NORD-1

COMPUTER SYSTEMS

MODEM INTERFACE

Hardware

by

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Mars 1971

1 INTRODUCTION

The Modem Interface is made to take care of asynchronous or synchronous serial communication in simplex, half-duplex or duplex operations, using a five, six, seven or eight-bit code. The Modem Interface will be different for the different types of operations. Therefore, the different modules will first be described (Sections 2, 3 and 4), and then description given of their use together in the different configurations (Section 5). This description is based on a knowledge of the Duplex Buffer 170, and how it works with the Simplex Control 160. The Modem Interface Specification and Operation explains how to program the interface.

2 MODEM CONTROL

The Modem Control module consists of one SIMPLEX CONTROL 160, one MODEM CONTROL 172, (Figure 2-1) and one MODEM DRIVER 173 (Figure 2-2). The SIMPLEX CONTROL 160 can serve two independent devices and is used to read control signals from Data Communication Equipment (Modem) and to set control signals to Data Communication Equipment. The Data Communication Equipment determines which control circuits are used and the operation of the control circuits are given by CCITT recommendation V. 24. (Appendix A).

2.1 Modem Control 172 (Figure 2-1)

If any of the control signals from the computer to the Modem have to be changed, a control word is loaded into the A-register of the computer and set in the Modem Output Control Register (MDO pos 14B, 16B and 16A in Figure 2-1) by an IOT ACT MDO-instruction. (The synchronous Operation Control Register, pos 14A in Figure 2-1 is set by the same instruction. See Section 4). The MDO-register holds the control signals until å new change is made by an IOT ACT MDO-instruction.

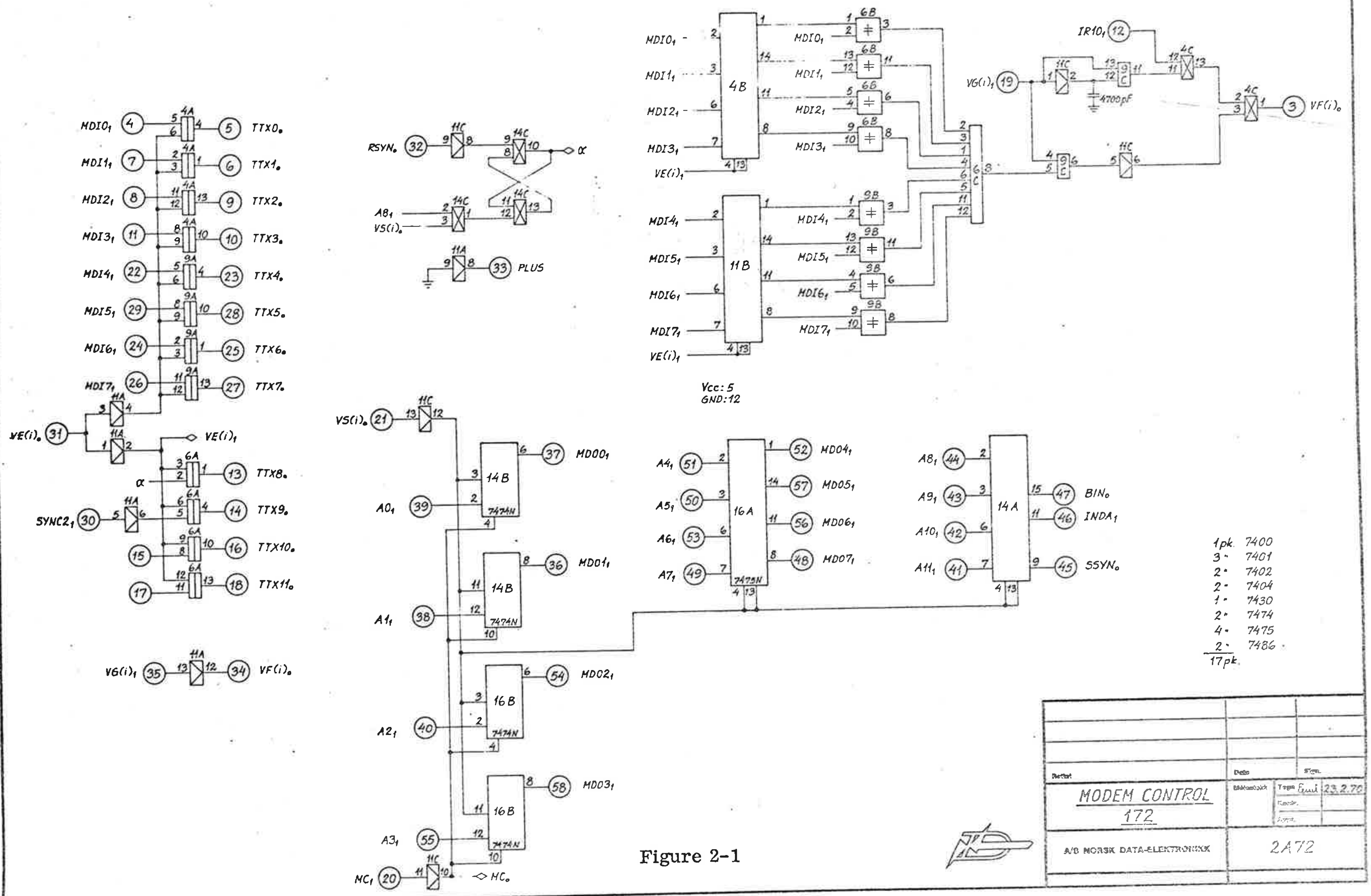
MODEM CONTROL
172
A/S NORSK DATA-ELEKTRONIKK
2A72
23.2.70
Vcc: 5
GND: 12
1pk. 7400
3 " 7401
2 " 7402
2 " 7404
1 " 7430
2 " 7474
4 " 7475
2 " 7486
17pk.
MDI0₁
MDI1₁
MDI2₁
MDI3₁
MDI4₁
MDI5₁
MDI6₁
MDI7₁
TTX0₀
TTX1₀
TTX2₀
TTX3₀
TTX4₀
TTX5₀
TTX6₀
TTX7₀
TTX8₀
TTX9₀
TTX10₀
TTX11₀
VE(i)₀
VE(i)₁
SYNC2₁
VG(i)₁
VF(i)₀
RSYN₀
A8₁
VS(i)₀
PLUS
IR10₁
4700pF
VS(i)₀
A0₁
A1₁
A2₁
A3₁
NC₁
HC₀
MD00₁
MD01₁
MD02₁
MD03₁
MD04₁
MD05₁
MD06₁
MD07₁
A4₁
A5₁
A6₁
A7₁
A8₁
A9₁
A10₁
A11₁
BIN₀
INDA₁
SSYN₀
4B
11B
14B
16B
16A
14A
7474N
7475N

Figure 2-1

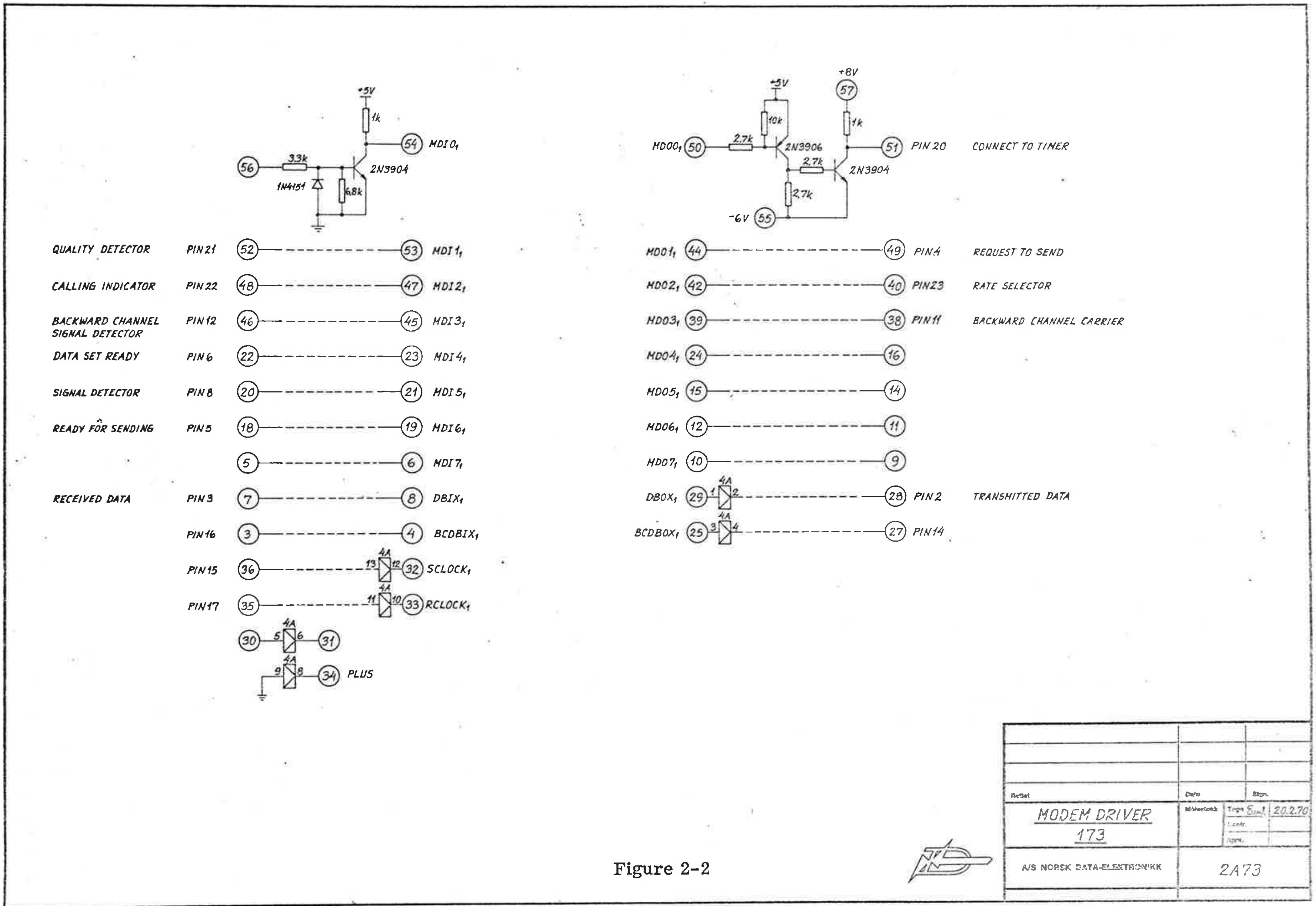
+5V
1k
54 MDI0₁
56
3.3k
2N3904
1N4151
6.8k
QUALITY DETECTOR PIN21 52 53 MDI1₁
CALLING INDICATOR PIN22 48 47 MDI2₁
BACKWARD CHANNEL SIGNAL DETECTOR PIN12 46 45 MDI3₁
DATA SET READY PIN6 22 23 MDI4₁
SIGNAL DETECTOR PIN8 20 21 MDI5₁
READY FOR SENDING PIN5 18 19 MDI6₁
5 6 MDI7₁
RECEIVED DATA PIN3 7 8 DBIX₁
PIN16 3 4 BCDBIX₁
PIN15 36 4A 13 12 32 SCLOCK₁
PIN17 35 4A 11 10 33 RCLOCK₁
30 4A 5 6 31
4A 9 8 34 PLUS
+8V
57
+5V
10k
1k
MDO0₁ 50
2.7k
2N3906
2.7k
2N3904
2.7k
-6V 55
51 PIN 20 CONNECT TO TIMER
MDO1₁ 44 49 PIN4 REQUEST TO SEND
MDO2₁ 42 40 PIN23 RATE SELECTOR
MDO3₁ 39 38 PIN11 BACKWARD CHANNEL CARRIER
MDO4₁ 24 16
MDO5₁ 15 14
MDO6₁ 12 11
MDO7₁ 10 9
DBOX₁ 29 4A 1 2 28 PIN 2 TRANSMITTED DATA
BCDBOX₁ 25 4A 3 4 27 PIN14
Arbeid
Dato
Sign.
MODEM DRIVER
173
Tegn. 20.2.70
A/S NORSK DATA-ELEKTRONIKK
2A73

Figure 2-2

From the MDO-register, the control signals are connected to level converters on the MODEM DRIVER 173 (Figure 2-2) to meet level specifications given by CCITT recommendation V. 24. Thereafter, they are connected to the modem via cable and a twenty-five-pin Cannon plug DB-25P. The pins used for the different control signals are given by EIA-STANDARD RS-232-C. (Appendix B)

As the MDO-register is always ready to receive a new control word, a COMPLETION (VF(i)) signal is returned from the MODEM CONTROL 172, terminal 34, at the moment a START (VG(i)) is received on terminal 35 from the SIMPLEX CONTROL 160.

