Thurlby DA100

Serial Data Protocol Analyser

(Incorporating DA101 and DA102)

OPERATING MANUAL

Thurlby

INDEX

Non-standard characters displayed using VIEW when set to ASCII or Count + ASCII modes:

CR = carriage return

LF = line feed

FE = framing error

PE = parity error

OR = over-run error

N.B. See inside rear cover for important addenda.

1. INTRODUCTION

The Thurlby DA100 is a compact protocol analyser for use on asynchronous serial data communication systems, particularly RS-232. Its diagnostic capabilities can assist in solving many of the common problems that occur when working with such systems.

The DA100 provides baud rate analysis, data word format analysis, data monitoring (ASCII or Hex), triggered data capturing, and test data generation.

The DA100 uses an oscilloscope as its display device. It connects to any standard oscilloscope via a single cable and displays 32 characters of alpha-numeric text. Alternatively the optional DA101 LCD display unit can be fitted which allows the analyser to be used independently of an oscilloscope.

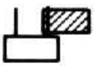
The data input and output for the DA100 is provided via BNC sockets suitable for a standard oscilloscope probe (1:1). The optional DA102 RS-232 "breakout box" provides a convenient means of making connections into an RS-232 system directly.

The DA102 provides full breaking and patching of 25 lines, data monitoring of the transmit and receive lines via the DA100, and level monitoring of the eleven most commonly used lines plus one uncommitted line.

2. POWER SOURCE

The DA100 is normally powered from a 9 volt PP3 size disposable battery (also referred to as 006P or 6F22). The current consumption is typically less than 4 mA which results in a potential operating life of over 100 hours using an alkaline battery. In standby mode the current set-up conditions of the DA100 are maintained and the power consumption is reduced to below 0.1 mA. Standby mode can be maintained for several months when using an alkaline battery.

Alternatively the DA100 can be powered from an external battery eliminator. The requirement is for a nominal DC voltage of 12 volts supplied through a 2.5 mm jack plug (tip positive). The battery is automatically disconnected when external power is applied provided that the jumper on the PCB is set to off. Note that if the battery eliminator is turned off when the DA100 is turned on, current will be taken from the battery again.

LINK POSITION:  **DISPOSABLE BATTERY**  **RECHARGEABLE BATTERY**

A rechargeable battery can be used as an alternative to a disposable battery. It can be charged inside the unit using a battery eliminator as described above if the jumper mounted on the PCB is set to on. The charge rate is typically 10mA.

3. CONNECTING TO AN OSCILLOSCOPE

The socket marked "Oscilloscope" should be connected to the vertical input of an oscilloscope using the BNC cable provided. The oscilloscope should be set as follows:

Input coupling: DC
Sensitivity: 50mV per division
Vertical position: Slightly clockwise
Horizontal position: Central

Timebase: 0.1ms (100us) per division
Sweep holdoff (if provided): Minimum
Trigger source: As input channel (not vertical mode)
Trigger settings: AC coupled, positive slope, zero level

Upon switching on the DA100, the unit will briefly display an identifying message and then display the main menu. If the display is unstable, readjust the trigger control. The display should show the message:

< SETUP VIEW SEND ANALYSE >

The word SETUP should be in reverse video. Readjust the horizontal position control such that the whole message is visible including the < and > symbols. On some oscilloscopes it may be necessary to adjust the sweep variable control slightly as well. The message should be about three quarters of the way up the graticule, readjust the vertical position control if necessary.

For more information about possible problems with the oscilloscope display see Appendix A.

4. CONNECTING TO THE DATA

The input data is supplied to the DA100 via a BNC socket. Any cable terminated with a BNC plug may be used but the most convenient is likely to be a standard oscilloscope probe. The probe must be 1:1 since an attenuated signal is liable to have too low a level to operate the analyser.

A similar socket is provided for the data output associated with the Send function.

In addition to the main data input and output sockets there is a 14 way connector at the bottom of the unit. This connector is for use with the optional DA102 RS-232C breakout box. When this is fitted, data input and output are available directly on the DA102 patch socket.

The input threshold of the analyser is approximately +1.5V and it can accept signals of up to ±25V. The analyser regards a signal more positive than +1.5V as a Space or a 0, and a signal more negative than +1.5V as a Mark or a 1.

When the DA100 is Sending, the levels it produces are approximately +5V for a Space and −5V for a Mark. These levels are consistent with RS-232C which defines a Space as more positive than +3V and a Mark as more negative than −3V.

5. USING THE ANALYSER

5.1 BASIC PRINCIPLES

The DA100 is fully menu driven. The basic function of each of the four buttons is as follows:

Select/Stop — Selects a function from a menu. Where the selected function is an "action" function (e.g. Send), pressing it again stops the function.

Toggle — Enables multiple choices to be selected in turn after a menu function has been selected.

Move — Moves the highlighting bar from one menu item to the next. Also selects the next digit when setting multi-digit numbers.

Finish/Menu — Terminates a function and returns to the previous menu.

