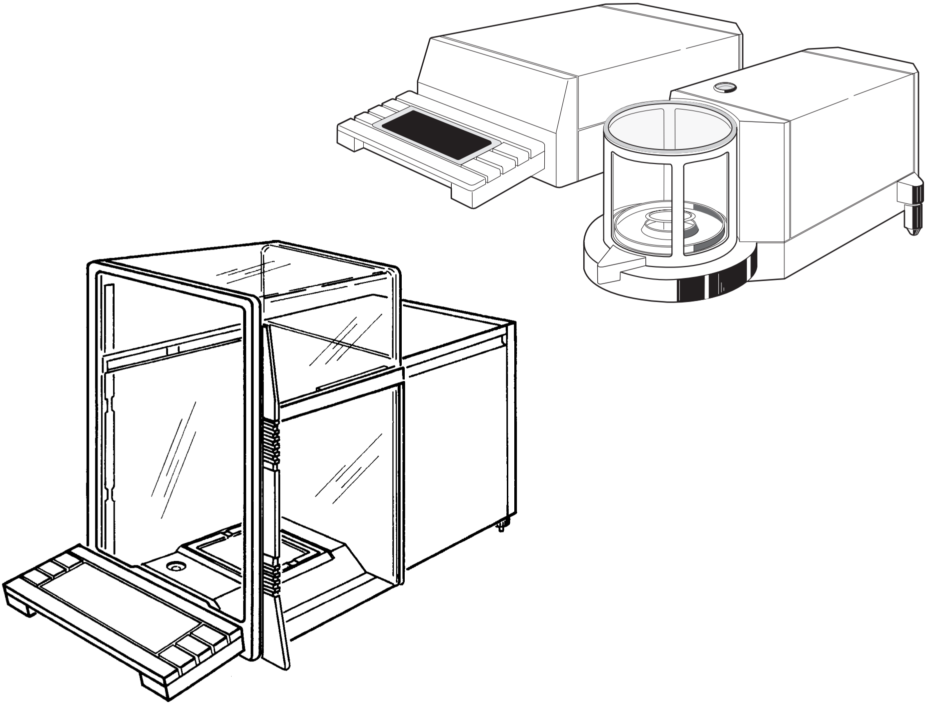
Operating instructions

METTLER TOLEDO

Bidirectional Data Interface

METTLER TOLEDO AT/MT/UMT Balances



Welcome...

...to data communications with the METTLER TOLEDO AT/MT/UMT balance! With this instrument you have purchased a top quality product of weighing technology. One of the goals in developing of the AT/MT/UMT family – outstanding ergonomics – will provide a completely new "feel" for weighing.

With computers and robots entering the laboratories, the remote control of instruments is becoming increasingly important. Two features introduced in the AT/MT/UMT, completely free access to the weighing chamber and motorized draft shield, are key elements that contribute to the ease with which the balance may be integrated into laboratory systems.

In addition, the AT/MT/UMT has been designed with a command set more versatile and complete than any previous METTLER TOLEDO balance. Careful attention has been paid to maintaining compatibility with previous models; there should be no need to rewrite existing applications.

Superb results may be attained by making full use of the potential that the AT/MT/UMT and its interface offer. More than thirty commands help solve even tough problems. This manual is intended to support these efforts.

The AT/MT/UMT interfaces features:

- Standard asynchronous serial format
- Baud rate and parity freely selectable
- Bidirectional data transfer
- Break recognition
- Galvanic isolation
- RS-232 and 20 mA current loop
- Several handshake modes
- 7-bit ASCII character set
- Extensive command set – access to virtually all balance parameters
- Easy connection to printers and computers

Contents

Overview

This manual is not intended to be a course in data communications, but rather to provide specific information regarding the interface characteristics of the AT/MT/UMT balances. It is divided into several sections:

- Interface characteristics
- Transmission modes
- Commands in alphabetical order
- Configuration of the interface
- RS-232 interface
- METTLER TOLEDO CL interface
- Interface connectors
- Data format
- 7-segment text representation
- If all fails…
- Glossary

It is assumed that you have already familiarized yourself with the operating characteristics of the AT/MT/UMT balance. You should also be aware of what the menus is, how it is accessed and how the parameter settings can be changed in the configuration register. Please refer to the Operating Instructions of the AT/MT/UMT if there is any uncertainty.

Note

A comprehensive overview of the METTLER TOLEDO peripheral units and the connection cables for commercial printers and computers can be found in the brochure *Technical specifications and accessories of the AT/MT/UMT balances*.

Interface Characteristics

All balances of the AT/MT/UMT series are equipped with a serial interface having the following parameters:

- Asynchronous transmission
- 1 Start bit
- 7 Data bits
- 1 Parity bit (selectable)
- 1 Stop bit

Depending on the application, you may select between unidirectional and bidirectional data transmission and between current and voltage operation. This section briefly describes the various modes.

Unidirectional Mode

In this mode data can be transmitted between a balance and a peripheral device in one direction only. (Example: to a simple printer).

Bidirectional Mode

Data can be exchanged in both directions. Typical application: A computer requests a weighing result by means of a command; as soon as the result is available the balance transmits it back to the computer. Of particular importance here is the concept of *break* (see below).

Current Loop Interface

The AT/MT/UMT balance has a passive 20 mA current loop interface. Its use is particularly attractive in situations where relatively large distances (several hundred feet) have to be covered. An additional feature is the high immunity to an electrically noisy environment. However, most off-the-shelf personal computers are not equipped to handle current loop operation.

Voltage-controlled Interface (RS-232)

This popular interface, which is found almost universally in data-processing equipment, is fully supported by the AT/MT/UMT balances.

Break

The situation where the interface input of the balance is inactive for longer than the duration of a single character (i.e. current interrupted or voltage level positive) is called a *break*. Computers can produce this condition under program control; many terminals are equipped with a special break key. Disconnecting the data cable or switching off the peripheral device obviously also generates a break in the current loop mode. With the RS-232 interface, the positive voltage value needed is, in general, not created on the data line. However, special electronic circuitry in the AT/MT/UMT balance ensures that the break can still be recognized.

As a result of a break, all changes in the balance parameters resulting from interface commands are cancelled. The balance returns to the condition it was in before it was switched on.

The minimum duration of the break depends on the baud rate; 100 ms or longer suffice for the AT/MT/UMT balances in all cases.

When a break is present, the I/O symbol in the balance display is turned off. A flashing symbol in the CL handshake mode means that there is an active input line but no full, bidirectional handshake has been set up.

Handshake

In most systems data can not be transmitted at an arbitrary rate and at all times. A handshake protocol ensures orderly data flow in such cases. The AT/MT/UMT balance can operate not only with software control characters but also with special control lines.

Galvanic Isolation

All interface connections of the AT/MT/UMT balance are isolated electrically from the rest of the electronics. This elaborate measure effectively shields the measurement circuits from electrical noise, which could otherwise enter the balance via the attached peripheral devices. Furthermore, there is no way for loop currents, resulting from differing potentials of the system devices (balance, computer), to flow along the data lines.

Only the *shielded conductor* of the data cable is connected galvanically to the balance case and therefore to the equipment grounding conductor of the balance.

It is generally recommended to connect the shield to the case on the computer side, too. This ensures optimum protection from both irradiation and radiation. If problems arise as a consequence of too high currents circulating in the shield, the connection between shield and case may be cut on the computer side.

Transmission Modes

The balance can be set to transmit results in a variety of ways:

"Print" (Transfer) Key

When the "Print" key is pressed, the balance sends the next stable or the current result, depending on the configuration of the Send parameter (S.Stb, S.ALL, S.Cont, S.Auto). If only stable results are to be transmitted and "doorAuto" is configured in the menu, the draft shield doors close automatically. At the same time the caution (triangle) symbol in the display lights up. After the transmission, a brief beep sounds and the doors open again. The result is held in the display for five seconds with a small ring symbol flashing to its right.

The print command can be cancelled anytime while waiting for the weighing result to achieve stability by pressing the "Print" key.

In contrast to result strings based on the Send commands, those triggered by the "Print" key always begin with a space character.

External Switch

Transmission of a result may also be initiated by providing a low-resistance connection between the two pins 11 and 14 of the "Re-Zero" connector at the rear of the balance. The rules are the same as those described above. As before, the command can be cancelled by pressing the "Print" key.

Automatic

If the one of the send modes "S.Cont" or "S.Auto" has been configured in the "Interface" sector of the configuration register, data transmission occurs either continuously or automatically after each load change; this is also the case if one of the interface commands "SIR", "SNR" or "SR" is active.

Request by Interface

Interface commands such as "S" or "SI" cause the transmission of a single measured value.

Command Overview

Command Naming

All commands appear in alphabetical order with the command name clearly emphasized in the upper left corner of the page. This helps in easily locating a specific description.

If the command name for a certain feature is unknown, the following tips may be helpful:

Commands that prompt the balance to send something begin with an **S.**

Commands that communicate something to the user, whether by a change in the display or by an audible signal, begin with a **D**.

Commands that influence the mode of the balance, for example, by setting the vibration adapter or the stability detector, begin with an **M**.

The remaining commands, which are not as easily categorized, use – wherever possible – a mnemonic abbreviation (like "T" for tare, "CFG" for configuration etc.).

Command Action

With one exception, all interface command changes affect the balance only temporarily. After the balance *or the computer* has been switched off, or after a break on the data line, the original settings of the user reappear. A special command may be used, if required, to store the changed settings permanently in the balance.

Command Format

Commands consist of one or more characters of the ASCII character set. Non-printable characters are not used (except Control-G which sounds the balance's beeper). No distinction is made between uppercase and lowercase letters, except in commands where this is significant, like in the *text* argument of the "D *text*" command.

The line end (EOL) is either a single return (ASCII 13) or a return followed by line feed (ASCII 10), depending on the EOL parameter selected in the configuration register.

The syntax of the commands is as follows:

`CF [ param1 |param2 [ param3 |param4]]`

`CF` represents the command name.

Square brackets [ ] enclose optional parameters. If left out, a preset (default) value is used.

Parameters written in *italics* represent values whose allowed range is specified in the command description.

Parameters that are separated by a vertical line (|) represent a choice. Only one of the possible values can appear in the command; combinations are illegal.

The ellipsis (...) means that the preceding parameter may be repeated several times.