The control signals from the Modem to the computer are connected through the same twenty-five pin Cannon plug and the cable to the level converters on the MODEM DRIVER 173. Thereafter, they are connected as MDI-signals to MODEM CONTROL 172.

The status of the control signals from the Modem can usually be read into the A-register by an IOT ACT MDI-instruction. If Instruction Register bit 10 (IR10, on terminal 12) is "0" at the moment the IOT ACT MDI-instruction is given, a COMPLETION (VF(i)) is returned on terminal 3 to SIMPLEX CONTROL 160 at the moment the START (VG(i)) is received on terminal 19. If IR10 is "1" meaning that the instruction is IOT ACT PIN MDI, the status of the control signals from the Modem will be transferred to the A-register, but no COMPLETION-signal will be returned to the SIMPLEX CONTROL 160 as a reply to the START before at least one of the control signals changes. When operating the computer with the interrupt system on, the program to take care of the status of the control signals from the Modem could be:

```
LEV11,    IOT  SNI  MDI
          JMP  DMDI

DMDI,     IOT  SKA  ACT  PIN  MDI
          LDA  MDISTAT
          STA  MDISTAT
```

On level 11, which is the input interrupt level, there is a SNI-test to find which device gave the interrupt. When an interrupt is given by the device MDI, the program will jump to DMDI and read the MDI-status. Then it will SKIP the next instruction and store MDI-status in a location called MDISTAT. If the program should enter DMDI by a mistake, and the IOT-instruction does not give a SKIP, the MDISTAT is protected against destruction by the instruction LDA MDISTAT.

When the device MDI is READY and an IOT ACT MDI-instruction is given, the register in pos. 4B and 11B (Figure 2-1) will be set to the same status as read into A-register. As long as this is the status of the control signals from the Modem, all the output from the gates in position 6B and 9B will be "1", and the output from 6C8 is "0". As soon as one of the control signals from the Modem changes, the output from the corresponding gate in pos. 6B or 9B becomes "0" and 6B8 becomes "1". That will be the situation until the register in pos. 4B and 11B is changed by a new IOT ACT MDI-instruction, or the same control signal changes once more.

2.2 Modem Driver 173 (Figure 2-3)

The level converters are made to meet the requirements of CCITT recommendation V. 24 (Appendix A). The logical "1" for data and the OFF-condition for the control circuits should be between -6V and -15V, and the logical "0" for data and the ON-condition for the control circuits should be between +6V and +15V. The signal-to-ground load should be between 3 kohm and 7 kohm, and the current if short circuit-to-ground, less than 0, 5A. The circuit at the left in Figure 2-2 is for converting from V. 24-levels to TTL-levels, and the circuit at the right is for converting from TTL-levels to V. 24-levels. The V. 24 to TTL converter could perhaps have been as illustrated in Figure 2-3.

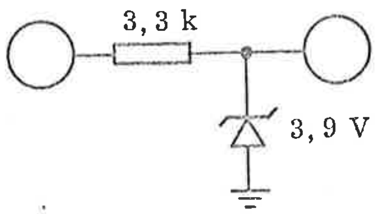

Figure 2-3 Alternative V. 24 - TTL level converter

To minimize the current if a negative output signal is connected to ground, a 330 ohm resistance could be included between the collector and the terminal on the TTL-V. 24 level converter. As used, the current is limited by the collector current for the transistor 2N3904 (200 mA).

3 DATA

The module for one transmitting channel and one receiving channel consists of one SIMPLEX CONTROL 160 and one "DUPLEX BUFFER 170". The operation for that module is described in "DUPLEX BUFFER 170". One Modem Interface has one or two data modules. In the case of synchronous communication, the data module is expanded with one Synchronous Operation Control Module. The signal levels are converted on MODEM DRIVER 173. (See 2. 2.)

4 SYNCHRONOUS OPERATION CONTROL

The Synchronous Operation Control module is the SYNCHRON CONTROL 171 (Figure 4-1) combined with the Synchronous Operation Control Register and a bistable on MODEM CONTROL 172 (pos. 14A, 14C and 6A in Figure 2-1). This module is used only when synchronous communication is specified. It has no influence on the Modem control signals, but it is an extension to the data module.

The Synchronous Operation Control module has four output control signals set by IOT ACT MDO and two input control signals read by IOT ACT MDI. One of the output control signals is Set Syn-Test which sets the bistable in position 14C on MODEM CONTROL 172 (Figure 2-1) in a "1" condition. This bistable is set to a "0"-condition by the first SYN-character after the IOT-instruction that made it a "1". One of the input control signals is the status of this bistable. The rest of the Synchron Operation Control is on SYNCHRON CONTROL 171.

4.1 Synchron Control 171 (Figure 4-1)

The other input control signal is the status of the bistable in pos. 4C (right) on SYNCHRON CONTROL 171. A "1" on terminal 4 will give a "0" in the corresponding status bit, and the meaning is that either two succeeding SYN-characters are received or Binary Data Transfer is specified.

Binary Data Transfer (BIN, on terminal 7) is one of the output control signals. If no SYN-character is received at the moment this signal is given, both SYNC1 and SYNC2 (pos. 4C) will be "0". SYNC2 will be set to "1" by the signal, preventing SYNC1 from being "1". This will give a set-pulse to the buffer register in pos. 6B and 9B each time a bit is received, and at the same time a COMPLETION signal (VF(i) on terminal 8) is given. If SYNC1 is "1" at the moment the Binary Data Transfer signal is given, the set-pulse to the buffer register and the COMPLETION signal is given each time a whole character is received. There are no restrictions on the characters.

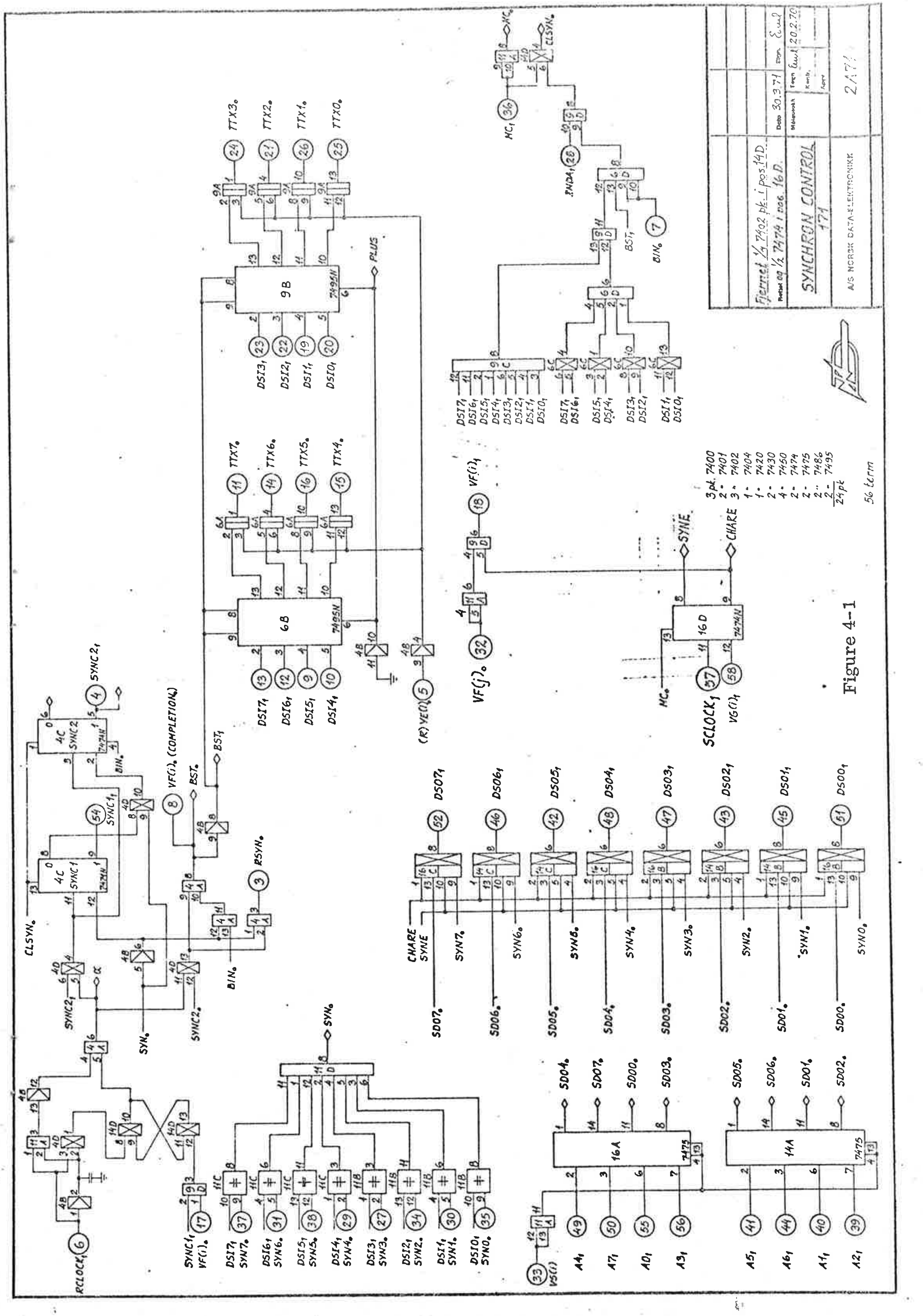

Figure 4-1

If Binary Data Transfer is not specified, there will be no set-pulse to the buffer register until two succeeding SYN-characters are received and both SYNC1 and SYNC2 are "1". After that, if the received character is a SYN, the set-pulse and COMPLETION are blocked for that character. If a character consisting of all ones or all zeroes is received, SYNC1 and SYNC2 will be reset, but the set-pulse to the buffer register and the COMPLETION signal is given for that character. It means that operating in synchronous mode not specifying Binary Data Transfer gives received data for all characters except SYN when the equipment is synchronized, and that characters of all ones or all zeroes causes the equipment to fall out of synchronization.

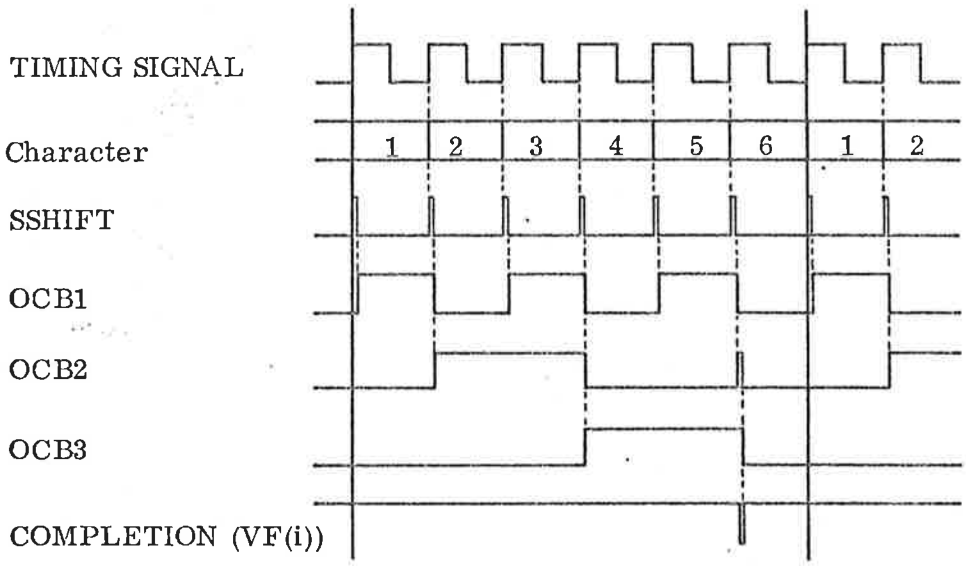

Figure 4-2 Output timing for synchronous transmission of a character with six information bits

During the transmission of the last bit of a character, a new character has to be transferred to the output buffer. (The timing signals referred to are illustrated in Figure 4-2). If the device controller has given a START signal ("1" to terminal 58) and the bistable in position 16D has made CHARE a "1", at the moment a COMPLETION (terminal 32) is received from the output buffer, the result will be that the content of the SDO-register (pos 14A and 16A) is transferred to the output buffer register by the COMPLETION signal. If no START is received from the device controller, the SYN-character will be transferred to the output buffer register. If a character is transferred to the output buffer register, a COMPLETION signal is given to the device controller. It is the last edge of the STROBE (=COMPLETION) signal is used as COMPLETION (terminal 18) to the device controller.

4.2 SYN-character and code length
(References to Figure 4-1)

The SYN-character is defined at terminals 37, 31, 38, 29, 27, 34, 30 and 35. Usually the value of the SYN-character is pre-wired, limiting the communication through this interface to one specified code. If the same interface is to be used for two or more codes with the same number of bits in the character, the value of the SYN-character can be manually selected by a switch. An example of this is the use of ASCII with SYN 26 and EBCDIC with SYN 62, both values given in octal number. A switch that connects terminal 34 to "1" and terminal 38 to "0" in one position, and 34 to "0" and 38 to "1" in the other position can be used for a manual selection between EBCDIC and ASCII. The other terminals are connected with 37 to "1", 31 to "1", 29 to "0", 27 to "1", 30 to "0" and 35 to "1". Note that it is the complemented value that is connected to the terminals. (If bit 4 of the SYN-character is a "1", then $SYN4_0$ is "0").

