Omri Serlin

Bell System Data Communications

TECHNICAL REFERENCE

WIDEBAND DATA STATIONS 303 TYPE

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August 1966

American Telephone & Telegraph Company

Engineering Director Data Communications

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ENGINEERING DIRECTOR DATA COMMUNICATIONS

PREFACE

This specification is solely intended for designers of business machine equipment to be used with Bell System 303-type wideband data station equipment in wideband data service.

If additional details on the interface and its operation are needed, please contact:

Engineering Director – Data Communications
American Telephone and Telegraph Company
195 Broadway
New York, N.Y. 10007

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GENERAL

This reference describes standard 303-type wideband data stations for use in the transmission of serial binary synchronous or nonsynchronous data over half-group, group, or supergroup facilities. It describes interface arrangements and points out the differences of these standard 303-type data stations from the earlier, "Interim" or "Model Shop" design X303A-type units that were described in the Preliminary Interface Specification dated October, 1964 and Supplement 1 dated July, 1965.

The 303-type wideband data station equipment is normally located at the customer's premises and provides the interface between his business machine equipment and the wideband data transmission system. The transmission system provides a full duplex wideband data channel for high speed data transmission using 303-type data sets and a full duplex voice frequency channel for coordination.

The 303-type data station is a versatile terminal that can be used to couple any of several kinds of business machines to transmission facilities generally provided for telephone service. The only imperfections in signals delivered to the distant business machines are probabilistic. There is a small probability that some of the bits will be in error, and that transitions in the data will depart somewhat from ideal timing.

The Data Sets 303-type condition the baseband signals for optimum performance over the various types of local and toll facilities encountered in telephone plant. Local cables must be specially conditioned and require the use of wideband amplifiers and equalizers to provide flat response over the required bandwidth. Where carrier systems are involved in either local or toll facilities, special wideband modulators and demodulators are used to handle the frequency spectrum of these half-group, group and supergroup services. They replace the voice channel units normally used on these carrier systems. The wide frequency spectrum that must be made available for these services requires that large numbers of voice channels be reassigned to other facilities. Because of the high degree of custom engineering and the installation of special equipment, these wideband services take a considerable amount of time to provide. In view of this fact, the prospective customer should contact the Telephone Company at the earliest possible time in his planning stages for any of these wideband services.

Three speed categories are available with this equipment. The highest speed capability is over a "Supergroup" channel which uses the bandwidth of 60 voice circuits, and is a convenient breakdown of bandwidth of telephone carrier systems. On a supergroup facility, a synchronous speed of 230.4 kilobits per second is available. The next lower convenient breakdown is the "group" channel which uses the bandwidth of 12 voice circuits. The 303-type equipment can transmit at a synchronous speed of 50 kilobits per second over group facilities. The group channel can be divided in half and provides the third speed category – 19.2 kilobits per second. Half of the group channel can be used to provide 6 regular voice circuits if desired. The clock speeds for synchronous operation of the 303-type equipment are:

230.4 kilobits/second for	supergroup facilities
50 kilobits/second for	group facilities
19.2 kilobits/second for	half-group facilities

Speeds of 18.75, 40.8 and 200 kilobits/second will be available for special applications.

When operated in the nonsynchronous mode, these data systems using 303-type equipment will accept and deliver nonsynchronous signals with a minimum signal element width of:

4.3 microseconds for	supergroup facilities
20 microseconds for	group facilities
52 microseconds for	half-group facilities

The nonsynchronous mode of operation is used with nonsynchronous serial devices such as 2-level black and white baseband facsimile equipment and with special government equipment for the transmission of encrypted data at 50 kilobits per second. The synchronous mode is used with synchronous serial equipment such as magnetic tape terminals and computers. A data station that is equipped with a clock for fixed-speed synchronous operation can also be operated in the nonsynchronous mode by the application of a control signal at the interface between the business machine equipment and the data station equipment. This arrangement is attractive from the customer's standpoint since it becomes possible to operate with magnetic tape terminals and facsimile equipment, for example, on an alternate use basis, using the same data station equipment

Synchronous business machines normally accomplish control functions and error check

operations by means of information contained in the wideband serial bit stream, whereas at least one type of nonsynchronous facsimile machine requires the transmission of control functions such as paper advance and "fault" indication over a channel separate from the wideband channel. This is accomplished in the 303-type wideband Data Station by the use of low speed parallel data transmission over the voice frequency coordination channel. Where no voiceband data sets are employed, it is possible to talk at the same time wideband data is being transmitted.

Figures 1 and 2 show the wideband data station cabinet designed to house the Data Set 303 and all auxiliary units. The Data Auxiliary Set 809 B1 shown on the lower tier will be omitted in group or supergroup services. The voiceband Data Set 404B1 will be omitted in the usual synchronous application. The cabinet measures 24" high x 24" wide x 12" deep and makes an attractive floor mounted installation.

A smaller cabinet is also available for group or supergroup services (where the 809B1 is not needed) as shown on Figure 3. However, the designers of the cabinet feel that it is somewhat tall for desk top mounting and too low for floor mounting. It may find use in shelf mounted installations or other similar applications.

The 303-type wideband data set is basically the same for all three speed categories, differing only in frequency and speed determining components. Extensive use has been made of plug-in circuit boards for flexibility. The basic choices in 303-type data stations are synchronous (with choice of internal or external clock) or nonsynchronous in each of the speed categories mentioned earlier with the added choice of equipment for slow speed control functions where required. There are of course, special arrangements, such as for certain government applications where a balanced interface is required (as opposed to the normal unbalanced interface) with 50 kilobit/second nonsynchronous operation. Also, there are a number of features and options that must be selected by the Telephone Companies based on the type of wideband transmission facilities to be used. The 303-type data sets are coded with a letter suffix to denote the speed capability and a numeral to denote combinations of features. At present there are 4 synchronous speeds available and the following letters are assigned for them:

Suffix Letter	Synchronous Speed
B	19.2 kilobits/second
C	50 kilobits/second
D	230.4 kilobits/second
E	200 kilobits/second

Suffix numerals 1 through 18 are assigned to denote the various combinations of features. It is not expected that the customer would normally request a data set by specific suffix number. He would probably request, for example, a nonysnchronous data station to work with certain facsimile equipment on a group band channel. The specific code for the data set in this case would be Data Set 303C1 or 303C2 depending upon whether or not a 50% or a 100% roll-off filter was required by the Telephone Company for transmission reasons. Similarly, a customer might request a synchronous 230.4 kilobit per second data set with internal clock. The specific code in this case might be 303D6 which is a set with internal clock, scrambler and a 100% roll-off filter. A section entitled "303-type Data Set Coding" is included. It enables one to select a specific code if desired.

The following paragraphs in this section relate to the use of "scramblers" and "descramblers" in the data sets when used with synchronous business machines. The scrambler is automatically self-synchronizing and is employed to uniformly spread telephone line energy throughout the available bandwidth to avoid crosstalk problems on carrier facilities.

Wideband transmission systems are particularly susceptible to single frequency tone interference. A repeated bit pattern, i.e., alternate ones and zeroes, produces strong single frequencies or tones within the data set. If these tones were to be transmitted continuously over carrier facilities, they could cause crosstalk between voice channels in the carrier system. Scramblers and descramblers are therefore employed in the data set to spread the transmitted energy over the entire frequency spectrum of the wideband data channel and eliminate any predominant single tone. This reduces the chance of crosstalk and permits operating the data channel at optimum signal power levels to produce a good signal to noise ratio.

The serial data stream from the business machine at the transmit end is randomized by the scrambler. At the receiving end, the incoming data stream is descrambled so that the resultant data output to the receiving business machine is the same as that produced by the business machine at the transmit end.

