DIGITAL CONTROL OF RADIO, TRANSMITTERS AND RECEIVERS

INTRODUCTION

The purpose of this section is to introduce the student to a widely used (in Collins equipment) method of digital control of a radio receiver, exciter, power amplifier, antenna coupler, or virtually any device compatible with remote control.

REFERENCES

1. Binary Logic and Digital Techniques, Correspondence Course, Collins Radio Company, 1 January 1970.

2. Communication/Computation/Control System, Training Document, Collins Radio Company, 10 November 1969.

3. Instruction, 7421D-1 and 7421D-2 Device Control Units, Collins Radio Company, 23 July 1969.

INFORMATION

GENERAL

The basic concept of remote control is relatively simple. It can be as basic as a transmitter that is turned on and off from a control station 5 miles away. All that is needed for remote control is a switch and 5 miles of wire. The system becomes only slightly more complex when audio lines are strung so that the transmitter may be modulated.

In more sophisticated communications systems, it may be desirable to select various modes of transmission, such as CW, AM, SSB, etc. Well, this too can be controlled remotely. However, our switch would have to be a little more than a simple on/off switch. Perhaps we would use a rotary switch. As our system grows in complexity, we may wish to use multichannel transmitters in which we can select preset channels from our remote control station. We may even wish to retune the transmitters by means of switch-controlled servosystem, or select various transmitters or receivers. Our system would now require a number of switches and a considerable amount of wire. Installation and maintenance costs would begin to increase, and maintenance could start to become a headache.

If we consider our plight for a moment, we begin to realize that one of our problems is that, during any one mode of operation, we have a number of wasted lines. If we are operating in the AM mode, the SSB and CW control lines are performing no function at all. They are just taking up space. The system could be simplified a great deal by using a telephone dial at the remote control station, a single pair of wires, and stepping switches at the transmitter. Then we could simply dial the desired mode. This same dial could turn the transmitter on and off, select preset channels, provide servo control for tuning, etc. If we compare this system with the direct dialing telephone system, it should be apparent that, just as a very large number of parties can be dialed, so can a very large number of functions be controlled. This type of system is known as "dial pulse," and was used in Collins' URG I system. It, of course, was more involved than the basic system just described.

While dial pulse eliminated many of the problems involved in remote control, there were still other problems that remained. One of these problems was speed. It requires a certain amount of time to operate the dial. Ordinarily, this would be no problem, but if a large number of transmitters had to be controlled, the expended time could become critical. Acother problem was the requirement for manual control. If a transmitter is required to change to a different mode of transmission or to a different channel at 4:00 o'clock, the burden is on the operator to see that it is switched at that time. One very important problem is that dial pulse only exerts control. It cannot monitor power output, modulation level, equipment condition, etc.

Now, let's see what we can do to alleviate some of our problems and improve our system. The concept of exerting control by sending pulses over a pair of wires is basically sound, but we'll replace our stepping switches with logic circuits. These logic circuits will decode, store and route binary data, and count timing pulses. These circuits operate faster than stepping switches, are smaller, require less power, and have a longer life expectancy.

To control our improved communication system, we'll establish some binary codes. It matters little what codes we use, since they will vary from system to system. Let's assume that our codes for mode selection are as shown below:

AM - 100
CW - 101
SSB - 110

We'll also assume that we have certain codes channel selection, as follows:

Channel 1 - 100
Channel 2 - 101
Channel 3 - 110

We'll have as many codes as we have functions to control. Now, obviously we must have some way of separating the functional codes. We can't just feed 110 to a circuit and hope that it will go to the SSB mode. Instead, it might switch to channel 3. To avoid this problem, we'll use a unit known as a Device Control Functional Element (DCFE). This unit will usually be included, as an integral part, of the transmitter or whatever equipment is being controlled.

Located on the DCFE is a register with a serial input and parallel outputs. This register will temporarily store the binary data and route the data sections to the proper switching devices. For example, if 110101 is loaded into a 6-bit register, decoding gates could route the 110 from the first three stages to the mode selection circuits. Other decoding gates could route the 101 from the last three stages to the channel selection circuits.

This type of system can be used to control not only mode and channel selection, but many other functions as well. One system that is being used can control as many as 100 different functions—such as transmitters on, transmitters off, high power or low power, filaments-on, plate-on, RF key, AF key, tune, etc.

The serial data that we have been discussing could come from a telephone dial and decimal-to-binary converter. The converter would convert the number of pulses into a binary code. Or, the data might come from a register that has been loaded with binary codes by means of manually controlled switches. On the other hand, the serial data might come from the processor of a computer. At the proper time, the computer would feed out the binary data to the DCFE. The DCFE would store the data, as well as route it. Thus, the computer may operate at a very fast rate and control a number of transmitters according to a prearranged program. Because of its storage capability, the DCFE can operate at a much slower speed, which is compatible with the speed of the transmitter switching devices.

We've been discussing methods of controlling the operation of a transmitter with binary codes. We've seen that a binary code can tell a transmitter to switch from AM to SSB, or to switch from one channel to another. There is no reason why the code could not tell the transmitter to measure its power output or percent of modulation and send back the information. The proper monitor circuit would be switched in and a reading obtained. This reading would go into an analog-to-digital converter where it would become a binary code. This code would be loaded into a register in the DCFE and sent back to the control device.