Valid variations of the above sample command would thus be:

```
CF
CF param1
CF param2
CF param1 param3
CF param1 param4
```

But not:

`CF`*`param1`*	(no space after command name)
`CF `*`param3`*	(*`param3`* or *`param4`* allowed only after *`param1`* or *`param2`*)
`CF `*`param1 param2`*	(either *`param1`* or *`param2`* allowed, but not both)

Error Messages

If the balance cannot process a command, it reports the reason as follows:

ES (Error Syntax) The command is incorrectly built, or it does not exist. Example: `U 1.5U2`.

EL (Error Logical) Although the command is syntactically correct, it can't be executed.

Example: `U 0` (division by zero!)

ET (Error Transmission) One or more characters of the command show a parity error.

The conditions that lead to an EL error are listed under the individual commands.

Restrictions

Communication with the balance is suspended as long as the user is acessing the configuration register. The peripheral is informed as follows:

`CFG BEGIN` (Configuration Begin). This message means that the configuration register has just been called up. Depending on the handshake mode, the balance inhibits command input by deasserting the handshake signal.

`CFG END` (Configuration End). The user has made changes in the configuration register and pressed the "Set" key.

`CFG STOP` (Configuration Stop). The user has pressed the "Cancel" key, or the "Set" key without changing a parameter, or no key has been pressed for one minute. *No change in the configuration has occurred.*

Note: The command `CFG` (and also R*n* or `RK`) may be used to inhibit the user from changing the configuration while an application is running. Using the `CFG` command has the advantage that the user is informed by the message "Conf off" when trying to access the configuration register.

Another condition that suspends communication is the calibration cycle. Similar messages are generated in this case:

`CAL BEGIN` (Calibration Begin). The calibration cycle has just been started.

`CAL END` (Calibration End). The calibration cycle has been completed successfully; the balance is recalibrated.

`CAL STOP` (Calibration Stop). The calibration cycle has been stopped prematurely by Cancel key or by the abort command (.).

`CAL ERROR` (Calibration Error). The calibration cycle has been aborted as result of an error condition.

The Calibration Status command (`CA S`) works even while calibration is under way.

After a temporary break in the power line, the balance shows "Off". The only command that is accepted in this situation is "T", which will restore normal balance operation.

An Example

The example below shows how the balance can be set up for a particular application through a series of commands. The assignment is to check boxes containing 100 parts weighing 0.25 g each. Overfilling by three parts or underfilling by one part is tolerated. The weight of the box is 21.5 g. The weighing results are to be transmitted automatically.

Command	**Action**
`@`	Resets the balance to the power-on state.
`UX g`	Ensures that the weight unit is grams.
`RG F`	Switches to the fine range. If the balance cannot be switched, the error message "EL" will appear here.
`AD 1`	Turns automatic draft shield operation on.
`T`	Tares the balance; the draft shield is closed, then reopened automatically.
`B 21.5`	Subtracts the box's weight. The net weight symbol "N" appears in the display.
`U0 .25 pcs`	Divides all subsequent weight results by the piece weight 0.25 g. The display appears without decimal digits; the unit is "PCS".
`DY 25 .75 .25`	The target weight is 25 g (100 x 0.25 g). The acceptable positive deviation is 3 pieces (0.75 g), the negative deviation 1 piece (0.25 g).
`SR 5`	After every weight change of 5 g, the balance sends one unstable result and then the next stable one.

Commands

AD AutoDoor

Function: **Turns the automatic draft shield operation on or off.**

Format: `AD[ n|?]`

Description: *n* is either 0 or 1.

AD 0 turns the automatic draft shield operation off.
AD 1 turns it on.
AD without parameter selects the factory setting.
AD ? reports the present setting as follows:

```
AD=0      automatic operation off
AD=1      automatic operation on
```

B Base

Function: **Subtracts a constant weight value from all weighing results (tare preset).**

Format: `B[ offset]`

Description:

`offset` is a positive weight value, expressed in the current weight unit 1. This value is subtracted from all future weighing results. The net weight symbol N identifies the mode in the display.

The sum of *`offset`* and any tare value must not exceed the maximum load range of the balance.

`B` without parameter returns to the normal weighing operation without tare preset.

Examples:

```
B 20
```

Subtracts 20 g from each weighing result (if unit 1 is set to grams).

```
UX oz
B .245
```

Subtracts 0.245 oz from each weighing result.

The stored tare preset is not affected by unit changing.

Error:

`EL` if

- offset negative
- tare plus offset greater than maximum load

CA Calibration

Function: **Triggers the automatic calibration or calibration test, changes the calibration mode, returns calibration status.**

Format: `CA[ n|U|S|T|?]`

Description:

n is either 0 or 1.

`CA` starts the automatic internal calibration and linearization.

`CA 0` sets the mode CALIN "Auto off" (the internal calibration is launched by the user or through the CA command).

`CA 1` sets the mode CALIN "Auto on" (fully automatic calibration).

`CA U` sets the mode CAL "User" (calibration with external reference weight).

`CA ?` sends the currently set mode as follows:

`CA=0`	mode "Auto off"
`CA=1`	mode "Auto on"
`CA=U`	mode "User"

A calibration operation in progress can be aborted with the cancel command "." .

CA S sends the current calibration control status as follows:

CA=I	"Idle"; no automatic calibration pending
CA=W	"Waiting"; automatic calibration cycle will occur at the next possible opportunity. The AUTOCALIN symbol is lit.
CA=CA	Automatic calibration is in progress.
CA=CX	Calibration has been started manually or by command.
CA=CT	Calibration test is running.

This command may be issued even while a calibration cycle is in progress.

CA T starts the calibration test. The internal weights are put on the pan. The display alternates between the weight and the message "test". The weight may be read out using normal send commands. The test mode is left automatically after one minute, or by issuing the cancel command, or by pressing the tare or cancel key.

Error: `EL` with `CA` or `CA T` command if "Cal User" has been configured, or if a calibration or test cycle is already in progress.

CFD Configuration Defaults

Function: **Sets all balance parameters, except those for the serial interface, to the factory setting.**

Format: `CFD`

Description: `CFD` essentially causes resetting of the balance to the standard configuration. The following parameters are affected:

- vibration adapter (wave symbol)
- weighing process adapter (drop symbol)
- stability detector (ASD)
- AutoZero
- automatic draft shield operation
- calibration mode
- automatic turning-off of the status displays
- sound generation (on or off)
- balance resolution (readout increment)
- weight units 1 and 2
- "nationality" of weight unit tael

The parameters for the serial interface remain unchanged in order to avoid disrupting communication with the peripheral device.

CFE Store Configuration

Function: **Saves the current configuration in the permanent memory (EAROM) of the balance.**

Format: `CFE`

Description: Most settings in the configuration register of the balance as well as the weighing parameters (vibration and weighing process adapters) can be changed with suitable interface commands. The changes are lost, however, when the balance is switched off or an interface break occurs.

With the `CFE` (Configuration to EAROM) command the changes can be permanently stored in the balance. This includes all changes that the user has made directly to the balance.

Error: `EL` if the storing failed (e.g. defective memory).

CFG Configuration Access

Function: **Controls the user's access to the configuration register.**

Format: `CFG[ n|?]`

Description:

n is either 0 or 1.

`CFG 0` inhibits the user from accessing the configuration register.

`CFG 1` allows access to the configuration register, provided the jumper in the program cassette is set to the "unprotected" position.

`CFG` without parameter selects the access mode according to the jumper in the program cassette.

`CFG ?` sends the currently set mode as follows:

`CFG=0`	no access
`CFG=1`	access allowed

Any attempt to access the configuration register while access is denied will result in the message "conf off" shown on the balance display.

Error:

`EL` with `CFG 1` command if the program cassette jumper is in the "protected" position.

CFP

Configuration Print

Function: **Prompts the balance to send the contents of the configuration register.**

Format: `CFP`

Description: After `CFP` the balance sends the contents of the configuration register as normal text. Note that this information does not necessarily reflect the *current* configuration since that could have been changed temporarily by interface commands. The configuration supplied is that which is permanently stored in the balance, and which is valid immediately after the balance has been switched on. The actual current settings may be recalled by the appropriate commands (e.g. `MS ?`).

A typical configuration is transmitted as follows:

```
S T O R E D   S E T T I N G S

SCALE:
Stability Detector (ASD): -3-
Display Resolution (dC) : step by 1
Display Resolution (dF) : step by 1
AutoZero                : on
Calibration Method      : internal auto

UNIT:
Unit 1                  : g
Unit 2                  : %
Display Symbols         : auto-off
Sound                   : on

INTERFACE:
Weight Send Method      : stable only (S)
Baudrate                : 2400
Parity                  : even
Handshake Method        : Pause after line
End-of-line             : CRLF

__
```

(coarse range)
(fine range)

CFR Configuration Read

Function: **Returns the current balance configuration as a string in the Intel hex format.**

Format: `CFR`

Description: After this command, the balance transmits its current configuration as a sequence of characters. The string is arranged in Intel hex format, that is, it begins with a colon and ends with a checksum.

`CFR` is usually used in tandem with the `CFW` (Configuration Write) command. Together they allow the reading, storing and writing of a complete balance configuration in a computer.

Application: A number of balances may be configured identically following the procedure outlined below:

1. Configure a "master balance" manually.
2. Connect a portable hand-held or laptop computer to the balance.
3. Receive and store the configuration with `CFR`.
4. Attach the computer to the balance to be configured.
5. Configure using the `CFW` command and the stored configuration.
6. Store the new configuration permanently with `CFE`.
7. Repeat steps 4 to 6 for all balances.

CFW **Configuration Write**

Function: **Sends a configuration setting in Intel hex format to the balance.**

Format: `CFW` *`config`*

Description: *`config`* is a string in the Intel hex format, usually acquired by using the `CFR` command.

This command selects the balance setting that was valid at the time *`config`* was determined. To avoid adverse effects on the communication, the "critical" parameters of the serial interface such as baud rate and parity are not changed until after permanently storing them with `CFE` and switching the balance off, then on.

The new configuration is only temporary and is lost after switching the balance off, or after an interface break. Permanent storage can be achieved with the `CFE` command.

The command is not accepted if *`config`* has been generated by a balance of a different type.

Error: `EL` if

- checksum wrong
- string length wrong
- balance type does not match already stored type

Example:

```
CFW :0E00000041250F010000BA53020200E000008B
```

D Display Text

Function: **Shows an arbitrary text on the balance display.**

Format: `D[ [text[;[unit][;[symbol]]]]]`

Description: *`text`* is a sequence of printable characters taken from the 7-bit ASCII character set. The text is written into the display left-justified. If *`text`* includes more characters than the display can hold, the characters first entered are lost.