MENU TREE

Action or (Toggle Options)

- SETUP
  - FORMAT
    - AUTO CHECK — Finds unknown baud rate, word format etc.
    - MANUAL — Baud Rate, Data Bits, Parity, Stop Bits (50-38400, 7 or 8, None/Even/Odd, 1 or 2)
  - MODE — (ASCII, HEX, COUNT + ASCII)
  - TRIGGER
    - EVENT — (TRG BYTE TRUE, DATA ERROR, P LINE TOGGLE)
    - TRG-BYT — (Up to three Hex Bytes)
    - COUNT — (01 to 99 Events)
    - DELAY — (0000 to 9999 Bytes)
  - OUTPUT
    - TERMINATOR — (CR & LF, LF & CR, CR, LF)
    - HANDSHAKE — (TRUE ALWAYS, XON/XOFF, MARK, SPACE)
    - BIT 8 — (0 or 1)
- VIEW
  - DATA — Views data continuously
  - TRG DATA — Views data and stops on trigger event
  - BRK BOX LINES — Displays status of breakout box lines
- SEND
  - SINGLE — Sends a simple ASCII string once
  - REPEAT — Sends ASCII string continuously
- ANALYSE
  - DATA ERRORS — Displays number of errors received
  - BAUD ERRORS — Displays percentage error of baud rate

5.2 THE MAIN MENU

The Main menu has four options:

SETUP — Enables the operational parameters of the analyser to be set up prior to operation. Setup incorporates a facility for automatically finding an unknown baud rate and data word format. Selecting SETUP brings up the Setup menu.

VIEW — Enables the unit to display data in either ASCII or HEX formats and to count the total numbers of words received. Data can be frozen either manually or by a variety of preset trigger conditions. Selecting VIEW brings up the View menu.

SEND — Causes the unit to send an ASCII character string and simultaneously to monitor any handshake activity. Selecting SEND brings up the Send menu.

ANALYSE — Enables the unit to analyse baud rate errors or data word errors against a user defined data format. Selecting ANALYSE brings up the Analyse menu.

5.3 THE SETUP MENU

The Setup menu has four options:

FORMAT — Enables the data word format and the baud rate to be set. Selecting FORMAT brings up the Format menu which has choices of AUTO-CHECK or MANUAL. See also Appendix B.

Selecting **AUTO-CHECK** causes the DA100 to attempt to set the baud rate and word format automatically by analysing the data stream. Initially it will analyse the baud rate and will display its estimate of the rate along with an error percentage. Once the displayed baud rate is stable with a low error rate, press Select/Stop to accept that baud rate. The unit will then move on to analysing the data word format.

In this mode it will set an arbitrary word format and then count the number of errors received using this format. Once the number of errors received exceeds five it will change the format and try again. It will continue to change formats until error free reception is achieved. Once this has occurred, press Select/Stop to accept that word format. The unit will then move on to analysing the number of stop bits.

In this mode it will set the stop bits to 1 and count the number of errors received. If the number of errors exceeds 5 it will return the stop bits setting to 2. Press Select/Stop to accept the number of stop bits. This causes the derived baud-rate, word format and number of stop bits to be written into the format memory of the analyser. Note that Auto-check requires a long data stream to be able to operate.

Selecting **MANUAL** brings up the current baud rate, data word length, parity, and number of stop bits from the format memory. The default, which is returned to each time that the analyser is switched off, is 9600 baud, 7 bits, no parity, 1 stop bit. To change any item, highlight it using the Move button and use the Toggle button to step through the options. When all four items are set as required press Finish/Menu.

The baud rate options are 50, 75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, or 38400. A further option of EXT is provided which enables an externally defined baud rate to be used. This is only available when the optional DA102 RS-232C breakout box is fitted (see section 7.5).

For further information on the FORMAT option see Appendix B.

MODE — Enables the display mode to be selected. Selecting MODE causes the present display mode to be shown, pressing the Toggle button steps through the three options of ASCII, HEX, and COUNT + ASCII. When the required mode is shown press Finish/Menu.

Selecting **ASCII** mode causes the display to show the most recent 32 data bytes as ASCII characters. The bytes are written onto the screen from left to right. When thirty two bytes have been received the data is scrolled left such that the thirty two most recent bytes are always displayed.

Selecting **HEX** mode is similar to selecting ASCII mode but the most recent 16 data bytes are displayed in Hexadecimal.

Selecting **COUNT + ASCII** mode causes the display to show a running decimal total of the number of bytes received plus the most recent 24 bytes as ASCII characters.

TRIGGER — Enables the conditions for triggering to be set (triggering freezes the display at a defined point in time). Selecting TRIGGER brings up the Trigger menu.

OUTPUT — Enables the format of the data output used with the SEND function to be set. Also enables the type of handshaking to be set. Selecting OUTPUT brings up the Output menu.

5.3.1 THE DEFAULT SETUP CONDITIONS

Whenever the DA100 is switched to Standby the existing setup conditions are maintained. However, when it is switched to off, the setup conditions are reset to their defaults which are:

Format:- 9600 baud, 7 bit data word, no parity, 1 stop bit.
Mode:- ASCII.
Trigger:- Event — Trg bytes true, Trg bytes — XX XX XX, Count — 01, Delay — 0000.
Output:- Terminator — CR + LF, Handshake — probe is Mark, Bit 8 — 0.

5.3.2 THE TRIGGER MENU

The Trigger menu has four options:

EVENT — Enables the trigger event to be defined as one of three types. Selecting EVENT causes the current trigger event type to be displayed, pressing the toggle button steps through the three options of TRG BYTES TRUE, PARITY ERROR, or P LINE TOGGLE. When the required type is shown press Finish/Menu.

Selecting **TRG BYTES TRUE** defines the trigger event as being the reception of up to three sequential data bytes as defined by the user.

Selecting **PARITY ERROR** defines the trigger event as being the occurrence of a parity error on the received data.

Selecting **P LINE TOGGLE** defines the trigger event as being a change in level on the P line from the optional DA102 RS-232C breakout box. This facility cannot be used when the DA102 is not fitted.'

TRG-BYT — Enables the data bytes to be defined for use with the TRG BYTES TRUE trigger event option. When TRG-BYT is selected the display shows the current setting of the three trigger bytes in Hex followed by the ASCII equivalent (if valid) in brackets. The default setting, which is returned to each time the analyser is switched off, is all bytes set to "don't care" (a don't care is signified by an X).

