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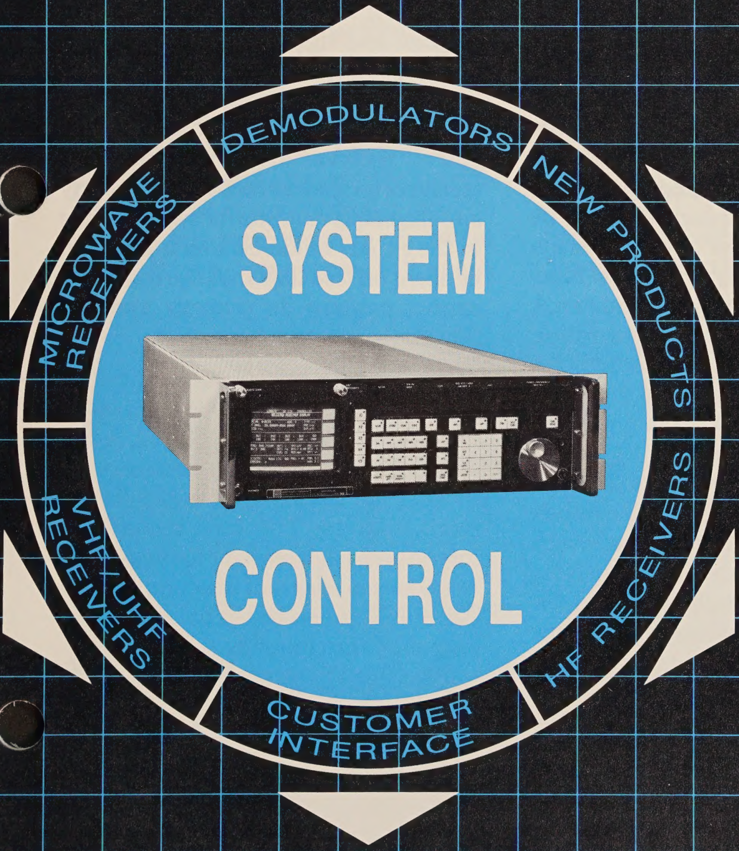
System Control Of VHF/UHF Receivers



WATKINS-JOHNSON COMPANY
Tech-notes

As the number of digitally controlled receivers in use at multiple-receiver collection sites has grown, the system designer has had to face a difficult decision in the choice of a controller. If the number of receivers to be controlled is small, or the number of basic receiver-type routines required few, then a dedicated computer is seldom required. If a computer, or even a microprocessor, is chosen as the multiple-receiver controller, the user has to develop the software for the required programs. This approach often proves to be impractical for small collection systems. The large collection system, operated in dense signal environments, would appear to be ideally suited for use of a computer as a multiple-receiver controller. However, in very dense high-activity signal environments, a central computer can be overloaded with service requests and response commands from a large number of frequency-scanning receivers. In this situation, collection of data and operational decisions may be impaired unless some of the decisions and basic receiver-type routine functions are removed from the computer. A multiple-receiver controller operating between the central computer and the collection receivers can ease the workload of the computer while providing rapid response to receiver demands. The controller not only expands the communication link, IEEE-488 or other, it also buffers data from the receivers. Many auxiliary functions, such as generation of a digitally refreshed display spectrum for a scanned frequency band or queueing of signals intercepted, may also be handled by the controller. The controller CRT presents a menu-driven alphanumeric display of the status of all receivers; and, in the event of central computer failure, would permit operator intervention and control. Front-panel appearance of the controller would be similar to that of a receiver with a tuning "knob" and frequency readout display.

The Need For A Controller

The number of receivers serviced by a single computer can be limited by the number of available bus locations and by the overall system response time. The IEEE-488 General-Purpose Interface Bus (GPIB) is a common choice for instrument and receiver control. It is fast and versatile; however, like other bus structures, the number of addresses and the physical length of the bus is limited.

Short-duration events, such as "pop up" transmissions, require rapid system response to signal parameters, such as frequency, modulation type, and percentage and signal strength. The system response time is limited by both the time required to acquire the signal and by the time required to service the active receiver over the bus. All receivers on the bus may require nearly simultaneous requests for service while in the SCAN mode. So much time can be spent on this task that the computer cannot perform its primary analysis function.

Figure 1 illustrates this problem. In this system, a single computer monitors 60 receivers over an IEEE-488 bus. A bus expander is required to increase the number of devices per controller to more than 14. The time required to interrogate each receiver for just-tuned frequency is over half a second.[1] Short-duration signals cannot be observed or logged by the computer.

A controller placed between the computer and the receiver can do much to relieve this problem. In Figure 2, the bus expanders have been replaced with receiver controllers. Each controller monitors 10 receivers and reports wanted activity to the computer. With a single command string, the computer

1. Assume an IEEE-488 byte rate of 2K bytes/second average with receiver query and response average of 6 bytes each.

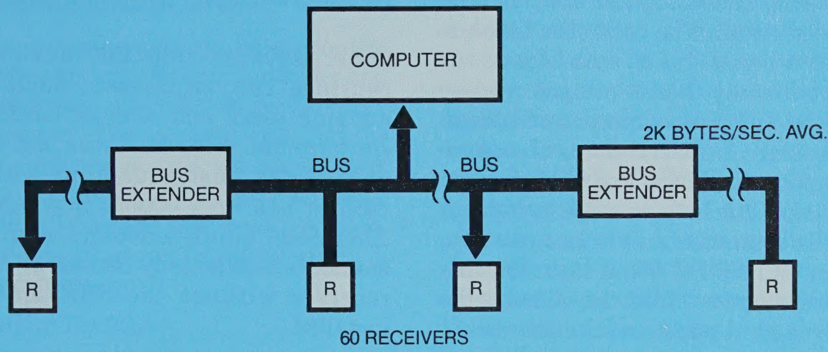


Figure 1. Receiving system without a controller.

can determine the status of up to six receivers, achieving a six-fold reduction in communications time. System programmers can control blocks of receivers with a few simple commands, as opposed to individually servicing each receiver in the system. The benefits of distributed processing and the specialized features of the controller serve to simplify the programming of system tasks. Program managers will appreciate the time that can be saved through reduction in software complexity.

