not have an adjustable digital gain. The reason is directly related overloading. We'll come back on this later. In practice the digital gain of the KWZ 30 has to be adjusted regularly, depending of the frequencies of interest: from about 20 in the broadcast bands where signals are strong, to 80 or more for weak signal reception in the amateur radio bands with noise reduction. It all requires a lot of fiddling, but you can perfectly adjust the receiver for optimal reception of the wanted station.

AGC Settings

There are several other important characteristics of the automatic gain control. These are:

- the time required before the AGC comes into action (the attack-time),
- the time that it keeps the gain of the receiver on a certain value after the signal has disappeared (the hold-time)

- the time that it takes before the receiver is on full gain again after the hold time has expired.

Normally we want the attack time to be as fast as possible, especially with SSB. Otherwise the first few milliseconds of the speech sounds very loud and then drops away to the right level. Very fast attack times can be a disadvantage under certain conditions. If there are fast impulses such as static crashes during thunderstorms, then the pulse reduces the sensitivity of the receiver immediately, resulting in a very variable volume of the wanted station.

In these situations a slower attack-time is better, so that the gain is not influenced by these short duration impulses. The hold time characteristic is ideal for SSB, because it keeps the receiver at the same gain level during the pauses in speech. A slow decay-time is fine for AM broadcasting, but if you listen to a radio amateur conversation in Morse Code, then the decay-time must be short. Otherwise you will lose the first part of the message from the other, weaker station after a switch over. Most receivers, including high class models, have only limited AGC settings. The attack-time is fixed, there is practically no hold-time and only the decay-time can be selected: slow and fast. The KWZ 30 is really different.

As far as we know, this is the only receiver with separate controls for the attack-, hold-, and decay time. There is total freedom to adjust the receiver exactly to the type of signal you want to hear. If the programmable function keys are used to change the mode, for instance from AM to SSB, than the settings of the AGC for that mode are stored in the function key, so you don't have to reprogram the receiver if you change the mode. If you change mode via the menus, then the AGC settings are not changed and you will have to reprogram. That's a pity, we think it would have been much better if the AGC time settings were always stored for each mode. This is one of the reasons why we say earlier in this review that just 4 function keys are not enough.

Selectivity

As explained earlier, the KWZ 30 DSP filters display characteristics that are determined by a computer program. The filters are very sharp and have a 6/60 dB shape factor of 1.15. Because 16 bits DSP is used, the average attenuation outside the pass-band is 90 dB. That's not as high as with good crystal filters. Worse still, the attenuation outside the pass-band does not get any higher at larger frequency distances: the attenuation curve outside the pass-band has many side-lobes. We call this a comb structure. The attenuation varies between more than 110 dB to 85 dB. First when the attenuation of the crystal filter (directly after the first mixer) comes into action, the attenuation for unwanted stations far-removed in frequency becomes higher. According to the manual, this filter is 15 kHz wide. We found, that the increase of attenuation above the 85 dB DSP value, first started at + or - 10 kHz from the centre frequency. Why this 20 kHz slot is wider than specified is not clear, as we didn't have access to a detailed schematic diagram. We conclude that the shape factor of this 8-pole crystal filter is not very high, because it is working at 75 MHz. Nevertheless, the rejection of unwanted stations, even in the 20 kHz wide slot, is more than 85 dB. That is very good, better than most other receivers in the same price class.

Dynamic Range and Intercept Points

The KWZ 30 doesn't have any selectivity in the front-end. All the thousands of signals received by the antenna are fed straight into the first mixer. If there is any non-linearity in this front-end chain, the receiver produces new, interfering signals from the received signals. These unwanted products, which can disturb the reception of real stations, are called intermodulation products.

There are several types of intermodulation (IM) products. Most disturbing are 2nd- and 3rd order IM products. To illustrate what happens, let's assume that two strong signals are received by the antenna, one on 9 MHz and the other on 10 MHz. In case of non-linearities, harmonics can be generated, i.e. 18 MHz and 20 MHz. Third harmonics, (27 and 30 MHz) are mostly so weak that they do not play an important role.

But these two signals can also generate intermodulation products. Second order products are the sum and the difference of both signals, i.e. 19 MHz and 1 MHz. If a receiver is equipped with selective bandpass filters at the input, these 2nd order intermodulation products do not play an important role, unless they are generated in the bandpass filters itself, or in the switching diodes at the front end of the receiver. If a communications set with bandpass filters is tuned to 19 MHz, the filter suppresses the signals on 9 and 10 MHz, so the intermodulation product on 19 MHz isn't generated.