`unit` turns on a unit symbol:

`U`	the currently set unit
`#` or **`PCS`**	the unit "PCS"
`Stk`	the unit "Stk"
`%`	the symbol "%"

`symbol` can be used to show one of the four weight symbols on the display:

`B`	Brutto (German for gross)
`N`	Net
`T`	Tare
`G`	Gross

An asterisk (*) appears automatically in the top left corner of the display, indicating that the balance is not displaying a valid weight value.

The send commands still provide weight values, even with the `D` command active.

`D` followed by one or more spaces clears the display.
`D` without parameter returns to normal display mode.

Many characters of the ASCII set can be represented only roughly with seven segments. The section "7-Segment Representation of Text" in the Appendices contains a list of the symbols used.

Examples:

```
D HALLO
D -23.5;%
D Net;;n
```

DB

Beep

Function: **Controls the built-in sound generator.**

Format: `DB[ n|C|E]`

Description: *n* is a natural number in the range 0 to 3.

With this command, the user can be alerted in a variety of ways.

`DB` without parameter generates a short signal.

`DB 1` generates a long signal.

`DB 2` produces a double beep.

`DB 3` triggers a long signal, followed by a short one.

`DB C` produces the termination signal ("Cancel") specific to the AT, which is the same as that resulting from pressing the tare key for more than three seconds.

`DB E` generates the AT/MT/UMT-specific error signal ("Error").

All commands shown above change the beep setting to "Beep On". After a break, or after the balance has been switched off, the original user setting is restored.

`DB 0` suppresses all sound generation in the balance, even if "Beep On" has been configured.

Reception of ASCII-BEL (Hex 7, Control-G) also produces a short beep.

DST Display Status

Function: **Controls the behavior of the status indicators for vibration adapter (wave symbol), weighing process adapter (drop symbol) and interface (I/O symbol).**

Format: **`DST[ n|A|?]`**

Description:

n is either 0 or 1.

Depending on the configuration, the status indicators are either permanently on or turned off automatically a few minutes after the balance has been switched on. This behavior can be changed with the `DST` command.

`DST 0` clears the symbols immediately.

`DST 1` keeps the symbols on permanently.

`DST A` switches the symbols on. They will turn off automatically after about three minutes.

`DST` without parameter selects the factory setting.

`DST ?` sends the current status as follows:

`DST=0`	symbols off
`DST=1`	symbols on
`DST=A`	symbols on, will be turned off soon

DSX **Display Select**

Function: **Selects the active display if an auxiliary display is attached.**

Format: `DSX[ n]`

Description: *n* is either 0 or 1.

If an auxiliary display (e.g. GT53) is attached to the balance, `DSX` can be used to ensure that only the balance display, only the remote display, or both together are controlled by the balance.

`DSX 1` activates the balance display. The last result obtained remains "frozen" on the auxiliary display.

`DSX 2` activates the auxiliary display. The last balance display remains "frozen".

`DSX 0` switches both displays back to synchronous operation.

`DSX` without parameter works the same as `DSX 0`.

Note: `DSX` can only be used with LCD displays.

DX DeltaTrac

Function: **Controls the DeltaTrac display.**

Format 1: **DX[*pos1*[*pos2*|-*pos2*][T]]**
Format 2: **DX T|C**

Description: *pos1* and *pos2* are natural numbers in the range 0 to 60.

With DX, one or two segments or any continuous range of the Mettler DeltaTrac display may be activated. The segments are numbered in the same manner as the minutes of a clock.

DX *pos1* activates the segment *pos1*.

DX *pos1 pos2* shows two individual segments.

DX *pos1-pos2* shows all segments from pos1 in clockwise direction up to and including *pos2*.

In addition, if the parameter T is specified, the tolerance markers are shown.

DX T shows the tolerance markers only.

DX C clears all DeltaTrac elements.

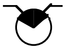
Error: EL if *pos1* or *pos2* not in the range 0 to 60.

Examples:

DX 5

DX 10 50

DX 10-50

DX 50-10 T 

DY **Weigh In**

Function: **Defines target weight and tolerances for checkweighing using the Mettler DeltaTrac.**

Format 1: `DY[ target[ tol+[ tol-]][ S]]`

Format 2: `DYB[ target[ tol+[ tol-]][ S]]`

Description: *target, tol+* and *tol-* are positive weight values expressed in the current weight unit 1.

After receipt of the DY command checkweighings can be performed with the balance as described in the operating instructions of the AT/MT/UMT under "Percent weighing". In contrast to that application, however, weight values continue to be displayed. In addition, the tolerances are not fixed to ±2.5% but can be specified separately for positive and negative deviations. Any tare preset must be added to the target weight using the B command. If this is not desired, the DYB command may be used.

If tolerances are not specified then *tol+ = tol- =* 2.5% of *target*. If *tol-* is omitted it assumes the same value as *tol+*.

DY or **DYB** without parameter clears the application.

S causes a double beep as well as automatic transmission of the weight as soon as stability is reached and the weight is inside the tolerance limits.

Error: EL if:

- one or more parameters negative
- target weight plus tare is larger than maximum load
- target weight is less than 0.01 g
- tolerance value is less than 0.0005 g
- one of the built-in applications is active

EC Command Acknowledge

Function: **Turns the command acknowledge mode on or off.**

Format: `EC[ n|?]`

Description:

n is either 0 or 1.

`EC 1` turns command acknowledge on. This causes the balance to send the message `OK` after every command that it has recognized as correct. This signifies that it is ready for a new command.

`EC 0` or **`EC`** without parameter switches back to normal mode (no acknowledge).

`EC ?` reports the current mode as follows:

`EC=0`	command acknowledge off
`EC=1`	command acknowledge on

An `OK` message does not necessarily mean that the command has been fully executed. With the tare command, for instance, `OK` appears as soon as taring begins. With an unstable weighing signal, however, it can take several seconds until the display has achieved stability and taring can be completed.

Error messages (`EL`, `ES` or `ET`) override the `OK` message.

Error:

`EL` if the handshake mode is set to METTLER TOLEDO CL. In this mode the character ACK assumes the role of the `OK` message.

EOL

End-of-Line Mode

Function: **Selects the end-of-line mode.**

Format: **`EOL [ mode | ?]`**

Description:

`mode` is either `CR` or `CRLF`.

With this command the end-of-line mode can be chosen. Use of this option is described in the section "End-of-Line".

`EOL CR` selects the mode "Carriage Return is End-of-Line".

`EOL CRLF` selects the mode "Carriage Return plus Line Feed is End-of-Line".

`EOL` without parameter selects the factory setting.

`EOL ?` reports the current setting as follows:

```
EOL=CR
EOL=CRLF
```

Error:

`EL` if an attempt is made to set "`CR`" in the CL handshake mode.

HS Handshake Mode

Function: **Selects the handshake mode.**

Format: `HS[ mode|?]`

Description:

mode is one of the modes `hard, soft, Pause, CL` or `off`.

`HS hard` selects the mode which uses the handshake lines DTR and CTS.

`HS soft` selects the mode which uses the handshake signals XON and XOFF.

`HS Pause` selects the mode which inserts a pause (1s) after every line sent.

`HS CL` selects the METTLER TOLEDO CL handshake mode.

`HS off` turns any handshake off.

`HS` without parameter selects the factory setting.

`HS ?` reports the current setting as follows:

```
HS=hard
HS=soft
HS=Pause
HS=CL
HS=off
```

ID Identification

Function: **Prompts the balance to transmit an identification text.**

Format: `ID`

Description: ID is useful in a weighing system if the controlling instrument (computer) needs to know the type and the version of the attached balance.

The AT balance sends a three-line (four-line*) identification similar to the following example:

```
STD 10.1.09
TYPE  : AT 250
0.00.00
SNR  : 1234567890*
```

The first line denotes the type and version of the software in the program cassette, the second denotes the balance model, and the third helps in recognizing special national and customized versions.

* The fourth line is only available with balance software version 1.23 and states the serial number of the balance.

IDX Extended Identification

Function: **Handles the reading and writing of a user-definable identification string.**

Format: `IDX [ id]`

Description: *id* is an identification string consisting of exactly seven characters as follows:

```
cnnnnnn
```

where:

c = alphabetic character (a…z or A…Z)
n = hexadecimal character (0…9 or A…F)

This command allows the user to store an arbitrary string (within the restrictions shown above) in the balance. This may be useful in a system where several balances are connected to a common controller.

`IDX id` stores `id` permanently in the balance.

`IDX` without parameter returns the currently stored identification string.

When leaving the factory, the balance contains a unique identification string. Once overwritten by the user, there is no way to retrieve this original value.

Error: `EL` if `id` contains an illegal character, i.e. not in the range specified above.

M Mode Reset

Function: **Sets the vibration adapter (wave symbol), the weighing process adapter (drop symbol), the stability detector (ASD), the AutoZero (AZ), and the readout increment (d) to the factory setting.**

Format: `M`

Description: With the `M` command a control unit can easily make sure that the balance is in a known state. It has the same effect as calling the six commands `MD`, `MI`, `ML`, `MS`, `MT` and `MZ` in a row, each without parameters.

MD Readout Increment

Function: **Modifies the readout increment.**

Format 1: **`MD[ step|?]`**
Format 2: **`MD[[ F| C] ?]`** and **`MD[ F|C[ step]]`**

Description: *`step`* is a natural number from the series 1, 2, 5, 10.

`MD` allows the reading and modifying of the readout increment parameter of the configuration register.

Format 1: (single range balances)

For balances with only one weighing range, format 1 applies.

`MD step` sets the readout increment to the value *`step`*.

`MD` without parameter selects the factory setting.

`MD ?` sends the current setting as follows:
`MD=`*`step`* readout increment set to position *`step`*

Format 2: (multiple range balances)

For balances with several weighing ranges, format 2 applies. The letter `F` specifies the *fine* range, the letter `C` the *coarse* range.

`MD F` *`step`* sets the readout increment of the fine range to the value step.

`MD C` *`step`* sets the readout increment of the coarse range to the value step.

`MD F` sets the readout increment of the fine range to the factory setting.

`MD C` sets the readout increment of the coarse range to the factory setting.