The three bytes represent three data bytes which, if they occur consecutively, will generate a trigger event. If only a single byte trigger is required (for example) the other two bytes should be set to don't care.

To set the bytes use the Move button to select the hex digit that you wish to change and use the toggle button to step through the 17 options (0 to F plus X). Where a byte represents a displayable ASCII character it will also appear between the brackets. When all the bytes have been set press Finish/Menu.

COUNT — Enables the number of times that the trigger event must occur before the analyser responds to be set beyond one. Selecting COUNT causes the display to show the current value of the Event Count as a two digit decimal number. The default value, which is returned to each time the analyser is switched off, is 01.

To set the number, use the Move key to select the digit that you wish to change and the toggle button to step through the numbers 0 to 9. When both digits have been set correctly press Finish/Menu.

DELAY — Enables the triggering of the analyser to be delayed by a user specified number of data bytes after the trigger event (post-trigger delay). Selecting DELAY causes the display to show the current value of the Post-trigger Delay as a four digit decimal number. The default value, which is returned to each time the analyser is switched off, is 0000.

To set the number, use the Move key to select the digit that you wish to change and use the Toggle button to step through the numbers 0 to 9. When all four digits have been set correctly press Finish/Menu.

When the Post-trigger Delay is set to zero, TRG DATA mode will capture only pre-trigger data. Setting a Post-trigger Delay enables any mixture of pre and post trigger data to be captured or allows data occurring long after the trigger event to be captured.

5.3.3 THE OUTPUT MENU

The Output menu has three options:

TERMINATOR — Enables the terminator for the SEND function to be defined as one of four types. Selecting TERMINATOR causes the current terminator to be displayed, pressing the toggle button steps through the four options of: CR followed by LF, LF followed by CR, CR alone, or LF alone. When the required type is shown press Finish/Menu.

HANDSHAKE — Enables the handshaking for the SEND function to be defined. The message is only sent while the handshake input to the DA100 is set "true". Selecting HANDSHAKE causes the current type to be displayed, pressing the toggle button steps through the four options of: TRUE ALWAYS, TRUE USING X-ON/X-OFF, TRUE IF MARK, or TRUE IF SPACE. When the required type is shown press Finish/Menu.

BIT8 — Enables bit 8 of the bytes sent when using the SEND function to be always a 1 (Mark) or always a 0 (Space). (Only applies when the word format is set to 8 bits). Selecting BIT8 causes the current level to be displayed, pressing the toggle button toggles between 1 and 0. When the required level is shown press Finish/Menu.

5.4 THE VIEW MENU

The View menu has three options:

DATA — Selecting DATA causes the analyser to display the input data in the format set by the Mode option from the Setup menu. The data is displayed continuously with new data overwriting the old until the Select/Stop button is pressed again. This freezes the data on the display. Any trigger conditions that have been set are ignored. The display shows "waiting" until the first byte of data is received.

TRG-DATA — Selecting TRG-DATA causes the analyser to display the input data in the format set by the Mode option from the Setup menu. The data is displayed continuously with new data overwriting the old until the trigger conditions set in the Trigger menu are met. When this occurs the displayed data is frozen. Alternatively the data can be frozen by pressing the Select/Stop button again. The display shows "waiting" until the first byte of data is received.

BRKT-BOX LINES — Selecting BRKT-BOX LINES causes the analyser to display the state of the lines from the optional DA102 RS-232 breakout box (when it is fitted). The eleven most commonly used lines are monitored. The state of each line is displayed as an "m" for Mark, an "s" for Space, or an "x" for indeterminate (level between ±3V), with the V.24 standard line number appearing to the left.

An extra line called P is also provided which can be patched onto any of the breakout box lines. The P line differs from the other lines in that it incorporates a pulse stretcher and a pulse memory. If the line is being toggled rapidly and continuously a "t" symbol will be displayed. Also, if the line changes state at any time after BRKT-BOX LINES has been selected a "p" symbol is displayed to the right hand side. To reset the "p" symbol press Finish/Menu.

5.5 THE SEND MENU

The Send menu has two options:

SINGLE — Selecting SINGLE causes a data string to be sent from the analyser data output socket using the baud rate and word format as set from the Setup menu. The string is the ASCII character set A to Z, followed by a space, followed by the character set 0 to 9, followed by a terminator. The terminator is as set from the Output menu. The string will only be sent while the handshake conditions are true as set from the Output menu.

REPEAT — Selecting REPEAT has the same effect as selecting SINGLE except that the string is sent continuously. Press the Select/Stop button to stop sending.

HANDSHAKING — The data input should be connected to the handshake line of the equipment to which the DA100 is connected. Handshaking can be set to be X-ON/X-OFF (via the TXD line of the receiving equipment) or Hardware (normally via the DTR or RTS line of the receiving equipment). The display monitors the state of the handshake line while data is being sent. Data will only be sent while the handshake condition is true.

5.6 THE ANALYSE MENU

The analyse menu has two options:

DATA-ERRORS – Enables the number of received data word errors to be analysed. Selecting DATA-ERRORS causes the display to show the current data word format from the format memory along with a count of the number of words received correctly (OK) and the number of words received with errors (ER). The count can be frozen by pressing Select/Stop.

BAUD-ERRORS – Enables the accuracy of the baud rate to be analysed. Selecting BAUD-ERRORS causes the display to show the baud rate from the format memory plus an error figure in percent.