The controller can act as a FAIL SAFE for the system. The controller can be designed to take over system responsibility if the computer fails. The front panel looks and acts like a receiver, and also displays the status of all receivers.

System reliability need not be totally dependent upon the proper operation of

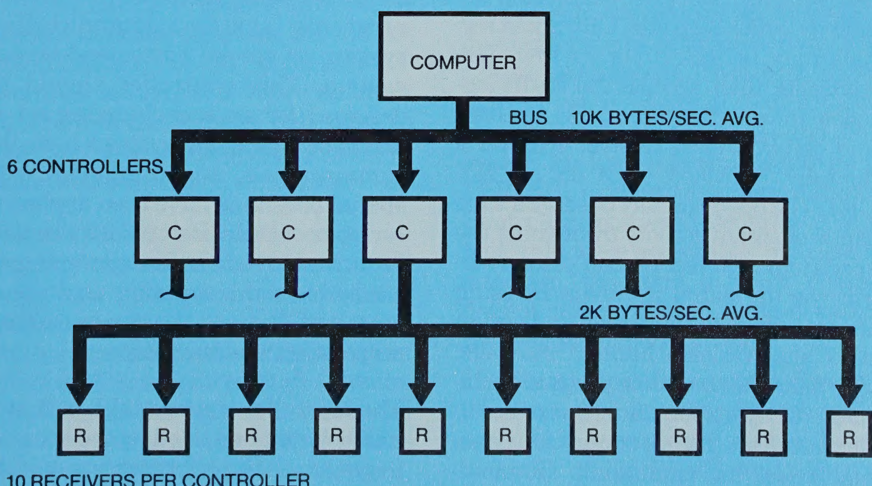


Figure 2. Receiving system with a controller.

a single piece of equipment. In some systems, the computer may not be needed at all. The controller alone is often a better choice, since it is much more friendly than a computer, while still retaining most computer features. A system controller consists of a microcomputer, keyboard and CRT display. It varies little in these respects from an Apple computer, and is less powerful than an IBM PC. What separates this "minicomputer" from the others is the unique front panel and the software.

The front panel looks and acts like a receiver, even though the receiver is remotely located. The handoff receiver is selected, and the operator may tune and listen to signal activity, while also watching for any activity on the CRT screen from other receivers with signals present.

The software makes the hardware think that it is a controller. Special routines call up each receiver through the IEEE-488 Bus, and control it or update its status on the alphanumeric CRT screen. Other software routines set up the parameters for putting a number of receivers in the scan mode. Each receiver gets a start frequency, stop frequency, and a step size. Unwanted signals may be locked out as well. The controller then accepts the 50-dB log-video information from the receiver, and displays each receiver scan on a digitally refreshed trace on an X-Y CRT. The operator may observe a wide range of signal activity throughout the spectrums selected. He can place a cursor over the signal of interest by using the frequency tuning knob, and assign it to his available handoff receivers. The headphone and any signal monitor in the system are now connected to this receiver. The operator can listen and select an appropriate IF bandwidth and detection mode before leaving this receiver to the audio recorder. Each signal of interest can be handed off using the cursor contrtol until all receivers are used.

Other software-controlled auxiliary routines can be chosen, such as antenna select and receiver labeling. Background software tasks aid the operator in distinguishing which receiver has what options and range. Therefore, single-sideband signals cannot be accidentally handed off in a receiver without the SSB option installed.

Some complicated signals, or a group of signals may require detailed analysis by an operator. A good handoff receiver with pan sector can ease the analysis task. Pan sector shows the operator a wide panoramic view of signal activity while a sector of that view is also displayed. An operator can then take the time to use all the features of this versatile receiver to make decisions. Several types of special demodulators, such as PSK, FSK and TDM, can be used to further analyze the signal.

The versatility of the software and commonality of the hardware allow the controller to be used in a microwave receiving system, demodulation system, or special customer-designed system. This controller should be designed for an ever-changing set of tasks. Few receiving systems have the same mission, and computers with special programs have been applied to each one of them. Best results can only be achieved when the operator can easily blend his training and experience with the organization and analysis power of the computer.

The controller is a special box that is uniquely tailored to allow the operator to get as much performance out of the system as possible, while still maintaining the speed, accuracy, and data-handling power of the computer.