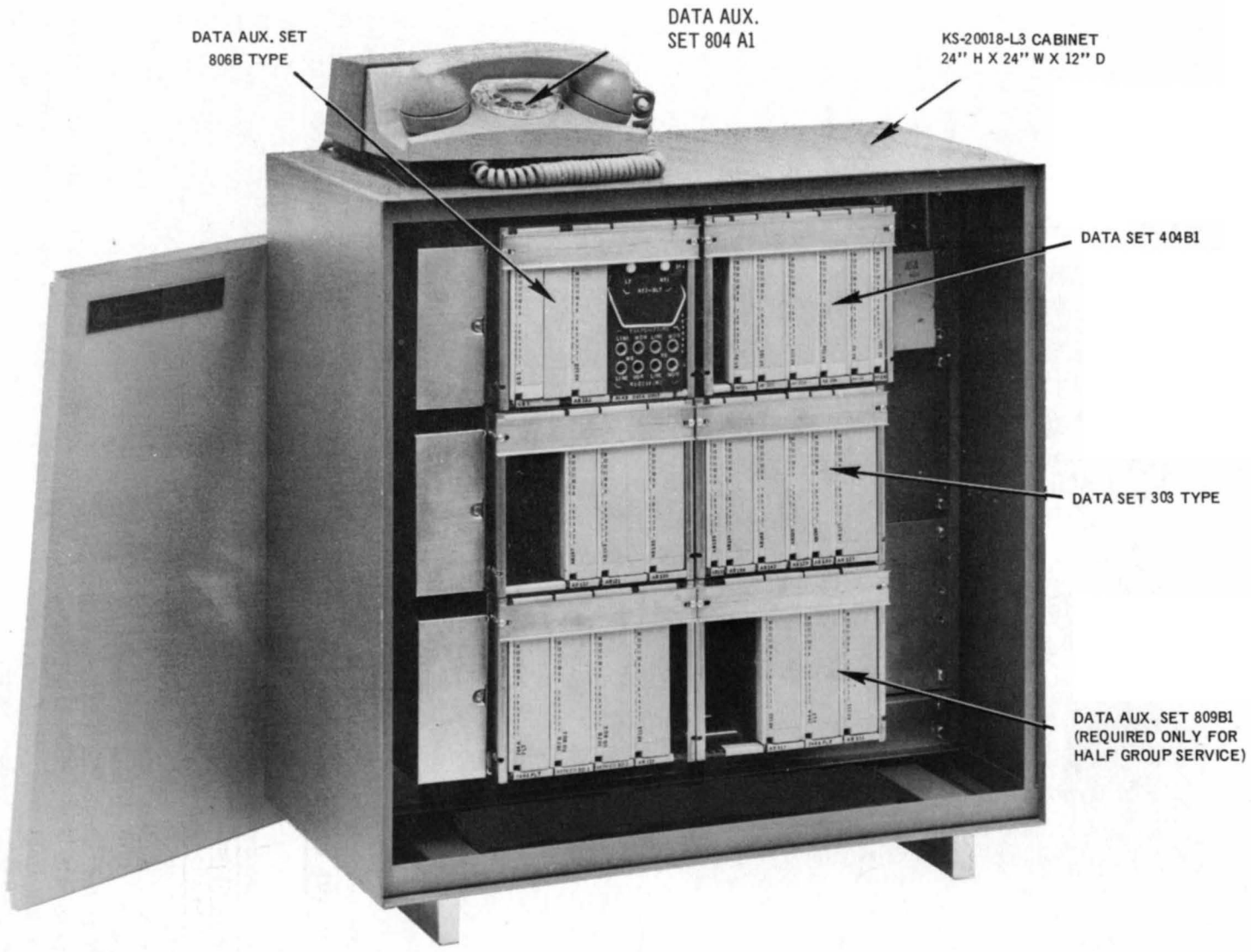


Fig. 1 – Front view, Cover Removed
303 Type Wideband Data Station

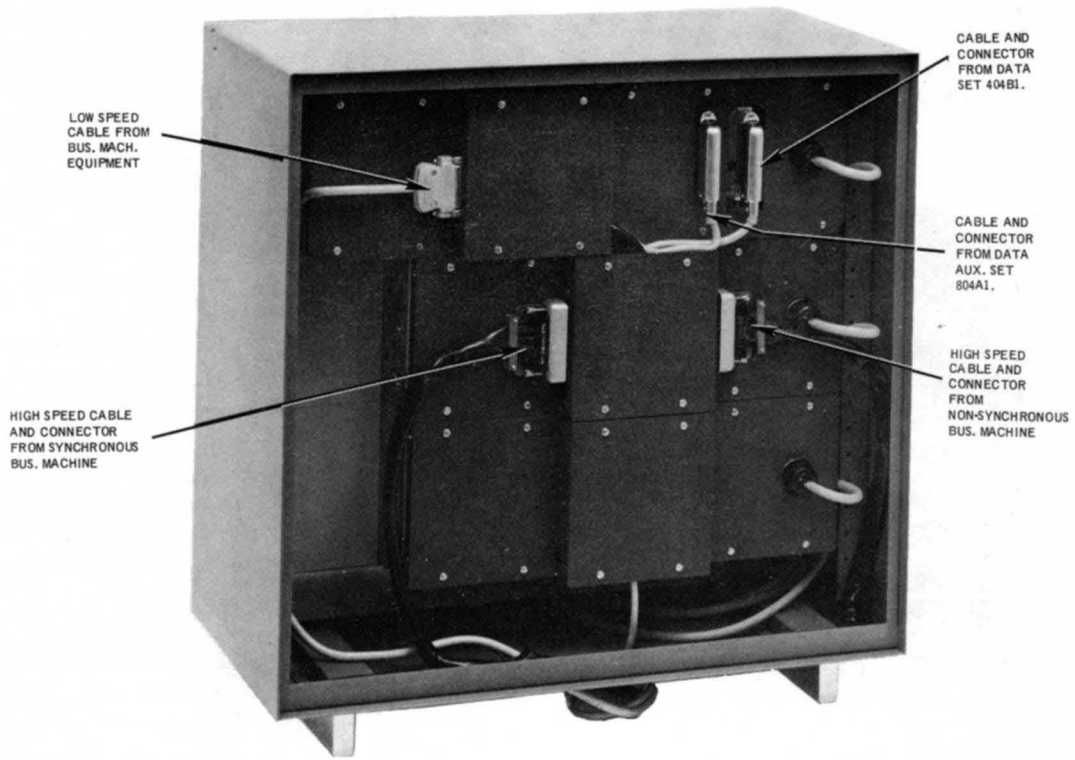


Fig. 2 – Rear View
303 Type Data Station
Equipped With All Auxiliary Units

Caution

1. Synchronous business machines should operate with synchronous 303-type data sets.
2. Synchronous business machines should not present more than 500 successive spaces to 303-type data sets.

The first precaution comes about because only the synchronous 303-type data set can scramble the business machine data. (It is felt that nonsynchronous facsimile type signals will not present the problem of single frequency tone interference due to their inherently random nature.) The second precaution is due to a limitation in the scrambler itself. When the business machine attempts to send steady spaces, the scrambler logic will cause either alternate ones and zeroes to be transmitted or no transitions at all. The alternate ones and zeroes can cause a serious single frequency tone interference problem while the absence of transitions can cause the receiver clock to go off frequency after a time and produce errors when meaningful data transmission is resumed. If a stream of data is interrupted by not more than 500 successive spaces and then meaningful data is again transmitted, no adverse effect should be noticed. The scrambler will be redesigned to provide the capability of scrambling steady spaces but it will not be available initially in standard production sets.

Additional information on the 303-type Wideband Data Station and the wideband transmission system is contained in the following papers presented at the IEEE International Convention in New York, March 1966. They are available in the 1966 IEEE International Convention Record, Part I, Wire and Data Communication.

Write to the Institute of Electrical and Electronic Engineers, Inc., 345 East 47 Street, New York, N.Y. 10017. Prices are: $2.00 for Members and $4.50 for Nonmembers.

Title	Author
The Evolution of Wideband Services	R.T. James, A.T.& T. Co. New York
Transmission Plan for General Purpose Wideband Services	J.J. Mahoney, Jr. Bell Telephone Laboratories Murray Hill, N.J.
A Wideband Data Station	R.D. Fracassi & F.E. Froelich, BTL, Holmdel, N.J.
Transmission Facilities for General Purpose Wideband Services on Analog Carrier Systems	J.S. Ronne, BTL North Andover, Mass.
T1 Carrier Transmission Systems for General Purpose Wideband Services	R. Tarbox, BTL North Andover, Mass.

The Wideband Data Station

The wideband data station equipment can be housed in a cabinet as shown in figures 1, 2 and 3 and located on the customer's premises near his business machine equipment. It can also be mounted on relay racks without a cabinet where required such as in Telephone Company central office buildings. Block diagrams of typical synchronous and nonsynchronous data stations are shown in figures 4 and 5. A complete wideband data station will include some (or all) of the following items:

Wideband Data Station Cabinet

The 24" high cabinet (Per KS20018 L3) shown in figures 1 and 2 can house all of the equipment that makes up the most complete wideband data station including the low-speed data equipment used on the voice frequency coordination channel for facsimile control functions. The unit shown on top of the cabinet is the Data Auxiliary Set 804A1 which has a telephone instrument and circuitry for controlling the voice frequency coordination channel and the wideband facilities. An 18"high cabinet is also available for use when all auxiliary equipment is not required. The designers feel that the smaller cabinet is not suited for desk top or floor mounting but might be useful for shelf mounted or similar installations.