6. DA101 LIQUID CRYSTAL DISPLAY UNIT

INTRODUCTION

The DA101 is an optional LCD display unit which fixes to the DA100 analyser in order that it can be operated as a self contained unit without the need for an oscilloscope as the display. Power for the DA101 is provided from the DA100.

6.1 FITTING INSTRUCTIONS

Plug the DA101 into the connector socket in the top of the DA100 and secure it on the base using the two countersunk screws provided.

6.2 OPERATING NOTES

The DA100 automatically senses the presence of the DA101 and switches its display driver mode accordingly. It is not possible to use the oscilloscope display output when the DA101 is fitted.

The DA101 display differs from the oscilloscope display in that the characters are in two rows of 16 instead of one row of 32. It is also incapable of showing reverse video and therefore menu items are highlighted by enclosing them between arrows instead of reversing them. Individual characters are highlighted by flashing them instead of reversing them.

Otherwise the operation of the DA100 with the DA101 fitted is identical to its operation using an oscilloscope display.

7. DA102 RS-232C BREAKOUT BOX

INTRODUCTION

The DA102 is an optional unit which fits onto the DA100 and provides a convenient means of making connections into an RS-232C V.24 system. It provides full breaking and patching of the lines and enables the data input and output of the DA100 to be linked directly into the RS-232C system. It also enables the DA100 to monitor the levels of the 11 most commonly used lines plus one user-defined line. The DA102 is powered from the DA100.

7.1 FITTING INSTRUCTIONS

Plug the DA102 into the connector socket in the bottom of the DA100 and secure it to the base of the DA100 using the two countersunk screws provided.

7.2 MAKING CONNECTIONS

The DA102 is fitted with four 25-way D connectors plus one 15-way D connector. The left hand pair of sockets is marked DCE and the right hand pair is marked DTE. The two outside connectors are for connection to the data equipment, the two inside connectors are for use as patch sockets.

The 24 slide switches connect pins 2 - 25 of the DCE side to pins 2 - 25 of the DTE side. Pin 1 (protective ground) is linked directly. Setting any switch to "off" breaks the connection. The lines can be "patched" to provide alternative connection patterns using the patch cables provided.

The 15-way socket provides two sets of 3 interconnected pins to enable several lines to be linked together, and two pairs of pins for "faking" RS-232C levels onto the lines, one at "mark" and one at "space". It also provides connections to the "data in" and "data out" lines of the DA100 analyser and a special monitor line marked P. There are also two further input lines which are marked with a ! symbol, these are explained in section 7.5.

Note that the ground connection of the DA100 is linked to pin 7 of the DCE side of the DA102.

7.3 MONITORING THE LINES

The eleven most commonly used RS-232C lines are monitored by high impedance comparators. These lines are 3, 5, 6, 8, 15, 17, 21, 23 on the DCE side and 2, 4, 20 on the DTE side.

The comparators define any voltage more negative than −3V as a mark (m), any voltage more positive than +3V as a space (s), and any voltage between −3V and +3V as undefined (x). The voltages are measured relative to pin 7 of the DCE side. The line levels are displayed using the BRKT-BOX LINES option from the VIEW menu of the DA100.

A further uncommitted monitoring line marked P is available on the 15-way socket. This differs from the other 11 lines in that it incorporates a pulse stretcher and pulse trap.

The P line has two symbols instead of one. The first symbol can be an "m", "s" or "x" as per the other lines, but if the line is being toggled continuously it will show a "t". The second symbol is normally blank, but whenever a pulse or series of pulses occurs it will show a "t" for 2 seconds after which it will show a "p". This "p" will remain there until it is reset by pressing Finish/Menu on the DA100.

7.4 USING THE PROTOCOL ANALYSER FUNCTIONS

The pins on the 15-way socket marked "data in" and "data out" are wired directly in parallel with the equivalent BNC sockets on the DA100. This allows the protocol analyser functions of the DA100 to be connected using patch wires.

7.5 ⚠ EXTERNAL CLOCK INPUT AND INVERTED DATA INPUT

Pins 4 and 5 of the 15-way patch connector are marked with a ⚠ symbol (which means refer to the manual). Pin 4 is an inverted data input. Pin 5 is an external clock input. Both inputs are TTL level and are unprotected.

If it is required to monitor a serial data signal that has been inverted by an input buffer, this can be done by connecting to pin 4 of the patch connector instead of pin 1.

If it is required to use a baud rate that is not standard to the DA100, an external clock can be supplied via pin 5 of the patch connector. The clock must be TTL level and have a frequency 8 times the desired baud rate. The baud rate setting from the Format option of the DA100 must be set to EXT.

8. MAINTENANCE, REPAIR AND GUARANTEE

The manufacturers or their agents overseas will provide repair for any unit developing a fault. Where owners wish to undertake their own maintenance work, this should only be done by skilled personnel in conjunction with the service manual which may be purchased directly from the manufacturers or their agents overseas.

In the UK, defective instruments should be returned, carriage paid, to the manufacturer's Service Department. Careful and substantial packing is essential — no responsibility can be accepted for damage caused in transit to the manufacturer — if possible, retain the original packing material. If the guarantee has expired or if the fault is the result of misuse, the repair will be carried out and charged unless other instructions are received.

Customers outside the UK should contact the dealer from whom the unit was purchased to ascertain service arrangements for that country.

The instrument is guaranteed as free from defects in workmanship or materials. The terms of the guarantee will vary dependent upon the country in which it was sold. Information concerning the guarantee can be obtained from the agent from whom the instrument was purchased.

APPENDIX A. — FURTHER NOTES ON THE OSCILLOSCOPE DISPLAY

The oscilloscope display output can only be used when the DA101 display unit is *not* fitted.