An extension module can be supplied to the interface, making it possible to communicate through the same interface with codes of six, seven or eight bits and SYN-characters selected by software. The SYN-character and number of bits in each character is transferred to the extension module by one IOT-instruction. This module is described in Section 5.4.

5 CONFIGURATIONS

The combination "Type of communication - Modem selected" gives quite a lot of possible configurations for the Modem Interface. To meet all of them, the Interface is made programable. The hardware is thus reduced to two main configurations with possibilities for one or two extensions. The main configurations are for asynchronous and synchronous communication, and the extensions are for backward channel and for multiple code communication.

5.1 Asynchronous Communication

The interface for asynchronous communication consists of two SIMPLEX CONTROL 160's, one DUPLEX BUFFER 170 for asynchronous communication, one MODEM CONTROL 172 and one MODEM DRIVER 173. The connections for control and data are as illustrated in Figure 5-1.

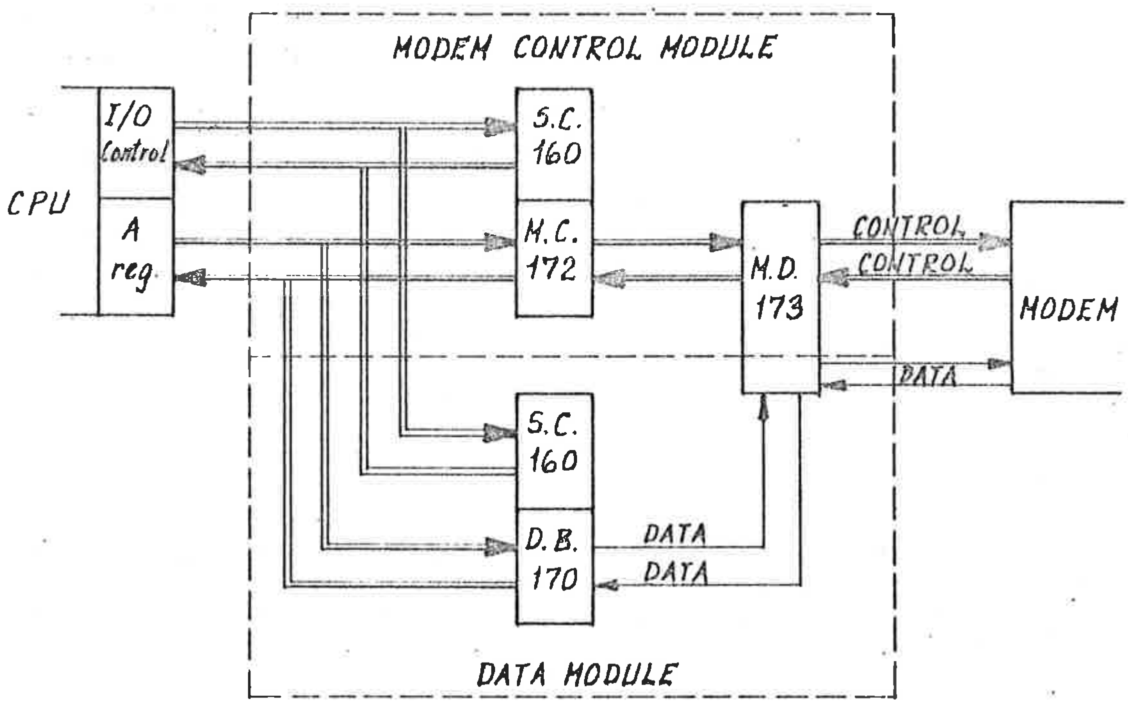

Figure 5-1 Control and data connections for Asynchronous Communications

For operation of the control circuits, see MODEM INTERFACE, Specification and Operation.

The data transfer is as described under DUPLEX BUFFER 170, except that the signal levels are TTL-levels, and they are converted to CCITT recommended levels on MODEM DRIVER 173. The distinction between simplex, half duplex and duplex operation has to be made by software.

5.2 Synchronous Communication

The interface for synchronous communication consists of one SYNCHRON CONTROL 171 in addition to the interface for asynchronous communication. Beyond that, the DUPLEX BUFFER 170 II is for synchronous communication. The connections for control and data are as illustrated in Figure 5-2.

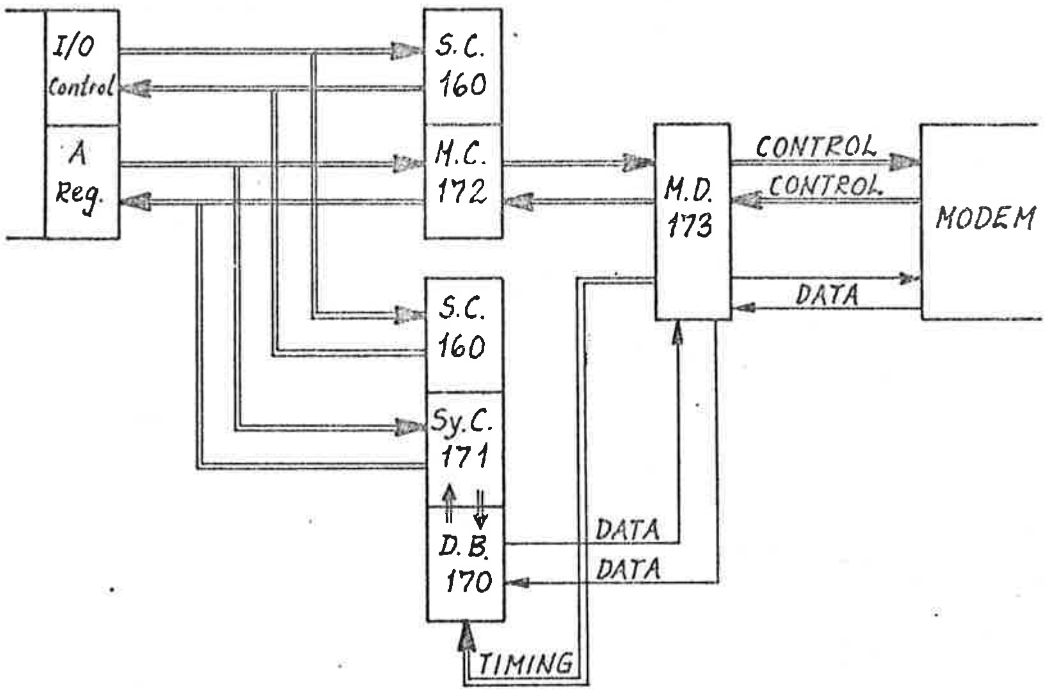

Figure 5-2 Control and data connections for Synchronous Communication

As for asynchronous communication, software has to make the distinction between simplex, half duplex and duplex operation. The automatic transmission of SYN-characters is controlled by software. As Figure 5-2 indicates, the transmitted and received data are buffered twice. Therefore, for half duplex operation, at least two idle characters should be transmitted after the last information character before the Modem is switched to reception mode.

If the characters consist of six or seven bits, the data connections between DUPLEX BUFFER 170 and SYNCHRON CONTROL 171 have to be matched to the character length. For a seven-bit code, the first bit received will be in the position of DSI1 in the input shift register when the whole character is received. Therefore, this is connected to DSIO on the SYNCHRON CONTROL 171. The connections for six, seven and eight-bit codes will be as illustrated in Figure 5-3.

DB 170 connected to SY. C 171

	For 8 bit	For 7 bit	For 6 bit
DSI 0	DSI 0		
DSI 1	DSI 1	DSI 0	
DSI 2	DSI 2	DSI 1	DSI 0
DSI 3	DSI 3	DSI 2	DSI 1
DSI 4	DSI 4	DSI 3	DSI 2
DSI 5	DSI 5	DSI 4	DSI 3
DSI 6	DSI 6	DSI 5	DSI 4
DSI 7	DSI 7	DSI 6	DSI 5
GND		DSI 7	DSI 6
GND			DSI 7

Figure 5-3 The connections for input data bits between DUPLEX BUFFER 170 and SYNCHRON CONTROL 171 for six, seven and eight-bit codes

The output data bits are connected independent of the character length, with DSO7 on SYNCHRON CONTROL 171 to A7 on DUPLEX BUFFER 170, and so on.

For the SYN-character, the terminals corresponding to the bit positions holding a "1" are connected to "0", and all others, including those not used for six and seven-bit codes, are connected to "1". (See Section 4. 2).

5. 3 Backward Channel

The Backward Channel data module is identical to the data module for asynchronous communication. Usually the transmission speed is limited to maximum 75 baud. The Backward Channel may be used as a service channel for asynchronous as well as synchronous communication, and is always operated asynchronously.

5. 4 Extension Module for Multiple Code Communication

Sometimes it may be desired to communicate with different terminals over the same Modem interface. These terminalse are not necessarily of the same kind, and may use different codes. The hardware dependent parameter that may be different for the terminals are the SYN-character and the character length. With the Extension Module for Multiple Code Communication, these parameters may be changed by one IOT-instruction. On the IOT-instruction, the content of the A-register is transferred to a Communication Status Register on the extension module. The eight last significant bits (0 - 7) hold the SYN-character, and bits eight and nine hold the character length information, given by Figure 5-4.

BIT 98	CHARACTER LENGTH (BITS)
00	8
01	7
10	6
11	not permitted

Figure 5-4 Character length as specified by bits eight and nine in the Communication Status Regiser, CSR

The eight least significant bits of the Communication Status Register (CSR) are connected to the terminals for the SYN-character specification on the SYNCHRON-CONTROL 171 card bit by bit in the zero polarity ($CSRO_0$ to $SYNO_0$). The two most significant bits of the Communication Status Register are used to form the signals $\alpha 1$ and $\alpha 2$. $\alpha 1$ and $\alpha 2$ are used on DUPLEX BUFFER 170 to give the length of the character. The equations for the signals are:

$$\alpha 1 = OCB1 \cdot OCB2 \cdot CSR8 + OCB2 \cdot CSR9$$
$$\alpha 2 = ICB1 \cdot ICB2 \cdot CSR8 + ICB2 \cdot CSR9$$

The equation for $\alpha 1$ is realized by the circuit given in Figure 5-5.

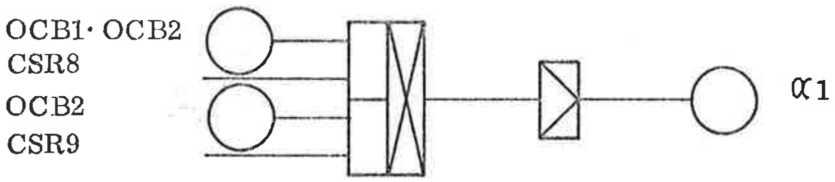

Figure 5-5 Hardware circuit for the equation $OCB1 \cdot OCB2 \cdot CSR8 + OCB2 \cdot CSR9$

The connections for the output data bits are independent of the character length, and therefore connected as under 5. 2.

The input data bits have to be connected as given by Figure 5-3. The equations for the connections to the DSI-terminals on SYNCHRON CONTROL 171 will be as follows:

$DSI(i) = DSI(i) \cdot CSR9_0 + DSI(i+1) \cdot CSR8 + DSI(i+2) \cdot CSR9$
where $i \in [0, 7]$ and DSI8 and DSI9 are defined to be "0". This equation is realized in hardware as illustrated by Figure 5-6 and 5-7.

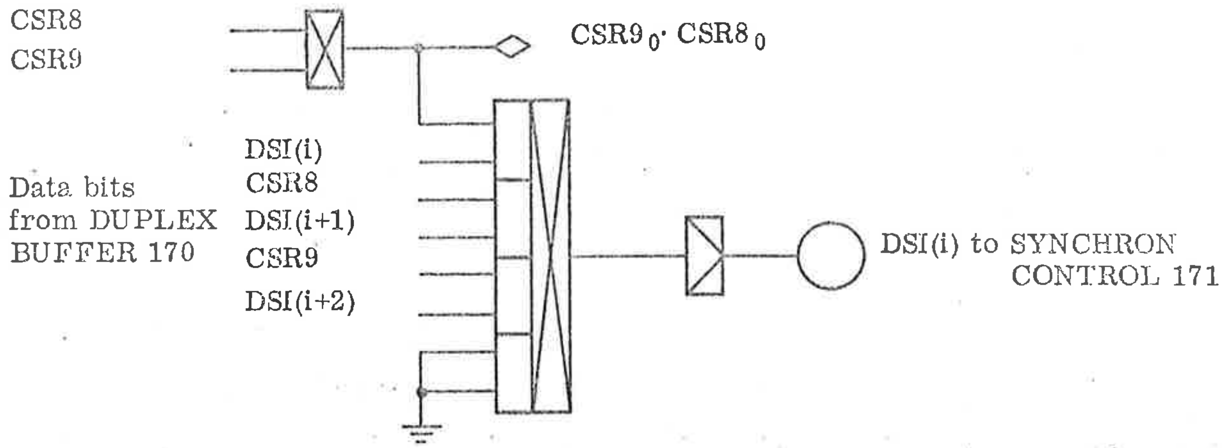

Figure 5-6 Hardware circuit used to get the input data bits to right position in the case of multiple code communication, $i \in [0, 5]$.