Types Of Communication Links

The communication between the receiver and controller or controller and system computer should be carefully evaluated. The requirements for the communication link are speed, two-way communication, and addressability. There are four relatively standard links that can be considered:

1. ETHERNET
2. MIL-STD-1553
3. RS-232 or RS-422
4. IEEE-488

ETHERNET is the latest communication standard, and is catching on quickly in the commercial area, led by INTEL and Xerox. The task of ETHERNET is to allow several computers, printers and terminals to communicate with each other at a high rate of speed of about 10 megabits per second. ETHERNET is also very immune to false communication, due to its built-in error checking. The hardware at the present time is very expensive, about $1,500 per station. A popular, less expensive version called CHEAPERNET uses single-ended transmitters and receivers, but will not communicate as far. ETHERNET promises to become a very important standard of the industry but, for now, does not have the support inherent in other well-established standards.

MIL-STD-1553 was designed as an interval time-division command/response multiplex data bus for military weapon systems. The 1 megabits per second serial communication bus is used mostly for aircraft avionics. The aircraft with MIL-STD-1553 serial bus control has less copper wire between flight control boxes and, therefore, weighs less. This standard is also expensive and not used much on ground-based systems.

RS-232C and the faster RS-422 on ground-based systems are very popular and well supported. They are medium-speed serial data links that are used by commercial, industrial and military users. They also have an international counterpart called, CCITT V.28. The main drawback of RS-232C and RS-422 is addressability. There are ways of correcting general devices on the bus, and talk and listen to them individually, but none of them are standard. The controller can support a serial data link to the system computer and individual links to each receiver. An advantage to this serial medium-speed data link is that systems can pass very stringent EMI/RFI requirements. Fiber-optics systems are also easily adaptable to serial links when the system is local.

The most frequently used communication bus between instruments that are local is the IEEE-488 bus. It is the accepted universal standard for automatic measuring systems and, therefore, lessens interfacing problems with both hardware and software. This byte serial/bit parallel bus is popular with surveillance receivers because, like test instruments, the receiver can be quickly queried for status of signal activity and signal parameters. This talk/listen data is via a 16-signal bi-directional bus. The total number of lines and high speed makes passing stringent EMI/RFI requirements very difficult. Controller/receiver systems have been built that were acceptable, but careful attention was paid to short busses, double shielding, and ground straps between equipment.

The choice for the communication link is not readily clear. The most familiar to both the hardware and software designer is IEEE-488 and RS-232. Figure 3 shows a comparison between the two. Speed and versatility would favor the IEEE-488 bus, but the EMI/RFI

Parameter	IEEE-488	RS-232C
Covered by standard	1. Hardware interface 2. Controller commands 3. Handshake pulse 4. Connector 5. Addressable	1. Hardware interface 2. Suggested connector 3. Possible configuration
Similar international specification	IEO 625-1	CCITT V.28
Media	24 conductor cable	21 conductor cable 0 to 7 commonly used
Maximum data rate	1 megabyte[1]	20 K bits/sec.
Maximum cable in system	20 M or 2 M times number of devices, whichever is LESS	15 M (per link)
Maximum separation of devices	4 M depending on speed	15 M
Maximum number of devices	15 per bus	2 per link
Type data transfer	Byte serial, bit parallel	Byte serial, bit serial
Common uses	1. Instrument control in system where speed is consideration 2. Systems where many devices are under control of computer (calculator)	1. Terminal-to-computer or other one-to-one short link 2. Computer-to-device medium-distance link
EMI/RFI	Poor	Good

Note: 1. IEEE-488 data rate limitations.

Maximum Speed	Bus Limitations
1 M byte	1. Tristate bus drivers 2. No devices turned off 3. Maximum 15 M of cable in system 4. One device per meter of cable
500 K byte	1. Tristate bus drivers 2. One device per 2 meters of cable 3. Maximum 20 M of cable in system
250 K byte	1. Standard bus requirements

Figure 3. Comparison of IEEE-488 and RS-232C.

requirement would favor the RS-232 if individual links to each receiver were acceptable. Of over 1200 digitally controlled surveillance receivers shipped to date, the ratio is 7-to-1 between IEEE-488 and RS-232.

Auxiliary Functions Of The Controller

The controller is capable of far more than receiver control. Functions associated with a multiple receiver system, such as antenna selection, audio and video routing, and signal-monitor switching can also be a part of the controller's job. The controller can be designed to activate auxiliary switches mounted to the rear panel on special mounting plates. These plates can be unique to each controller, and provide only those switch-selectable functions that are needed. The control for these switches would be an additional PC card located in the controller card-cage assembly. The operator can control these auxiliary functions by using front-panel keys, or selecting from a menu-driven alphanumeric display.

Spectrum surveillance through panoramic displays can aid the operator in selecting a signal of interest to pass to a monitoring receiver. The controller has space in the card cage for this optional function. To implement this panoramic display, the controller sends the scan parameters to a receiver; i.e., start and stop frequency, step size, etc. The receiver does not stop on the signals, but sends the Log Video back to the controller. This function is discussed in the controller enhancement section of this article, and illustrated in Figure 8.

Another important function of the controller is to let the system computer or operator know when any component or receiver on the bus is malfunctioning. Most good receivers have a built-in test, but are unable to distinguish a broken antenna cable from poor sensitivity. The controller queries the BITE function on each receiver, and presents the status to the operator or computer. Next, a system test is performed by tuning all receivers to several well-known transmitted frequencies, and a comparison of signal parameters from each receiver and auxiliary circuits is made. Any malfunction is again reported to the operator through the alphanumeric CRT or to the system computer.