The text display is achieved by using seven scans of the timebase to draw bit-mapped characters on the screen. The characters are drawn by deflecting the beam between two positions about 5 divisions apart. Thus the upper position consists of characters which are the reverse of the lower position. The upper position is normally adjusted to be off the top of the screen.

A trigger pulse is sent at the start of each scan. Each character is made up of 7 vertical pixels by 5 horizontal pixels. There are 32 characters in all.

Problems that could be experienced are:

Low brightness — because of the relatively low duty cycle of the trace, low EHT oscilloscopes will not produced very bright characters.

Characters are badly distorted — if the pulse response of the oscilloscope is poor, the characters will appear distorted. The input coupling *must* be set to DC.

Characters extend beyond the screen area — the 32 characters require 1.05 milliseconds of sweep length. If there is inadequate space at either end of the graticule or if the scope timebase is poorly calibrated it will be necessary to use the sweep variable control to reduce the time/div below 0.1ms.

Characters are unstable or sections of them are missing — this is most likely to be caused by incorrect trigger setting or by excess sweep hold-off time. The trigger souce must be from the input channel (not vertical mode), sweep hold-off must be set to minimum. If the problem persists try setting the timebase to 50us/div and using the sweep variable to slow the timebase down to around 0.1ms/div.

N.B. When receiving data continuously at baud rates of 9600 and above, the oscilloscope display may become erratic and unstable. This is normal.

APPENDIX B. — NOTES ON THE "FORMAT" OPTION (AUTO-CHECK AND MANUAL)

The FORMAT option (selected from the SETUP menu) allows the data word format and baud rate to be set. Two options are provided — AUTO-CHECK and MANUAL.

AUTO-CHECK causes the DA100 to attempt to set the baud rate and data word format automatically by analysing a data stream on the line to which it is connected. The automatic checking is done in three sections. The user must press the Select/Stop button to move from one section to the next.

The first section, which is entered as soon as the Auto-check option is selected, is baud rate. If no data is being sent the display will show "waiting". When data is received, the unit will analyse the first 16 transitions of the data stream and then display a baud rate based on the minimum transition period found. Note that the rate will be one of its 12 internal baud rates (50, 75, 110, 134.5, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, or 38400) along with an error figure in percent.

As it receives more data it will continually update the baud rate figure. For the result to be accepted as reliable the baud rate should be stable and showing a low and stable error rate (no more than 3%). Note that the data being sent must include at least one character which contains a minimum width transition. Most printable ASCII characters contain one minimum width transition, but there are a few which do not. For example sending a string of F characters in 7-bit ASCII would give a baud rate which was half of the correct rate because the minimum pulse width would be two bits.

Pressing Select/Stop accepts the displayed baud rate, writes the result into the format memory, and moves auto-check on to the second section.

The second section is word format excluding stop bits (i.e number of data bits and parity). Six combinations are possible comprising 7 or 8 data bits and odd, even or no parity. The unit starts by setting the word format to 7 bits, no parity. It then counts the number of words that it receives both without framing or parity errors (OK) and with framing or parity errors (ERR). As soon as the latter number exceeds 5 it will change the word format, reset the counters and start again. When the correct word format is found the error count should remain at zero.

Pressing Select/Stop accepts the displayed word format, writes the result into the format memory, and moves auto-check on to the third section.

The third section is number of stop bits. This can be set as either 1 or 2 (anything over 1 will be defined as 2). The analyser starts by setting the number of stop bits to 2. It then counts the number of words that it receives both without framing or parity errors (OK) and with framing or parity errors (ERR). As soon as the latter number exceeds 5 it will set the number of stop bits to 1, reset the counters and start again.

Pressing Select/Stop accepts the displayed number of stop bits, writes the result into the format memory, and terminates the auto-check function.

N.B. The second and third sections of the auto-check function may take a considerable length of time to produce a result if the data stream is present when the function is started. Word format analysis operates most efficiently when the data stream is stopped prior to the function being started. Otherwise the analyser may fail to synchronise with the data. If this occurs it will display "format not found" for 2 seconds and then re-try.

MANUAL should be used whenever the data format is already known. The baud rate options are 50, 75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200 or 38400. A further option of EXT is provided which enables an externally defined baud rate to be used. This is only available when the optional DA102 RS-232C breakout box is fitted. A TTL level clock with a frequency of 8 times the desired baud rate must be connected to pin 5 of the DA102 patch connector.

APPENDIX C. A SIMPLIFIED GUIDE TO RS-232C

Introduction

The RS-232C standard was introduced by the American Electronics Industries Association (E.I.A.) in 1962 to standardise the interface between data terminals and computer equipment using serial binary data via telecommunication links. Thus it was designed to interface computers and terminals with modems. The standard defines a system which can be synchronous or asynchronous but by far the most common usage of it is asynchronous.

The CCITT (Comite' Consultatif International Telegraphique et Telephonique) equivalent of RS-232C is V.24/V.28. V.24 defines the mechanical characteristics including the connector and the function of the circuits. V.28 defines the electrical signal characteristics.

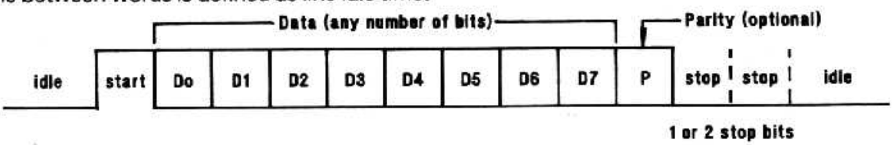
Today RS-232C is used as a general purpose standard for asynchronous serial data systems linking together many types of equipment. Because most of the common applications of RS-232C do not require the full complexity of the system as originated, many different variations of usage now exist. In particular, the functions of some of the lines may be ignored or used for alternative purposes, and a variety of different connector types are used.