Unfortunately more and more receivers manufacturers omit bandpass filters at the input, in order to reduce the costs. This re-introduces the problems of 2nd order intermodulation. In addition to 2nd order IM, there is also 3rd order intermodulation. These are generated on frequencies directly near both strong signals, according to the formula: 2 x F1 - F2 and 2 x F2 - F1. In our example these 3rd order products appear on 8 MHz and 11 MHz. In practice, the antenna receives hundreds of strong stations resulting in thousands of IM products.

The Intermodulation Measurements

During the intermodulation measurement, we measure how strong two signals can be before the intermodulation product is as strong as the noise-floor of the receiver. The noise-floor is the minimum discernible signal strength (MDS) which can be heard without noise reduction. The difference in signal strength of the strong signals and the noise floor of the receiver is called the intermodulation free dynamic range. It is expressed in dB's.

In practice the intermodulation free dynamic range shows the capability of the receiver to listen to a weak station, without disturbance from an IM product generated by strong stations on other frequencies. The larger the dynamic range the better. But be careful when comparing claims in advertisements because the dynamic range is greatly influenced by the bandwidth of the used filter.

To be able to specify large values, many manufacturers use a 500 Hz wide filter in this measurement instead of the more common 2.3 kHz SSB filter used in practice. From the values found during the dynamic range measurements, two figures can be calculated, the 2nd order and 3rd order intercept point. Knowing these figures, it is possible to calculate how strong intermodulation products will be with a given level of unwanted stations.

In practice, however, the figures are mostly used by listeners to compare receivers. Therefore it is necessary that all receivers are measured using the same measurement method. In the past, intercept points of receivers in Radio Netherlands tests were always calculated with an IM product that was as strong as the receiver noise (noise floor). We realise, however, that this is a laboratory situation. In practice the atmospheric and man-made noise received by the antenna is greater than the noise floor. Therefore, we now use IM product values of 1 uV and 10 uV, because these levels are sufficient to disturb a very weak station. Theoretically, the intercept point value should be the same, regardless of the strength of the IM product. In practice however, some receivers show cancellation effects or don't follow an exact quadratic or cubic law, so the figures are influenced by the used level of IM products.

IM Results

The KWZ 30 receiver has a noise floor of - 124 dBm (0.14 uV) in SSB using a bandwidth of 2.3 kHz, a digital gain of 40 and no noise reduction. Both strong signals were on 9 MHz and 9.030 MHz, i.e. 30 kHz separation to avoid the influence of the crystal filter directly after the first mixer. The 3rd order IM products appear on 8.970 and 9.060 MHz, 30 kHz left and right from both carriers. The receiver was tuned first to 8.970 and then to 9.060, This was done in order to check if there was difference in the level of the intermodulation products. There was no difference.

A third order IM product equal to the noise floor (0.14 uV) was generated with a level of both carriers of - 20 dBm (22 milliVolts). This equals a dynamic range of no less than 104 dB! Remember, this is measured in SSB with the 2.3 kHz filter, not with a 500 Hz CW filter! The calculated 3rd order intercept point with these values is + 32 dBm, an excellent value. When we raised the level of both carriers to - 15 dBm (40 mV), the level of the IM products became 1 uV (-107 dBm). This equals a 3rd order intercept point of + 31 dBm. The receiver thus follows strictly the cubic law, no cancellation. The KWZ 30 has an AGC that cannot be switched off, and the influence of the AGC was visible when we made the level of the IM product 10 uV (-87 dBm). The level of each carrier had to be made - 5 dBm (no less than 126 milliVolts) before the IM product was 10 uV, resulting in a 3rd order intercept point of + 36 dBm. The measurements were repeated on other frequencies. There was no difference up to 20 MHz. Due to the increased conversion loss of the first mixer, resulting in a slightly reduced sensitivity, the 3rd order IP's were even higher in the 20 - 30 MHz band.

During this measurement we checked the 2nd order products, appearing on 9 + 9.030 = 18.030 MHz. At 1 uV, 2nd order IM product was generated by a level of - 20 dBm (22 mV) for the carriers on 9 and 9.030. With a level of 2 x - 10 dBm (71 milliVolts) the IM product was 10 uV. Both measurements resulted in a 2nd order intercept point of + 87 dBm, again an excellent value.