The DCFE that we have been discussing performed several functions. It provided temporary storage for the control data, it provided routing for the binary codes, and it provided a monitor response. It is difficult to say exactly what a DCFE will or will not do, because each DCFE is different. Generally speaking, a DCFE provides, for the control data, whatever is necessary to make it compatible with the unit it is to control. It also arranges monitor data in a form that will be acceptable to the computer or other control device.

Our single-transmitter communication system is now quite sophisticated. We have a transmitter that can be remotely controlled, either manually or by a computer. Operation can be monitored, as well. Now, let's suppose that we wish to expand our system by adding a receiver, a teletype or, perhaps, several transmitters, receivers, teletypewriter machines, and other remotely controlled devices. We could do this by stringing a set of lines for each device, but then we'd be back to one of our original problems. All of these lines would just be taking up space except when the associated devices are being controlled.

We can solve this problem by connecting all of the controlled devices in parallel and sending all control signals over a single set of lines. However, we must have some way of routing the control word to the proper device. If we send a command to the transmitter, we certainly don't want to affect the operation of the teletype.

Control word routing may be accomplished by recognition of a binary code sent with each control word. This code is known as an ADDRESS. An address can be recognized the same way a count is decoded. The bits are applied to a gating circuit that generates an output only when all of the bits are correct. When this output is generated, it, in turn, generates a data gating signal that lasts for the control data interval. Thus, the control word is gated only to the device addressed.

Address recognition is accomplished in a unit called the Device Control Unit (DCU). The DCU is usually included as an integral part of the controlled device. It may be mounted on the same circuit card with the DCFE, or it may be mounted on a separate card. The DCU performs several other important functions, but we'll discuss these a little later.

Right now, let's look at the standard word format in figures 9-1 and 9-2. This format is used in all DCU/DCFE circuits. There are a few minor variations, which we will discuss as we go along.

Figure 9-1 shows the word construction by bit time slot. This will be the same for the control word and the monitor word. The first four time slots form the supervisory interval, which signals the beginning of a word. The DCU detects the supervisory interval to synchronize an internal counter with the incoming word. This counter establishes times for the execution of logic within the DCU and DCFE.

The dialogic bit is used in equipment at the control station. It does not affect DCU/DCFE operation. Its purpose is to identify the word as a control word or as a monitor word. The dialogic bit in a control word is always a 1; in a monitor word, it is a 0. The dialogic bit in the monitor word is generated by the counter in the DCU.

The address consists of either the first five or the first 7 bits following the dialogic bit, depending on how the DCU is strapped. Only when the address corresponds to the address strapped into the DCU will data be allowed to enter the associated DCFE.

The remaining 24 or 26 bits contain data. Several different commands may be contained in one control word. In some systems, each bit is a separate command. Parity bits may be included in the data to ensure that certain sections of the word have an odd or an even numbers of 1's. Then, parity could be checked in the DCFE to ensure that no bits have been lost. In some systems, the first two bits of data are used as a subaddress to aid in routing in the DCFE.

Figure 9-2 shows the word format and associated signals that exist on the DCU bus. The DCU bus consists of all the lines between the DCU and the control station. These lines are the control bus, the monitor bus, and the carrier bus. The signals on the DCU bus are of sine-wave form. This is because the conrol station and the controlled device are usually separated by a considerable distance. Square-wave signals would suffer the effects of attenuation and distortion.