Figure 2 shows a rear view of the data station and shows how units are interconnected by means of cables between them. The synchronous and/or nonsynchronous high-speed business machine connectors are plugged directly into the rear of the 303-type wideband data set as shown. Where applicable, the low-speed connector is plugged directly into the rear of the Data Set 404B1 as shown. The business machine cables are brought into the wideband cabinet through an opening in the bottom.

The wideband data station cabinet also contains a power distribution panel with AC outlets for the various units. Only one AC power connection is required for the data station.

Data Set 303-Type

A detailed description of the Data Set 303-type interface signals is given on the following pages. The wideband data set takes up the middle tier of the cabinet shown in figure 1. The DC power supply is on the left side of the data set. The front of the plug-in circuit boards are shown in figure 1. Locking bars to hold the circuit boards in place can be seen and test points on the boards for use by Telephone Company personnel are visible.

The high-speed nonsynchronous and synchronous connectors are shown plugged into the rear of the data set in figure 2. The detachable power cord is shown plugged into the right side of the data set.

Vestigial Sideband Unit – Data Auxiliary Set 809B1

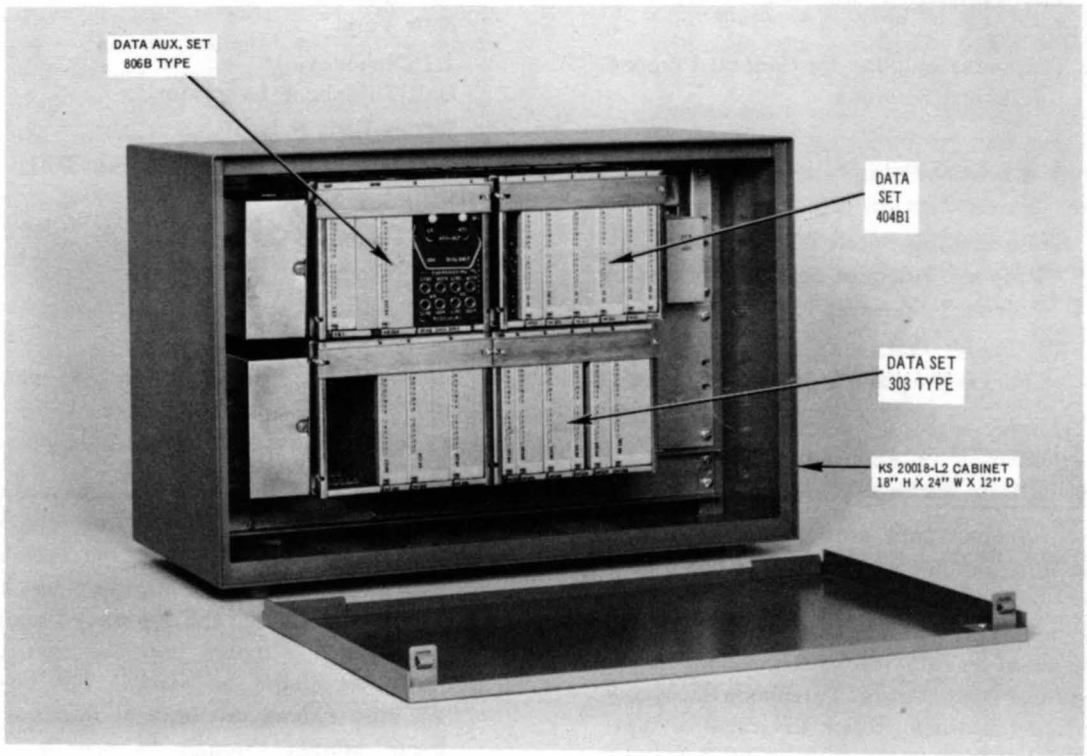


Fig. 3 – Front View

The VSB unit occupies the lower tier of the wideband cabinet shown in figures 1 and 2. At present only the half-group data system uses the Data Auxiliary Set 809B1. This unit modulates the output of the 303B-type (19.2 kilobit per second capability) data set to the proper band for transmission over half-group facilities. The detachable power cord is shown on the right side of the VSB unit in figure 2. Connections between the Data Auxiliary Set 809B1 and the Data Set 303-type are made by means of a cable supplied with the 809B1. This cable cannot be seen in the photographs, since it is underneath the rear cover plates shown on figure 2.

Line Terminating and Test Unit – Data Auxiliary Set 806B-Type

The Data Auxiliary Set 806B-type with its power supply occupies the left half of the top tier of the cabinet shown in figure 1. The jacks on the front are for Telephone Company testing purposes. The 806B can put the wideband station in either of two remote test modes by means of signals from the telephone central office over the voice frequency coordination channel. It can put the wideband data station into the local test mode by means of an "ON" signal from the customer's business machine equipment through the high-speed interface or by means of the test button on the Data Auxiliary Set 804A1. In this mode, the customer's equipment can transmit to itself through the data set with the telephone line disconnected. This feature is extremely valuable in isolating troubles on a system with a minimum of lost time, particularly if the business machine can also transmit to itself locally without the data set.

In the rear view, figure 2, two cables can be seen plugged into the 806B. The cable on the left is from the Data Auxiliary Set 804A1 which is shown on top of the wideband cabinet. The cable on the right is from the Data Set 404B1 described next.