Asynchronous serial data transmission

In a serial data transmission system the digital bits which make up a data word are transmitted sequentially using one wire instead of being transmitted simultaneously using several wires. In an asynchronous serial system such as RS-232C there is no common timing reference, instead the transmitter and receiver operate at different but similar bit repetition rates (called the baud rate) and are regularly re-synchronised to prevent them from getting out of step.

In RS-232C this synchronisation is done at the start of each word. The receiver waits for a start bit and, when it detects one, it resets its own bit counter to count time from that point. Because the receiver looks for the data bit values in the predicted centre of each bit, this allows the timing reference oscillators of the transmitter and receiver to be mismatched by several per-cent. Using the industry standard UART (universal asynchronous receiver-transmitter) the two oscillator frequencies can be up to ±3% different.

At the end of each data word one or more stop bits are sent. The stop bit has the opposite level from the start bit and allows time for the receiver to return to looking for a start bit after the data bits have been received. The number of stop bits defines the minimum delay between the transmission of two data words. The normal maximum number of stop bits is two, any further time between words is defined as line idle time.



RS-232 serial data (note that the LSB is transmitted first)

A further complication to the system can be the inclusion of a parity bit following the data. The parity bit is a simple means of error checking, the number of logic 1s in the data word are added together and the parity bit is set true if the result is even (even parity) or alternatively set true if it is odd (odd parity).

Data transmission standards

RS-232-C does not define any standards for either the baud rate or the word format. The most common baud rates are 50, 75, 150, 300, 600, 1200, 2400, 4800, 9600 or 19200, but others are in regular usage. The word format may include any number of data bits and any combination of parity and stop bits. Most data transmission uses 7 or 8 data bits because seven is the minimum number required to allow a full ASCII character set to be sent.

Electrical standards

RS-232-C defines an electrical standard as follows:

Max. O/C driver output voltage — ±25V
Min. loaded driver output voltage — ±5V
Min. driver output resistance — 300 ohms
Max. driver short circuit current — ±500mA
Max. driver slew rate — 30V/us
Receiver input resistance — 3kohms to 7kohms
Receiver input thresholds — −3V to +3V (max.)

The electrical interface uses unbalanced circuits all referenced to signal ground. A positive voltage between 3V and 25V is interpreted as a binary 0 or signal space for data, and ON for control circuits. A negative voltage between 3V and 25V is interpreted as a binary 1 or signal mark for data, and OFF for control circuits. The data transmission line idles at a signal mark negative.

+3V to +25V = binary 0, signal space, control on, start bit.
−3V to −25V = binary 1, signal mark, control off, stop bits, line idle.

DTE and DCE

Equipment using an RS-232-C link is defined as being either DTE (data terminal equipment) such as terminals, or DCE (data communication equipment) such as modems. Other equipment, such as computers, may be implemented as DTE or DCE.

RS-232-C was originally intended to link one DTE device to one DCE device. In these circumstances the cable links similarly numbered pins at each end. Each link is referred to as a circuit. If two DTE or two DCE devices are to be linked, a special "crossover" type cable will be required. This is commonly referred to as a "null-modem" cable since the crossover function would normally be performed by the two interconnected modems.

Function of the lines

EIA RS-232-C (equivalent to CCITT V.24) defines the use of a 25 pin "D" type connector whose pins have the following function:

Pin	Name	Function	Origin of Signal	Circuit Designators CCITT	EIA
1	FG	Frame Ground	—	101	AA
2	TD	Transmitted Data	DTE	103	BA
3	RD	Received Data	DCE	104	BB
4	RTS	Request to Send	DTE	105	CA
5	CTS	Clear to Send	DCE	106	CB
6	DSR	Data Set Ready	DCE	107	CC
7	SG	Signal Ground	—	102	AB
8	DCD	Data Carrier Detect	DCE	109	CF
9		+ve DC Test Voltage			
10		−ve DC Test Voltage			
11					
12	SDCD	Sec. Data Carr Detect	DCE	122	SCF
13	SCTS	Sec. Clear to Send	DCE	121	SCB
14	STD	Sec. Transmitted Data	DTE	118	SBA
15	TC	Transmitter Clock	DCE	114	DB
16	SRD	Sec. Received Data	DCE	119	SBB
17	RC	Receiver Clock	DCE	115	DD
18					
19	SRTS	Sec. Request to Send	DTE	120	SCA
20	DTR	Data Terminal Ready	DTE	108.2	CD
21	SO	Signal Quality Detect	DCE	110	CG
22	RI	Ring Indicator	DCE	125	CE
23		Data Rate Selector	DCE	112	CI
(23)		Data Rate Selector	DTE	111	CH
24	XTC	Ext. Transmit Clock	DTE	113	DA
25					

Note: Lines 11, 18 and 25 are undefined. Lines 9 and 10 are reserved for test voltages. Lines 12, 13, 14, 16, and 19 are reserved for a secondary transmit/receive channel (only used by special modems). Lines 15, 17 and 24 are used when synchronous data is being transmitted.

The most commonly used lines for non-modem applications are 2, 3, 4, 5, 6, 8 & 20 plus the two grounds 7 & 1.

Definition of the most commonly used circuits

The following definitions apply to the RS-232C standard as originated for use between a terminal (DTE) and a modem (DCE). Note that a circuit is a line linking equivalent pins on the DTE and the DCE.

TD (Transmit Data) — circuit for sending serial data from the DTE to the DCE.

RD (Receive Data) — circuit for sending serial data from the DCE to the DTE.