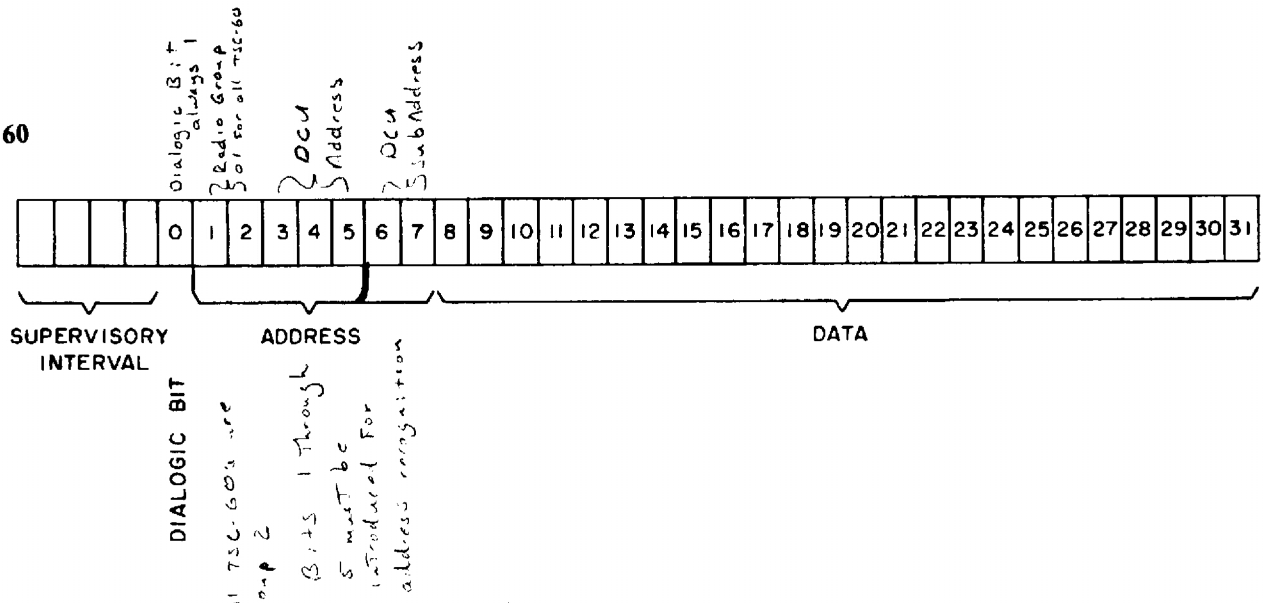

Figure 9-1. Word Construction by Bit Time Slot

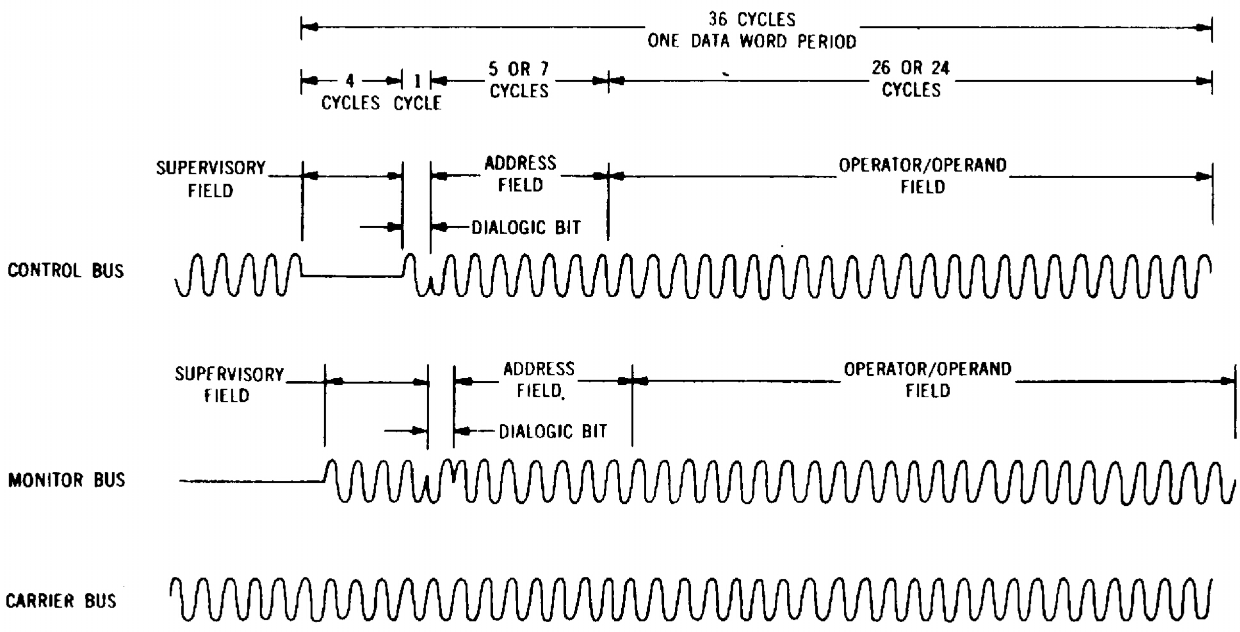

Figure 9-2. DCU Bus Signals

The control bus normally has a continuous sine-wave signal, called a carrier, which is phase modulated. Each sine wave occupies one bit time slot and is inverted to represent a 0. An in-phase sine wave represents a 1. Any time that a carrier exists on this bus, it is considered to be modulated because it will either be in phase (logic 1) or inverted (logic 0). The supervisory interval, or supervisory field, consists of four cycles of carrier off on the control bus. The dialogic bit on the control bus is an in-phase sine wave (logic 1). The address and control data in figure 9-2 are shown as all zeros. This is known as a dummy word and is sent when no commands are being sent. Dummy words are sent because we must have a continuous carrier on the line if we are to signal the beginning of a word by turning the carrier off.

The monitor bus normally does not have a continuous sine wave. A sine wave is placed on the bus only when a DCU is responding. The supervisory interval on the monitor bus consists of four cycles of carrier on. This is followed by the dialogic bit, which is a logic 0. The address field and monitor data are shown in figure 9-2 as all ones. This has no particular significance. The address is generated by the counter in the DCU. The strapping will determine what address will be generated. This address will be the same one recognized in the control word.

The carrier bus is so called because it has a pure carrier; that is, there is no modulation. Its purpose is twofold; it keeps track of the bit time slots and it establishes a phase reference. This signal will be converted to a square wave in the DCU. This square wave will be known as the bit clock signal and will step the counter in the DCU and maintain timing in the DCU and DCFE.

CCCS BUS CONTROL WORD FORMATS

The radio receiver and transmitter are each controlled by four different 32-bit control words and the maintenance display is serviced by three similar control words. Tables 9-1 through 9-6 identify the data contained in each bit of these 11 control words.

Each control word transmitted by the computer on the CCCS control bus is addressed to a specified DCU by bits 1 through 5 of the control word (figure 9-1). Strapping on the DCU's permit the DCU to accept only those control words containing their unique address. Other DCUs on the control bus take no action on control words not containing their address. When a DCU recognizes its address in a control word, subaddress bits 6 and 7 (figure 9-1) route the information in the data field to the proper location in the device control functional elements (DCFE). The four possible subaddresses are represented in bits 6 and 7 as logic 0-0, 0-1, 1-0, and 1-1. Binary addresses of the radio equipment DCU's appearing in bits 1 through 5 are as follows:

Receiver DCU 0-0-1
Exciter DCU 0-1-0
Antenna coupler DCU 0-1-1
Power amplifier DCU 1-0-0
A/D Converter DCU 1-1-0
(AN/TSC-60 (V1))
Maintenance display DCU 1-1-1

CCCS BUS MONITOR WORD FORMATS

After a DCU recognizes an address directed to it, the data field is passed on to the radio equipment through the appropriate DCFE. The DCFE and/or the radio equipment decodes the control data and performs the required function (frequency change, mode select, etc.). A response is then generated by the DCFE and the radio equipment. This response constitutes bits 6 through 31 (figure 9-1) and is applied to the DCU. A dialogic bit (logic 0), the 5-bit address field, and 2-bit subaddress are added by the DCU to form the complete monitor word that is transmitted to the computer. Tables 9-7 through 9-11 identify the information contained in each bit of the monitor words originated by the receiver, the transmitter, and the maintenance display.