`MD F ?` sends the current setting of the fine range as follows:
`MD F=`*`step`* readout increment at position *`step`*

`MD C ?` sends the current setting of the coarse range as follows:
`MD C=`*`step`* readout increment at position *`step`*

`MD` without parameter selects the factory setting for both ranges.

`MD ?` sends the current setting as follows:
`MD C=`*`step`* `F=`*`step`*

Error: `EL` if the range specified with `F` or `C` is not available.

Example: The fine range of a dual range balance is to be set to a readout increment of 5, the coarse range to 2.

`MD F 5`	fine range
`MD C 2`	coarse range
`MD ?`	query
`MD C=2 F=5`	balance response

MI Vibration Adapter

Function: **Modifies the vibration adapter (wave symbol).**

Format: `MI[ n|?]`

Description: *n* is a natural number in the range 1 to 3.

n =1: vibration-free environment (small wave symbol)
n =2: normal environment (medium wave symbol)
n =3: severe vibrations (large wave symbol)

`MI n` sets the vibration adapter to the value *n*.

`MI` without parameter selects the factory setting.

`MI ?` sends the current setting as follows:

`MI=n` vibration adapter at position *n*

ML Weighing Process Adapter

Function: **Modifies the weighing process adapter (drop symbol)**

Format: `ML [ n | ? ]`

Description: *n* is a natural number in the range 0 to 3.

n =0: no adaption
n =1: dispensing
n =2: universal setting
n =3: absolute weighing

`ML n` sets the weighing process adapter to the value *n*.

`ML` without parameter selects the factory setting.

`ML ?` sends the current setting as follows:

`ML=`*n*	weighing process adapter at position *n*

MS

ASD

Function: **Modifies the stability detector (ASD).**

Format: `MS [ n | ? ]`

Beschreibung: *n* is a natural number in the range 0 to 7.

`MS  n` sets the stability detector to level *n*.

`MS  0` disables the stability detector (position "off").

`MS` without parameter selects the factory setting.

`MS  ?` sends the current setting as follows:

`MS=n` stability detector at level *n*

MT Transmission Mode

Function: **Modifies the data transmission mode ("Send Mode")**

Format: **`MT [ `*`mode`*`]`**

Description:

`mode` is either *`Stb`*, *`All`*, *`Auto`*, or *`Cont`*.

`MT Stb` selects the mode "Send Stable".

`MT All` selects the mode "Send All".

`MT Auto` selects the mode "Send Auto".

`MT Cont` selects the mode "Send Cont".

`MT` without parameter selects the factory setting.

`MT ?` sends the current setting as follows:
`MT=`*`mode`*

MZ AutoZero

Function: **Turns AutoZero (AZ) on or off.**

Format: **`MZ [ n|?]`**

Description:

n is either 0 or 1.

`MZ 0` turns AutoZero off.

`MZ 1` turns AutoZero on.

`MZ` without parameter selects the factory setting.

`MZ ?` sends the current setting as follows:

`MZ=0`	AutoZero off
`MZ=1`	AutoZero on

RG Range Select

Function: **Selects the weighing range.**

Format: `RG[ C|F|?]`

Description: With multiple-range balances `RG` can be used to select the weighing range.

`RG C` selects the coarse range (resolution 0.1 mg)

`RG F` selects the fine range (resolution 0.01 mg)

`RG` without parameter toggles between fine and coarse range, like the front panel key.

`RG ?` reports the current setting as follows:

`RG=C`	coarse range active
`RG=F`	fine range active

Error: `EL` if

- `RG`, `RG C`, or `RG F` used with single range balance
- Trying to set the fine range when fine range limit exceeded

RK Restrict Keyboard

Function: **Allows disabling or enabling of individual balance front-panel keys.**

Format: **RK [*bbbbbbbb*]**

Description: Each *b* represents a single key and can have the value 0 or 1. From left to right the following assignments apply:

Re-Zero	On/Off	Print	Menu	0.1/0.01 mg	⟳	Select 2	Select 1

A "0" in the corresponding position disables the key, a "1" enables it.

Re-Zero refers to *pressing* the «On/Off» key, On/Off refers to *lifting* this key.

The symbol REMOTE is shown on the display as long as at least on of the keys is disabled.

RK without parameter enables all keys, with the exception of the door keys which are disabled by a `WI D` command.

RK ? reports the current setting as follows:

```
RK=bbbbbbbb
```

Error: `EL` if the parameter does not contain exactly eight 0's or 1's.

Example:

```
RK 00100011
```

Disables all keys except "Print" and the door keys. Note that the balance can no longer be switched off by the user.

R*n* Remote

Function: **Allows simultaneous disabling or enabling of all balance front-panel keys.**

Format: `R0|R1`

Description:

`R0` enables the keys except for the door keys if they have been disabled by a `WI D` command.

`R1` disables all keys.

This command has been kept for compatibility reasons. The `RK` command serves the same purpose, at the same time offering much more flexibility.

The symbol REMOTE is shown on the display as long as the keys are disabled.

RX **Restrict External Switches**

Function: **Allows the individual disabling or enabling of the external switches (connection "Re-zero")**

Format: `RX[ bbbbbbbb]`

Description:

Each *b* represents a single switch and can have the value 0 or 1. From left to right the following assignments apply:

x	x	x	x	x	Doors	Transfer	Tare

A 0 in the corresponding position disables the switch, a 1 enables it. The positions marked with x are unassigned and are ignored by the balance.

RX without parameters allows all switch functions again.

RX ? reports the current setting as follows:
RX=*bbbbbbbb*

Error:

EL if the parameter does not contain exactly eight 0's or 1's.

Example:

```
RX 11111010
```

Disables the switches for taring and door operation. However, the transfer switch remains operative.

S Send Stable

Function: **Prompts the balance to send a single stable weighing result.**

Format: `S`

Description: This command causes the balance to send the next stable weighing result. If the balance is already stable when receiving the command, transmission occurs immediately. The data string begins with "S ", identifying a stable result.

An overload condition returns SI+, underload returns SI–.

Any existing send command is cancelled by S.

The data format is described in the section "Data Format".

The S command is equivalent to pressing the Print key when the transmission mode "Send Stable" is configured.

SI Send Immediate

Function: **Prompts the balance to send a single weighing result immediately, regardless of the stability status.**

Format: `SI`

Description: After receipt of this command the balance immediately transmits the next weighing result without waiting for stability. The data string begins with "`S `" if the weight value is stable, with "`SD`" if it is unstable.

If no valid result can be transmitted at the moment (the balance might be waiting for stability, showing only hyphens), the message `SI` is sent instead.

Overload is reported as `SI+`, underload as `SI-`.

Any existing send command is cancelled by `SI`.

The data format is described in the section "Data format".

The `SI` command is equivalent to pressing the Print key when the transmission mode "Send All" is configured.

SIR

Send Immediate and Repeat

Function: **Prompts the balance to continuously send weighing results, regardless of the stability status.**

Format: `SIR`

Description:

After receipt of this command the balance sends weighing results continuously (about two and a half results per second) under the same conditions as the `SI` command. The data strings begin with "`S` " in the case of a stable weighing result, with "`SD`" if the weighing results are unstable.

Invalid results (for example, the balance is waiting for stability and shows only hyphens) appear as `SI`.

Overload is reported as `SI+`, underload as `SI–`.

Any existing send command is cancelled by `SIR`.

When using this command, special attention should be paid to the correct setting of the handshake mode since the receiving device might otherwise be unable to keep up with the data flow.

The `SIR` mode can be cancelled simply by sending an `SI` command (or by any other send command).

The data format is described in the section "Data Format".

The `SIR` command has the same effect as if the balance had been configured to the transmission mode "Send Continuous".

SNR Send Next and Repeat

Function: **Prompts the balance to send the next stable weighing result automatically whenever a load change occurs.**

Format: `SNR`

Description:

After receipt of this command the balance sends the next stable result (immediately if it is already stable) and then another one after every load change of at least 0.01 g.

Overload is reported as `SI+`, underload as `SI–`.

Any existing send command is cancelled by `SNR`.

The data format is described in the section “DataFormat”.

The `SNR` command has the same effect as if the balance had been configured to the transmission mode “Send Auto”.

SR

Send and Repeat

Function:

Prompts the balance to send an unstable result whenever a load change occurs and then transmit the next stable weighing result.

Format:

SR[*threshold*]

Description:

threshold is a positive weight value in the current unit 1.

After receipt of this command the balance sends the next stable weighing result (immediately if it is already stable), then an unstable result after every load change of at least the *threshold* value, as an indication that the load on the weighing pan has been changed, and finally the next stable weighing result. This procedure is constantly repeated.

The minimum value for *threshold* is 0.001 g.

If *threshold* is omitted, a value of 12.5% of the last stable result, but at least 0.01g, is used.

SR 0 switches the SR mode off.

Overload is reported as SI+, underload as SI–.

Any existing send command is cancelled by SR.

The data format is described in the section “Data Format”.

Error:

EL if

- *threshold* is negative or less than 0.001 g
- stability detector is switched off (ASD=0)

T Tare

Function: **Tares the balance or switches it on again after a power failure.**

Format: `T`

Description: The `T` command has the same effect as pressing the tare key. If the weight result is stable or the stability detector is switched off, taring occurs immediately. Otherwise, hyphens are shown in the display and results requested by `SI` or `SIR` appear as "`SI`".

In contrast to manual taring, no `TA` message is generated.

If the taring process can not be completed within one minute, it is aborted. The error message `EL` is sent to the interface.

Following an interruption of the power supply to the balance, `T` is the only command accepted. The tare command restores normal balance operation.

Error: `EL` if

- taring not possible within one minute
- overload or underload

U Unit

Function: **Selects a weight unit or a constant divisor for all weighing results.**

Format 1: `U[ unit]`

Format 2: `U[dec] div[ name]`

Description:

Format 1:

unit is one of the weight units of the AT/MT/UMT balance:
g mg oz ozt tl GN dwt ct C.M. mo

The selected weight unit replaces the previous weight unit 2. Weight unit 1 is not accessible as long as the `U` command is active. Commands that specify a weight value, such as `B`, `DY` or `SR`, still refer to the original weight unit 1.

The unit tael (tl) uses one of the three national conversion factors, as selected in the configuration register.

`U` with no parameter clears the unit and reselects unit 1.

Format 2:

dec is a natural number in the range 0 to 7.

div is a divisor expressed in weight unit 1with or without decimal places.

name specifies a display symbol as follows:

# or **PCS**	the symbol "PCS"
Stk	the symbol "Stk" (German for "PCS")
%	the symbol "%"

If *name* is omitted, no unit appears.