Where i = 6 and 7, the circuits are as in Figure 5-7, since DSI8 and DSI9 are defined to be zero.

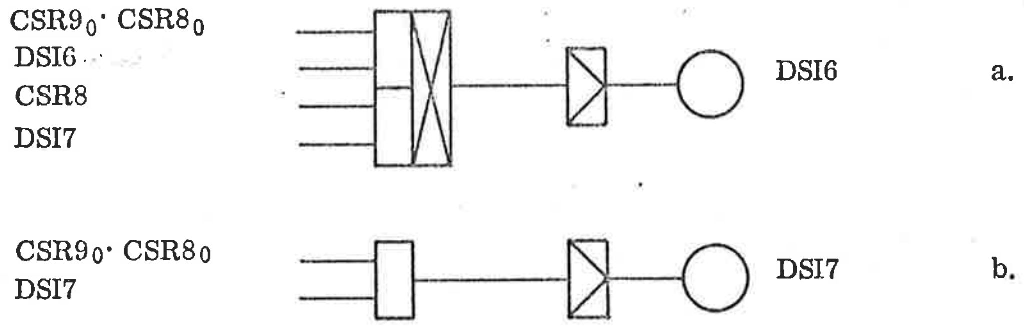

Figure 5-7 Hardware circuits used to get the input data bits to right position in the case of multiple code communication

a. Input data bit 6

b. Input data bit 7

APPENDIX A CCITT RECOMMENDATION V. 24

RECOMMENDATION V.24

FUNCTIONS AND ELECTRICAL CHARACTERISTICS OF CIRCUITS AT THE INTERFACE BETWEEN DATA TERMINAL EQUIPMENT AND DATA COMMUNICATION EQUIPMENT

(Geneva, 1964, amended at Mar del Plata, 1968)

CONTENTS

I. SCOPE

I–1 This Recommendation applies to the interconnecting circuits, being called interchange circuits, between data terminal equipment and data communication equipment* for the transfer of binary data, control and timing signals. This Recommendation also applies to both sides of separate intermediate equipment, which may be inserted between these two classes of equipment.

In any type of practical equipment a selection will be made from the range of interchange circuits defined in this Recommendation, as appropriate. When by mutual arrangement other circuits are to be used, these additional circuits should conform to the electrical characteristics specified in this Recommendation.

The actual interchange circuits to be used in a particular data communication equipment are those indicated in the appropriate C.C.I.T.T. Recommendation, e.g., the usage of circuits 108/1, 108/2, 126 and 127 in modems for 200 and 600/1200 bits per second are indicated in Recommendations V.21 and V.23. However, it is intended in addition to formulate, at a later stage, operational guide lines for the selection of interchange circuits for data communication equipment which are not currently covered by a C.C.I.T.T. Recommendation.

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* See definition 53.05.

I–2 The data communication equipment may include signal converters, timing generators, pulse generators, and control circuitry together with equipment to provide other functions such as error control, automatic calling and automatic answering.

Some of this equipment may be separate intermediate equipment or located in the data terminal equipment.

I–3 The range of interchange circuits defined in this Recommendation is applicable, for example:

a) to synchronous and asynchronous data communications;

b) to data communication on leased-line service, either two-wire or four-wire, either point-to-point or multipoint operation;

c) to data communication on switched network service, either two-wire or four-wire;

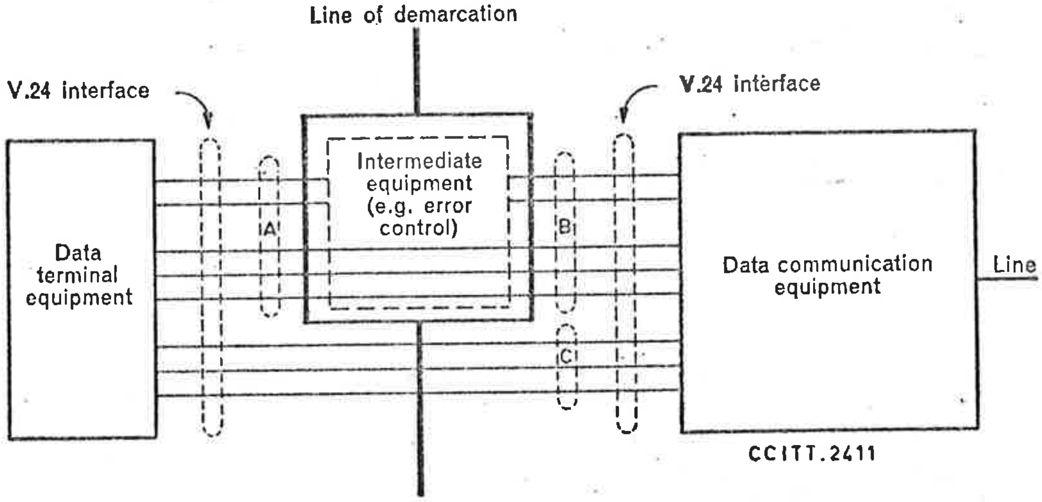
d) only where short interconnecting cables are used between data terminal equipment and data communication equipment. An explanation of short cables is given in section II.

I–4 The electrical characteristics defined in this Recommendation only apply to:

a) interchange circuits, on which the signalling rate does not exceed the limit of 20 000 bits per second;

b) interchange circuits, which can be represented by the equivalent circuit in section V.1.

II. Line of demarcation



Without intermediate equipment the selections A and B are identical.
Selection C may be a selection specifically for automatic calling.

FIGURE 1. — Illustration of general layout of communication equipment

The interface between data terminal equipment and data communication equipment is located at a connector, which is the interchange point between these two classes of equipment. Separate connectors may be provided for the interchange circuits associated with the signal-conversion or similar equipment and those associated with the automatic calling equipment.

The connector(s) will not necessarily be physically attached to the data communication equipment and may be mounted in a fixed position near the data terminal equipment.

An interconnecting cable or cables will normally be provided with the data terminal equipment. The use of short cables is recommended with the length solely limited by the load capacitance and other electrical characteristics, specified in section V.

III. Definitions of interchange circuits

III–1 *100-series. General application*

A list of these interchange circuits is presented in tabular form in Figure 2.

Circuit 101—Protective ground or earth

This conductor shall be electrically bonded to the machine or equipment frame. It may be further connected to external grounds as required by applicable regulations.

Circuit 102—Signal ground or common return

This conductor establishes the common reference potential for all interchange circuits in the 100-series, except circuit 101 (protective ground or earth). Within the data communication equipment, this circuit shall be brought to one point, and it shall be possible to connect this point to circuit 101 by means of a wire strap inside the equipment. This wire strap can be connected or removed at installation, as may be required to meet applicable regulations or to minimize the introduction of noise into electronic circuitry.

Circuit 103—Transmitted data

Direction: TO data communication equipment.

The data signals originated by the data terminal equipment to be transmitted via the data channel to one or more remote data stations are passed on this circuit to the data communication equipment.

The data terminal equipment shall hold circuit 103 in the binary 1 condition during any time interval between characters or words, and at all other times when no data are to be transmitted via the data channel. The data terminal equipment shall not transfer data on circuit 103 unless an ON condition is present on all of the following four circuits, where implemented:

1. Circuit 105 — Request to send
2. Circuit 106 — Ready for sending
3. Circuit 107 — Data set ready
4. Circuit 108.1/108.2 — Connect data set to line/data terminal ready

All data transferred on circuit 103 during the time an ON condition is present on all of the above four circuits, where implemented, shall be transmitted by the data communication equipment.

Circuit 104—Received data

Direction: FROM data communication equipment.

The data signals generated by the data communication equipment in response to data channel line signals received from a remote data station are passed on this circuit to the data terminal equipment.

For operation with clamping of circuit 104 refer to section IV.

Circuit 105—Request to send

Direction: TO data communication equipment.

Signals on this circuit control the data channel transmit function of the data communication equipment.

The ON condition causes the data communication equipment to assume the data channel transmit mode. This mode may also include the transmission of line signals required for data channel conditioning (equalization, synchronization, clamp removal, etc.), provided that circuit 107 (data set ready) is ON. The ON condition must be maintained as long as the data terminal equipment desires to transmit or is transferring data on circuit 103 (transmitted data).

The OFF condition causes the data communication equipment to assume the data channel non-transmit mode, when all data transferred on circuit 103 (transmitted data) have been transmitted. When circuit 105 is turned OFF it shall not be turned ON again until circuit 106 (ready for sending) is turned OFF by the data communication equipment.

For operation with clamping of circuit 104 (received data), refer to section IV.

Circuit 106—Ready for sending

Direction: FROM data communication equipment.

Signals on this circuit indicate whether the data communication equipment is conditioned to transmit data on the data channel.

The ON condition indicates that the data communication equipment is conditioned to transmit data on the data channel.

The OFF condition indicates that the data communication equipment is not prepared to transmit data on the data channel.

Where circuit 105 (request to send) is provided, the ON and OFF conditions on circuit 106 shall be responses to the ON and OFF conditions on circuit 105. For the appropriate response times of circuit 106, and for the operation of circuit 106, when circuit 105 (request to send) is not provided refer to the relevant Recommendation for data communication equipment.

Circuit 107—Data set ready

Direction: FROM data communication equipment.

Signals on this circuit indicate whether the data communication equipment is ready to operate.

The ON condition indicates that the signal-conversion or similar equipment is connected to the line and that the data communication equipment is ready to exchange further control signals with the data terminal equipment to initiate the exchange of data.

The conditioning of a data channel, such as equalization and clamp removal, will not take place before circuit 107 is turned ON.

The OFF condition indicates that the data communication equipment is not ready to operate. The OFF condition on this circuit shall not impair the operation of circuit 125 (calling indicator).

Circuit 108/1—Connect data set to line

Direction: TO data communication equipment.

Signals on this circuit control switching of the signal-conversion or similar equipment to or from the line.

The ON condition causes the data communication equipment to connect the signal-conversion or similar equipment to the line regardless of the condition on any other interchange circuit.

The OFF condition causes the data communication equipment to remove the signal-conversion or similar equipment from the line, when the transmission of all data previously transferred on circuit 103 (transmitted data) has been completed. The OFF condition shall not disable the operation of circuit 125 (calling indicator).

When circuit 108/1 is turned OFF, it shall not be turned ON again until circuit 107 (data set ready) is turned OFF by the data communication equipment.

Note. — A wiring option shall be provided within the data communication equipment to select the circuit 108/1 or circuit 108/2 operation.

Circuit 108/2—Data terminal ready

Direction: TO data communication equipment.

Signals on this circuit control switching of the signal-conversion or similar equipment to or from the line.

The ON condition, indicating that the data terminal equipment is ready to operate, prepares the data communication equipment to connect the signal-conversion or similar equipment to the line and maintains this connection after it has been established by external means.

When the data communication equipment is conditioned for automatic answering of calls, connection to the line occurs only in response to a combination of the calling signal and an ON condition on circuit 108/2.

The data terminal equipment is permitted to present the ON condition on circuit 108/2 whenever it is ready to transmit or receive data.

The OFF condition causes the data communication equipment to remove the signal-conversion or similar equipment from the line, when the transmission of all data previously transferred on circuit 103 (transmitted data) has been completed. The OFF condition shall not disable the operation of circuit 125 (calling indicator).

When circuit 108/2 is turned OFF, it shall not be turned ON again until circuit 107 (data set ready) is turned OFF by the data communication equipment.

Note. — A wiring option shall be provided within the data communication equipment to select the circuit 108/1 or circuit 108/2 operation.

Circuit 109—Data channel received line signal detector

Direction: FROM data communication equipment.

Signals on this circuit indicate whether the received data channel line signal is within appropriate limits, as specified in the relevant Recommendation for data communication equipment.

The ON condition indicates that the received signal is within appropriate limits.

The OFF condition indicates that the received signal is not within appropriate limits.

For operation with clamping of circuit 104 (received data), refer to section IV.

Circuit 110—Data signal quality detector

Direction: FROM data communication equipment.

Signals on this circuit indicate whether there is a reasonable probability of an error in the data received on the data channel.

The ON condition indicates that there is no reason to believe that an error has occurred.