CARRIER (CLOCK) BUS

The carrier bus is a 4800 Hz sine-wave signal with a nominal 1-volt peak-to-peak (line-to-line) amplitude. This signal is generated by the hybrid bus driven on accessible memory card A7A6. Bit timing and word transfer rate on the control and monitor buses are controlled by this carrier signal.

CONTROL BUS

The control bus contains 36-bit word intervals consisting of a 4-bit supervisory field followed by 32 bits of binary data (figure 9-1). The supervisory field is transmitted as carrier off and synchronizes the sine-wave data with the carrier bus signal. Data sine-wave signals in phase with the carrier (true) signal result in

Table 9-1

CCCS BUS CONTROL WORDS: TRANSMITTER

	BIT NO.	CONTROL WORD 1 (frequency)	EXCITER DCU 010	ANT. CPLR. DCU 011 (490X-1)	ANT. CPLR. DCU 011 (490T-8)	PWR. AMP. DCU 100
	0	Logic 1 (dialogic)	X	X	X	X
	1	Logic 0 (radio	X	X	X	X
	2	Logic 1 group)	X	X	X	X
	3	DCU	X	X	X	X
	4	|	X	X	X	X
	5	ADDRESS	X	X	X	X
	6	Logic 0 (sub-	X	X	X	X
	7	Logic 0 address)	X	X	X	X
1	8	Parity	X	X	X	X
2	9	Not used				
3	10	10 MHz (2)	X	X	X	X
4	11	10 MHz (1)	X	X	X	X
5	12	1 MHz (8)	X	X	X	X
6	13	1 MHz (4)	X	X	X	X
7	14	1 MHz (2)	X	X	X	X
8	15	1 MHz (1)	X	X		X
9	16	100 KHz (8)	X	X		X
10	17	100 KHz (4)	X	X		X
11	18	100 KHz (2)	X	X		X
12	19	100 KHz (1)	X	X		X
13	20	10 KHz (8)	X			
14	21	10 KHz (4)	X			
15	22	10 KHz (2)	X			
16	23	10 KHz (1)	X			
17	24	1 KHz (8)	X			
18	25	1 KHz (4)	X			
19	26	1 KHz (2)	X			
20	27	1 KHz (1)	X			
21	28	0.1 KHz (8)	X			
22	29	0.1 KHz (4)	X			
23	30	0.1 KHz (2)	X			
24	31	0.1 KHz (1)	X			

NOTE: Numbers in parenthesis indicate BCD.
Symbol "X" indicates a bit ~~is~~ to be used by the DCU.
all others are not responded to by equipment

Table 9-2

CCCS BUS CONTROL WORDS: TRANSMITTER

BIT NO.	CONTROL WORD 2 (mode)	EXCITER DCU 010	ORTHO ANT. CPLR. DCU 011 (490X-1)	WHIP ANT. CPLR. DCU 011 (490T-8)	PWR. AMP. DCU 100
0	Logic 1 (dialogic)	X	X	X	X
1	Logic 0 (radio	X	X	X	X
2	Logic 1 group)	X	X	X	X
3	DCU	X	X	X	X
4	|	X	X	X	X
5	ADDRESS	X	X	X	X
6	Logic 0 (sub-	X	X	X	X
7	Logic 1 address)	X	X	X	X
8	Parity	X	X	X	X
9	Not used				
10	VOX enable	X			
11	Simplex enable	X			
12	B1 channel enable	X			
13	Not used				
14	A1 channel enable	X			
15	Not used				
16	Not used				
17	Self-test	X			
18	B2 channel enable	X			
19	CW enable	X			
20	AM enable	X			
21	Not used				
22	A2 channel enable	X			
23	Not used				
24	Not used				
25	Exciter tune (not necessary with oscar)	X (to Tune Exciter)	X	X	X
26	(Medium power)*				(X)
27	Low power				X
28	P. A. tune				(not necessary w/oscar) X
29	Transmitter enable (power on)	X (to Turn on)			X (To Turn on)
30	Plate on				X (To Turn on)
31	Key	X (to Turn on)	X	X	X (To Turn on)

*Can be sent only with 7404A-1. (oscar)

NOTE: Symbol "X" indicates a bit ~~is~~ can be used by the DCU.
all others are not responsive