The controller can act as an important analysis tool to aid the operator in finding certain signals with unique modulation characteristics. Upon acquisition of a signal, the receiver sends a service request to the controller. The controller will ask the receiver for the modulator parameters, such as peak AM, peak deviation, FM offset, etc. The receiver signal parameters can also be read directly from the alphanumeric CRT,

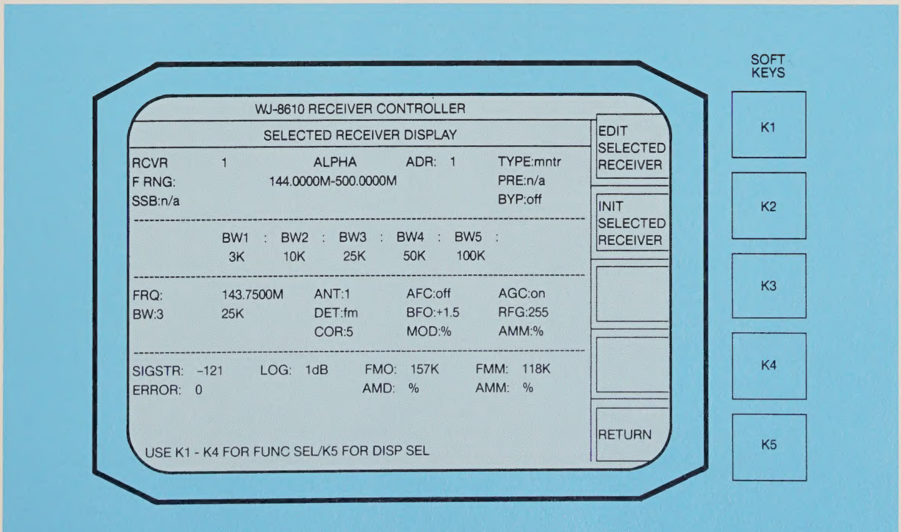


Figure 4. Receiver parameter display.

as shown in Figure 4. The controller can compare these parameters with those stored in memory for special signal characteristics, and alert the operator of a match. Scanning scenarios like this can easily skip standard commercial signals, and only stop on those of sonobuoys, transponders, and other special signals of interest.

A very important auxiliary function of the controller is to manage the many different options, IF bandwidths and frequency ranges of receivers in the system. The controller can display several configuration tables to the operator, as shown in Figure 5. By using other menus, such as signal parameter presentations, the operator

WJ-8610 RECEIVER CONTROLLER

CONFIGURATION TABLE 1

RCV	LABEL	ADR	LOW FREQ	HGH FREQ	PRE
1	ALPHA	1	144.0000	500.0000	n/a
2	BETA	2	88.7500	140.5000	n/a
3	CHARL	3	440.0000	448.5000	n/a
4	DELTA	4	27.1000	30.0000	n/a
5	EDW	5	50.0000	54.0000	n/a
6	FRANK	6	220.0000	225.0000	n/a
7	GAMMA	7	448.0000	500.0000	n/a
8	HENRY	8	14.2100	14.8000	n/a
9	IDA	9	420.0000	440.0000	n/a
10	JOHN	10	7.0000	7.3000	n/a
11					
12					
13					
14					

USE K1 - K4 FOR DISP SEL/K5 FOR RCVR FUNC.

RECEIVER STATUS TABLE — K1
SELECTED RECEIVER DISPLAY — K2
RECEIVER CONFIG. TABLE 2 — K3
CONTROL-LER PARAM. — K4
MORE KEYS — K5

SOFT KEYS

WJ-8610 RECEIVER CONTROLLER

CONFIGURATION TABLE 2

RCV	LABEL	BW1	BW2	BW3	BW4	BW5	SSB
1	ALPHA	3K	10K	25K	50K	100K	n/a
2	BETA	3K	10K	20K	50K	100K	n/a
3	CHARL	3K	10K	50K	75K	100K	n/a
4	DELTA	6K	50K	75K	100K	110K	n/a
5	EDW	3K	5K	10K	25K	50K	n/a
6	FRANK	3K	5K	10K	25K	50K	n/a
7	GAMMA	3K	5K	10K	15K	25K	n/a
8	HENRY	1K	3K	5K	10K	20K	n/a
9	IDA	3K	5K	7K	10K	20K	n/a
10	JOHN	3K	5K	7K	10K	20K	n/a
11							
12							
13							
14							

USE K1 - K4 FOR DISP SEL K5 FOR RCVR FUNC.

RECEIVER STATUS TABLE — K1
SELECTED RECEIVER DISPLAY — K2
RECEIVER CONFIG. TABLE 1 — K3
CONTROL-LER PARAM. — K4
MORE KEYS — K5

SOFT KEYS

Figure 5. Configuration table displays.

can hand off wide-spectrum signals to receivers configured with the wider IF bandwidths. The operator, by use of the head-set on the controller, can hand off single-sideband signals to only those receivers with the single sideband installed.

Management Of Fast-Scan Spectrum Data

Application of a controller between receivers and computer becomes particularly important when the receiving system must provide fast-frequency scanning in high-signal density environments. The controller can assist the computer in the management of the signal data acquired. There are several types of receivers available for rapid signal acquisition, using various IFM, microscan and channelized technologies.[2] For the purpose of examining typical fast-scan spectrum data, this paper considers only performance typical to a scanning or frequency-stepping superheterodyne receiver. Ideally, the superheterodyne receiver chosen for a fast-scanning application should be frequency-synthesized and microprocessor controlled.