The OFF condition indicates that there is a reasonable probability of an error.

Circuit 111—Data signalling rate selector

(data terminal equipment source)

Direction: TO data communication equipment.

Either circuit 111 or circuit 112 may be used, but not both.

Signals on this circuit are used to select one of the two data signalling rates of a dual rate synchronous data communication equipment, or to select one of the two ranges of data signalling rates of a dual range asynchronous data communication equipment.

The ON condition selects the higher rate or range of rates.

The OFF condition selects the lower rate or range of rates.

Circuit 112—Data signalling rate selector

(data communication equipment source)

Direction: FROM data communication equipment.

Either circuit 111 or circuit 112 may be used, but not both.

Signals on this circuit are used to select one of the two data signalling rates or ranges of rates in the data terminal equipment to coincide with the data signalling rate or range of rates in use in a dual rate synchronous or dual range asynchronous data communication equipment.

The ON condition selects the higher rate or range of rates.

The OFF condition selects the lower rate or range of rates.

Circuit 113—Transmitter signal element timing

(data terminal equipment source)

Direction: TO data communication equipment.

Either circuit 113 or circuit 114 may be used, but not both.

Signals on this circuit provide the data communication equipment with signal element timing information.

The condition on this circuit shall be ON and OFF for nominally equal periods of time, and the transition from ON to OFF condition shall nominally indicate the centre of each signal element on circuit 103 (transmitted data).

Timing information on circuit 113 shall be provided at all times when circuit 107 (data set ready) is in the ON condition. In addition, it is permissible to provide timing information when circuit 107 is OFF.

During periods when timing information is not provided, circuit 113 shall be held in the OFF condition.

Circuit 114—Transmitter signal element timing
(data communication equipment source)

Direction: FROM data communication equipment.

Either circuit 113 or circuit 114 may be used, but not both.

Signals on this circuit provide the data terminal equipment with signal element timing information.

The condition on this circuit shall be ON and OFF for nominally equal periods of time. The data terminal equipment shall present a data signal on circuit 103 (transmitted data) in which the transitions between signal elements nominally occur at the time of the transitions from OFF to ON condition of circuit 114.

Timing information on circuit 114 shall be provided at all times when circuit 107 (data set ready) is in the ON condition. In addition, it is permissible to provide timing information when circuit 107 is OFF.

During periods when timing information is not provided, circuit 114 shall be held in the OFF condition.

Circuit 115—Receiver signal element timing
(data communication equipment source)

Direction: FROM data communication equipment.

Either circuit 115 or circuit 128 may be used, but not both.

Signals on this circuit provide the data terminal equipment with signal element timing information.

The condition on this circuit shall be ON and OFF for nominally equal periods of time, and a transition from ON to OFF condition shall nominally indicate the centre of each signal element on circuit 104 (received data).

Timing information on circuit 115 shall be provided at all times when circuit 109 (data channel received line signal detector) is in the ON condition. This timing information may be present following the transition from ON to OFF condition on circuit 109 for a period of time consistent with the stability of the timing circuitry in the data communication equipment.

During periods when timing information is not provided, circuit 115 shall be held in the OFF condition.

Circuit 116—Select stand-by

Direction: TO data communication equipment.

Signals on this circuit are used to select the normal or stand-by facilities, such as signal converters and communication channels, provided within the data communication equipment.

The ON condition selects the stand-by mode of operation, causing the data communication equipment to replace predetermined facilities by their reserves.

The OFF condition causes the data communication equipment to replace the stand-by facilities by the normal. The OFF condition on this circuit shall be maintained whenever the stand-by facilities are not required for use.

Circuit 117—Stand-by indicator

Direction: FROM data communication equipment.

Signals on this circuit indicate whether the data communication equipment is conditioned to operate in its stand-by mode with the predetermined facilities replaced by their reserves.

The ON condition indicates that the data communication equipment is conditioned to operate in its stand-by mode.

The OFF condition indicates that the data communication equipment is conditioned to operate in its normal mode.

Circuit 118—Transmitted backward channel data

Direction: TO data communication equipment.

This circuit is equivalent to circuit 103 (transmitted data) except that it is used to transmit data via the backward channel.

The data terminal equipment shall hold circuit 118 in the binary 1 condition during any time interval between characters or words, and at all other times when no data are to be transmitted via the backward channel. The data terminal equipment shall not transfer data on circuit 118 unless an ON condition is present on all of the following four circuits, where implemented:

1. Circuit 120 — Transmit backward channel line signal
2. Circuit 121 — Backward channel ready
3. Circuit 107 — Data set ready
4. Circuit 108/1-108/2 — Connect data set to line/data terminal ready.

Circuit 119—Received backward channel data

Direction: FROM data communication equipment.

This circuit is equivalent to circuit 104 (received data), except that it is used for data received on the backward channel.

For operation with clamping of circuit 119, refer to section IV.

Circuit 120—Transmit backward channel line signal

Direction: TO data communication equipment.

This circuit is equivalent to circuit 105 (request to send), except that it is used to control the backward channel transmit function of the data communication equipment.

The ON condition causes the data communication equipment to assume the backward channel transmit mode. This mode includes the transmission of line signals required for backward channel conditioning, provided that circuit 107 (data set ready) is ON.

The ON condition must be maintained as long as the data terminal equipment desires to transmit via the backward channel or is transferring data on circuit 118 (transmitted backward channel data).

The OFF condition causes the data communication equipment to assume the backward channel non-transmit mode, when all data transferred on circuit 118 (transmitted backward channel data) have been transmitted. When circuit 120 is turned OFF, it shall not be turned ON again until circuit 121 (backward channel ready) is turned OFF by the data communication equipment.

For operation with clamping of circuit 119 (received backward channel data), refer to section IV.

Circuit 121—Backward channel ready

Direction: FROM data communication equipment.

This circuit is equivalent to circuit 106 (ready for sending), except that it is used to indicate whether the data communication equipment is conditioned to transmit data on the backward channel.

The ON condition indicates that the data communication equipment is conditioned to transmit data on the backward channel.

The OFF condition indicates that the data communication equipment is not conditioned to transmit data on the backward channel.

Where circuit 120 (transmit backward channel line signal) is provided, the ON and OFF conditions on circuit 121 shall be responses to the ON and OFF conditions on circuit 120. For the appropriate response times of circuit 121, and for the operation of circuit 121, when circuit 120 (transmit backward channel line signal) is not provided, refer to the relevant Recommendation for data communication equipment.

Circuit 122—Backward channel received line signal detector

Direction: FROM data communication equipment.

This circuit is equivalent to circuit 109 (data channel received line signal detector), except that it is used to indicate whether the received backward channel line signal is within appropriate limits, as specified in the relevant Recommendation for data communication equipment.

For operation with clamping of circuit 119 (received backward channel data), refer to section IV.

Circuit 123—Backward channel signal quality detector

Direction: FROM data communication equipment.

This circuit is equivalent to circuit 110 (data signal quality detector), except that it is used to indicate the signal quality of the received backward channel line signal.

Circuit 124—Data channel receiver cut-off

Direction: TO data communication equipment.

This circuit may be used only when the clamping option, as defined in section IV, is not used.

The ON condition causes the data communication equipment to clamp circuit 104 (received data) to the binary 1 condition.

The OFF condition permits received data to be transferred to the data terminal equipment on circuit 104 (received data).

Circuit 125—Calling indicator

Direction: FROM data communication equipment.

Signals on this circuit indicate whether a calling signal is being received by the data communication equipment.

The ON condition indicates that a calling signal is being received.

The OFF condition indicates that no calling signal is being received, and shall appear also approximately coincident with any interruptions within a pulse-modulated calling signal.

Circuit 126—Select transmit frequency

Direction: TO data communication equipment.

Signals on this circuit are used to select the required transmit frequency of the data communication equipment.

The ON condition selects the higher transmit frequency.

The OFF condition selects the lower transmit frequency.

Circuit 127—Select receive frequency

Direction: TO data communication equipment.

Signals on this circuit are used to select required receive frequency of the data communication equipment.

The ON condition selects the lower receive frequency.

The OFF condition selects the higher receive frequency.

Circuit 128—Receiver signal element timing
(data terminal equipment source).

Direction: TO data communication equipment.

Either circuit 128 or circuit 115 may be used, but not both.

Signals on this circuit provide the data communication equipment with signal element timing information.

The condition on this circuit shall be ON and OFF for nominally equal periods of time. The data communication equipment shall present a data signal on circuit 104 (received data) in which the transitions between signal elements nominally occur at the time of the transitions from OFF to ON condition of the signal on circuit 128.

During periods when timing information is not provided, circuit 128 shall be held in the OFF condition.

Circuit 129—Backward channel receiver cut-off

Direction: TO data communication equipment.

This circuit is equivalent to circuit 124 (data channel receiver cut-off), except that it controls a clamp on circuit 119 (received backward channel data). This circuit may be used only when the clamping option, as defined in section IV, is not used.

Circuit 130—Transmit backward tone

Direction: TO data communication equipment.

Signals on this circuit control the transmission of a backward channel tone.

The ON condition causes the data communication equipment to transmit a backward channel tone.

The OFF condition causes the data communication equipment to stop the transmission of a backward channel tone.

Circuit 131—Received character timing

Direction: FROM data communication equipment.

Signals on this circuit provide the data terminal equipment with character timing information, as specified in the relevant Recommendation for data communication equipment.

Circuit 132—Return to non-data mode

Direction: TO data communication equipment.

Signals on this circuit are used to restore the non-data mode provided with the data communication equipment, without loosing the line connection to the remote station.

The ON condition causes the data communication equipment to restore the non-data mode. When the non-data mode has been established, this circuit must be turned OFF.

Circuit 133—Ready for receiving

Direction: TO data communication equipment.

Signals on this circuit control the transfer of data on circuit 104 (received data), indicating whether the data terminal equipment is capable to accept a certain amount of data (e.g. a block of data), specified in the appropriate Recommendation for intermediate equipment, for example error control equipment.

The ON condition must be maintained, whenever the data terminal equipment is capable to accept a block of data, and causes the intermediate equipment to transfer the received data to the data terminal equipment.

The OFF condition indicates that the data terminal equipment is not capable to accept a block of data, and causes the intermediate equipment to retain that block.

Circuit 134—Received data present

Direction: FROM data communication equipment.

Signals on this circuit are used to separate the information message from the supervisory message, transferred on circuit 104 (received data).

The ON condition indicates the data, which represent information message.

The OFF condition shall be maintained at all other times.

Interchange circuit No.	Interchange circuit name	Ground	Data		Control		Timing	
		Ground	From DCE **	To DCE **	From DCE **	To DCE **	From DCE **	To DCE **
1	2 PROPOSED NAMES	3	4	5	6	7	8	9
101	Protective ground (or earth)	x						
102	Signal ~~ground or~~ common return	x						
103	Transmitted data			x				
104	Received data		x					
105	~~Request to send~~ Send request Send request					x		
106	~~Ready for sending~~ Data channel ready				x			
107	Data set ready				x			
108/1	Connect data set to line					x		
108/2	Data terminal ready					x		
109	Data channel ~~received line~~ signal detector				x			
110	D... Signal quality detector				x			
111	Data signalling rate selector (DTE *)					x		
112	Data signalling rate ~~selector~~ indicator (DCE **)				x			
113	Transmitter ~~signal element~~ timing (DTE *)							x
114	Transmitter ~~signal element~~ timing (DCE **)						x	
115	Receiver ~~signal element~~ timing (DCE **)						x	
116	~~Select~~ stand-by selector					x		
117	Stand-by indicator				x			
118	Transmitted backward ~~channel~~ data			x				
119	Received backward ~~channel~~ data		x					
120	Transmit backward ~~channel line signal~~ send request					x		
121	Backward channel ready				x			
122	Backward ~~channel received line~~ signal detector				x			
123	Backward ~~channel signal~~ quality detector				x			
124	Data channel receiver cut-off Receiver clamp					x		
125	Calling indicator				x			
126	Select transmit frequency selector					x		

Interchange circuit No.	Interchange circuit name	Ground	Data		Control		Timing	
		Ground	From DCE **	To DCE **	From DCE **	To DCE **	From DCE **	To DCE **
1	2	3	4	5	6	7	8	9
127	~~Select receive frequency~~					x		
128	Receiver ~~signal element~~ timing (DTE *)							x
129	~~Backward channel receiver cut-off~~ (Backward receiver clamp)					x		
130	Transmit backward ~~tone~~ signal					x		
131	Received character timing						x	
132	Return ~~to~~ non-data ~~mode~~					x		
133	Ready ~~for receiving~~ to accept					x		
134	Received data present				x			
135 136 ESJ	Se ** Question 2/17 point AE							

* Data terminal equipment

** Data communication equipment

FIGURE 2. — 100-series interchange circuits by category

III-2. *200-series. Specifically for automatic calling*

A list of these interchange circuits is presented in tabular form in Figure 3.