RTS (Request To Send) — this circuit signals that the DTE wishes to send data to the DCE. Normally RTS will be OFF (mark). As soon as the DTE has data to send and has determined that the channel is not busy it will set RTS ON (space) and await an ON condition from CTS on the DCE, it will then start sending data. When the DTE has finished sending it will reset RTS to

OFF. If the modem channel is simplex or full-duplex RTS may be set ON at initialisation and left there. Note that there is no equivalent line to RTS in the opposite direction hence the DTE must always be ready to accept data.

CTS (Clear To Send) — this circuit signals that the DCE is ready to accept data from the DTE. Normally CTS will be OFF. When the DTE sets RTS ON, the DCE will perform whatever tasks are needed to be able to send data (a modem would raise a carrier) and then set CTS to ON thus allowing the DTE to send the data. When the DTE returns RTS to OFF, the DCE would release the channel (a modem would drop the carrier) and then set CTS back to OFF. Note that a typical DTE must have an incoming CTS before it can transmit. If this signal is not provided by a circuit from the DCE, it must be provided locally by a wraparound at the DTE end of the cable (e.g. from DTR).

DSR (Data Set Ready) — this circuit signals to the DTE that the DCE is alive and well. It is normally set to ON by the DCE at power-up and left there. Note that a typical DTE must have an incoming DSR in order to function. If this signal is not provided by a circuit from the DCE, it must be provided locally by a wraparound at the DTE end of the cable (e.g. from DTR).

DCD (Data Carrier Detect) — this circuit signals to the DTE that the DCE has detected an incoming carrier. It can be used by the DTE to determine whether a channel is busy or not busy prior to requesting use of the channel using RTS. Note that some DTEs must have an incoming DCD in order to function. If this signal is not provided by a circuit from the DCE, it must be provided locally by a wraparound at the DTE end of the cable (e.g. from DTR).

DTR (Data Terminal Ready) — this circuit signals to the DCE that the DTE is alive and well. It is normally set to ON by the DTE at power-up and left there. The DTR signal is provided by most DTE equipment and can therefore be used at the DTE end of a cable to "fake" an ON condition to the DTE inputs (such as DSR, CTS and/or DCD) if their normal function is not required.

Identifying DTE or DCE devices

Equipment that is neither a data terminal nor a piece of data communication equipment, such as a modem, may be configured as DTE or DCE. The majority of equipment is configured as DTE, although the serial ports of multi-user computers which are normally directly connected to terminals are more likely to be configured as DCE.

Equipment configured as DTE can be identified by the fact that they SEND data on the TD line (pin 2 on the V.24 standard 25-pin D connector) and RECEIVE data on the RD line (pin 3 on the V.24 standard 25-pin D connector).

Linking two DTE devices

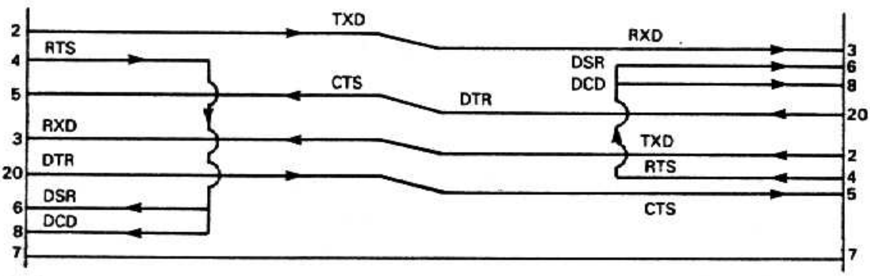
Because the majority of equipment is configured as DTE, the most common requirement is to link two DTE devices. This can normally be done by a crossover cable (often referred to as a null-modem cable) in which the pairs TD/RD, RTS/CTS and DTR/DSR have been crossed over. Hence the TD of one DTE is connected to the RD of the other DTE and vice versa.

Unfortunately there are several reasons why this basic type of crossover cable often does not provide a satisfactory interface. Many devices do not use the circuit lines in the way that the standard originally intended. Some lines may be left open circuit, pulled permanently high or permanently low, or they may be used to provide "handshaking" for data transfer between the two devices in a different way from that originally intended. Also there is no crossover equivalent for DCD.

The actual connection pattern will depend upon the hardware configuration of each device, and the type of data handshaking (if any) that is being used. For a DTE device: RTS and DTR are outputs, while CTS, DSR and DCD are inputs. Typically a DTE device requires that all of its inputs are pulled to ON before it can send data.

Where XON/XOFF handshaking is being used, all that is needed is to ensure that CTS, DSR and DCD are all pulled to ON. This can be done either locally for each device or through the cable from the RTS or DTR of the other device. The method chosen will depend upon how the two devices assert their respective RTS and DTR lines.

Where hardware handshaking is being used, the handshake input is normally CTS but can alternatively be DCD. The handshake output can be either RTS or DTR. Having determined which lines are used for handshaking, the unused inputs should be connected to an output line which is asserted permanently ON.



Null-modem cable wiring for two DTE devices handshaking on DTR and CTS and which assert RTS permanently ON

Associated standards (RS-423, RS-422, RS-485 and RS-449)

Since the publication of RS-232-C, the EIA has published a number of other standards for serial data interfaces. These latter standards make use of the improved capabilities of circuit components and remove the severe restrictions imposed on data rate and cable length imposed by RS-232-C.

RS-423 is an electrical standard only. RS-423 is fairly similar to RS-232. It uses an open circuit driver voltage of between 4V and 6V and a receiver threshold of ±100mV. RS-423 can be operated up to 100kbaud with short cables and with cable lengths up to 1200 metres at low baud rates. Line polarities are the same as for RS-232-C. RS-423 equipment can often be connected directly with RS-232-C equipment.