The Fast Scan/Step operation, then, may be largely software based, using an internal microprocessor. Required time-per-frequency point can be expected to be approximately 400 microseconds.[3] If frequency steps equal to the IF bandwidth being used are taken, a 50-MHz spectrum can be scanned in less than one second with IF bandwidths as narrow as 25 kHz. Figure 6 shows the relationship of spec-

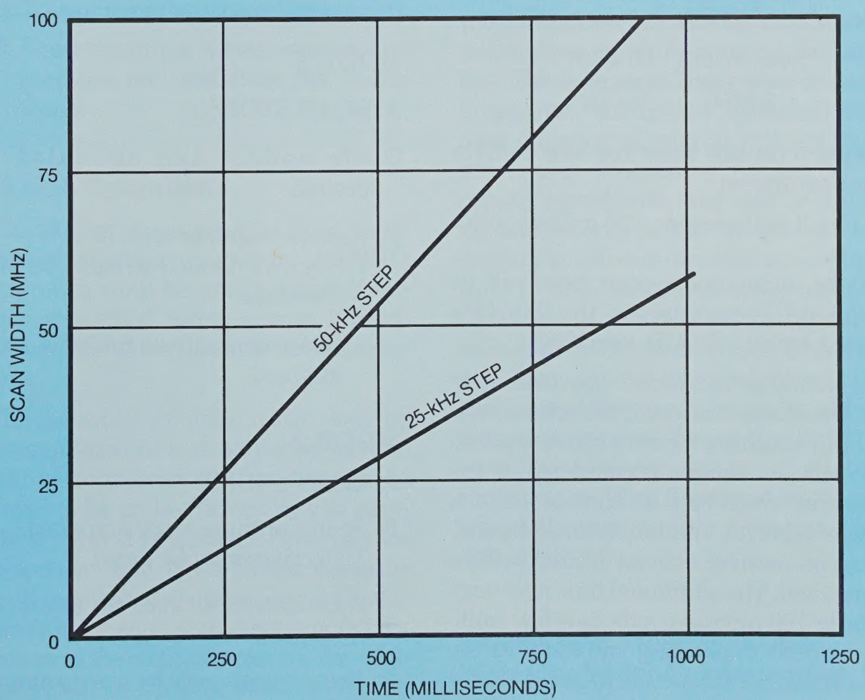


Figure 6. Typical scan speed.

2. Watkins-Johnson Company Tech-notes, *Competitive Receiver Technologies, Volume 11 No. 4, July-August 1984.*
3. Software Design of Microprocessor Controlled Receivers, Proceedings of Watkins-Johnson Company Annual Technical Symposium, October 20, 1983.

trum width, IF bandwidth, and scan time.

The following example illustrates the scan-speed performance to be expected with this type of narrowband superheterodyne receiver.

Assume a requirement to scan a 50-MHz spectrum using an IF bandwidth of 50 kHz as an example.

Number of frequency steps will be:

$$\frac{\text{Scan Width}}{\text{IF BW}} = \frac{50 \times 10^6}{50 \times 10^3} = 1 \times 10^3 \text{ Steps}$$

Approximate time per frequency step is 400 microseconds:

$$\begin{aligned}\text{Steps} \times \text{Time/Step} &= (1 \times 10^3) \\ &\quad \times (400 \times 10^{-6}) \\ &= 400 \times 10^{-3} \\ &\quad \text{Seconds}\end{aligned}$$

Approximate time at each 5-MHz crossing is 3 milliseconds:

Number of 5-MHz crossings will be:

$$\frac{\text{Scan Width}}{5 \text{ MHz}} = \frac{50 \times 10^6}{5 \times 10^6} = 10$$

Approximate time for ten 5-MHz crossings is:

10 x 3 milliseconds = 30 milliseconds

Total approximate scan time will be 430 milliseconds for the 50-MHz scan, using a 50-kHz step size.

It should be noted that approximately 439 milliseconds would be required only if the scanning receiver is not required to stop on signals encountered. If the receiver must stop on signals above a selected level, additional time, depending on receiver actions desired, will be required. The additional time may vary from 100 microseconds to a few milliseconds, depending on the routine initiated; i.e., afc action to center signal in IF passband; agc action to adjust receiver gain; comparison, measurement, or recognition of signal or modulation characteristics, etc. Many, if not all, of these routines can be programmed into the microprocessor resident in each receiver. However, more versatility and flexibility can be achieved if most of these functions or routines are assigned to additional microprocessor capability in a multiple receiver controller.

Before discussing how a controller can be used to aid in the management of fast-scan spectrum data, a description of what could be termed *Basic Scanning Modes of Operation* may be useful.

Typically, signal activity within the scanned frequency range can be determined by comparing the output of a log-video amplifier to the threshold level set into the receiver COR circuit over approximately an 80-dB range. When a signal with a level above selected threshold is intercepted, there are at least three major modes of action possible:

MODE 1

A. SCAN STOPS.

B. afc and/or agc activated if desired.

C. Receiver resumes scan if:
   1. Signal level drops below threshold.
   2. Bus command to continue scan initiated.

MODE 2

A. SCAN STOPS.

B. Scan Continue Mode activated.
   1. Receiver may be tuned.
   2. Command starts scan at stopped frequency.

C. Restart scan *only* by bus command (this assures that the controller gets frequency of acquired signal).

MODE 3

A. SCAN STOPS.

B. Frequency entered in Buffer Queue.

C. Scan continues and stops on signals only long enough to enter frequency in Buffer Queue.

D. Scans to end of selected band.

E. SRQ set.

F. Scan Continue Mode activated (scan stops and waits for controller restart).

OR

A. SCAN STOPS.

B. Frequency entered in Buffer Queue.

C. Scan continues and stops on signal only long enough to enter frequency in Buffer Queue.

D. Scan stops when Buffer Queue filled.

E. Scan resumes when stored frequencies are read from the Buffer Queue.

Queue Operation

The Buffer Queue may be filled in all modes of scan operation. A FIFO approach may be used so that if the Queue is filled before a scan is completed, the oldest data is written over first.