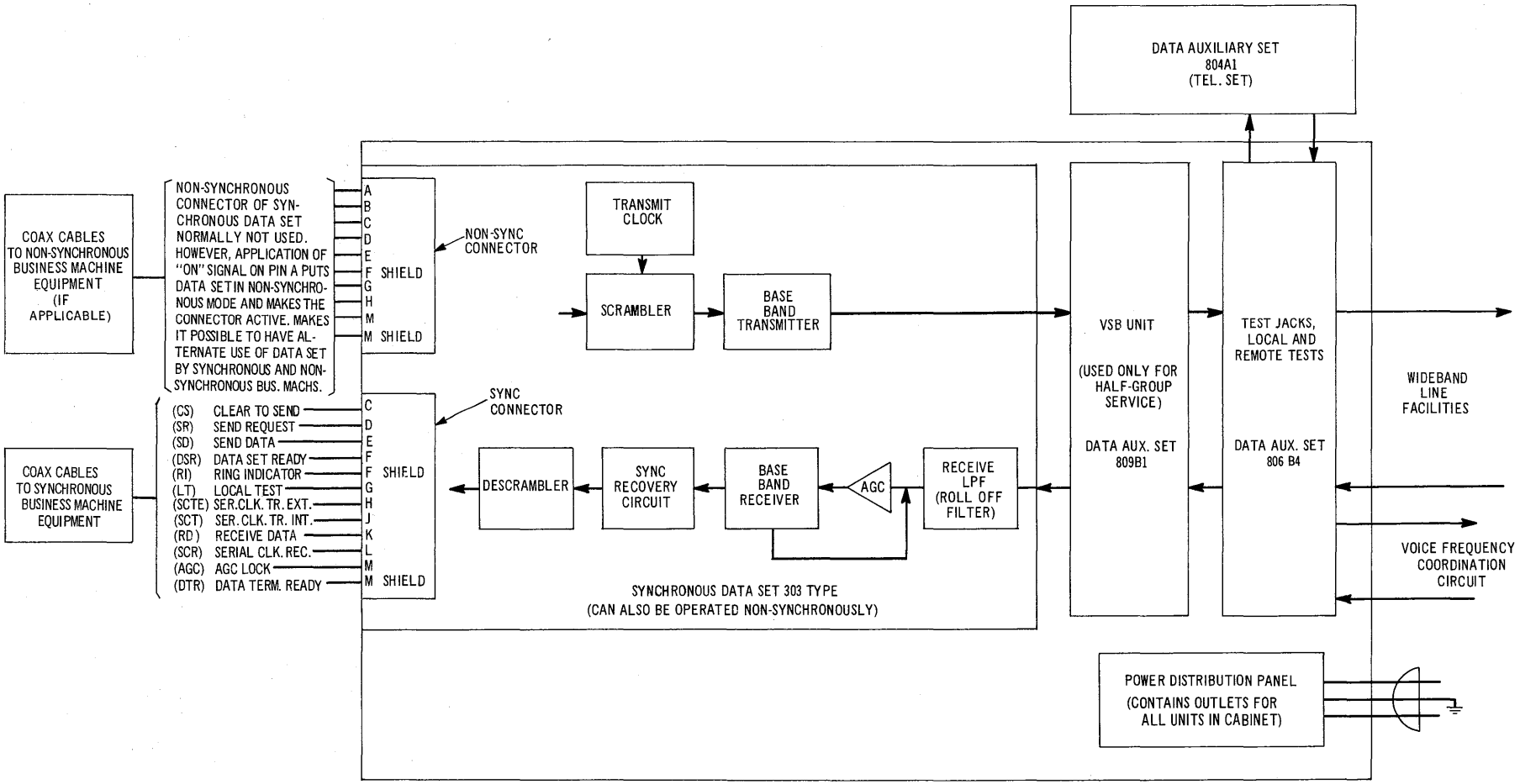


FIGURE 4
TYPICAL SYNCHRONOUS DATA STATION

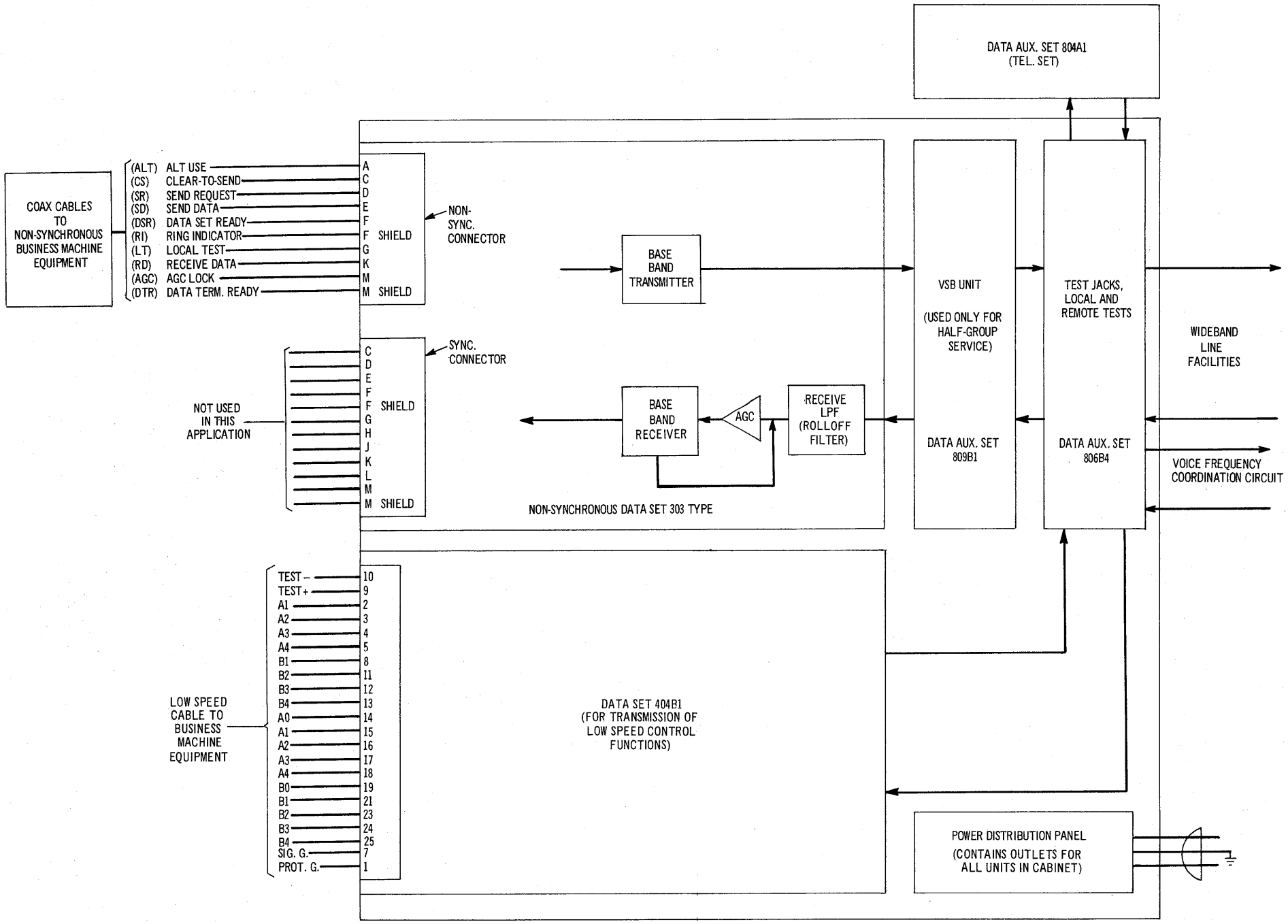


FIGURE 5

TYPICAL NON-SYNCHRONOUS DATA STATION ARRANGED FOR TRANSMISSION OF LOW SPEED CONTROL SIGNALS (AS REQUIRED BY CERT[illegible]CSIMILE MACHINES)

Data Set 404B1

The Data Set 404B1 occupies the right half of the top tier of the wideband cabinet, figure 1. It is a low-speed, multi-frequency transceiver capable of parallel transmission up to 20 characters per second. The business machine interface has the electrical characteristics of EIA Standard RS232-A. It is used for the transmission of low-speed data for business machine control functions where required, as with certain facsimile machines.

Data Auxiliary Set 804A1

This set provides a telephone instrument and circuitry for controlling the voice frequency coordination channel and the wideband facilities. It will be at a location convenient for the customer and is shown on top of the wideband data station cabinet

Interface

This sections describes the business machine interface arrangements of both the Wideband Data Set 303-type and the low-speed Data Set 404B1. It describes in detail the electrical characteristics of each type of interface and covers the operation of the data station from an interface standpoint on a lead-by-lead basis giving specific pin assignments. Much of the method of operation of the Data Set 303-type will thereby be covered. Also, there is a section summarizing the differences, from an interface standpoint, of this standard 303-type wideband data station equipment from the earlier "Interim" or "Model Shop" X303A-type equipment.

There are two high-speed interface connectors at the rear of the Wideband Data Set 303-type. One is for synchronous operation, the other is for nonsynchronous operation. Note that the "ON" signal, (greater than 23 ma) must be held on Pin A of the "NON-SYNC" connector to operate in the nonsynchronous mode. As an option, the Telephone Company can, if requested strap the data set permanently in the nonsynchronous mode. There is also a low-speed connector located on the rear of the Data Set 404B1 for use when business machine control signals are transmitted over the voice frequency coordination channel.

The High Speed Connectors

The high-speed business machine interface connector on the Data Set 303-type is the 12-pin Burndy MD 12 MXR-8T coaxial connector. The business machine should be equipped with a cable not exceeding fifty feet in length with a Burndy MD 12 MXP-17R Plug and a Burndy No. M2H 50RC-1P2 Protective Shield. (The Burndy Corporation states that this plug and shield is readily available. However, if difficulty is encountered from the local supplier, he should be informed that they are stocked at the Norwalk, Connecticut branch of Burndy.)

An exception to the fifty-foot cable length exists where the balanced interface is provided for 50 kilobit per second government cryptographic data applications. Cable lengths in excess of 50 feet are possible. The same Burndy plug and shield are used but the pin assignments are different and are covered in another section of this Interface Specification. Certain applications of this Government 50 kilobit per second equipment require the use of regenerators at intermediate points. These are variations of the 303-type data station equipment and interface with telephone lines. They utilize the same Burndy Plug and Shield on one side and screw-type terminals on the other side

Description of High-Speed Interface Signals (Unbalanced-For General Commercial Use

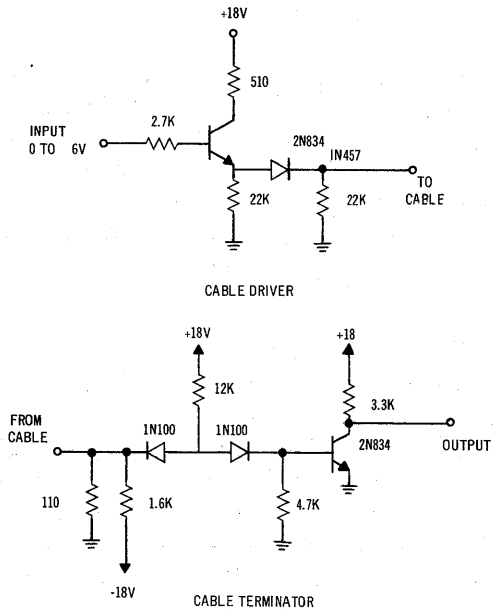
For general commercial use, the Wideband Data Set 303-type is provided with cable drivers and cable terminators which become part of the interchange circuits that interconnect the data set and the business machine. The cable drivers operate into, and the cable terminators operate from, coaxial cables of from 90 ohms to 120 ohms characteristic impedance. The high-speed interface is provided on a current switching basis with the exception of two functions and the use of coax is necessary to achieve optimum interchange of interface signals.