Oscillator Sideband Noise and Stability

The IF filters in the KWZ 30 have excellent shape factors. But good filter characteristics can be spoiled by sideband noise of the oscillators, not only with digital IF filters, but with conventional analogue filters as well, This is due to reciprocal mixing. So, we measured the overall sideband noise of the oscillator signals in the KWZ 30. This is not specified in the official specifications, but in the instruction manual a figure of - 140 dB/Hz at 10 kHz distance is mentioned for the first oscillator.

For the overall value (all oscillator signals combined) we came to the following results (without noise reduction): -132 dB/Hz at 20 kHz distance -137 dB/Hz at 30 kHz distance -143 dB/Hz at 50 kHz distance This is very good, much better than most other receivers, but not as good as the AOR AR 7030.

Thanks to the temperature compensated crystal oscillator, which is standard instead of an option, the KWZ 30 is very stable. With a constant ambient temperature, one hour after warm-up, the receiver drifts by not more than 3 Hz at 30 MHz. A change of 10 degrees Centigrade in ambient temperature caused a drift of just 6 Hz.

Signal Strength Meter

The S-meter on most receivers is usually just an indicator. The official International Amateur Radio Union calibration for an S-meter in the short wave bands is as follows: S9 is equal to 50 uV. Every S-value lower than S 9 is a -6 dB step, so S8 is 25 uV, S7 is 12.5 uV and so on. Above S9 a dB figure is added, S9 + 10 dB is 3.16 x 50 uV, thus 158 uV, S9+20 dB is 10 times S9, 500 uV and so on.

With conventional analogue receivers, the S-meter is usually a voltmeter, calibrated in S points, showing the AGC voltage. This is often not dB linear. In the KWZ 30 an 8 bits A/D converter is used to process the AGC voltage. With a digital signal, it's much easier to obtain a calibrated S-meter. The S-meter in the KWZ 30 not only uses a graphic bar as S-meter, but also displays the level of the received signal to the nearest 3 figures in dBm! This S-meter is for a receiver extremely accurate. Over the range from S2 (0.4 uV = -115 dBm) up to S9 + 50 dB (15,8 mV = -23 dBm), the indicated value is accurate to within 1 dB!

On the extreme edges of the range S1, 0.2 uV and above S9 + 55 dB the accuracy dropped to 3 dB, but this is still accurate enough to use the KWZ 30 as a precision RF level meter. No other receiver we have tested earlier has such an accurate S-meter.

There is something strange with the bar-graph indicator. The calibration in S units is printed on the clear plastic protection plate of the LCD display. Although the S-meter is accurate, the printed indication has shifted somewhat. This means that if the signal is for instance S4 (1.6 uV, -103 dBm), the dBm figures show - 103 dBm, the bar is as long as needed for S4, but the printed indication implies that this bar-length equals S3. We hope the printing will be changed in the next production runs, because there is no reason to do this.

The bar-graph has a maximum pointer, which is a nice touch. When the bar decreases, a small block of the bar remains for a while at the maximum indicated value. This makes reading easier. Because nearly everything in the KWZ 30 is programmable, the time that the maximum pointer holds its value can also be set. The hold-time can be programmed from 0 to 2 seconds. The dBm reading of the S-meter is coupled to this pointer, so the figures indicate the maximum value, and not the average signal strength.

Audio Quality

Heavy distortion during reception can influence the intelligibility of speech. We measured the distortion of the detectors in CW/SSB and AM. Thanks to the DSP processing, there is practically no distortion. At an audio output power of 100 mW, we measured 0.3 % in SSB, which was mainly caused by the internal 2 Watt audio amplifier. Measured without loading the internal amplifier with an 8 ohm speaker, the total distortion in CW and SSB was 0.1%. In AM this must be the same. We measured 0.25% with a 60% modulated signal and without load, which is in fact the distortion of our measuring equipment. With an 8 ohm load and 100 mW output power, the AM distortion was still under 0.5 %, much better than from any conventional AM detector.

Listening on the KWZ 30

Naturally, we have also used the KWZ 30 for several weeks in practice. It is important to listen to a new receiver as well as measuring it. This is particularly the case with DSP receivers, because there are no standard measuring methods which cover all the special effects you'll find DSP receivers. An experienced listener can immediately recognise the sound of a DSP receiver. But it is difficult to give a clear description as to WHY it sounds different from a good analogue receiver.