This command allows the conversion of the weighing results into any "custom" weight unit. The number of decimal places can be selected with the parameter *dec*. Omission of *dec* shows the maximum possible number of places for the current unit 1.

Error: `EL` if *div* is so small that the display capacity would be exceeded.

Example: Parts having an average piece weight of 0.125 oz are to be counted:

```
U oz      change unit 1 to ounces
U0 .125 divisor = 0.125, no decimal places
```

Note: If one of the built-in applications (percent weighing or piece counting) is active at the time of the `U` command, it will be reset. The stored reference weight is lost.

US

Unit Switch

Function: **Selects the active weight unit.**

Format: `US[ n|?]`

Description:

n is a natural number, either 1 or 2.

With this command one of the two weight units unit 1 or unit 2 can be made current.

US n selects the weight unit *n*.

US without parameter switches to the next weight unit (from 1 to 2, from 2 to 1). This is equivalent to pressing the corresponding balance key.

US ? sends the current setting as follows:

`US=n` weight unit *n* active.

Error:

EL if

- U command active
- both weight units identical
- external command active (B, DY, etc.) and weight unit 2 is piece or percent
- weight unit piece or percent selected but no reference weight stored.

UX **Unit Change Extended**

Function: **Redefines the weight units 1 and 2.**

Format: **UX [[*unit1*] [;*unit2*] | ?]**

Description: *unit1* and *unit2* each denote one of the weight units of the AT/MT/UMT balance:

g mg oz ozt tl GN dwt ct C.M. mo

UX *unit1* sets weight unit 1 to *unit1*.

UX *unit1;unit2* sets weight unit 1 to *unit1* and weight unit 2 to *unit2*. A space character may be used in place of the semicolon.

UX *;unit2* sets weight unit 2 to *unit2*.

UX without parameter sets the two weight units to the factory setting.

UX ? sends the current setting as follows:

UX=*unit1 unit2*

After the changing one or both weight units, the balance switches automatically to weight unit 1.

Error: EL if the selected weight unit cannot be displayed (e.g. µg with analytical balance).

Example:

UX ;oz	sets weight unit 2 to ounces
US 2	activates weight unit 2 (oz)

W Write Output

Function: **Controls the GM54 Output Module or the LV10 Automatic Feeder.**

Format 1: `W[ stat]`
Format 2: `W stat time stat[ time stat]…`

Description: **Format 1:**

stat is a natural number in the range 0 to 255.

With this command the eight digital outputs of the GM54 Output Module accessory can be switched on and off individually. Each of the eight outputs is assigned a value as follows:

digital output 0:	1
digital output 1:	2
digital output 2:	4
digital output 3:	8
digital output 4:	16
digital output 5:	32
digital output 6:	64
digital output 7:	128

stat is specified as the sum of the values of those switches that should be closed. Example: With `W 5` the digital outputs 0 and 2 are closed, all others are opened.

W without parameter opens all eight switches.

A break in the interface line also opens all switches.

Error: `EL` if *stat* is not in the range 0 to 255.

Format 2:

`stat` is a natural number in the range 0 to 255.

`time` is a natural number in the range 1 to 60,000.

This command can be used to program a series of status changes of the digital outputs with selectable time intervals. The first and the last argument are always a *`stat`* condition. The *`time`* intervals between the status changes are expressed in milliseconds, with an actual resolution of about 6 ms. The shortest interval is 15 ms, for technical reasons, the longest 60 seconds.

The command can handle a maximum of **six** *`stat`* conditions with **five** *`time`* intervals.

After the entire sequence has been executed, the message `WA` is sent to the interface. If the balance receives another `W` command before this occurs, the old command is aborted immediately.

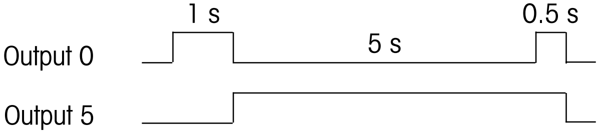
Error:

`EL` if

- *`stat`* not in the range 0 to 255
- *`time`* not in the range 1 to 60,000

Example:

The following pattern is to be generated:



`W` (makes sure all eight switches are open)

```
W 1 1000 32 5000 33 500 0
```

WI

Windows

Function: **Controls the motorized draft shield doors.**

Format: `WI[ n|?|D[F|X]|E[F|X]]`

Description:

n is either 0 or 1. With the `WI` command the doors can be either opened or closed, or their position requested. In addition, the mechanical door switches (on the front-panel or external) can be disabled or enabled.

`WI 0` opens the doors.

Special command for MT/UMT balances only:

`WI 0 R` opens the door to the right

`WI 0 L` opens the door to the left

Lear function of the MT/UMT balances:

`WI 0` opens the door to the same side as the last time it opened electrically (with the press of a key or with the commands **`WI 0 R/WI 0 L`**)

`WI 1` closes the doors.

`WI` without parameter moves the doors (like the front-panel door keys).

`WI ?` reports the current position as follows:

`WI=0`	doors open
`WI=1`	doors closed
`WI=2`	doors in intermediate position
`WI=3`	doors moving

`WI D` disables the door keys and the external switches.

`WI DF` disables the two door keys only.

`WI DX` disables the external switches only.

`WI E` enables all door keys and switches.

`WI EF` enables the two door keys only.

`WI EX` enables the external switches only.

The symbol REMOTE is shown on the display as long as the door keys are disabled. Use of external door switches is described in the section "The Re-Zero Connector".

@ Break

Function: **Cancels all balance setting changes effected via the interface.**

Format: **@**

Description: This command has the same effect as a break on the input data line of the balance. It is particularly suited for systems in which a physical break of the data line is not feasible or not desirable, for example in a remote control installation based on modems, or when a local area network (LAN) is involved.

? Help

Function: **Sends an overview of the interface commands.**

Format: `? [`*`s`*`]`

Description: Causes the balance to send a list of the major interface commands. Proper representation requires a video terrminal or computer screen, or a printer capable of printing at least 80 characters per line.

`?D`	shows the command list in German.
`?F`	shows the command list in French.
`?E` or `?`	without parameter shows the command list in English.

The printout can be cancelled by sending any valid command.

. Cancel

Function: **Aborts a time-consuming command execution.**

Format: .

Description: Some commands take quite some time to execute or are unable to finish because of an unstable environment. Rather than wait for a time-out, these commands may be aborted by the cancel command. Like all commands, it requires a return character termination (possibly followed by a line feed) to execute.

Commands that may be cancelled include:

- taring
- calibrating
- calibration test
- the “S” command *(Send Stable)*

Error: `EL` if there is no command capable of being aborted in progress.

<crlf> Repeat Command

Zweck: **Repeats the last command.**

Format: `<cr>|<crlf>`

Description: By simply sending a return character (or return followed by line feed, depending on the configuration of the EOL parameter) the last valid command is executed again. This feature is especially useful where only a simple terminal is connected to the balance.

Error: `EL` if no valid command is stored (i.e. immediately after turning the balance on or after an interface break).

Appendices

Interface Configuration

All parameters that control the behavior of the interface can be selected in the fourth sector of the configuration register. The four send modes described below define the behavior of the balance after switching on or after an interface break. The send mode can be overwritten at any time by send commands.

Send Stable ("S.Stb")

After the key "Print" or the external transfer key has been pressed, the next stable result is transmitted. A brief beep sounds at the same time. If the fully automatic door function ("doorAuto") has been selected in the menu, the draft shield first closes automatically and then reopens after transmission.

To distinguish data strings initiated this way from those resulting from an "S" command, the first character is a space instead of an "S".

Send All ("S.ALL")

After the "Print" or the external transfer key has been pressed, a result is transmitted immediately without closure of the draft shield. Stable values are identified by a beep.

To distinguish data strings initiated this way from those resulting from an "SI" command, the first character is a space instead of an "S".

Send Continuous ("S.Cont")

The balance continuously transmits approximately two and a half results per second . The "Print" key and the external transfer key have the same effect as in the "Send Stable" mode.

The data format is not distinguished from that following an "SIR" command.

Send Automatic (“S.Auto”)

After every weight change of at least 0.01 g the balance automatically transmits the next stable result. A brief beep sounds at the same time. The “Print” key and the external transfer key have the same effect as in the “Send Stable” mode.

The data format is not distinguished from that following an “SNR” command.

Baud Rate

The AT/MT/UMT balance can work with any of the following baud rates:

150, 300, 600, 1200, 2400, 4800, 9600 baud

In all cases, even at very low baud rates and with continuous result transmission, only the most recent values are sent. There is no storing of “old” results.

Parity

A parity bit may be appended automatically to each character (7 data bits) before transmission. The parity bit of the received characters is checked. If it does not match the expected value, the entire message (up to the next line end) is considered invalid. This causes the balance to send the error message ET. Not affected by the parity check are the handshake characters SYN, ACK, XON and XOFF. This reduces the risk that the data exchange between balance and peripheral device is broken due to “lost” (i.e. unrecognized) handshake characters.

The possible parity settings are:

even: The parity bit is selected such that the sum of all 1 bits (data word plus parity) is even.

odd: The parity bit is selected such that the sum of all 1 bits (data word plus parity) is odd.

off (mark): The parity bit is always set to 1. On receipt it is *not* tested. For the receiver this data format has the same effect as "no parity, two stop bits".

space: The parity bit is always cleared (0). On receipt it is *not* tested.

Handshake

Many peripheral devices are not capable of processing a continuous data flow, particularly at high baud rates. Likewise, the balance can also not receive and execute commands at just any speed. A handshake protocol is generally used to ensure an orderly data flow.

In addition to the proven METTLER TOLEDO CL handshake the AT/MT/UMT is equipped with the industry-standard protocols CTS/DTR (hardware) and XON/XOFF (software). For devices without any handshake possibility, the AT/MT/UMT balance can be instructed to insert a pause at the end of every line.

The possible handshake settings are:

hard (CTS/DTR): The attached device can stop the data flow from the balance at any time by deasserting the DTR line (negative voltage on the line). Most printers can handle this type of handshake. On the other hand, the balance informs the device that it can not currently receive more data by deasserting the CTS line.

soft (XON/XOFF): This method requires a simple bidirectional data line; no control lines are necessary. Both balance and peripheral device can stop the incoming data flow at any time by sending the character XOFF (ASCII 19, control-S). The character XON (ASCII 17, control-Q) reenables the communication. Many printers as well as most computers can operate with this method (the IBM PC only after suitable programming).