The two exceptions are two new control functions, Data Terminal Ready and Ring Indicator which have the electrical characteristics of EIA Standard RS232A. These characteristics are given under the section entitled "Description of Signals On Low-Speed Interface Connector." The two new functions, Data Terminal Ready and Ring Indicator were added to the high-speed connector for use where calls are answered automatically by means of the Data Auxiliary Set 804A1.

It was desirable to use the same 12 pin Burndy connector used on the Interim X303A-type Data Sets. In order to accommodate the added functions, the outer conductors of Pin F and Pin M were assigned to the RI and DTR functions. The center conductors are still used for their original functions, Data Set Ready and AGC Lock. If the new functions, DTR and RI are not needed, (which is more likely the case) no harm will come from plugging a connector into the data set that has these two shield conductors grounded.

It is expected that the business machine will be supplied with cable drivers and terminators and with the coax cables. Circuit diagrams for typical drivers and terminators are shown in figure 6. (The circuit diagrams of cable drivers and terminators in the Data Set 301B Technical Reference are also applicable.)

In the wideband data set, cable drivers are provided where signals are delivered from the data set to the connecting business machine equipment and cable terminators are provided where signals are delivered from the business machine equipment to the data set. A binary "1," control "OFF" or "marking" signal is represented by a current less than 5 ma into 100 ohms. A binary "0," control "ON" or "spacing" signal is represented by a current greater than 23 ma into 100 ohms. All interchange circuits are fail-safe in that an open circuit is considered a control "OFF" or "Mark Hold" condition.



TYPICAL CABLE DRIVERS AND CABLE TERMINATORS

FIGURE 6

The above-mentioned currents are supplied at the output of the cable drivers. The open circuit voltage of the terminator will range between -1.3 and -0.8 volts. The negative voltage is added by a bias in the terminator. With greater than 23 ma into 100 ohms supplied to a cable terminator, the terminator input voltage is more positive than +1.0 volts. An open circuit must be recognized by a terminator as "OFF," as mentioned above.

For commercial use, the connector labeled "NON-SYNC" has the following pin assignments:

A	(ALT)	Alternate Use
B		
C	(CS)	Clear to Send
D	(SR)	Send Request
E	(SD)	Send Data
F	(DSR)	Data Set Ready (Center Conductor)
F	(RI)	Ring Indicator (Outer Conductor
G	(LT)	Local Test
H		
J		
K	(RD)	Receive Data
L		
M	(AGC)	AGC Lock (Center Conductor)
M	(DTR)	Data Terminal Ready (Outer Conductor)

The connector labeled "SYNC" has the following pin assignments:

A		
B		
C	(CS)	Clear to Send
D	(SR)	Send Request
E	(SD)	Send Data
F	(DSR)	Data Set Ready (Center Conductor)
F	(RI)	Ring Indicator (Outer Conductor)
G	(LT)	Local Test
H	(SCTE)	Serial Clock Transmit (External Sync. Option)
J	(SCT)	Serial Clock Transmit (Internal Sync.)

K	(RD)	Receive Data
L	(SCR)	Serial Clock Receive
M	(AGC)	AGC Lock (Center Conductor)
M	(DTR)	Data Terminal Ready (Outer Conductor)

A description of signals between the business machine equipment and the Wideband Data Set 303-type follows:

1. Alternate Use (Signal Originates in Business Machine)

The "Alternate Use" circuit selects the mode of operation and activates the appropriate high speed connector. If the circuit is in the "ON" condition, the nonsynchronous mode is selected and the "NON-SYNC" connector is active. If the circuit is in the "OFF" condition (or if the circuit is open) the synchronous mode is selected and the "Sync." connector is active. As an option, the Telephone Company can, if requested, strap the data set so that it remains in the nonsynchronous mode permanently. (Option A)

2. (SR) Send Request (Signal Originates in Business Machine)

The Send Request lead must be in the "ON" condition to send wideband data. It can be wired permanently ON in the business machine equipment or it can be wired permanently ON in the Wideband Data Set by the Telephone Company if requested by the customer. In synchronous operation, there is an additional option. In this mode, the data set is normally arranged to transmit steady mark ("mark hold") to the far end when Send Request is turned off. The signals transmitted over the telephone channel are "randomized" by the scrambler as mentioned earlier. As an option, the wideband data set can be wired to stop transmission when Send Request is turned off. (Option M)

3. (CS) Clear to Send (Signal Originates in Data Set)

This control signal from the wideband data set is the logical AND of a signal from the wideband data set and the Data Auxiliary Set 804A1 on the voice frequency coordination circuit. It will indicate that both are in a condition that will permit the transmission of data or test signals in the local test mode and as such it will come on after Request to Send is turned ON. For nonsynchronous services such as facsimile where Data Sets 404B1 are used, it is not possible to talk on the voice line at the same time that control signals are being transmitted between 404's. Therefore, Clear to Send "ON" also indicates that the voice frequency coordination circuit is not in the "talk" mode. For services where no Voiceband Data Sets are employed, it is possible to talk on the voice line while wideband data is being transmitted. The Telephone Company can, if requested, wire the data station to permit simultaneous talking and transmission of wideband data. In this case Clear to Send means only that the data station has Request to Send ON and is not in the Remote Test mode.

The Clear to Send lead does not have a time delay built in to signify that the receiving end has had time to come in to bit synchronization in synchronous applications. Since these synchronous Systems normally transmit data or the scrambled "Mark hold" continuously in both directions, bit synchronism is constantly maintained. It is only in the initial start-up time that the receiver must be brought into synchronism. It takes about 3000 bits of random data (such as the scrambler transmits when the business machine puts steady 1's or data on the Send Data lead) to bring the Receiver Clock into proper bit synchronism with the transmitter. This is covered more fully under the Receive Data lead discussion. When voiceband data sets are employed, there is an interval generated in the Data Auxiliary Set 804A which delays Clear to Send by 5 seconds.

4. (SD) Send Data (Originates in Business Machine)

The Send Data circuit is designed to accept serial binary data from the customer's data equipment. For nonsynchronous service, these signals can be as short as 52, 20 and 4.3 microseconds in length for half-group, group and supergroup services.

For synchronous service, this data will be timed by the "internal" serial clock of the data set, or by the "external" clock of the business machine. In either

case, the data should be changed at or near (within 25% of a bit interval of) the positive going transition of the timing signal. The data signal should be maintained on the Send Data lead for the full period duration (consistent with the tolerance just mentioned). The data is sampled by the data set coincident with the negative going transition of the timing signal. The synchronous speeds available are:

Half-group band service – 19.2 kilobits per second

Group band service – 50 kilobits per second

Supergroup band service – 230.4 kilobits per second

Clock speeds of 18.75, 40.8 and 200 kilobits per second will be available for special applications.

NOTE: See discussion on scrambler and the limitation it imposes on sending steady zeroes in the last part of the section entitled "General."

5. (SCT) Serial Clock Transmit (Originates in Data Set)

This function will be used only in synchronous service. The SCT (Internal Timing Option) is used by the customer when the data set supplies the timing signal (Option Z) When operated in this manner, the data set supplies a square wave with a 50% ±5% duty cycle at a rate equivalent in cycles to the bit rate. For example: the clock for 230.4 kilobits per second would be 230.4 kilocycles per second. (Plus or minus .01%.) The customer should change data on the SD circuit coincident (within 25% of the bit interval) with the positive going transition of the SCT as measured at the data set connector. The data is sampled by the data set coincident with the negative going transition of the SCT signal.

6. (SCTE) Serial Clock Transmit External (Originates in Business Machine)

The SCTE circuit is used only in synchronous service and only when the data set is to be driven by the customer's clock signal. (E Option) When operated in this manner, the customer's timing source must supply a square wave with a 50% ±5% duty cycle at a rate equivalent in cycles to the bit rate. For example, the clock for 230.4 kilobit per second operation would be 230.4 kilocycles per second. The frequency tolerance requirement is ±.01% on external clocks. Positive going transitions of the clock signal and the transitions of the data signal should be coincident (with 25% of the bit interval). The data will be sampled by the data set coincident with the negative going transition of the SCTE signal.