The quantity of data which can be accumulated in a short period of time with a large number of receivers may prove to be an inefficient way to operate a central computer. This may be especially true if the frequency-scan routine selected requires several milliseconds for each signal intercepted. In this case, the computer may be forced to spend too much time waiting for the data from each receiver. The controller can provide a central point for the accumulation of the scan data in a multiple-receiver system so that the computer can be fully engaged in comparing and analyzing, rather than waiting for data or providing detailed commands. The controller may be used to both store and/or presort data from the receivers. For example, the controller could make a decision to store a signal intercept, depending on the signal level or modulation type, thereby reducing the amount of data to be analyzed by the computer.

As a central control and collection point in a receiver system, the controller may also assist in the management of very fast scan data. For instance, a number of fast-scanning receivers could be set to provide only frequency and amplitude data for each intercepted signal. The scanning receivers would stop scanning just long enough to obtain the frequency and level of the intercepted signal, which would then be fed directly to the controller memory without using the data bus. The data stored may then be used to generate a digitally refreshed display showing all signal activity in a particular frequency range. This rapidly stored data may also be called up and priority-sorted by the central computer without causing any reduction in the scanning speed of the receivers. In addition to the digitally refreshed spectrum display, a CRT display may also be provided as an integral part of the controller as an aid to data management. The controller CRT would display the status of all the receivers, enabling the operator to more efficiently manage the resources and data available.

Search And Monitor Systems With Controller Enhancement

As examples of controller-enhanced systems, three potential systems are presented in this section. Each system is discussed from both a configuration and an operational viewpoint. Each example has been chosen to illustrate the potential enhancement a controller can offer to surveillance-system users.

A Tactical Air-Comm Monitoring System configuration is shown in Figure 7. In this system, the controller is used mainly as a central operator monitor/control position. In this illustration, four receivers are designated as scan receivers. Each receiver's scan width may be set from the controller front panel. Log-video and frequency information from each scanning receiver is returned to the controller, where a digitally refreshed display is generated. Four independent digitally refreshed spectrums are generated and displayed on a four-trace X-Y CRT Display. The controller may also be used to generate a frequency marker to indicate the frequency of any signal appearing on the digitally refreshed spectrum. By momentarily stopping the scan of the selected receiver, and tuning the receiver either directly or from the controller, a marker can be generated on the digitally refreshed display, which remains fixed, or frozen until the receiver is reset to scan. Figure 8 illustrates what a digitally refreshed four-scan display may look like.

As a signal of interest is identified, it can be "handed-off" to one of the monitor receivers from the front panel of the controller. The monitor receiver may then activate a recorder whenever the signal is present. A CRT display on the front panel of the controller can present the status of all the receivers, both scan and monitor, so that the operator is able to efficiently apply the receivers to the activity in the monitored spectrum. By using the IEEE-488 Bus, up to 14 receivers can be included in the control/monitor scheme.

The system configuration shown in Figure 9 is similar to the Tactical Air-Comm Monitor System in that the controller is again at the center of the operating system. The major difference

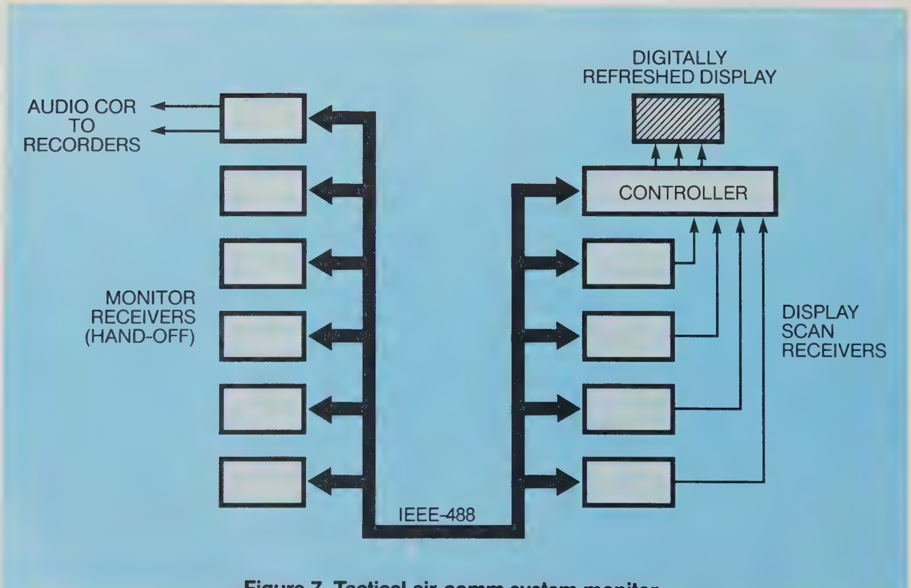


Figure 7. Tactical air-comm system monitor.