Table 9-3

CCCS CONTROL WORDS: TRANSMITTER

BIT NO.	CONTROL WORD 3 (carrier level) Exciter, DCU 010	CONTROL WORD 3 (A/D mux address) A/D Conv. or P. A. DCU	CONTROL WORD 4 (mon. request) All DCU's
0	Logic 1 (dialogic)	Logic 1 (dialogic)	Logic 1 (dialogic)
1	Logic 0 (radio	Logic 0 (radio	Logic 0 (radio
2	Logic 1 group)	Logic 1 group)	Logic 1 group)
3	Logic 0	DCU	DCU
4	Logic 1 (exciter)	↕	↕
5	Logic 0	ADDRESS	ADDRESS
6	Logic 1 (sub-	Logic 1 (sub-	Logic 1 (sub-
7	Logic 0 address)	Logic 0 address)	Logic 1 address)
8	Parity	Parity	Logic 0 (parity)
9	Not used	Not used	Logic 0
10	↕	Not used	↕
11	↕	A/D address (16)	↕
12	↕	A/D address (8)	↕
13	↕	A/D address (4)	↕
14	↕	A/D address (2)	↕
15	↕	A/D address (1)	↕
16	↕	Not used	↕
17	↕	↕	↕
18	↕	↕	↕
19	Not used	↕	↕
20	Carrier level (8)	↕	↕
21	Carrier level (4)	↕	↕
22	Carrier level (2)	↕	↕
23	Carrier level (1)	↕	↕
24	Not used	↕	↕
25	↕	↕	↕
26	↕	↕	↕
27	↕	↕	↕
28	↕	↕	↕
29	↕	↕	↕
30	↕	↕	↕
31	Not used	Not used	Logic 0

NOTE: Numbers in parenthesis indicate weighted BCD.

Table 9-4

CCCS BUS RECEIVER CONTROL WORDS

DCU Address 001

BIT NO.	CONTROL WORD 1 (freq word)	CONTROL WORD 2 (mode word)	CONTROL WORD 3 (squelch word)	CONTROL WORD 4 (mon request word)
0	Logic 1 (dialogic)	Logic 1 (dialogic)	Logic 1 (dialogic)	Logic 1 (dialogic)
1	0 (radio	0 (radio	0 (radio	0 (radio
2	1 group)	1 group)	1 group)	1 group)
3	0 (4) DCU	0 (4) DCU	0 (4) DCU	0 (4) DCU
4	0 (2) address	0 (2) address	0 (2) address	0 (2) address
5	1 (1)	1 (1)	1 (1)	1 (1)
6	Logic 0 ⎤ subaddress	Logic 0 ⎤ subaddress	Logic 1 ⎤ subaddress	Logic 1 ⎤ subaddress
7	Logic 0 ⎦	Logic 1 ⎦	Logic 0 ⎦	Logic 1 ⎦
8	Parity bit	Parity bit	Parity bit	Parity bit
9	Spare	Receiver mute	Logic 0 (not used)	Logic 0
10	10 MHz (2)	Logic 0	Logic 0	Logic 0
11	10 MHz (1)	Logic 0	Logic 0	Logic 0
12	1 MHz (8)	B2 channel data enable	Logic 0	Not used
13	1 MHz (4)	B2 channel voice enable	Logic 0	Not used
14	1 MHz (2)	A2 channel data enable	Logic 0	Not used
15	1 MHz (1)	A2 channel voice enable	Logic 0	Not used
16	100 kHz (8)	Logic 0	Logic 0	Not used
17	100 kHz (4)	Self-test	Logic 0	Not used
18	100 kHz (2)	B1 channel data enable	Logic 0	Not used
19	100 kHz (1)	Logic 0	Logic 0	Not used
20	10 kHz (8)	AM enable	Logic 0	Not used
21	10 kHz (4)	B1 channel voice enable	Logic 0	Not used
22	10 kHz (2)	A1 channel data enable	Logic 0	Not used
23	10 kHz (1)	A1 channel voice enable	Logic 0	Not used
24	1 kHz (8)	Self-test low level	B squelch (8)	Not used
25	1 kHz (4)	Logic 0 (bits not used)	B squelch (4)	Not used
26	1 kHz (2)	Logic 0	B squelch (2)	Not used
27	1 kHz (1)	Logic 0	B squelch (1)	Not used
28	0.1 kHz (8)	Logic 0	A squelch (8)	Not used
29	0.1 kHz (4)	~~Power on~~	A squelch (4)	Not used
30	0.1 kHz (2)	Logic 0	A squelch (2)	Not used
31	0.1 kHz (1)	Logic 0	A squelch (1)	Not used

Data Field

NOTE: 1. Numbers in parenthesis indicate weighted BCD.
2. Not used indicates don't care.

Table 9-5

CCCS BUS MAINTENANCE DISPLAY UNIT CONTROL WORDS

BIT NO.	white lights CONTROL WORD 1	multimeter CONTROL WORD 3	Amber lights CONTROL WORD 2
0	Logic 1 (dialogic)	Logic 1 (dialogic)	Logic 1 (dialogic)
1	logic 0 } radio group	logic 0 } radio group	logic 0 } radio group
2	logic 1	logic 1	logic 1
3	(4) logic 1 } maintenance display unit address	(4) logic 1 } maintenance display unit address	(4) logic 1 } maintenance display unit address
4	(2) logic 1	(2) logic 1	(2) logic 1
5	(1) logic 1	(1) logic 1	(1) logic 1
6	Logic 0 } subaddress	Logic 1 } subaddress	Logic 0 } subaddress
7	Logic 0	Logic 0	Logic 1
8	Parity bit	Parity bit	Parity bit
9	Monitor data*	Pwr ampl pwr interrupt	Spare
10	Monitor data*	Pwr ampl pwr fault summary	Spare
11	Monitor data*	Pwr ampl tune fault summary	Spare
12	Monitor data*	Filament timer	Spare
13	Monitor data*	A/d complete	Spare
14	Monitor data*	A/d sign	Spare
15	Monitor data*	A/d overrange	Spare
16	Monitor data*	A/d output (8) } hundreds	Spare
17	Monitor data*	A/d output (4)	Spare
18	Monitor data*	A/d output (2)	Spare
19	Monitor data*	A/d output (1)	Spare
20	Monitor data*	A/d output (8) } tens	Spare
21	Monitor data*	A/d output (4)	Spare
22	Monitor data*	A/d output (2)	Display control fault
23	Monitor data*	A/d output (1)	Receiver control fault
24	Monitor data*	A/d output (8) } units	Exciter control fault
25	Monitor data*	A/d output (4)	Power amplifier control fault
26	Monitor data*	A/d output (2)	Antenna coupler control fault
27	Monitor data*	A/d output (1)	Parity error control fault
28	Monitor data*	Spare	No response control fault
29	Monitor data*	Spare	Address error control
30	Monitor data*	Spare	Radio fault
31	Monitor data*	Spare	Operate