For the proper procedures, refer to the relevant Recommendation for automatic calling procedures.

Circuit 201—Signal ground or common return

This conductor establishes the common reference potential for all 200-series interchange circuits except circuit 212 (protective ground or earth). Within the automatic calling equipment, this circuit shall be brought to one point, and it shall be possible to connect this point to circuit 212 (protective ground or earth) by means of a wire strap inside the equipment. This wire strap can be connected or removed at installation as may be required to meet applicable regulations or to minimize the introduction of noise into electronic circuitry.

Circuit 202—Call request

Direction: TO data communication equipment.

Signals on this circuit are used to condition the automatic calling equipment to originate a call and to switch the automatic calling equipment to or from the line.

The ON condition causes the data communication equipment to condition the automatic calling equipment to originate a call and to connect this equipment to the line. Circuit

202 must be turned OFF between calls or call attempts and shall not be turned ON again before circuit 203 (data line occupied) is turned OFF.

The OFF condition causes the automatic calling equipment to be removed from the line and indicates that the data terminal equipment has completed its use of the automatic calling equipment.

Circuit 203—Data line occupied

Direction: FROM data communication equipment.

Signals in this circuit indicate whether the communication channel is in use (e.g. for automatic calling, data or voice communication, test procedures).

The ON condition indicates that the communication channel is in use.

The OFF condition indicates that the communication channel is not in use, and that the data terminal equipment may originate a call, provided that circuit 213 (power indication) is ON.

Circuit 204—Distant station connected

Direction: FROM data communication equipment.

Signals on this circuit indicate whether a connection has been established to a remote data station.

The ON condition indicates the receipt of a signal from a remote communication equipment, that a connection to that equipment has been established. The ON condition on this circuit must be maintained until the data terminal equipment has completed its use of the automatic calling equipment, i.e. until circuit 202 (call request) is turned OFF.

The OFF condition shall be maintained at all other times.

Circuit 205—Abandon call

Direction: FROM data communication equipment.

Signals on this circuit indicate whether a pre-set time has elapsed between successive events in the calling procedure.

The ON condition indicates that a pre-set time has elapsed.

The OFF condition indicates that call origination can be proceeded. The OFF condition shall be maintained after circuit 204 (distant station connected) comes ON.

The initial time interval starts when circuit 202 (call request) comes ON. Subsequent time intervals start each time circuit 210 (present next digit) is turned OFF.

Digit signal circuits:

Circuit 206 — Digit signal (2^0)
Circuit 207 — Digit signal (2^1)
Circuit 208 — Digit signal (2^2)
Circuit 209 — Digit signal (2^3)

Direction: TO data communication equipment.

On these circuits the data terminal equipment presents the following code combinations, being the digits to be called and associated control characters.

The conditions on these four circuits shall not change while circuit 211 (digit present) is ON.

Information	*Binary states*			
	209	208	207	206
Digit 1	0	0	0	1
Digit 2	0	0	1	0
Digit 3	0	0	1	1
Digit 4	0	1	0	0
Digit 5	0	1	0	1
Digit 6	0	1	1	0
Digit 7	0	1	1	1
Digit 8	1	0	0	0
Digit 9	1	0	0	1
Digit 0	0	0	0	0
Control character EON	1	1	0	0
Control character SEP	1	1	0	1

The control character EON (end of number) causes the data communication equipment to take the appropriate action to await an answer of the called data station.

The control character SEP (separation) indicates the need for a pause between successive digits, and causes the automatic calling equipment to insert the appropriate time interval.

Circuit 210—Present next digit

Direction: FROM data communication equipment.

Signals on this circuit indicate whether the automatic calling equipment is ready to accept the next code combination on digit signal circuits 206, 207, 208 and 209.

The ON condition indicates that the automatic calling equipment is ready to accept the next code combination.

The OFF condition indicates that the automatic calling equipment is not ready to accept signals on the digit signal circuits. When circuit 210 is turned OFF, it shall not be turned ON again before circuit 211 (digit present) is turned OFF.

Circuit 211—Digit present

Direction: TO data communication equipment.

Signals on this circuit control the reading of the code combination presented on the digit signal circuits 206, 207, 208 and 209.

The ON condition causes the automatic calling equipment to read the code combination presented on the digit signal circuits.

Circuit 211 shall not be turned ON when circuit 210 (present next digit) is in the OFF condition, and not before the data terminal equipment has presented the required code combination on the digit signal circuits.

The OFF condition on this circuit prevents the automatic calling equipment from reading a code combination on the digit signal circuits.

Circuit 211 shall not be turned OFF before circuit 210 (present next digit) is turned OFF.

Circuit 212—Protective ground or earth

This conductor shall be electrically bonded to the machine or equipment frame. It may further be connected to external grounds as required by applicable regulations.

Circuit 213—Power indication

Direction: FROM data communication equipment.

Signals on this circuit indicate whether power is available within the automatic calling equipment.

The ON condition indicates that power is available within the automatic calling equipment and that the automatic calling equipment is ready to operate.

The OFF condition indicates that power is not available, and shall be detected as specified in paragraph V–6.

Interchange circuit No.	Interchange circuit name	Ground	Data		Control	
			From DCE *	To DCE *	From DCE *	To DCE *
201	Signal ground or common return	x				
202	Call request					x
203	Data line occupied				x	
204	Distant station connected				x	
205	Abandon call				x	
206	Digit signal (2^0)			x		
207	Digit signal (2^1)			x		
208	Digit signal (2^2)			x		
209	Digit signal (2^3)			x		
210	Present next digit				x	
211	Digit present					x
212	Protective ground or earth	x				
213	Power indication				x	

* DCE = Data communication equipment

FIGURE 3. — 200-series interchange circuits by category. Specifically for automatic calling

IV. CLAMPING

When clamping is used the following clamping conditions shall be provided by the data communication equipment:

1. In all applications the data communication equipment shall hold, where implemented:

a) Circuit 104 (received data) in the binary 1 condition when circuit 109 (data channel received line signal detector) is in the OFF condition, and

b) Circuit 119 (received backward channel data) in the binary 1 condition when circuit 122 (backward channel received line signal detector) is in the OFF condition.

2. In addition the data communication equipment, arranged for half duplex (C.C.I.T.T. definition: simplex) operation (turn-around systems), shall also hold, where implemented:

a) circuit 104 (received data) in the binary 1 condition and circuit 109 (data channel received line signal detector) in the OFF condition when circuit 105 (request to send) is in the ON condition, and for a short interval (to be specified in Recommendations for data communication equipment) following the ON to OFF transition on circuit 105, and

b) circuit 119 (received backward channel data) in the binary 1 condition and circuit 122 (backward channel received line signal detector) in the OFF condition when circuit 120 (transmit backward channel line signal) is in the ON condition, and for a short interval (to be specified in Recommendations for data communication equipment) following the ON to OFF transition on circuit 120.

Without these clamping conditions, there is no inhibition of signals, due to excessive noise, supervisory and control signals, switching transients, etc., from appearing on circuit 104, circuit 119, circuit 109 and circuit 122.

V. Electrical characteristics of interchange circuits

The electrical characteristics defined in this section apply to all interchange circuits defined in sections III–1 and III–2. These are represented by the equivalent circuit of Figure 4 and the signalling rate must not exceed the limit of 20 000 bits per second.

V–1 *Interchange equivalent circuit*

Figure 4 shows the interchange equivalent circuit with the electrical parameters, which are specified in this section.

This equivalent circuit applies to all interchange circuits regardless of the category (data, timing or control) to which they belong.

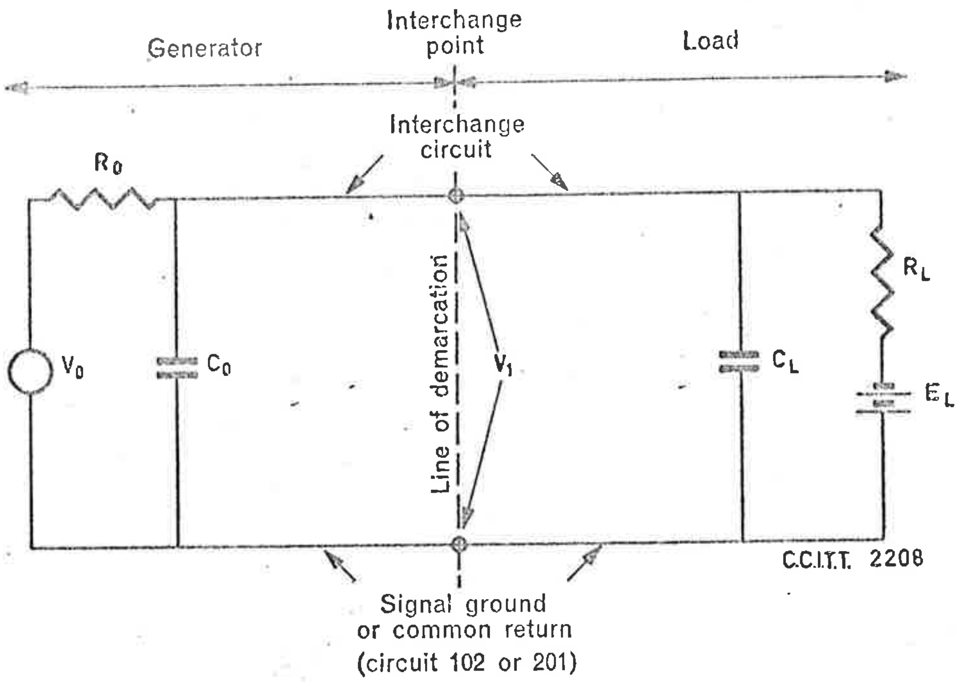


FIGURE 4. — **Interchange equivalent circuit**

This equivalent circuit is independent of whether the generator is located in the data communication equipment and the load in the data terminal equipment or vice versa.

The impedance associated with the generator (load) includes any cable impedance at the generator (load) side to the interchange point.

V_0 is the open-circuit generator voltage;

R_0 is the total effective d.c. resistance associated with the generator, measured at the interchange point;

C_0 is the total effective capacitance associated with the generator, measured at the interchange point;

V_1 is the voltage at the interchange point with respect to signal ground or common return;

C_L is the total effective capacitance associated with the load, measured at the interchange point;

R_L is the total effective d.c. resistance associated with the load, measured at the interchange point;

E_L is the open-circuit load voltage (bias).

V–2 *Load*

The impedance on the load side of an interchange circuit shall have a d.c. resistance (R_L) of not less than 3000 ohms, nor more than 7000 ohms, measured with an applied voltage (either positive or negative polarity) of 3 to 15 volts in magnitude.

The effective shunt capacitance (C_L) of the load, measured at the interchange point, shall not exceed 2500 picofarads.

To avoid inducing voltage surges on interchange circuits the reactive component of the load impedance shall not be inductive.

The open-circuit load voltage (E_L) shall not exceed 2 volts in magnitude.

The load on an interchange circuit shall not impair continuous operation with any input signals within the voltage limits specified in paragraph V-3.

V-3 *Generator*.

The generator on an interchange circuit shall withstand an open-circuit and a short circuit between itself and any other interchange circuit (including generators and loads) without sustaining damage to itself or its associated equipment.

The open-circuit generator voltage (V_0) on any interchange circuit shall not exceed 25 volts in magnitude. The impedance (R_0 and C_0) on the generator side of an interchange circuit is not specified; however, the combination of V_0 and R_0 shall be selected such that a short circuit between any two interchange circuits shall not result in any case in a current in excess of one-half ampere.

Additionally, when the load open-circuit voltage (E_L) is zero, the voltage (V_1) at the interchange point shall not be less than 5 volts and no more than 15 volts in magnitude (either positive or negative polarity), for any load resistance (R_L) in the range between 3000 ohms and 7000 ohms.

The effective shunt capacitance (C_0) at the generator side of an interchange circuit is not specified. However, the generator shall be capable of driving all of the capacitance at the generator side (C_0), plus a load capacitance (C_L) of 2500 picofarads.

Note. — Relay or switch contacts may be used to generate signals on an interchange circuit, with appropriate measures to ensure that signals so generated comply with paragraph V-5.

V-4 *Significant levels (V_1)*

For data interchange circuits, the signal shall be considered in the binary 1 condition when the voltage (V_1) on the interchange circuit measured at the interchange point is more negative than −3 V. The signal shall be considered in the binary 0 condition when the voltage (V_1) is more positive than +3 V.

For control and timing interchange circuits, the circuit shall be considered ON when the voltage (V_1) on the interchange circuit is more positive than +3 V, and shall be considered OFF when the voltage (V_1) is more negative than −3 V.

$V_1 < -3$ volts	$V_1 > +3$ volts
1	0
OFF	ON

FIGURE 5. — **Correlation table**

Note. — In certain countries, in case of direct connection to d.c. telegraph-type circuits only, the voltage polarities in Figure 5 may be reversed.