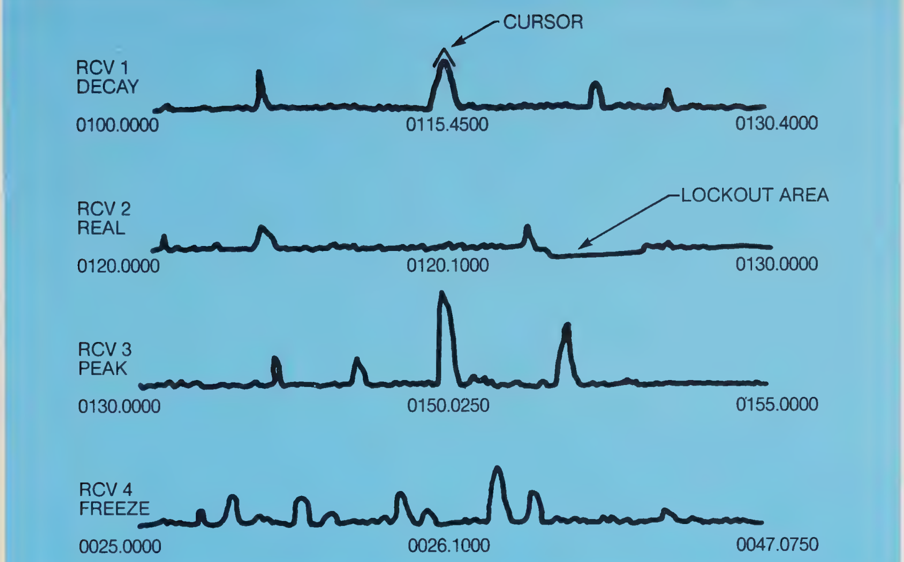


Figure 8. Digitally refreshed display spectrum.

between the two systems is the application of the controller as an interface between a computer and the receivers. With this configuration, semi-automatic and automatic operation is possible. Via the Bus, the computer may command the controller to set up special scan or step routines, or lock out particular frequencies or bands of frequencies. The computer can evaluate the signal data stored in the controller memory as a result of fast-scanned spectrums. Programs to search for, and intercept, specific types of signals may be employed by the computer. The computer can also lock out frequencies

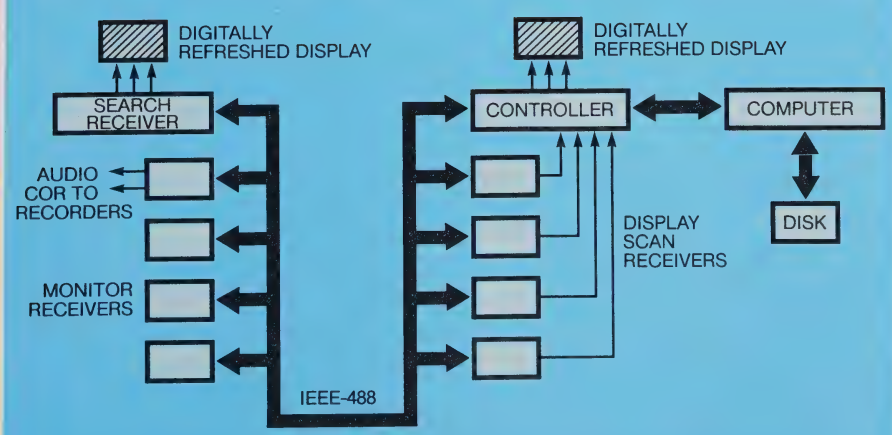


Figure 9. Auto scan/monitor system.

as required, and perhaps look for particular types of modulation in certain frequency bands.

In addition to the four-trace digitally refreshed display of the four scanning receivers, a second digitally refreshed display is provided to operate with a search receiver. The search position receiver permits an operator to view a particular spectrum in more detail by providing a fixed scan and a continuously adjustable sector width SCAN display. The monitor receivers may be controlled from either the computer directly, or via the controller. The status of all the receivers in the system is displayed on a CRT integral to the controller. In the event of computer failure, much of the station routine, such as scanning, logging and storing signals, can continue from, and under direction of the controller.

Of course, a most natural application for a controller is a remote-operated system, such as the example shown in Figure 10. In such a system application, it is advantageous to have a controller which "looks like" a receiver to the operator. With up to 14 receivers located at the remote site, it becomes important to not only be able to control the receivers, but also to know the current status of each receiver. Again, the controller CRT display provides a continuous update of the status of each receiver.

The response time between the controller and the receivers depends on the baud rate of the telephone line used. As an example, a 9600 baud rate would permit controller-to-receiver reaction time of approximately 100 milliseconds, and a CRT update time for a ten-receiver system of approximately 10 seconds. Typical response and update times required for a ten-receiver system using different baud-rate telephone lines are shown in Tables 1 and 2.