7. (RD) Receive Data (Originates in Data Set)

Received data is delivered serially on the Receive Data circuit to the customer's data equipment. In the nonsynchronous case, when random length pulses that meet the minimum pulse width requirement above are presented to the data set transmitter, it is expected that the pulses delivered at the receiver will have a peak jitter of less than 17% (or a degree of isochronous distortion of less than 34%). This means that after a correction is made for absolute delay, a received data transition will be within ±8.9 microseconds for half-group, ±3.4 microseconds for group and ±.73 microseconds for supergroup of where it should be as measured at the 14 ma level. The rise and fall time of the received transitions will be less than 0.2 microseconds between the 7 ma and 21 ma levels.

For synchronous operation the received data pulses will be regenerated and therefore in phase with the received serial clock. The rise and fall time of the received data transitions will again be less than 0.2 microseconds. The peak jitter of the received serial clock is expected to be less than 10%. The negative clock transition will be centered ±10% in the nominal bit interval.

8. (SCR) Serial Clock Receive (Originates in Data Set)

This signal applies only to synchronous operation. The Data Set Receiver derives a bit synchronization signal by means of using transitions in the received data to correct a local oscillator which

would run at a higher speed than the transmitter oscillator in the absence of transitions. It takes about 3000 bits of random data to pull the receiver clock to within 90% of its final frequency.

The data on the RD lead will be changed coincident (within .3 microseconds) with the positive going transition of SCR. The customer's business machine should sample the received data on the RD lead coincident with the negative going transition of the SCR signal.

As mentioned under the Receive Data circuit, the received serial clock may suffer jitter. A jitter of less than 10% is expected. The negative clock transition will be within ±10% of the center of the nominal bit interval.

9. (LT) Local Test (Originates in Business Machines)

This circuit provides for electrical control of looping both the wideband data set and the voiceband data set, if provided, on the telephone line side. When the data sets are in the local test mode, the telephone lines are terminated. When the business machine equipment turns this lead "ON," the data station will go into the local test mode. This permits the business machine equipment to send to itself through the wideband data set and the voiceband data set, if provided, for local testing. In addition to this interface lead control, a button on the Data Auxiliary Set 804A1 performs this function on a manual basis. Any time the local test circuit is operated a lamp lights under the local test button on the 804A1. The same lamp lights on the 804A1 when the data station is in the remote test mode.

10. AGC Lock (Originates in Data Set)

An "ON" signal on this lead is one indication that signals on the Receive Data lead are reliable. The signal comes on quickly – after about 5 milliseconds of random data – and decays slowly – after about two seconds of no transitions. When it is "ON," it is an indication that the signals being received over the telephone facilities have an adequate amplitude. If it goes "OFF" while data transitions are still present on the Receive Data lead, it is an indication that the Automatic Gain Control is approaching the end of its range because of a weak signal (or no signal) and the data probably contains errors. The foregoing applies to group and supergroup facilities. In the case of half-group facilities, with the VSB modem (Data Auxiliary Set 809B1) located at the data station, the presence or absence of VSB carrier is detected and the indication delivered to the AGC Lock lead. Thus it becomes an indication of circuit continuity in synchronous or nonsynchronous operation.

It should be noted that in both types of AGC Lock operation, the indication comes "ON" before the data set will be in bit synchronism on the first start up of the system since the data set must receive about 3000 bits of data to get into synchronism.

11. (DSR) Data Set Ready (Originates in Data Set)

An "ON" condition on this lead indicates to the business machine equipment that the data station is capable of operating and can receive wideband data (and can transmit and receive voiceband data if so equipped) and provided the Clear to Send circuit is ON, it can transmit wideband data. If DSR is OFF, it indicates:

A. A local test, Remote Test or power-off condition.

B. That the voice frequency coordination channel is not capable of operating.

C. That the local data station is not connected to the communication channel.

The "ON" condition appears at all other times. The "ON" condition should not be interpreted as an indication of the status of any remote station or equipment.

This lead was assigned to the low-speed connector in the "Model Shop" or "Interim" design X303A-type equipment. It now appears on the high-speed connector on a current switching basis.

12. (DTR) Data Terminal Ready (Originates in Business Machine)

Signals on this circuit are generated within the business machine equipment to control the switching of the data station

to the communication channel where automatic answering of calls is required. (We foresee few applications.) When automatic answering is not used, this lead will be wired in the "ON" condition internally by the Telephone Company. When automatic answering is used, the Data Terminal Ready lead must be turned ON by the business machine equipment in order for the data station to answer a call automatically and turned OFF to terminate the call. This lead and the Ring Indicator lead were assigned to the low-speed connector in "Interim" or "Model Shop" design X303A-type equipment. They will appear on the high-speed connector and will have the electrical characteristics of EIA Standard RS-232A.

13. (RI) Ring Indicator Lead (Originates in Data Set)

Signals on this circuit are generated within the Wideband Data Station to indicate to the business machine equipment that a ringing signal is being received from a remote station. This circuit is independent of the condition on Data Terminal Ready.

The Ring Indicator lead will be turned "ON" for each ring on the voice frequency coordination line. It is useful when arranging a station to answer calls automatically. It follows the rings to permit the answering data terminal to prepare itself, (such as getting a motor up to a stable speed) if necessary, before the business machine equipment signals to answer the call by turning Data Terminal Ready "ON." When Data Terminal Ready is turned "ON," the call will be answered and Data Set Ready will be turned "ON" about 5 seconds later. (See Data Terminal Ready lead also.)

Low-Speed Connector

This connector is associated with the Data Set 404B1 that operates over the voice frequency coordination channel. The voice frequency coordination channel is used for voice communication and alternately for the transmission of low-speed data signals to control business machine equipment when required.

The 25 pin connector commonly associated with Bell System Voiceband Data Sets is used. This connector is equivalent to a Cinch or Cannon DB-19604-433 Connector. The business machine should be equipped with a cable not longer than 50 feet and a Cinch or Cannon DB-19604-432 Plug mounted in a Cinch DB-51226-1 Hood Assembly.

The data station will include, when required, (as with certain facsimile equipment) a Data Set 404B1 for the transmission of low-speed control signals and an 804-type Data Auxiliary Set. When the 404B1 is omitted, the low-speed cable is omitted also since the Data Set Ready, Data Terminal Ready and Ring Indicator functions of the 804A1 are assigned to the high-speed connector. These functions were formerly assigned to the low-speed connector in "Model Shop" and "Interim" X303A equipment.

Pin assignments for the low-speed connector are listed below:

1. Protective Ground
2. Transmit A1
3. Transmit A2
4. Transmit A3
5. Transmit A4
6. Not Used
7. Signal Ground
8. Transmit B1
9. Reserved for Telephone Company Testing
10. Reserved for Telephone Company Testing
11. Transmit B2
12. Transmit B3
13. Transmit B4
14. Receive AO
15. Receive A1
16. Receive A2
17. Receive A3
18. Receive A4
19. Receive BO
20. Not Used
21. Receive B1
22. Not Used
23. Receive B2
24. Receive B3
25. Receive B4

Description of Signals on Low-Speed Connector

The electrical characteristics of all low-speed signals (as well as Data Terminal Ready and Ring Indicator on the high-speed connector)

conform to those outlined in Electronic Industries Association Standard RS-232A. These characteristics are described briefly in the following paragraphs.

The eight Transmit and ten Receive Circuits are considered Control Circuits. A control signal is in the "ON" condition when the voltage on the circuit is more positive than +3 volts with respect to signal ground and the signal is considered in the "OFF" condition when the voltage is more negative than -3 volts with respect to signal ground.

The maximum open-circuit voltage to either Protective Ground or Signal Ground on any interchange circuit should not exceed 25 volts, and the maximum short-circuit current flow between any two conductors (including grounds) should not exceed one-half ampere.

The terminating impedance of the receiving end of interchange circuits should have a d-c resistance of not less than 3000 ohms, and the voltage in open-circuited condition should not exceed -2 volts. The source impedance of the sending end of interchange circuits is not specified.