RS-422 is an electrical standard only. It uses a balanced driver and differential signalling over a pair of conductors. This provides excellent rejection of common mode signals and enables the interface to operate at up to 10Mbits/sec over short cables. RS-422 equipment is not compatible with RS-232-C equipment.

RS-485 is similar to RS-422 but uses tri-state drivers to enable several transmitters to share the same line.

RS-449 is a mechanical standard only. It is a general purpose interface which is intended to perform a similar function to RS-232-C but avoids many of the latter's problems and limitations. It uses a 37-pin D connector with an additional 9-pin D connector for the secondary channel when required. RS-449 can use either the RS-422 or RS-423 electrical standard.

ADDENDA

Format (AUTO-CHECK)

Note that selecting AUTO-CHECK will immediately set the word format back to 7 data bits, no parity, 2 stop bits.

Consequently if AUTO-CHECK is selected and then abandoned, it will be necessary to reset the word format using MANUAL.

DA101 LIQUID CRYSTAL DISPLAY UNIT

INTRODUCTION

The DA101 is an optional LCD display unit which fixes to the DA100 analyser in order that it can be operated as a self contained unit without the need for an oscilloscope as the display. Power for the DA101 is provided from the DA100.

6.1 FITTING INSTRUCTIONS

Plug the DA101 into the connector socket in the top of the DA100 and secure it on the base using the two countersunk screws provided.

6.1 OPERATING NOTES

The DA100 automatically senses the presence of the DA101 and switches its display driver mode accordingly. It is not possible to use the oscilloscope display output when the DA101 is fitted.

The DA101 display differs from the oscilloscope display in that the characters are in two rows of 16 instead of one row of 32. It is also incapable of showing reverse video and therefore menu items are highlighted by enclosing them between arrows instead of reversing them. Individual characters are highlighted by flashing them instead of reversing them.

Otherwise the operation of the DA100 with the DA101 fitted is identical to its operation using an oscilloscope display.

DA102 RS-232C BREAKOUT BOX

INTRODUCTION

The DA102 is an optional unit which fits onto the DA100 and provides a convenient means of making connections into an RS-232C V.24 system. It provides full breaking and patching of the lines and enables the data input or output of the DA100 to be linked directly into the RS-232C system. It also enables the DA100 to monitor the levels of the 11 most commonly used lines plus one user-defined line. The DA102 is powered from the DA100.

7.1 FITTING INSTRUCTIONS

Plug the DA102 into the connector socket in the bottom of the DA100 and secure it to the base of the DA100 using the two countersunk screws provided.

7.2 MAKING CONNECTIONS

The DA102 is fitted with four 25-way D connectors plus one 15-way D connector. The left hand pair of sockets is marked DCE and the right hand pair is marked DTE. The two outside connectors are for connection to the data equipment, the two inside connectors are for use as patch sockets.

The 24 slide switches connect pins 2 - 25 of the DCE side to pins 2 - 25 of the DTE side. Pin 1 (protective ground) is linked directly. Setting any switch to "off" breaks the connection. The lines can be "patched" to provide alternative connection patterns using the patch cables provided.

The 15-way socket provides two sets of 3 interconnected pins to enable several lines to be linked together, and two pairs of pins for "faking" RS-232C levels onto the lines, one at "mark" and one at "space". It also provides connections to the "data in" and "data out" lines of the DA100 analyser and a special monitor line marked P. There are also two further input lines which are marked with a ! symbol, these are explained in section 7.5.

Note that the ground connection of the DA100 is linked to pin 7 of the DCE side of the DA102.

7.3 MONITORING THE LINES

The eleven most commonly used RS—232C lines are monitored by high impedance comparators. These lines are 3, 5, 6, 8, 15, 17, 21, 23 on the DCE side and 2, 4, 20 on the DTE side.

The comparators define any voltage more negative than −3V as a mark (m), any voltage more positive than +3V as a space (s), and any voltage between −3V and +3V as undefined (x). The voltages are measured relative to pin 7 of the DCE side. The line levels are displayed using the BRKT-BOX LINES option from the VIEW menu of the DA100.

A further uncommitted monitoring line marked P is available on the 15-way socket. This differs from the other 11 lines in that it incorporates a pulse stretcher and pulse trap.

The P line has two symbols instead of one. The first symbol can be an "m", "s" or "x" as per the other lines, but if the line is being toggled continuously it will show a "t". The second symbol is normally blank, but whenever a pulse or series of pulses occurs it will show a "t" for 2 seconds after which it will show a "p". This "p" will remain there until it is reset by pressing Finish/Menu on the DA100.

7.4 USING THE PROTOCOL ANALYSER FUNCTIONS

The pins on the 15-way socket marked "data in" and "data out" are wired directly in parallel with the equivalent BNC sockets on the DA100. This allows the protocol analyser functions of the DA100 to be connected using patch wires.

7.5 ⚠ EXTERNAL CLOCK INPUT AND INVERTED DATA INPUT

Pins 4 and 5 of the 15-way patch connector are marked with a ⚠ symbol (which means refer to the manual). Pin 4 is an inverted data input. Pin 5 is an external clock input. Both inputs are TTL level and are unprotected.

If it is required to monitor a serial data signal that has been inverted by an input buffer, this can be done by connecting to pin 4 of the patch connector instead of pin 1.

If it is required to use a baud rate that is not standard to the DA100, an external clock can be supplied via pin 5 of the patch connector. The clock must be TTL level and have a frequency 8 times the desired baud rate. The baud rate setting from the Format option of the DA100 must be set to EXT.

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