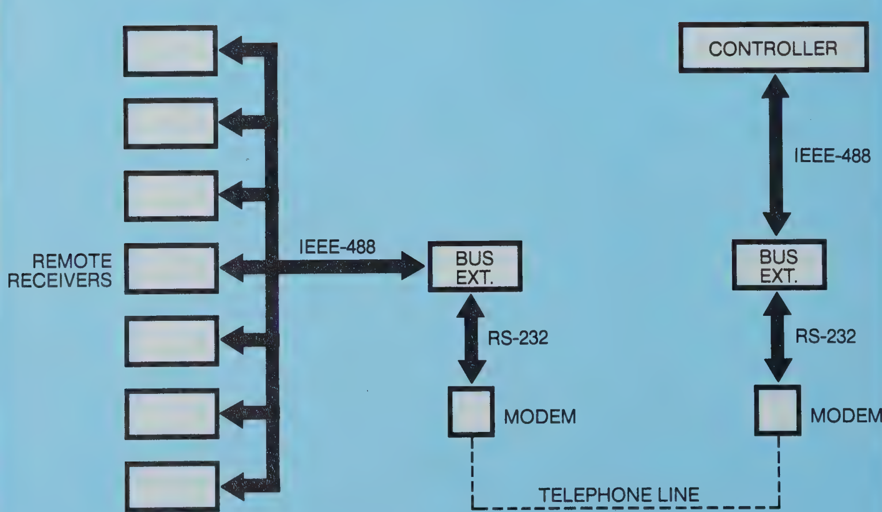


Figure 10. Remote monitor system.

Time To Update CRT With New Receiver Information For Ten-Receiver System

Baud Rate	Modem System	Update Time (10 receivers)
300	Bell 103	5 min., 30 sec.
1200	Bell 202	2 min., 50 sec.
9600	Sync modem	11 sec.
19.2 K	Sync modem	6.4 sec.
38.4 K	Async 2 twisted pair (RS-422)	4.3 sec.

Table 1. Serial link controller delays.

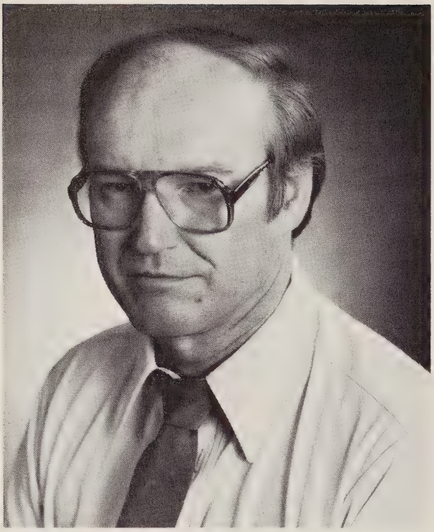
Baud Rate	Modem System	Slowest	Fastest	Typical
300	Bell 103	5.3 sec.	0.355 sec.	2 sec.
1200	Bell 202	2.7 sec.	0.085 sec.	1 sec.
9600	Sync modem	0.2 sec.	0.062 sec.	0.1 sec.
19.2 K	Sync modem	0.1 sec.	0.036 sec.	0.08 sec.
38.4 K	Async 2 twisted pair (RS-422)	0.07 sec.	0.030 sec.	0.05 sec.

Table 2. Response time LAG from controller change to receiver change.

Summary

The use of a controller in a large multiple VHF/UHF receiving system can ease the workload of the system computer by the use of distributed processing. The controller can also stand alone in small receiving systems by providing the operator with both a computer-like alphanumeric presentation with the status of all receivers, and can also look like the receiver under control and provide feedback for local monitoring purposes. Examples of several systems have been presented that illustrate the use of a controller.

Authors:



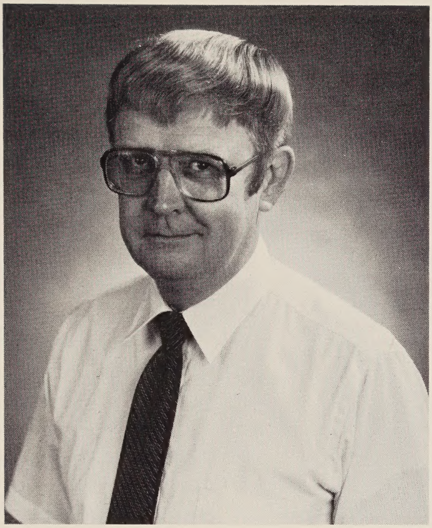
Charles E. Dexter

Mr. Dexter is Manager of Surveillance Receivers, Special Projects Division. This includes the WJ-861X family of microprocessor-controlled VHF/UHF receivers, controllers and tracking preselectors.

Mr. Dexter was previously Program Manager for the WJ-8718 HF Receiver, a high-volume version of the WJ-8888 HF Receiver. He has been a member of the Advanced Development Section, where new product ideas are evaluated. His responsibilities included advanced frequency-synthesizer techniques to improve spectral purity and to make synthesizers more cost effective.

Mr. Dexter has also been Head of the Frequency Counter and Synthesizer Group, and was responsible for the design of frequency counters, frequency extenders, and frequency synthesizers for use with surveillance receivers and surveillance receiving systems. Major design activities were directed toward designing frequency synthesizers and digital control of receivers and frequency synthesizers. The frequency range of these synthesized receivers range from 0.5 to 1000 MHz.

Mr. Dexter holds a B.S.E.T. degree in Applied Science from Capital Institute of Technology.



Thomas W. Goodell

Mr. Goodell is Head, Program Engineering, Special Projects Division. He is currently responsible for directing engineers, technicians and support personnel in various program engineering tasks for successful completion of program objectives within performance specifications, schedules, sales and profit. He is also involved in support to sales personnel and product-line section managers to obtain new business via quotations, proposals, concept evaluations and customer liaison.

Mr. Goodell has held positions of: Head, Export Sales for Watkins-Johnson International; Program Manager, Green Rose Program; Head, Production Test Section; and Special Projects Engineer.

Mr. Goodell holds an A.S. degree in Engineering Physics from George Washington University.

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