Pause: This setting is provided for devices that are not prepared to handle any kind of handshake. At the end of each line the balance inserts a pause of one second before it starts transmitting the next line. Almost any device can thus be attached to the METTLER TOLEDO AT/MT/UMT if it is capable of receiving at least one line at a given baud rate, store it temporarily, and process it within the pause time.

CL: This is METTLER TOLEDO's own protocol and was developed particularly with current loop operation in mind. Like XON/XOFF it is a software-only handshake. The control characters used are SYN (ASCII 22, control-V) and ACK (ASCII 06, control-F). A special feature of instruments with CL capability is that after switched on, they attempt to set up handshake operation in the transmitting and receiving directions separately. If this fails – possibly because one of the devices cannot handle the CL handshake protocol – no control characters appear on the data lines later on. Another feature of CL is that it operates on whole blocks (lines) of data and not individual characters as do the other methods. Short-form instructions for programmers regarding the use of the CL handshake are included in this manual.

End-of-Line ("EOL")

Messages sent by the balance are normally terminated by the character sequence CRLF (Carriage Return and Line Feed). Commands are executed only after receipt of the same sequence. Most computer languages regard the character CR alone as end-of-line, however. This might lead to inconvenient programming caused by the necessity of having to strip the line feed character from the beginning of data strings, for example.

The EOL parameter of the AT/MT/UMT balance solves this problem by optionally allowing the suppression of the line feed. At the same time, a command is executed as soon as CR is received. This mode is recommended whenever the balance is to be controlled by a computer program.

The CL handshake depends on the existence of the line feed; the end-of-line option is suppressed in this case.

The RS-232 Interface

This section describes the electrical features of the RS-232 interface and provides tips on how to use it.

RS-232 is without a doubt one of the most widely used interfaces in the world of data communication. Despite its great popularity, it is also the cause of much trouble and frustration. The possible causes of most problems may be summarized in a surprisingly short list:

- plugs don't match
- handshake lines either don't work or stop all data flow
- only garbled characters are received
- transmitted data does not appear at the other end of the cable

The ABC of RS-232

This section illustrates a few basic concepts of the RS-232 data transmission. If your prior attempts to master RS-232 have been successful, you may safely skip the following section.

Many users are not aware that with RS-232 connections, as with the cables of the mains power system, a distinction must be made between connectors and receptacles (somewhat frivolously referred to as male and female plugs). If data leaves a device at pin 2 then it must enter the partner device at the same pin. This way a simple wiring scheme is possible, namely pin 1 to pin 1, pin 2 to pin 2, etc. In the RS-232 world, devices with male connectors are called **DTE** (Data Terminal Equipment), whereas devices with female connectors are known as **DCE** (Data Communication Equipment).

The cabling problem would not exist if all manufacturers would stick to these rules. As in the well-behaved world of the 110 Volt cable, where safety against electrical shocks is paramount, each cable would have a male connector at one end and a female connector at the other. In reality, however, one might encounter data terminals with female and computers with male plugs (sometimes even correctly so, as they behave like a terminal). In such cases it is no longer possible to set up a working installation by just providing the matching cables.

A further reason for confusion lies in the **naming conventions of the interface lines.** For instance, line 2 is called "Transmitted Data". But this is only correct when seen from the side of the DTE. A DCE actually *receives* data on the Transmitted Data line.

Handshake lines are a particularly rich source of problems. The most frequent symptoms are the lack of any communication in one or both directions, or the overflowing of the devices with data, resulting in loss of characters. The cause is usually found in open (i.e. unconnected) handshake lines. Most devices read this as "handshake deasserted" and inhibit the data output. A well-known example is the asynchronous serial adapter of the IBM PC. Some devices, such as the AT/MT/UMT balances, treat an unused handshake input line as asserted (signifying "OK to send").

Garbled characters are usually a consequence of mismatched interface parameters such as baud rate, parity, number of data bits and are therefore not a problem specific to RS-232.

If transmitted data does not appear anywhere, chances are that a device has been connected to another of the same kind (DCE to DCE or DTE to DTE) without **wire crossing.** Imagine message characters travelling down the cable in opposing directions crash into each other, resulting in mutual annihilation...A less dramatic reason might simply be the fact that the cable is not plugged in, or has fallen off, or is broken.

The RS-232 Connection of the AT/MT/UMT

The balance is wired as a DCE device. The most common application, namely connecting an RS-232 printer to the balance, should therefore pose no problems. Connection to another DCE device (computer, modem, etc.) requires that the data and handshake lines be crossed. Such cables are sometimes referred to as "null modem" and are available from many sources. In addition, so-called "intelligent" cables exist that perform the necessary crossings automatically whenever they detect a conflict.

The factory setting of the handshake is "Pause". This ensures that a printer without handshake works right away in most cases. If a computer or a video terminal is attached, selecting one of the other handshake methods is recommended as the delay time between the messages is quite noticeable.

The diagrams in the section "The DATA I/O Connector" show some typical cabling suggestions. It should be noted that it is normally up to the computer program to deal with the handshake lines. It is entirely possible that simpler configurations than those shown work without problems.

The METTLER TOLEDO CL Interface

This section describes the electrical features of the CL interface.

The interface operates with a constant current of 20 mA. It must be supplied by an external current source, one each for the transmitting and receiving loop (see illustration).

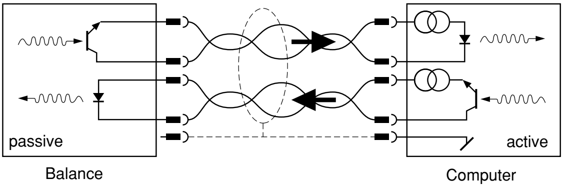
The best results are obtained when the following technical limits are observed:

Voltage compliance of source: 15V (+10%, -0%)
Current range: 18...24 mA
Rise/fall time: 2...20 mA/µs

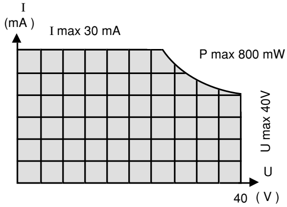
Cable: shielded, twisted pair, ca. 125 /km or less, conductor cross-section 0.14 mm^2 or larger, capacitance 130 nF/km or less

Max. length: 1000 m at 300 baud, 500 m at 2400 baud.

The CL interface section of the balance is based on two independent passive transmission loops:



The passive current loops of the balance must be conntected to external current sources. To avoid destruction of the CL interface by these sources, it is essential to observe the following limiting data:



The U/I characteristic of the source must lie within the hatched area.

CL for Programmers

This method has the quite undeserved reputation of being complicated and only suitable for current loop connections. It owes its apparent complexity mainly to the sophisticated procedure used to set up the handshake, and the rigid distinction between text characters, termination characters, and code extensions (ESC sequences). In practice, however, simplifications can usually be applied (e.g. it can be assumed that the termination character is always a line feed). Since the CL handshake protocol offers advantages in many applications – like the feature where complete messages can be requested from the balance individually, or the absence of unwanted control characters when handshake is not established – a few tips will be given here to facilitate working with this protocol.

Initialization

The balance attempts to establish handshake operation not only after it is switched on, but also after every break in the data line (disconnecting and connecting the cable, receipt of a break from the peripheral device, switching on the peripheral device), and also after selecting the CL mode in the configuration register. About 200 ms after the electrical connections have been established, your device will receive the SYN character (Synchronous Idle, ASCII 22, Control-V). The procedure that follows now depends on whether you wish simply to slow down the balance’s transmissions using handshake signals, or whether the balance also should report its readiness to receive commands.

Device-controlled Balance Output

Send the character ACK (Acknowledge, ASCII 06, control-F) to the balance. It will then respond with exactly one data block, if available. Each additional ACK authorizes the balance to send another message. Do not send more than one ACK before receiving a data string; the balance will not store them.

Balance-controlled Device Output

Transmit the character SYN to the balance to inform it that your device understands the CL handshake. The balance responds by echoing the SYN character, indicating that it is now set up for CL handshake. From now on do not send commands to the balance unless you have received an ACK.

Bidirectional Handshake

Ideally, your device can recognize the end of the break condition. Wait about 200 ms to let the signals settle and then send the SYN character.

If break recognition is not possible, make sure that the interface of your device is fully operational within 200 ms after the balance is turned on. Do not send SYN.

In both cases, you will receive the inquiry signal SYN from the balance. Confirm receipt of the character and awareness of the CL handshake mode by sending SYN. As soon as you are ready to receive balance messages, send an ACK. From now on two rules apply:

1. Do not send a command to the balance unless you have received an ACK.

2. Send exactly one ACK whenever you are ready to receive a data block from the balance.

The state of the CL handshake mode may be checked on the balance display: If the handshake is set up in *both* directions, the symbol I/O is permanently on, otherwise it blinks. The I/O symbol is not shown at all if a break is detected on the input data line.

Once handshake has been set up, it can be cancelled only by switching off the instruments, by an interface break, or by changing the handshake mode in the configuration register.

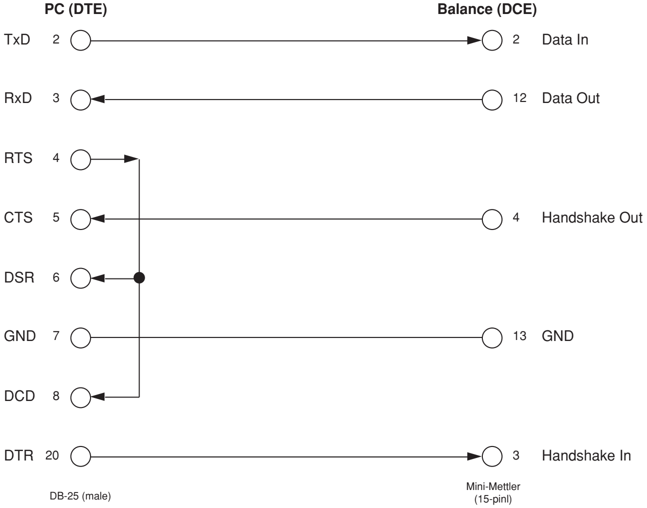
The DATA I/O Connector

This connector at the rear of the balance is used for attaching peripheral devices with a serial interface, either for RS-232 or CL operation. Ordering information for suitable plugs and cables can be found in the brochure *Technical specifications and accessories*. This publication also contains tips on the correct setting of several general-purpose printers, as well as a list of the separately available *Engineering Support Bulletins* describing the connection of METTLER TOLEDO balances to a number of popular personal computers.