Description of Data Set 404B1 Signals

The eight Transmit circuits in the interface are provided in two signaling "channels," A and B. At any given time, Channel A will send one of five signaling tones and simultaneously, Channel B will send one of five signaling tones. These will be turned ON by interface leads A1, 2, 3, 4 and B1, 2, 3, 4. The fifth tone will be sent in Channel A, if none of the four "A" interface leads are turned ON. Similarly, a fifth tone will be sent in Channel B when all the "B" interface leads are OFF. Thus, five signal outputs are presented at the receiver for each channel for a total of ten Receive outputs. If two or more transmit circuits are turned ON in either channel, no tone will be transmitted for that channel and, of course, all five Receive outputs for that channel will be OFF at that time.

This arrangement, then, accepts and delivers a restricted two out of ten code allowing for twenty-five possible symbols. These control signals can be sent in both directions simultaneously since the voice frequency coordination channel is full duplex.

A character input to the transmitter consists of a positive potential applied to one lead in one or both of the two groups of transmitting leads for not less than 25 milliseconds followed by a period of not less than 15 milliseconds when all transmitting leads are held at a negative potential. The total time of these states representing one character must not be less than 50 milliseconds. A received character is delivered as a positive potential on one lead in each of two groups of control leads approximately 12 milliseconds after the multifrequency signal is received and persists until after the input is removed. Character synchronization of the receiving business machine is achieved by making use of the return to negative of all receiving leads between characters.

Power Requirements and Physical Characteristics

Commercial ac power is fed to the wideband data station through a ten-foot detachable 3-wire power cord. The cord has a 3-wire plug for connection to a customer-provided 105-129 volt, 60 ±0.6 cycle source not under switch control. It should be on the same ac circuit which serves the associated business machine equipment so that the same ground bus is used for both. This is necessary to prevent impulse noise potentials which might otherwise develop between grounds.

The power requirements, dimensions and weight of the individual units that make up the wideband data stations are listed below. The wideband data station cabinet is finished in two-tone grey.

Item	Power Requirements	Dimensions	Weight
Wideband Data Station Cabinet (KS20018L3)	–	24" H 24" W 12" D	24 lbs.
Wideband Data Station Cabinet (KS20018L2)	–	18" H 24" W 12" D	17 lbs.
Data Set 303-Type	26 Watts	6" H 17" W 10" D	23 lbs.
Data Auxiliary Set 806B-Type	20 Watts	6" H 10" W 9" D	16 lbs.

Data Set 404B1	(Powered from 806B)	6'' H 11'' W 10'' D	15 lbs.
Data Auxiliary Set 804A1	(Powered from 806B)	4.5'' H 9'' W 9'' D	7 lbs.
Data Auxiliary Set 809B1	16 Watts	6'' H 17'' W 10'' D	20 lbs.

Controls Accessible to the Station Attendant

The Data Auxiliary Set 804A1 is normally used to set up a data call. The unit includes a telephone set and six buttons and is shown on figure 7. It is located conveniently for the customer.

There are six buttons, as described below. They are listed in order from left to right:

Figure 7 Data Auxiliary Set 804A1

1. This button is spare and will normally be blocked up. If point-to-point ringing is needed and a button is required, this button will be used.
2. Local Test Button – a locking button that allows the station attendant to loop both the wideband data set and the voice-band data sets on the telephone line side. This permits the business machine equipment to send to itself through the data set for local testing. When this button is depressed, or when the high-speed interface circuit Local Test control is in the ON condition, the lamp associated with this button is lit. It also lights for Remote Test. When any other button is pressed, the button releases.
3. Auto Answer – a locking button that selects automatic answering feature if provided.
4. Wideband Data Lamp – button is blocked. When lamp is lit, it indicates that wideband data system is operable.

5. Talk Button – a locking button that should be depressed to talk on the voice frequency coordination circuit. This button is released when any other button is pressed. Placing the station in the Talk mode prevents the transmission of wideband data, when Data Sets 404B1 are being used for transmission of low speed control signals. The Telephone Company can wire the station so that simultaneous transmission of voice and wideband data can take place when 404B1's are not needed. However, the Talk button must still be depressed.

6. Data Button – a non-locking button that is pressed to place the wideband data station in the data mode when Data Sets 404B1 are provided. This button is pressed until its associated lamp (under the button) lights. If the data set is arranged for the simultaneous transmission of voice and wideband data, this button need not be depressed.

Special Government Application – 50 Kilobits per second, Balanced Interface

Variations of the standard 303C-type data set are available to provide for 50 kilobit per second operation with a balanced interface for use with government cryptographic equipment. Regenerators for these signals are also available. The same Burndy plug and shield mentioned under the description of the High-Speed interface is used. Pin assignments for the data set connector are as follows: Pins E and K – Send Data, Pins C and D – Receive Data.

The interface circuits are balanced electrically. Impedance is 135 ohms. The level of the Send Data Signal at a terminal data set is expected to be 0 dbm ±6 db into 135 ohms. The Receive Data Signal level is 0 dbm ±0.6 db into 135 ohms.

No clock signals are exchanged between the government equipment and the data set for these applications. The data set accepts the serial isochronous bit stream at 50 kilobits per second and delivers this stream without a clock at the receiving end of the circuit. There are some applications where scramblers and regenerators may be used.

Differences at Interface from "Model Shop" or "Interim" Units

There are a few minor differences at the interface that exist between the Standard 303-type Wideband Data Station equipment described herein and the "Model Shop" or "Interim" X303A-type equipment which was described in the Technical Reference dated October 1964 and Supplement 1 dated July 1965. These differences consist of the addition of new control functions, Ring Indicator and Data Terminal Ready, to the high-speed connector and in a different Synch recovery circuit used in the Data Set receiver.

The functions DTR and RI are assigned to the high-speed data set connector for use where calls are answered automatically by means of the Data Auxiliary Set 804A1. (We foresee few applications.) In order to make room on the connector, the outer conductors of pin F and pin M were assigned to the Ring Indicator and Data Terminal Ready functions. The center conductors are still used for their original functions, Data Set Ready and AGC Lock. If the new functions are not needed (which is the more likely case) no harm will come from plugging in a connector with these shield conductors grounded. (Business machines designed to operate with the Data Set 301B are compatible with the Data Set 303-type interface also.)

The behavior of the two Synch recovery schemes are compared below:

Standard 303-Type

This Synch recovery circuit has a crystal oscillator with an idling rate which is .05% above the nominal data rate. It is designed to recover clock from a data train that does not depart by more than .01% in bit rate from nominal. The receive clock has an operating lock-in range of .03% of the data rate. The transmit clock frequency is controlled to an accuracy of .01%.

It takes about 3000 bits of "random" data to pull the receive clock into synchronization. The receive clock can bridge gaps in line signal for about 500 bits before it drifts off frequency enough to cause data errors when the line signal is resumed. There is an output from the Serial Clock Receive lead at all times as long as ac power is ON.

Earlier "Model Shop" or "Interim" X303A-type

There is no clock output from the Serial Clock Receive lead before data is received since there is no free running oscillator. Rather, a high Q tuned circuit is employed. It takes

about 30 bits of data to synchronize with the transmit clock which is .01% accurate. Receiver clock can bridge line signal gaps of about 30 bits before it drifts off frequency far enough to cause data errors when data is resumed.

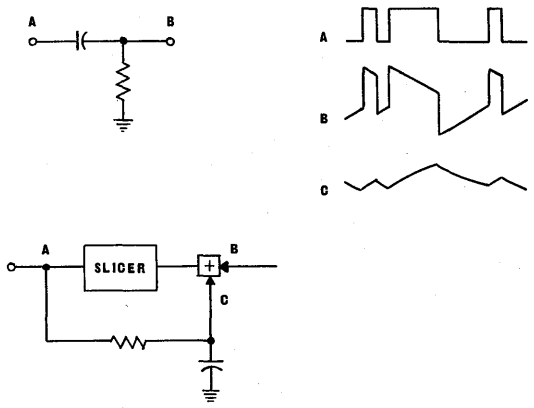
Theory of Operation of 303-type System

In service involving group and supergroup facilities, the wideband data system plan is to operate with baseband signals at the input and output of each transmission facility. This requires that the dc and low frequency components of the data signal be removed to facilitate transmission through the transformers and other blocking circuits that are encountered. Also, dc and low frequency components of the data signal must be removed to prevent interference with the vestigial sideband method of transmission employed by these facilities. The VSB carrier is transmitted at a low level and must be recaptured at the demodulator, both in frequency and phase, without interference from extraneous signals. In half-group service, VSB modems are used at the data stations, thus necessitating the removal of dc for this case also.