The region between +3 V and −3 V is defined as the transition region. The signal state or circuit condition is not uniquely defined when voltage (V_1) is in the transition region. For an exception to this, see paragraph V-6.

V–5 *Signal characteristics*

The following limitations to the characteristics of signals transmitted across the interchange point, exclusive of external interferences, shall be met at the interchange point when the interchange circuit is loaded with any receiving circuit, which meets the characteristics specified in paragraph V–2.

These limitations apply to all (data, control and timing) interchange signals unless otherwise specified.

1. All interchange signals entering into the transition region shall proceed through this region to the opposite signal state and shall not re-enter this region until the next significant change of signal condition.
2. There shall be no reversal of the direction of voltage change while the signal is in the transition region.
3. For control interchange circuits, the time required for the signal to pass through the transition region during a change in state shall not exceed one millisecond.
4. For data and timing interchange circuits, the time required for the signal to pass through the transition region during a change in state shall not exceed 1 millisecond or 3% of the nominal duration of a signal element on that interchange circuit, whichever is the lesser.
5. To reduce crosstalk between interchange circuits the maximum instantaneous rate of voltage change will be limited. A provisional limit will be 30 volts per microsecond.
6. When electromechanical devices are used on interchange circuits, paragraphs 1 and 2 above do not apply to data interchange circuits.

V–6 *Circuit failures*

The following interchange circuits, where implemented, shall be used to detect either a power-off condition in the equipment connected through the interface or the disconnection of the interconnecting cable:

Circuit 105	(request to send)
Circuit 107	(data set ready)
Circuit 108/1-108/2	(connect data set to line/data terminal ready)
Circuit 120	(transmit backward channel line signal)
Circuit 202	(call request)
Circuit 213	(power indication)

The power-off impedance of the generator side of these circuits shall not be less than 300 ohms, measured with an applied voltage (either positive or negative polarity) not greater than 2 volts in magnitude referenced to signal ground or common return.

The load for these circuits shall interpret the power-off condition or the disconnection of the interconnecting cable as an OFF condition on these circuits.

APPENDIX B EIA STANDARD RS-232-C, Figure 3. 1

Pin Number	Circuit	Description
1	AA	Protective Ground
2	BA	Transmitted Data
3	BB	Received Data
4	CA	Request to Send
5	CB	Clear to Send
6	CC	Data Set Ready
7	AB	Signal Ground (Common Return)
8	CF	Received Line Signal Detector
9	–	(Reserved for Data Set Testing)
10	–	(Reserved for Data Set Testing)
11		Unassigned (See section 3.2.3)
12	SCF	Sec. Rec'd. Line Sig. Detector
13	SCB	Sec. Clear to Send
14	SBA	Secondary Transmitted Data
15	DB	Transmission Signal Element Timing (DCE Source)
16	SBB	Secondary Received Data
17	DD	Receiver Signal Element Timing (DCE Source)
18		Unassigned
19	SCA	Secondary Request to Send
20	CD	Data Terminal Ready
21	CG	Signal Quality Detector
22	CE	Ring Indicator
23	CH/CI	Data Signal Rate Selector (DTE/DCE Source)
24	DA	Transmit Signal Element Timing (DTE Source)
25		Unassigned

Figure 3.1

Interface Connector Pin Assignments

APPENDIX C

SIGNAL DEFINITIONS

SIGNAL	SOURCE	DEFINITIONS
BIN	172	Transparent mode receiption
CLEAR	170	Input buffer clear
DBOX	170	Serial output data
DSI(x)	170II	Input data, synchronous communication
DSO(x)	171	Output data, synchronous communication
ICA0	170	Input stop-bit indicator
ICB1	170	Input timing signal, five-bit code
ICB1· ICB2	170	Input timing signal, seven-bit code
ICB2	170	Input timing signal, six-bit code
INDA	172	Received data enable
LINEI(x)	170	Line connection, input data
LINEO(x)	170	Line connection, output data
MDI(x)	1731	Control signal from Modem
MDO(x)	172	Control signal to Modem
OCAO	170	Output stop-bit indicator
OCA3· OCB1	170	Output timing signal, 1 1/2 stop-bit
OCB1	170	Output timing signal, five-bit code and one stop-bit (independent)
OCB1· OCB2	170	Output timing signal, seven-bit code
OCB2	170	Output timing signal, six-bit code and two stop-bits (independent)
OSC	170	Timing oscillator
PIN(x)	173	Signals connected to the specified contact pin on the DB-2SP Cannon plug
RCLOCK	173	Timing signal, received data
RSHIFT	170II	Input shift signal
SCLOCK	173	Timing signal, transmitted data
SSHIFT	170II	Output shift signal
SSYN	172	Transmitted data enable
SYN(x)	171	Wired SYN-character
SYNC1	171	Received SYN-character
SYNC2	171	Synchronized
TLX(x)	170	Input data bus
TTX(x)	171, 172	Input data bus

--ooOoo--

APPENDIX D CONTROL CIRCUIT CONNECTIONS

A Cannon plug pin
B CCITT circuit
C Bit in A-register, signals from DTE to DCE
D Bit in A-register, signals from DCE to DTE
E Name

A	B	C	D	E
1	101			Protective ground or earth
2	103			Transmitted data
3	104			Received data
4	105	1		Request to send
5	106		6	Ready for sending
6	107		4	Data set ready
7	102			Signal ground or common return
8	109		5	Data channel received line signal detector
11	120	3		Transmit backward channel line signal
12	122		3	Backward channel received line signal detector
13	123		7	Backward channel signal quality detector
14	118			Transmitted backward channel data
15	114			Transmitter signal element timing
16	119			Received backward channel data
17	115 (128)			Receiver signal element timing
20	108	0		Connect data set to line/Data terminal ready
21	110		1	Data signal quality detector
22	125		2	Calling indicator
23	111	2		Data signalling rate selector

The circuits necessary in a given configuration are determined by the type of modem selected.

APPENDIX E MODEM CABLE

TWISTED PARS IN CABLE	CANNON	BURNDY	C.P.U.	NAMES
Green/Blue	6/1	P/chass		
Blue /Brown	2/7	D/A		
Grey /Blue	3/7	E/J		
White/Blue	4/5	K/N		
Brown/Green	7/14	Y/BB		
Grey /Green	7/15	FF/CC		
Brown/Orange	7/16	HH/LL		
Grey /Orange	7/17	RR/MM		
White/Orange	8/9	T/S		
Green/Orange	10/11	V/W		
Blue /Orange	12/13	U/X		
Black/Orange	18/19	EE/DD		
Blue /Black	20/21	PP/SS		
White/Grey	22/23	VV/WW		
Brown/Grey	24/25	UU/XX		

DRAWN BY T.U./em	Remarks	Replacement for	Date
APPROVED BY		Replaced by	Date
DATE 24.2.70			

APPENDIX F TEST EQUIPMENT

The Test Equipment for Modem Interface is a Burndy plug which makes the following connections:

A-REG. OUT	BURNDY PLUG	A-REG. IN
A0	PP - P	A4
A1	K - T	A5
A2	WW- N	A6
A3	W - U	A3
DATA OUT	D - E	DATA IN
BACKWARD CHANNEL OUR	BB - LL	BACKWARD CHANNEL IN

CC and MM are connected to a free wire, and this have to be connected to an oscillator if the interface is for synchronous communication.

MODEM CONTROL

```
START/TRA   OPR
        IOT   SKA   ACT   MDO
        JMP         *-1
        SAA   0
        IOT   SKA   ACT   MDI
        JMP   *-1
        COPY SA     DT
        JMP   START
```

If OK, this program will give:

OPR0 = T4
OPR1 = T5
OPR2 = T6
OPR3 = T3

MDO = MODEM DATA OUT (71)
MDI = MODEM DATA IN (70)

TEST DATA

```
START, SAA   0
        BSET BCM   110   DA
        IOT   ACT   MDO
BEG,    TRA   OPR
        IOT   SKA   ACT   SDO
        JMP   *1
        SAA   0
        IOT   ACT   SDI
        COPY  SA    DT
        JMP   BEG
```

If OK, this program will give

OPR = T

after synchronization, and if OPR are not all ones, all zeroes or equal to SYN.

SDO = SYNCHRONOUS DATA OUT (73)
SDI = SYNCHRONOUS DATA IN (72)

If the interface is for asynchronous communication, we should always have

OPR = T

TEST WHOLE CONFIGURATION

MAIN CHANNEL : OPR → T

BACKWARD CHANNEL: COUNTING IN D.

SA

```
TEST, SAA 0
BSET BCM 110 DA
IOT SKA ACT 271
JMP *-1
IOT SKA ACT 270
JMP *-1
BSKP Z20 100 DA
JMP *-3
JMP START
START, IOF
SAA -1
MCL PID
MCL PIE
ION GR234
WAIT
LDA (BACK
STA I (61
LDA (LEV7
STA I (160
LDA (LEV11
STA I (224
LDA (4201
MST PIE
MIN VENT
JML *-1
IOT PIN 272
IOT PIN 273
IOT PIN 274
IOT PIN 275
JMP I *
VENT, 0

LEV7, IOT SNI 275
JMP D275
IOT SNI 273
JMP D273
IOF
WAIT 377
JMP START

D275, TRA OPR
IOT ACT PIN 275
A12, WAIT
JMP LEV7
```

CONTINUE.

```
D273, MIN COUNT
LDA COUNT
IOT ACT PIN 273
COPY SA DX
JMP A12
COUNT, 0

LEV11, IOT SNI 272
JMP D272
IOT SNI 274
JMP D274
IOF
WAIT 376
JMP START

D272, IOT ACT PIN 272
COPY SA DT
A13, WAIT
JMP LEV11

D274, IOT ACT PIN 274
COPY SA DD
JMP A13

BACK, LDF I (226
JMP *-1

)FILL

)LINE
```

A/S NORSK DATA-ELEKTRONIKK	Title: SIMPLEX CONTROL 160 232-235	Drawing no.

Terminal	G=output	Signal	Polarity	Connected to terminals		Terminal	G=output	Signal	Polarity	Connected to terminals	
1		+5V				31	W	INI	0	G14.31	G20.31
2		Ground				32		MT3	0	G14.32	G20.32
3						33		IR8	0	G16.42	G20.33
4		IOTE	1	G16.52	G20.04	34		IR10	0	G14.34	G20.34
5						35		IOTC	0	G14.35	G20.35
6		VF32	0	G18.08		36		MC	1	G15.32	G18.36
7		IR3	1	G14.07	G20.07	37		IR9	0	G16.31	G20.37
8		IR0	0	G14.08	G20.08	38	W	IN0	0	G14.38	G20.38
9		IR1	1	G14.54	G23.54	39					
10		IR2	0	G16.56	G20.10	40					
11						41					
12						42					
13						43					
14						44					
15						45	G	VS35		G18.33	
16						46					
17						47					
18						48					
19		IR5	0	G16.53	G20.19	49		VF35	1	G18.18	
20		IR4	1	G14.20	G20.20	50					
21	G	VE32	0	G18.05	23	51					
22		VE30	0	G20.21		52					
23		VE32	0	21		53		IR0	1	G16.57	G20.53
24	G	DR30	1	28		54		IR1	0	G16.58	G20.54
25	W		0	G16.30	G20.25	55		IR2	1	G08.55	G23.10
26						56					
27		DR30	1	28		57		GND		60	
28		DR30	1	24	27	58	G	VG35	1	G18.58	
29	W	DR	0	G14.29	G23.29	59		+5V			
30	W	DK	0	G16.29	G20.30	60		Ground			

DRAWN BY TKF/eml	Remarks	Replacement for	Date
APPROVED BY	G 17	Replaced by	Date
DATE 15.4.71			

A/S NORSK DATA-ELEKTRONIKK

Title: SYNCHRON CONTROL 171

Drawing no.