Connecting a Personal Computer

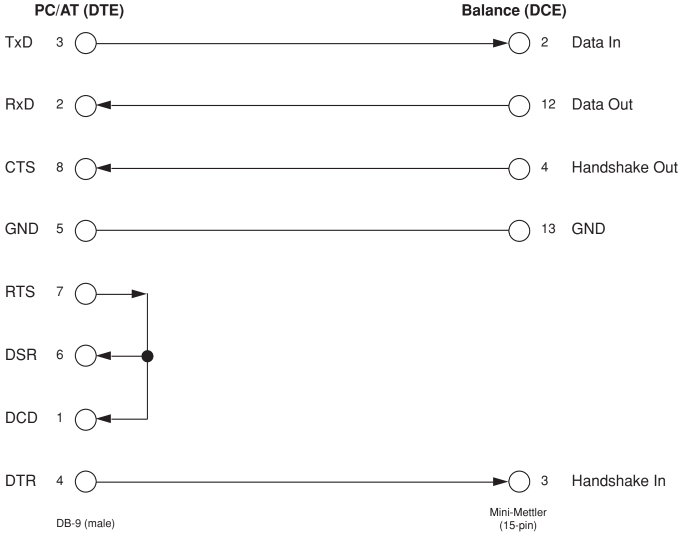
The Engineering Support Bulletins mentioned above describe the simplest case of connecting a balance to a computer, which is by not taking advantage of the handshake lines. If the additional capabilities offered by the AT/MT/UMT balance are to be used, the wiring diagrams below may serve as a guide.

Examples:
IBM-PC, PC/XT and compatibles



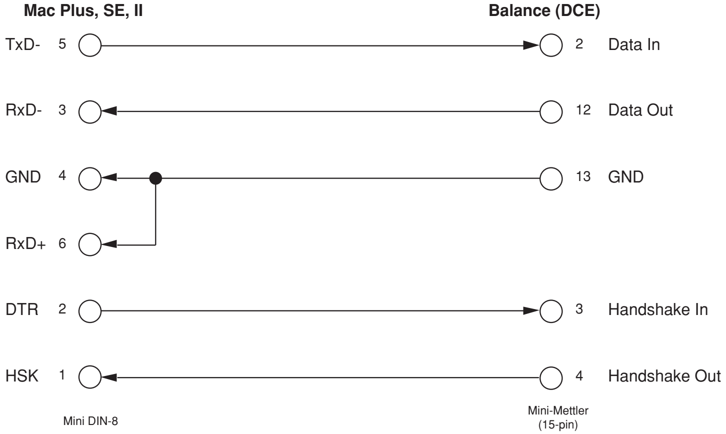
Appropriate cable: 210491

IBM-PC/AT and compatibles



Appropriate cable: 210493

Apple Macintosh Plus, SE, SE/30 and Macintosh II, IIx, IIcx



Appropriate cable: 210495

The GT Connector

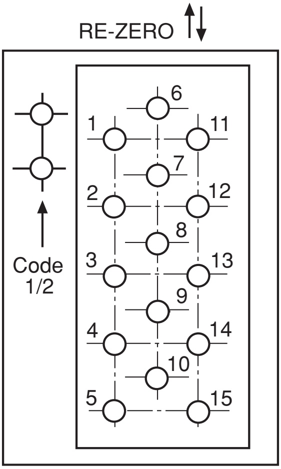
All METTLER TOLEDO GT devices are attached to the AT/MT/UMT balance using this connector. In addition, certain devices of the GM series can be connected by use of the GM/GT adapter (210498) (see brochure *Technical specifications and accessories* of the AT/MT/UMT balance). The connectors are T-shaped so that several devices can be operated at the same time.

The Re-Zero Connector

Remote control of the functions "Open/close Doors", "Print/Transfer" and "Tare" without using the serial interface is made possible by this connector. Since signals indicating the status of the doors (open, closed or in-between) are also available, a small laboratory automation system can be set up easily. For such purposes METTLER TOLEDO offers a control cable (210494) with loose ends. The documentation enclosed with the cable shows the pin assignments of the lines and provides application tips.

The remote control functions may be disabled or enabled individually by the RX command.

A *Twin Foot Switch* (210580) is also available as an accessory. It allows the triggering of a data transfer operation as well as taring by pressing the appropriate foot switch. This way, hands remain free for loading the scale and other tasks. This, when used together with the automatic door closing operation ("doorAuto"), provides an unusually high degree of convenience.



Data Format

Weighing result strings are formatted as follows:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ID		▨	DATA										▨	UNIT				CR	LF

where:

ID	Identification
DATA	Weighing result
UNIT	Weight unit
hatched	Space (ASCII 32)
CR, LF	Carriage Return, Line Feed

The **identification** ID denotes the type of communication:

The *first character* is a

Space if the weighing result has been triggered by the "Print" key or the foot switch.

S if the weighing result has been requested by an "S" command or the balance is in the Send Continuous mode ("S.Cont").

The *second character* is a

Space if the weighing result is stable

D if the weighing result is unstable ("dynamic").

The **weighing result** appears right-justified in the DATA field. If the value is negative, the sign is placed immediately in front of the first digit. Leading zeros are not shown except for the zero to the left of the decimal point. The position of the decimal point depends on the balance model and the selected weight unit. In the coarse range of the balance, position 13 always contains a space. Whenever DeltaDisplay is active, the last result digit is replaced by a space.

The **weight unit** appears left-justified in the UNIT field. The number of characters used is determined by the length of the unit string, up to four characters.

The message is terminated by Carriage Return and Line Feed, immediately following the weight unit. If "EOL cr" has been selected in the configuration register, Line Feed is suppressed.

If, for some reasons, the balance cannot transmit a valid result (e.g. on an over-/underload condition, or when waiting for stability), only the identification block with the character **"I"** in the second position appears. In the case of overload, an additional **"+"** is appended, for underload a **"–".**

Examples:

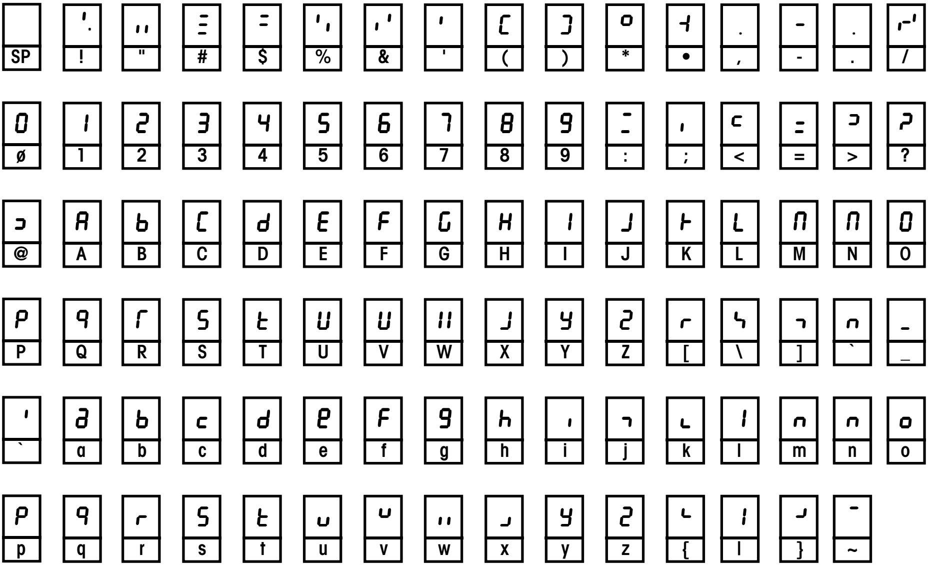
`SI` Invalid result after "S" command or in the "Send Continuous" mode

`SI-` As above, but additionally identified as underload

` I+` Overload; data transmission triggered by "Print" key or external transfer switch (note the space in the first position)

7-Segment Representation of Text

The "D" command allows the display of any kind of text on the balance, restricted only by its capability to represent characters using only seven segments. The following table shows the 95 printable characters of the ASCII character set (ISO-646) and how they appear on the AT/MT/UMT balance.


SP ! " # $ % & ' ( ) * • , - . /
ø 1 2 3 4 5 6 7 8 9 : ; < = > ?
@ A B C D E F G H I J K L M N O
P Q R S T U V W X Y Z [\ ] ` _
` a b c d e f g h i j k l m n o
p q r s t u v w x y z { | } ~

What if...

Murphy's Law states that" if anything *can* go wrong, it *will* go wrong". This applies particularly to the situation where devices of different manufacturers have to be interconnected. The following tips are meant to help put you on the right track to the solution of your problems more quickly.

The messages of the balance are too short/too long and completely unintelligible.

The baud rates of balance and peripheral device do not match.

The messages of the balance are almost correct, but some characters are garbled.

The parity settings do not match.

The messages of the balance appear error-free on the peripheral device, but most commands are answered with "ET".

This is also a parity problem. Many peripheral devices simply ignore the parity bit and show the characters correctly in all cases. The AT/MT/UMT responds to commands containing characters with wrong parity with the error message "ET", but only if parity "even" or "odd" has been configured.

The messages of the balance appear at a very slow rate (about one per second), no matter what the baud rate.

The AT/MT/UMT is running in the handshake mode "Pause", which is intended for printers without handshake facilities. Since this is the factory setting, you should select another mode when working with high-speed peripherals.

The printer remains silent although all settings and connections are correct.

Printers are frequently equipped with a unidirectional interface, i.e. the data line in the balance direction is inoperative. This is recognized by the AT/MT/UMT as a break, resulting in the balance not transmitting if CL handshake mode is configured. Solution: Configure a different handshake mode. (CL handshake wouldn't make sense in a unidirectional environment, anyway).

Many printers have a ready key (labeled "Online", "Ready", "Select" or something similar). Pressing this key ensures that the printer is ready to receive. An indicator lamp sometimes helps you verify this mode.

The computer recognizes the first weighing result without problem, but subsequent results lead to errors.

Most computer languages treat the character Carriage Return (CR) as an end-of-line indication, not the Line Feed (LF) as is standard with Mettler balances. Therefore, the LF will appear as the first character of the next message. Solution: Select "EOL cr" in the configuration register. Remember that this implies that commands sent to the balance are terminated with CR, too, not CRLF. "EOL cr" is not available in the handshake mode "CL".