The dc is removed in the baseband transmitter of the wideband data set. The polar data signal is passed through a simple R-C high pass filter circuit where a cutoff at four percent of the maximum bit rate removes the dc component and about one-eighth of the ac spectral energy. The signal transmitted to the line has been termed the restored polar line signal. While this signal has little low frequency content, the transmission facilities are controlled sufficiently at the low frequency end to prevent nonlinear phase effects from distorting data signal components lying within three octaves of the transmitter cutoff.

The dc is restored by a regenerative slicer arrangement as shown in figure 8. The dc reinsertion circuit is a low pass R-C configuration having a cutoff frequency to match the one at the transmitter. The waveforms have been drawn for ideal signals. The principle applies equally well to band limited signals. The slicer output is a binary polar signal.

The receiving low pass filter is shaped in the passband region to provide the well known Nyquist rolloff for the overall data signal spectral density characteristic. Fifty percent raised cosine rolloffs are used in applications



PRINCIPLE OF D-C RESTORATION

FIGURE 8

involving band limiting carrier facilities while 100% rolloffs are used in nonband limited applications involving repeatered cable circuits or T1 carrier

Data Set 303-Type Coding

The Data Set 303-Type is coded with a suffix letter to denote the speed capability and a numeral to designate the specific combination of features that are provided by means of plug-in circuit boards. There are 4 lettered clock speeds at present (B through E) and 16 suffix numerals which denote combinations of features irrespective of speed. The signaling rates and suffix letters are listed below:

Data Signaling Rate	Suffix Letter
19.2 kilobits/second	B
50 kilobits/second	C
230.4 kilobits/second	D
200 kilobits/second	E

The features available are listed below along with some comments relating to situations where the features are required. There are no suffix numerals in this list because the numbers denote combinations of features. Suffix numbers are obtained by referring to figure 9 and following the procedure given just ahead of the figure.

Feature	Comment
Synchronous	Magnetic Tape machines and computers require synchronous data sets. Synchro-

	nous data sets can be operated nonsynchronously but nonsynchronous data sets cannot be operated synchronously.
Nonsynchronous	Facsimile machines normally use nonsynchronous data sets.
Internal Clock	It appears that most synchronous business machines will require the clock in the data set. A data set equipped with a clock – the "Internal Clock" feature – can operate as an "External Clock" data set by strapping option. The reverse is not true (unless, of course, a clock board is obtained and inserted).
External Clock	See above.
50% Rolloff Filter	Used where band limited facilities such as N or L carrier are used in the transmission path, particularly in group band service. For supergroup service, the 100% rolloff filter is required on all facilities for the time being and until a standard modem replaces the X-130A. Half-group service always requires the 50% filter.
100% Rolloff Filter	Used with nonband limited facilities such as nonloaded cable or T carrier. The 100% filter is required in all cases with supergroup facilities as mentioned above.
Unbalanced Interface	The unbalanced interface is used for all applications except for special 50 kb/s government arrangements covered on the following pages.
Scrambler	The scrambler is required for all synchronous applications except for special 50 kb/s government arrangements covered on the following pages.

Special Government 50 kb/s Applications for Encrypted Data

Note: In applications using the 303-type Data Set for encrypted speech, a Digital Recognizer and circuit switcher will be employed to direct high-speed digital data to the wideband facilities and signaling and supervisory tones to the voice coordination channel.

Feature	Comment
Synchronous Nonsynchronous	Gov't 50 kb/s encrypted systems can use nonsynchronous data sets for long haul 2 point systems but require synchronous data sets that are used as signal regenerators in some applications.
Scrambler No Scrambler	Gov't 50 kb/s encrypted systems that require synchronous data sets, (see above), may in some cases operate without scramblers, since the data is already random. In some encrypted applications, however, the scrambler may be required to keep the data set AGC stabilized where fast system start-up is required.
Internal Clock	Gov't 50 kb/s encrypted systems that require synchronous data sets will use the "Internal Clock" feature.
Balanced Interface	Gov't 50 kb/s encrypted systems require the Balanced Interface.
50% Rolloff Filter 100% Rolloff Filter	Gov't kb/s encrypted systems use the 50% rolloff filter where band limited facilities such as L or N carrier are used in the transmission path. They use the 100% filter with nonband limited facilities such as nonloaded cable or T carrier.

Figure 9 may be used to select the proper suffix number, after all desired features are known. Figure 9 is used as follows: Select the desired feature from the top, bottom, left and right sides of the square. Connect the top and bottom features desired with an imaginary vertical line. Do the same with left and right sides and connect with a horizontal line. The lines will cross in the box that contains the proper suffix number.

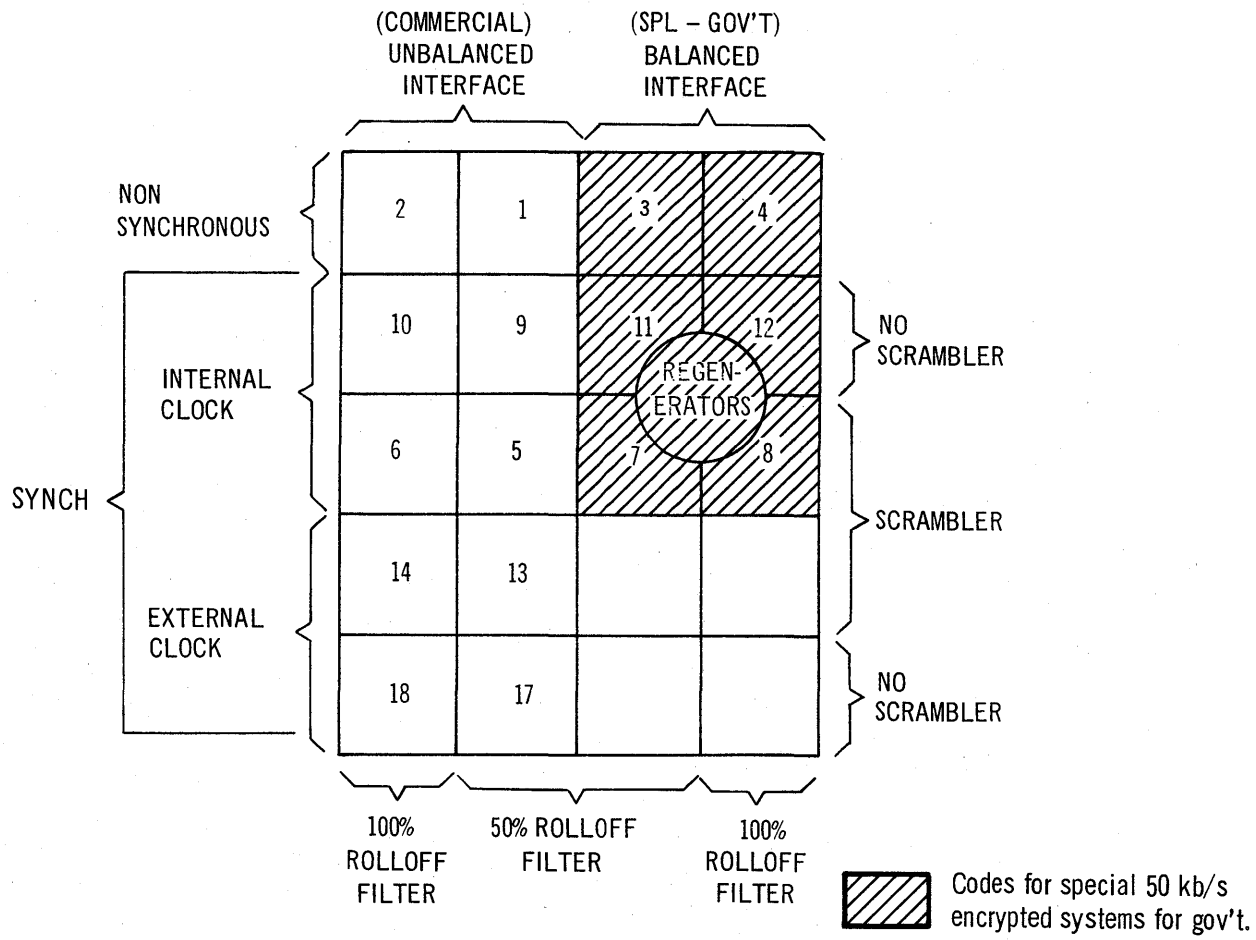


FIGURE 9 USEFUL FOR OBTAINING SUFFIX NUMBER WHEN DESIRED FEATURES ARE KNOWN. – SEE TEXT.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