Terminal	G=output	Signal	Polarity	Connected to terminals	
1		+5V			
2		Ground		29	
3	G	RSYN	0	G21.32	
4	G	SYNC2	1	G21.30	
5		VE32	0	G17.21	
6		RCLOCK		G19.09	
7		BIN		G21.47	
8	G	VF32	0	G17.06	
9		DSI5	1	G19.11	
10		DSI4	1	G19.08	
11	W	TTX7	0	G15.07	G21.27
12		DSI6	1	G19.10	
13		DSI7	1	G19.07	
14	W	TTX6	0	G15.10	G21.25
15	W	TTX4	0	G15.08	G21.23
16	W	TTX5	0	G15.11	G21.28
17		VFX	0	G19.22	
18	G	VF35	1	G17.49	
19		DSI1	1	G19.24	
20		DSI0	1	G19.20	
21	W	TTX2	0	G15.25	G21.09
22		DSI2	1	G19.25	
23		DSI3	1	G19.21	
24	W	TTX3	0	G15.21	G21.10
25	W	TTX0	0	G15.20	G21.05
26	W	TTX1	0	G15.24	G21.06
27		SYN3	0	G21.33	31
28		INDA	1	G21.46	
29		SYN4	0	2	30
30		SYN1	0	29	34

Terminal	G=output	Signal	Polarity	Connected to terminals	
31		SYN6	0	27	35
32		VFY	1	G19.36	
33		VS35	0	G17.45	
34		SYN2	0	30	
35		SYN0	0	31	37
36		MC	1	G17.36	G19.3[illegible]
37		SYN7	0	35	38
38		SYN5	0	37	
39		A2	1	G16.16	G21.4[illegible]
40		A1	1	G16.08	G21.3[illegible]
41		A5	1	G16.19	G21.5[illegible]
42	G	DS05	1	G19.39	
43	G	DS02	1	G19.46	
44		A6	1	G16.27	G21.5[illegible]
45	G	DS01	1	G19.47	
46	G	DS06	1	G19.38	
47	G	DS03	1	G19.45	
48	G	DS04	1	G19.40	
49		A4	1	G16.18	G21.5[illegible]
50		A7	1	G16.26	G21.4[illegible]
51	G	DS00	1	G19.48	
52	G	DS07	1	G19.37	
53					
54	G	SYNC1	1	G19.23	
55		A0	1	G16.07	G21.3[illegible]
56		A3	1	G16.15	G21.5[illegible]
57		SCLOCK	0	G19.26	
58		VG35	1	G17.58	
59		+5V			
60		Ground			

DRAWN BY TKF/eml

APPROVED BY

DATE 15.4.71

Remarks: G 18

Replacement for | Date

Replaced by | Date

A/S NORSK DATA-ELEKTRONIKK	Title: DUPLEX BUFFER 170 II	Drawing no.

Terminal	G=output	Signal	Polarity	Connected to terminals		Terminal	G=output	Signal	Polarity	Connected to terminals	
1		+5V				31		GND		12	
2		Ground		12		32		MC	1	G18.36	G20.36
3						33		VFY	0	36	
4						34					
5						35					
6						36	G	VFY	0	33	G18.32
7	G	DSI7	1	G18.13		37		DS07	1	G18.52	
8	G	DSI4	1	G18.10		38		DS06	1	G18.46	
9		RCLOCK	1	G18.06	G22.33	39		DS05	1	G18.42	
10	G	DSI6	1	G18.12		40		DS04	1	G18.48	
11	G	DSI5	1	G18.09		41					
12		GND		2	31	42					
13						43		SSYN	0	G21.45	
14						44					
15						45		DS03	1	G18.47	
16						46		DS02	1	G18.43	
17						47		DS01	1	G18.45	
18						48		DS00	1	G18.51	
19						49					
20	G	DSI0	1	G18.20		50					
21	G	DSI3	1	G18.20		51					
22	G	VFX	0	G18.17		52					
23		SYNC1	1	G18.54		53					
24	G	DSI1	1	G18.19		54					
25	G	DSI2	1	G18.22		55		DBIX	1	G22.08	
26		SCLOCK	1	G18.57	G22.32	56					
27						57	G	DBOX	1	G22.29	
28						58					
29						59		+5V			
30						60		Ground			

DRAWN BY TKF/eml	Remarks	Replacement for	Date
APPROVED BY	G 19	Replaced by	Date
DATE 15.4.71			

A/S NORSK DATA-ELEKTRONIKK	Title: SIMPLEX CONTROL 160 230-231	Drawing no.

Terminal	G=output	Signal	Polarity	Connected to terminals		Terminal	G=output	Signal	Polarity	Connected to terminals	
1		+5V				31	W	INI	0	G17.31	G23.31
2		Ground				32		MT3	0	G17.32	G23.32
3						33		IR8	0	G17.33	G23.33
4		IOTE	1	G17.04	G23.04	34		IR10	0	G17.34	G23.34
5	G	VG30	1	G21.19		35		IOTC	0	G17.35	G23.35
6		VF30	0	G21.03		36		MC	1	G19.32	G21.20
7		IR3	1	G17.07	G23.07	37		IR9	0	G17.37	G23.37
8		IR0	0	G17.08	G23.08	38	W	IN0	0	G17.38	G23.38
9		IR1	0	54	G23.09	39					
10		IR2	0	55	G17.10	40					
11						41					
12						42					
13						43					
14						44					
15						45	G	VS31	0	G21.21	
16						46					
17						47					
18						48					
19		IR5	0	G17.19	G23.19	49					
20		IR4	1	G17.20	G23.20	50					
21	G	VE30	0	G21.31		51					
22						52					
23						53		IR0	1	G17.53	G23.53
24						54		IR1	0	9	G17.54
25	W	DC	0	G17.25	G23.25	55		IR2	0	10	G23.55
26						56					
27						57		VF31	0	G21.34	
28						58	G	VG31	1	G21.35	
29						59		+5V			
30	W	DK	0	G17.30	G23.30	60		Ground			

DRAWN BY	TKF/em	Remarks: G 20	Replacement for	Date
APPROVED BY			Replaced by	Date
DATE	15.4.71			

A/S NORSK DATA-ELEKTRONIKK	Title: MODEM CONTROL 172	Drawing no.

Terminal	G = output	Signal	Polarity	Connected to terminals		Terminal	G = output	Signal	Polarity	Connected to terminals	
1		+5V				31		VE30	0	G20.21	
2		Ground				32		RSYN	0	G18.03	
3	G	VF30	0	G20.06		33	G	PLUSS	1	G18.27	
4		MDI0	1	G22.54		34	G	VF31	0	G20.57	
5	W	TTX0	0	G18.25	G24.20	35		VG31	1	G20.58	
6	W	TTX1	0	G18.26	G24.24	36	G	MD01	1	G22.44	
7		MDI1	1	G22.53		37	G	MD00	1	G22.50	
8		MDI2	1	G22.47		38		A1	1	G18.40	G24.47
9	W	TTX2	0	G18.21	G24.25	39		A0	1	G18.55	G24.48
10	W	TTX3	0	G18.24	G24.21	40		A2	1	G18.39	G24.46
11		MDI3	1	G22.45		41		A11	1	G17.39	
12		IR10	1			42		A10	1	G17.40	
13	W	TTX8	0	G12.13		43		A9	1	G17.33	
14	W	TTX9	0	G12.14		44		A8	1	G17.32	
15						45	G	SSYN	0	G19.43	
16	W	TTX10	0	G12.16		46	G	INDA	1	G18.28	
17						47	G	BIN	0	G18.07	
18	W	TTX11	0	G12.18		48	G	MD07	1	G22.10	
19		VG30	1	G20.05		49		A7	1	G18.50	G24.37
20		MC	1	G20.36	G23.36	50		A5	1	G18.41	G24.39
21		VS31	0	G20.45		51		A4	1	G18.49	G24.40
22		MDI4	1	G22.23		52	G	MD04	1	G22.24	
23	W	TTX4	0	G18.15	G24.08	53		A6	1	G18.44	G24.38
24		MDI6	1	G22.19		54	G	MD02	1	G22.42	
25	W	TTX6	0	G18.14	G24.10	55		A3	1	G18.56	G24.45
26		MDI7	1	G22.06		56	G	MD06	1	G22.12	
27	W	TTX7	0	G18.11	G24.07	57	G	MD05	1	G22.15	
28	W	TTX5	0	G18.16	G24.11	58	G	MD03	1	G22.39	
29		MDI5	1	G22.21		59		+5V			
30		SYNC2	1	G18.04		60		Ground			

DRAWN BY TKF/eml	Remarks: G 21	Replacement for	Date
APPROVED BY		Replaced by	Date
DATE 15.4.71			

A/S NORSK DATA-ELEKTRONIKK	Title: MODEM DRIVER 173	Drawing no.

Terminal	G=output	Signal	Polarity	Connected to terminals		Terminal	G=output	Signal	Polarity	Connected to terminals	
1		+5V				31					
2		Ground				32	G	SCLOCK	1	G19.26	
3		PIN16			LL	33	G	RCLOCK	1	G19.09	
4	G	BCDBIX	1	G24.55		34					
5		PIN13			X	35		PIN17			MM
6	G	MDI7	1	G21.26		36		PIN15			CC
7		PIN3			E	37					
8	G	DBIX	1	G19.55		38		PIN11			W
9		PIN19			DD	39		MD0	1	G21.58	
10		MD07	1	G21.48		40		PIN23			WW
11		PIN18			EE	41					
12		MD06	1	G21.56		42		MD02	1	G21.54	
13						43					
14						44		MD01	1	G21.36	
15		MD05	1	G21.57		45	G	MDI3	1	G21.11	
16						46		PIN12			U
17						47	G	MDI2	1	G21.08	
18		PIN5			N	48		PIN22			VV
19	G	MDI6	1	G21.24		49		PIN4			K
20		PIN8			T	50		MD00	1	G21.37	
21	G	MDI5	1	G21.29		51		PIN20			PP
22		PIN6			P	52		PIN21			SS
23	G	MDI4	1	G21.22		53	G	MDI1	1	G21.07	
24		MD04	1	G21.52		54	G	MDI0	1	G21.04	
25		BCDBOX	1	G24.57		55		-6V			
26						56					
27		PIN14			BB	57		+8V			
28		PIN2			D	58					
29		DBOX	1	G19.57		59		+5V			
30						60		Ground			

DRAWN BY TKF/el	Remarks: G 22	Replacement for	Date
APPROVED BY		Replaced by	Date
DATE 15.4.71			

A/S NORSK DATA-ELEKTRONIKK	Title: SIMPLEX CONTROL 160 233-234	Drawing no.

Terminal	G=output	Signal	Polarity	Connected to terminals		Terminal	G=output	Signal	Polarity	Connected to terminals	
1		+5V				31	W	INI	0	G20.31	
2		Ground				32		MT3	0	G20.32	
3						33		IR8	0	G20.33	
4		IOTE	1	G20.04		34		IR10	0	G20.34	
5	G	VG34	1	G24.04		35		IOTC	0	G20.35	
6		VF34	0	G24.22		36		MC	1	G21.20	
7		IR3	1	G20.07		37		IR9	0	G20.37	
8		IR0	0	G20.08		38	W	IN0	0	G20.38	
9		IR1	0	G20.09		39					
10		IR2	1	G17.55		40					
11						41					
12						42					
13						43					
14						44					
15						45	G	VS33	0	G24.33	
16						46					
17						47					
18						48					
19		IR5	0	G20.19		49					
20		IR4	1	G20.20		50					
21	G	VE34	0	G24.27	22	51					
22		VE34	0	21	23	52					
23		VE34	0	22		53		IR0	1	G20.53	
24	G	DR34	1	28		54		IR1	1	G17.09	
25	W	DC	0	G20.25		55		IR2	0	G20.55	
26						56					
27		DR34	1	28		57		VF33	0	G24.36	
28		DR34	1	27	24	58	G	VG33	1	G24.42	
29	W	DR	0	G17.29		59		+5V			
30	W	DK	0	G20.30		60		Ground			

DRAWN BY TKF/eml	Remarks	Replacement for	Date
APPROVED BY	G 23	Replaced by	Date
DATE 15.4.71			

A/S NORSK DATA-ELEKTRONIKK	Title: DUPLEX BUFFER 170	Drawing no.

Terminal	G=output	Signal	Polarity	Connected to terminals		Terminal	G=output	Signal	Polarity	Connected to terminals	
1		+5V				31		GND		26	43
2		Ground				32		MC	1	G23.36	
3						33		VS33	0	G23.45	
4		VG34	1	G23.05		34	G	OCB1	1	30	
5						35					
6						36	G	VF33	0	G23.57	
7	W	TTX7	0	G21.27		37		A7	1	G21.49	
8	W	TTX4	0	G21.23		38		A6	1	G21.53	
9		GND		2	12	39		A5	1	G21.50	
10	W	TTX6	0	G21.25		40		A4	1	G21.51	
11	W	TTX5	0	G21.28		41					
12		GND		9	26	42		VG33	1	G23.58	
13						43		GND		31	
14						44					
15						45		A3	1	G21.55	
16						46		A2	1	G21.40	
17						47		A1	1	G21.38	
18						48		A0	1	G21.39	
19						49					
20	W	TTX0	0	G21.05		50	G	VCL	1	51	
21	W	TTX3	0	G21.10		51		VCL	1	50	
22		VF34	0	G23.06		52					
23						53					
24	W	TTX1	0	G21.06		54					
25	W	TTX2	0	G21.09		55		BCDBIX	1	G22.04	
26		GND		12	31	56					
27		VE34	0	G23.21		57		BCDBOX	1	G22.25	
28						58					
29						59		+5V			
30		OCB1	1	34		60		Ground			

DRAWN BY TKF/eml	Remarks: G 24	Replacement for	Date
APPROVED BY		Replaced by	Date
DATE 15.4.71			