NOTE:

1. *Data contained in these bits is the equipment DCU monitor data requested by bits 17 through 21 of the maintenance display unit monitor word.
2. Numbers in parentheses indicate weighted BCD.
3. Spare bits are transmitted as logic 0.

Table 9-6

915X-2 CONTROL AND MONITOR WORDS
AN/TSC-60 (V1) only

CONTENT AND FORMAT			CONTENT AND FORMAT		
BIT NO.		CONTROL WORD 3	BIT NO.		MONITOR WORD 2 (ANALOG)
0		Dialogic bit (1)	0		Dialogic bit (0)
1	Logic 0	Radio Group	1	Logic 0	Radio Group
2	Logic 1		2	Logic 1	
3	Logic 1		3	Logic 1	
4	Logic 1	A/D Converter	4	Logic 1	A/D Converter
5	Logic 0		5	Logic 0	
6		DCFE subaddress (1)	6		DCFE subaddress
7		DCFE subaddress (0)	7		DCFE subaddress
8		Parity	8		Parity
9		Not used	9		Power interrupt
10		A/d inhibit	10		Power fault summary
11		A/d mux address 16	11		Not used
12		A/d mux address 8	12		Not used
13		A/d mux address 4	13		A/d complete
14		A/d mux address 2	14		A/d sign
15		A/d mux address 1	15		A/d overrange (100)
16		Not used	16		A/d output (80)
17		Not used	17		A/d output (40)
18		Not used	18		A/d output (20)
19		Not used	19		A/d output (10)
20		Not used	20		A/d output (8)
21		Not used	21		A/d output (4)
22		Not used	22		A/d output (4)
23		Not used	23		A/d output (1)
24		Not used	24		A/d output (0.8)
25		Not used	25		A/d output (0.4)
26		Not used	26		A/d output (0.2)
27		Not used	27		A/d output (0.1)
28		Not used	28		Not used
29		Not used	29		Not used
30		Not used	30		Not used
31		Not used	31		Not used

From Receiver To Computer

Table 9-7

CCCS BUS RECEIVER MONITOR WORD

BIT NO.		MONITOR WORD 1	
0		Logic 0 (dialogic)	
1		Logic 0	Radio group
2		Logic 1	Radio group
3	(4)	Logic 0	Receiver
4		Logic 0	Receiver
5	(1)	Logic 1	Receiver
6		*Subaddress	
7		*Subaddress	
8		Parity error bit	
9		Power interrupt	
10		Power fault summary	
11		Loop lock summary	
12		Logic 0	
13		**Logic 0 (high-level self-test fault)	
14		**Logic 0 (low-level self-test fault)	
15		Logic 0	
16		Tune complete	
17		9.9 kHz lock	Summed in bit 11
18		10 kHz lock	Summed in bit 11
19		9.9 MHz lock	Summed in bit 11
20		250 kHz lock	Summed in bit 11
21		243.71 kHz lock	Summed in bit 11
22		256.29 kHz lock	
23		Logic 0	
24		Logic 0	
25		RF overload	
26		Receive RF translator out	
27		AGC monitor	
28		A1 channel receive audio	
29		B1 channel receive audio	
30		A2 channel receive audio	
31		B2 channel receive audio	

*Subaddress bits 6 and 7 are logic 0-0 in response to control word 1, logic 0-1 in response to control word 2, logic 1-0 for control word 3, and logic 1-1 for control word 4.

**Bits 13 and 14 are transmitted as logic 0 from the receiver and are modified by the computer program before transmission to the maintenance display.

Maintenance display etc.

Lamps

Rcv + Exc

Logic level one will indicate either a fault or absence of something

Tran P.A. To Computer

Table 9-8

CCCS BUS TRANSMITTER POWER AMPLIFIER MONITOR WORD

AN/TSC-60 (V1)

BIT NO.	1 KW POWER AMPLIFIER MONITOR WORD (responds to power amplifier control words 1, 2, and 4)
0	Logic 0 (dialogic)
1	Logic 0 (radio
2	Logic 1 group)
3	Logic 1
4	Logic 0 Power amplifier
5	Logic 0
6	Subaddress
7	Subaddress
8	Parity bit
9	Power interrupt
10	Plate current overload
11	Tune fault summary
12	Strapped to Logic 0
13	Pwr ampl operate request
14	Pwr ampl tune complete
15	Strapped to logic 0
16	Tune fault
17	Reflected power fault
18	Key monitor
19	RF volt fault
20	Forward power
21	RF input
22	High-voltage monitor
23	Low-voltage monitor
24	Logic 0
25	Logic 0
26	Logic 0
27	Logic 0
28	Logic 0
29	Logic 0
30	Logic 0
31	Logic 0