We compared the KWZ 30 to a Japan Radio Company NRD 525 and a professional Rohde and Schwarz EK 070, both analogue receivers. We used a professional RF Systems MLBA MK4 longwire antenna. This is an all stainless steel antenna with a special Magnetic Longwire Balun, now in use at Dutch embassies and at BBC Monitoring in Caversham, UK. The antenna is 20 m long and is hung at a height of 13 m. As second antenna, we used a DX One professional, also from RF Systems. Kneisner and Doering can deliver as option a + 30 dBm active antenna, the KWZ-A1, but we didn't use that with our example.

In fact it is useless to tell you that we received very weak local shortwave stations from Australia, China, South America and Indonesia during the tests. The reception of these stations is mainly determined by the antenna and not by a receiver. What really counts is how the receiver can separate the wanted station from adjacent strong stations, if reception of weak stations is clear or "polluted" by a heavy varying intermodulation noise floor, if the modulation is "clear and open" or muffled and hard to understand and so on. The sensitivity of the KWZ 30 with these large antennas is more than sufficient, although with shorter antennas a bit more sensitivity, especially above 20 MHz could be an advantage.

The KWZ 30 sounds incredibly "precise". We do not have a better description: it's clean, a little bit "hard" and very open. This kind of description is very subjective of course, but there is no measuring method to specify these sound impressions in figures. But we find it a pleasure to listen to the KWZ 30, especially compared to the somewhat "muffled" sound of the NRD 525. The best way to describe the difference is the analogy with the CD and the analogue 33 rpm long play record. Even when listening to a medium-wave AM broadcasting station with 4.5 kHz as the highest audio frequency, you can hear the difference between a normal record and a CD. The same type of difference can be heard when comparing the KWZ 30 with both other receivers. The difference between the KWZ 30 and EK 070 was much less pronounced than between the KWZ 30 and the NRD 525. We know that these impressions have a lot to do with the very good shape factor of the filters, the constant group delay of the filters, the low intermodulation distortion within the pass-band of the filters and detector, the low detector distortion, combined with a very good signal to noise ratio in the detector- and the audio chain. But there is no international agreement on how to measure these differences.

The shape factor of the filters is very good, and an adjacent station that does not splatter is suppressed completely unless the signal is extremely strong. The sharpness of the DSP filters is better than from the crystal filters of the NRD 525, and even better (although by not much) than by the professional crystal filters of the EK 070. In some situations however, (a very strong signal at several kHz distance while listening to a weak station), the better attenuation of the crystal filters for larger frequency distances in both analogue receivers could be clearly heard. Quite a number of bandwidth's can be selected, more than with the other receivers. But in future models we like to see more steps between the 3.6 kHz and 9 kHz filters for AM Broadcast Listening. For data reception the digital filtering is ideal. Even the 50 Hz filter can be used to copy fast CW signals without ringing, much better than with for instance the 250 Hz CW filter in the NRD 525.

But there are also shortcomings by the use of DSP in receivers. Let's describe a few effects. Although it is internationally agreed to limit the bandwidth of a broadcast station to 9 kHz, not all broadcasters do that. Some occupy a bandwidth of more than 15 kHz! If you tune slightly off on the centre frequency of such a wide station, then the high level sidebands are much broader than the bandwidth filter of the receiver. Because the average suppression of the DSP filters is 85 dB even far away from the pass-band, the high level sidebands of the received signal do not fall equally into the comb-structure of the filter. Sometimes, this gives whistles or a "hollow" sound. Guitar players with a comb-filter effect pedal will know what we mean.

The effect is not very strong and doesn't reduce the intelligibility. Another problem is when the received station is very strong (we found the effect with signal strength's above S9 + 10 dB), the signal is distorted in a specific way. It sounds if the speaker cone is not moving freely. The KWZ 30 is not the only receiver with this effect, we noticed it with other DSP receivers. The KWZ 30 however, has an on-board solution. You probably remember that an A/D converter must never be overloaded. But it can happen: this effect is generated by an overloaded A/D converter.

Most other DSP receivers have a fixed gain to the A/D converter, so you cannot do much more than switch in an attenuator. The KWZ 30 however has an adjustable digital gain. By lowering this gain from the default value of 40 to around 10 or 20, these effects disappear completely! In practice this means, that you have regularly adjust the digital gain: low in the strong signal broadcast bands, high in low-level bands.