Messages received from the balance are OK, but all commands are ignored.

Cabling problems apart, the cause may be that your computer terminates commands with Carriage Return. With the balance expecting a Line Feed, it will never begin to interpret your command. Solution: Select "EOL cr" in the configuration register. Note that the Line Feed will then be stripped from the balance messages, too.

The I/O symbol does not appear in the display although a peripheral device is attached.

The peripheral device is probably still keeping the data input line of the balance in the break condition. Also, check for broken wires and loose connectors.

The I/O symbol flashes.

The handshake mode is set to "CL" but fully bidirectional handshake has not yet been set up.

Every command sent to the balance produces an "EL" error message.

The balance is in the "Off" condition as a result of a power interruption. The only command it will accept is "T", which will restore normal operation.

The symbol REMOTE is lit and can’t be removed.

> This symbol appears whenever one or more front-panel keys have been disabled by an interface command. Possible commands are: `R1, RK` or `WI D`. Try sending `R0` or `RK` without parameter. If the symbol still appears, the door keys have been inhibited by `WI D` or `WI DF`. Send `WI E` to reenable the door keys. The REMOTE symbol should be off now.

1st Aid Kit

Finally, a few helpful tips taken from seemingly hopeless real-life situations:

1. Make sure that the physical cable connections are in order. This is very important. The best software can't help you fix a broken or misconnected wire. The wiring diagrams shown earlier may be useful here.

2. Configure the balance as follows:

Send Mode:	Send Continuous ("S.Cont")
Baud rate:	same as peripheral device (extremely important!)
Parity:	same as peripheral device (ignore if unknown))
Handshake:	off
EOL:	CRLF

3. The balance now transmits results continuously. If you still don't get any data, chances are that the peripheral device is inhibiting itself because of open handshake lines. Consider connecting handshake inputs with asserted outputs (see page 81 for an example). Solve this problem before proceeding.

4. Data transfer from the balance to the peripheral is now almost up and running. Don't worry if some of the messages appear garbled; this is due to the balance operating without handshake.

5. Send the four characters `S`, `I`, Carriage Return and Line Feed to the balance. If your device does not have a Line Feed key, use Control-J.

6. The balance now transmits…

…nothing anymore: The command `SI` has been accepted, causing the Send Continuous mode to end. Congratulate yourself and advance to step 7.

…`ET`: Excellent. The connection is in order, only the parity settings are not matched yet.

…results as before: The balance has not recognized the command. Change the parity setting of the balance and try again. Set the EOL parameter to `CR` and send the command without Line Feed. If nothing helps (and you feel sure you have *really* followed the directions in step 1), then it looks very much like a handshake problem as described in step 3. If still unsuccess ful, get yourself a cup of coffee, lean back and think it all over.

7. Communication is now working in both directions. If the balance responds to commands with `ET`, the parity settings are still different. The correct setting of the handshake mode is usually important only if you wish to use the Send Continuous mode of the balance, or if you wish to send commands to the balance as quickly as possible. In the latter case the echo mode (`EC 1`) might come in handy, too.

Glossary

ACK — Short for acknowledge. A control character of the ASCII character set having the value 06 (hexadecimal). It is used in the METTLER TOLEDO CL handshake protocol to tell other device that it may send exactly one line of data.

ASCII — American Standard Code for Information Interchange. This ubiquitous standard defines how printable and control characters are encoded into 7 bits. For example, any device that speaks ASCII will interpret the code 41 (hexadecimal) as an uppercase "A".

Asynchronous — Most data transmission between personal computers and instruments like the AT/MT/UMT occurs asynchronously, meaning that each character is individually synchronized, usually by using a start bit and a stop bit. The duration of the individual bits is defined by the baud rate.

Balance settings — The condition a balance is in at a given moment, based on the currently valid configuration and the menu settings.

Baud — Strictly speaking, baud is the number of changes in signal levels, frequency, or phase per second on a communication channel. If each change represents one bit of data, as is the case with the AT/MT/UMT, baud is the same as bits per second. However, it is possible for one signal change (one baud) to equal more than one bit of data. By default, the AT/MT/UMT transmits 2400 bits per second, so its **baud rate** is 2400 baud.

Bit — The smallest unit of data. Represented by a 1 or a 0.

Break — The condition where the data line remains in the spacing state for longer than the duration of a character.

Character — A letter, number, or special symbol (such as a comma or percent sign) contained in data or used to control communication devices.

CL — Current Loop. 1) An alternative to RS-232 using constant current (20 mA) instead of voltage. It is much less common and has no standard connector. Its main advantage is that it can cover larger distances. 2) The name of a handshake protocol used by METTLER TOLEODO.

Computer — A device, usually in a box, consisting of a Central Processing Unit (CPU), memory and connections to the outside world (ports). Programs, called software, allow it to make errors much faster than a human being.

Configuration register — A set of menus and menu items on the AT/MT/UMT which allow the user to configure the balance for his particular application.

Control character — A character of the ASCII character set which does not print, but may be used to control communication devices. Examples: Carriage Return, ACK, XOFF.

CR — Carriage Return. A control character of the ASCII character set (OD hexadecimal). Originally used to cause a printing device to move its print head to the left margin, it now generally signifies the end of a line or a command.

CTS — Clear-to-Send. One of the signals defined by the RS-232 standard. It is sent by the DCE on pin 5 of the standard 25-pin connector. It is an indication to the data terminal equipment (the peripheral connected to the balance) whether the DCE can accept data on the Transmit Data line or not.

Current Loop — *see CL.*

DCE — Data Communication Equipment. One side of a RS-232 setup. It must be linked to a DTE. Transmits data on pin 3 of the standard RS-232 connector.

DTE — Data Terminal Equipment. One side of a RS-232 setup. It must be connected to a DCE. Transmits data on pin 2 of the standard RS-232 connector.

DTR — Data Terminal Ready. One of the signals defined by the RS-232 standard. It is sent by the DTE on pin 20 of the standard 25-pin connector as an indication to the balance whether the DTE can accept data on the Received Data line or not.

EAROM — Electrically Alterable Read-Only Memory. An electronic memory device that may be read or written to. Its main characteristic is its ability to keep the stored data even if power is removed. It is used in the AT/MT/UMT balances to store user settings, calibration data and many more items.

ESC — Escape. A control character of the ASCII character set (1B hexadecimal). Has many uses, e.g. exiting from a mode or operation, starting a special character sequence and more.

Handshake — A method designed to synchronize data flow between devices. May be realized using special characters (see XON, XOFF) or dedicated hardware lines (see CTS, DTR). Handshaking may also occur when your boss has verified that your new weighing system is up and running.

Hexadecimal — A number system based on 16 numbers instead of the common 10. This allows the easy expression of 4-bit entities. The numbers used are 0…9, then A for 10, B for 11 and so on up to F for 15.

LAN — Local Area Network. A system of several devices (usually more than two) connected via a common cable, capable of talking to each other using a defined set of protocols. Normally not associated with RS-232 setups.

Leading zeros — Zero digits shown to the left of the integer part of a number, where they are not really necessary. Example: 000123 instead of 123. Sometimes used in critical balance applications where it is important to distinguish between digits turned off because they are leading zeros and digits not shown because of a hardware malfunction.

LF — Line Feed. A control character of the ASCII character set (0A hexadecimal). Causes a printing device to move its print head one line down. It may also mark the end of a message or a command.

mark — Indicates the presence of a data signal on a communication line (current flowing in current loop or voltage negative in RS-232). The idle state of a connection is mark.

Menu — With the AT/MT/UMT balances, pressing the key labelled "Menu" leads the user to a number of menu items allowing him to change the behavior of the balance with respect to the environment. Also found in the menu are the calibration and the reference weight defining part of the built-in applications piece and percent weighing.

mnemonic — Abbreviations designed to help your memory. If you can remember this word you probably don't need mnemonics.

Modem — A device which converts bit-serial communication signals to signals compatible with the phone system, thus extending a serial data link almost indefinitely. This is the prime example of a DCE device.

Parity — The number of all bits set to 1 in a sequence of bits. Depending on the mode chosen, a "1" is added to the sequence if the sum is even or odd, a "0" otherwise. Using the same algorithm, the receiving device may detect transmission errors that change an odd number of bits in the sequence.

Protocol — A specification that describes the rules and procedures that products should follow to perform activities on a data link, such as transmitting data. Protocols allow products from different vendors to communicate.

RS-232 — A standard introduced in 1962 by the EIA (Electronic Industries Association) describing the "Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange". It covers the mechanical as well as the electrical characteristics of the interface. The latest revision, EIA-232-D (1986), is closely related to the CCITT V.24 specification.

Serial communication — A method for sending data from one place to another where the information is split up into single electrical bits, which are sent out one after another. Obviously, this takes more time than sending chunks of bits - each chunk representing a character, for example - simultaneously. The main advantage of serial communication is that it requires only a single wire in each direction.

space — Indicates the absence of a data signal on a communication line (no current flowing in current loop or voltage positive in RS-232).

Space (Blank) — The first printable character of the ASCII character set. Although it's called printable, it doesn't put any ink on the paper (or electrons on the video screen). Rather, it advances the print head by the space usually occupied by a character.

String — A sequence of characters. In computer parlance, a word is a certain number of bits, so a word is not called a word but a string. (Who said computers make life easier?)

SYN — Synchronous Idle. A control character of the ASCII character set having the value 16 (hexadecimal). It is used in the METTLER TOLEDO CL handshake protocol to tell other devices that CL handshake is available.

Terminal — Any device that can send and/or receive data via a communication line. Normally a box with a video screen and a keyboard, but also a personal computer running a terminal emulation program.

XOFF — Also DC3 (Device Control 3). A control character of the ASCII character set having the value 13 (hexadecimal). It is used in the METTLER TOLEDO handshake mode "soft" to inhibit the other device from sending data.

XON — Also DC1 (Device Control 1). A control character of the ASCII character set having the value 11 (hexadecimal). It is used in the METTLER TOLEDO handshake mode "soft" to authorize the other device to resume sending data after it has been stopped by a XOFF character.

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Mettler-Toledo AG, Laboratory & Weighing Technologies, CH-8606 Greifensee, Switzerland
Phone +41-1-944 22 11, Fax +41-1-944 30 60, Internet: http://www.mt.com