From Equipment To Computer

Table 9-9

CCCS BUS TRANSMITTER POWER AMPLIFIER MONITOR WORDS AN/TSC-60 (V2) and AN/TSC-60 (V3)

BIT NO.	2.5 KW AND 10 KW PWR AMPLIFIER MONITOR WORD 2 (responds to transmit control word 3)	2.5 KW AND 10 KW PWR AMPLIFIER MONITOR WORD 1 (responds to transmit control words 1, 2, and 4)
0	Logic 0 (dialogic)	Logic 0 (dialogic)
1	Logic 0 (radio	Logic 0 (radio
2	Logic 1 group)	Logic 1 group)
3	(4) Logic 1 Power Amplifier	(4) Logic 1 Power Amplifier
4	(2) Logic 0	(2) Logic 0
5	(1) Logic 0	(1) Logic 0
6	Subaddress	Subaddress
7	Subaddress	Subaddress
8	Parity bit	Parity bit
9	Power interrupt	Power interrupt
10	Power fault summary	Power fault summary
11	Tune fault summary	Tune fault summary
12	Filament timer	Strapped to logic 0
13	A/d complete	Pwr ampl operate request
14	A/d sign bit	Pwr ampl tune complete
15	A/d overrange indicator	Strapped to logic 0
16	A/d output (8) hundreds	Tune fault
17	A/d output (4)	Reflected power fault
18	A/d output (2)	Key monitor
19	A/d output (1)	Pwr ampl plate current fault
20	A/d output (8) tens	Pwr ampl screen current fault
21	A/d output (4)	RF input monitor
22	A/d output (2)	Access plug interlock fault
23	A/d output (1)	Circuit breaker fault
24	A/d output (8) units	Antenna interlock monitor
25	A/d output (4)	Regulator monitor
26	A/d output (2)	Blower transfer
27	A/d output (1)	Servo-error bit 2
28	Not used	Servo-error bit 1
29	Not used	Tune sequence position A
30	Not used	Tune sequence position B
31	Not used	Tune sequence position C

From Equipment To Computer

Table 9-10

CCCS BUS TRANSMITTER EXCITER AND ANTENNA COUPLER MONITOR WORDS

BIT NO.	EXCITER MONITOR WORD	ANTENNA COUPLER MONITOR WORD (490T-8)	ANTENNA COUPLER MONITOR WORD (490X-1)
0	Logic 0 (dialogic)	Logic 0 dialogic)	Logic 0 (dialogic)
1	Logic 0 (radio	Logic 0 (radio	Logic 0 (radio
2	Logic 1 group)	Logic 2 group)	Logic 1 group)
3	(4) Logic 0	(4) Logic 0	(4) Logic 0
3	(2) Logic 1 Exciter	(2) Logic 1 Ant.	(2) Logic 1 Ant.
5	(1) Logic 0	(1) Logic 1 Cplr.	(1) Logic 1 Cplr.
6	Subaddress	Subaddress	Subaddress logic 1
7	Subaddress	Subaddress	Subaddress logic 1
8	Parity error	Parity error	Parity error
9	Power interrupt	Power interrupt	Power interrupt
10	Power fault summary	Power fault summary	RF overvoltage
11	Loop lock summary	Tune fault summary	Tune fault summary
12	Coupler present	Coupler tune complete	Coupler tune complete
13	Logic 0	Logic 0	Logic 0
14	Logic 0	Logic 0	Logic 0
15	Transmit gain control monitor	Logic 0	Logic 0
16	Tune complete	Arc fault	*Sequence code A
17	9.9 kHz lock (Summed in bit 11)	Tune fault	*Sequence code B
18	10 kHz lock (Summed in bit 11)	Temperature fault	*Sequence code C
19	9.9 MHz lock (Summed in bit 11)	Transmit RF	Transmit RF
20	250 kHz lock (Summed in bit 11)	Spare	Series circuit in
21	243.71 kHz lock (Summed in bit 11)	Spare	Phasing maximum
22	256.29 kHz lock (Summed in bit 11)	Spare	Phasing minimum
23	Logic 0	Spare	Loading maximum
24	Logic 0	Spare	Loading minimum
25	Multiplex combiner output	Spare	6-ft closed
26	Transmit RF transmitter output	Spare	6-ft open
27	Transmit IF amplifier output	Spare	4-ft closed
28	A1 channel transmit IF	Spare	4-ft open
29	B1 channel transmit IF	Spare	1.5-ft closed
30	A2 channel transmit IF	Spare	1.5-ft open
31	B2 channel transmit IF	Spare	Keyinterlock closed

*Tune sequence code defined as follows:

BIT 16 (A)	BIT 17 (B)	BIT 18 (C)	TUNE STEP
1	0	0	1-tune start
1	1	0	2-home
1	1	1	3-receive
0	1	1	4-preposition
0	0	1	5-tune
0	0	0	6-operate
0	1	0	Illegal
1	0	1	Illegal

Table 9-11

From SB-3390 To OK 145

CCCS BUS MAINTENANCE DISPLAY MONITOR WORD (Request)