The effects of the comb-structure of the attenuation outside the pass-band of the DSP filters, combined with a non-linear working area of the A/D converter can also be noticed as another effect. If you try to receive a weak station adjacent to very strong stations, for instance in the broadcast bands, you will hear the modulation of these stations on a very low level mixed with the modulation of the received station. We noticed this effect for instance during the test of the Watkins-Johnson DSP receiver. Another tester described it as "monkey chatter". With the KWZ 30 this problem can also be solved with the adjustment of the digital gain. The analogue receivers didn't have these effects. Do not get the impression that these effects are a serious drawback: the selectivity of the DSP filters of the KWZ 30 is much better than most other receivers in this price-class. The mentioned effects are only detectable in extreme situations.

The KWZ 30 does not have any front-end selectivity. Although the intercept points are very high, we were eager to learn if intermodulation products could be heard. During the early evening hours we listened in the 14.2 - 14.7 MHz band in AM. In that band 2nd and 3rd order IM products appear from the short wave broadcast bands. Don't forget that the broadcast stations are very strong during twilight: we measured with the MK 4 longwire antenna many stations with a level of - 20 dBm (22 mV) and even a few with - 10 dBm (71 milliVolt!) levels. With these strong stations, a few IM products were noticed, but on a very low level. Although the JRC NRD 525 has a tuned front-end filter, this receiver showed more and stronger IM products, the EK 070 was free of IM products. A 6 dB attenuator between the antenna and antenna input of the KWZ 30 solved this problem. Intermodulation products were not noticed at other times of the day. That is good, but we'd like to see a step attenuator in the front-end of the receiver, for instance with 6, 10 and 20 dB attenuation. This makes the regular adjustment of the digital gain partially superfluous.

Other Practical Impressions

The noise reduction works very well, but it performs best during the reception of data and CW signals. The use of narrow bandwidths together with the noise reduction helps "dig" stations deep out of the noise. With AM the effect is less. Careful adjustment is required: too much noise reduction reduces the intelligibility of the received station. The notch filter works very fine to suppress one or more continuous heterodynes and it suppresses also disturbing Morse signals, although not as good as steady tones. But with AM reception, for instance in the tropical bands, the notch has great problems in recognising the difference between the AM modulation and interference signals. ARQ data signals are practically not suppressed.

Conclusions

The KWZ 30 receiver costs 3485 DM, including VAT, in Germany and the European Union (EU). Outside the EU, the price is 3005 DM. That translates to about 1710 US dollars, plus whatever import duties are applicable. That's a lot of money, but to our knowledge there is no other receiver on the amateur market that has better specifications and more possibilities. The

AOR AR 7030 performs, from a RF specification point of view, roughly equal and is lower in cost. But to obtain several bandwidths, quite a number of expensive mechanical Collins filters have to be purchased. Also an add-on audio DSP processing unit would have to be used to obtain noise reduction and multi-tone notch filtering. The total price is then higher than the KWZ 30.

The KWZ 30 is ideal for SSB, CW and data reception. For AM broadcast listeners there are fewer possibilities. The AM detector is distortion free, even with heavy fading, but we missed selectable sideband listening in AM. It's also a pity that the bandpass tuning does not work in AM. Naturally, it's possible to listen in USB or LSB to a broadcast station and in these modes the pass-band tuning does work.

The adjustment possibilities on the KWZ 30 are enormous: nearly everything is programmable. To get the most out of this machine you must spend time gaining a lot of experience. But then it's possible to adjust the receiver to every type of signal for optimum results. We think that the quality of this receiver is so good, that an increase in price caused by a few more function keys —direct access keys for mode switching, a step attenuator and a direct control for the digital gain —would not deteriorate the excellent price/performance ratio of this receiver. For the KWZ 30 as it is produced now, a good computer control program in the style of Visual Radio of the ICOM PCR 1000 should be of great help. Such a program, which shows the receiver on screen with direct access to all the functions, makes operation much easier. It adds better scanning possibilities, such as searching a limited band segment and band scanning, without the need to program every channel before it can be scanned. Maybe Kneisner and Doering will pick up on this point. The KWZ 30 performs very well, better than our NRD 525, but naturally not as good as the US$30,000 EK 070 from Rohde and Schwarz. But every station that could be received with the EK 070, could also be heard on the KWZ 30. That's not bad for a DM 3500 receiver. For us, testing the KWZ 30 was like the fairy-tale of the ugly duck: in the beginning it looks ugly, at the end it is really a beauty!

More Information

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Credits

The vast majority of this special report was compiled by Willem Bos who made all the technical measurements. Diana Janssen, Jonathan Marks, Andy Sennitt and Tom Sundstrom contributed to this review.

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