BIT NO.	MAINT DISPLAY MONITOR WORD
0	Logic 0 (dialogic)
1	Logic 0 (radio
2	Logic 1 group)
3	(4) Logic 1
4	(2) Logic 1 Maintenance Display
5	(1) Logic 1
6	Subaddress – Same as control word causing transmission
7	Subaddress – Same as control word causing transmission
8	Parity result
9	Power interrupt
10	Logic 0
11	A/d mux address (16) – multimeter
12	A/d mux address (8) – multimeter
13	A/d mux address (4) – multimeter
14	A/d mux address (2) – multimeter
15	A/d mux address (1) – multimeter
16	Radio control self-test enable
17	Antenna coupler display request
18	Receiver display request
19	Exciter display request
20	Pwr amplifier display request
21	Pwr amplifier analog display request
22	Spare
23	Spare
24	Spare
25	Spare
26	Spare
27	Spare
28	Spare
29	Spare
30	Spare
31	Spare

when Oscar is used as the Local Control, switch positions indicate the control word going out. The lights indicate the monitor data coming in.

when Oscar is used as the piece of equipment, switch positions indicate the monitor data going out, the lights indicate the Control word coming in

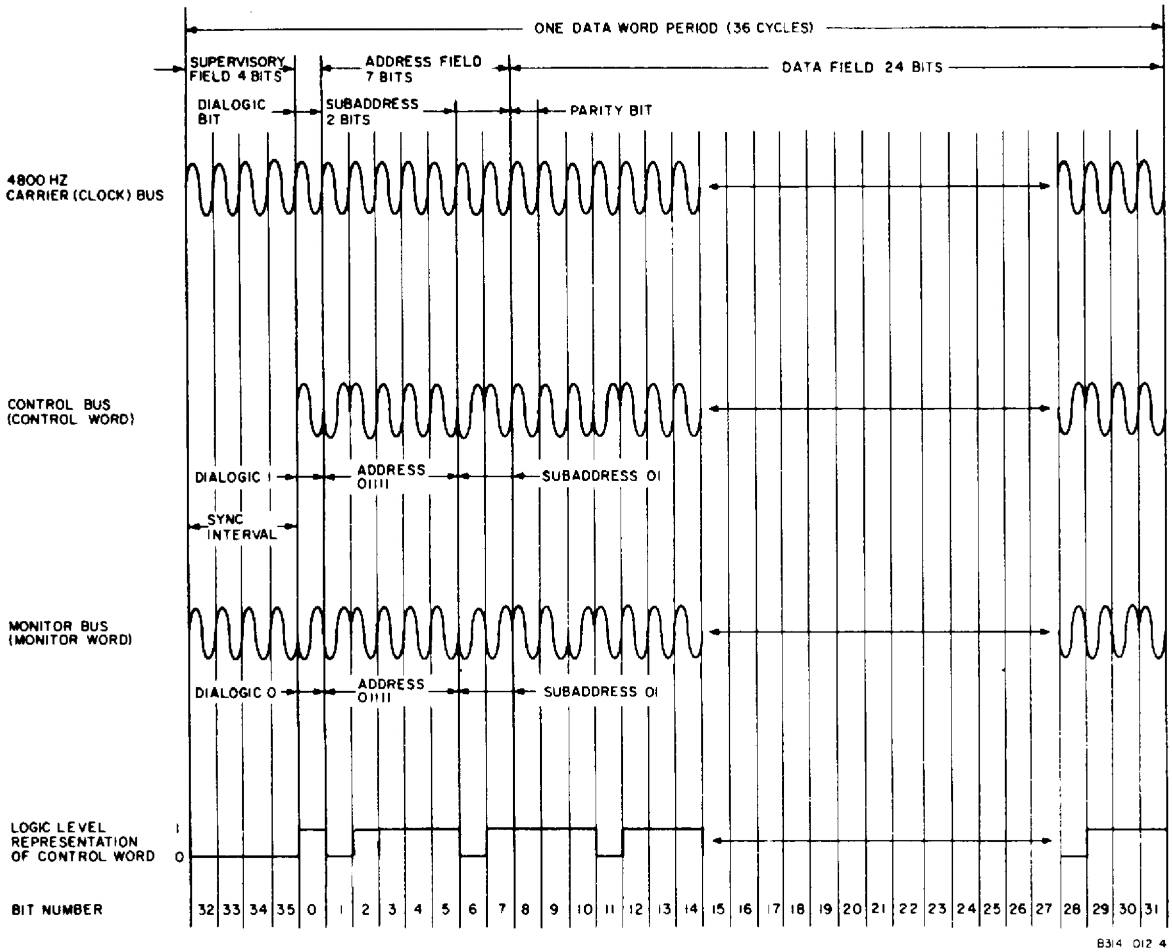

Figure 9-3. CCCS Bus Signal Relationship

a logic 1. The sine-wave data on the control bus is applied to the control bus by the modulator section of accessible memory card A7A6.

As indicated in figure 9-3, each word transmitted on the control bus is composed of a dialogic bit (always logic 1), a 7-bit address field, and a 24-bit data field. The address field is divided into a 5-bit DCU address field and a 2-bit subaddress for second-level routing within the DCU. The first bit of the data field (bit 8) is the parity bit that is encoded so that bits 8 through 31 contain an even number of logic 1's. Bits 9 through 31 contain instructions that operate and/or control the radio equipment.

MONITOR BUS

The monitor bus contains response words from the controlled radio equipment. These words are also transmitted in a 36-bit format as illustrated in figure 9-3 and are timed to follow the control word. However, the supervisory field is composed of four biphase logic 1's, instead of 4 bits of carrier off, and the dialogic bit is always a logic 0. The address field contains the same address as the associated control word. Information contained in the monitor word originates in the radio equipment. The associated DCU accepts digital data from the radio equipment, converts this digital data to biphase modulated sine-wave data, and transmits the data to the computer on the monitor bus.

NOTES