# DTM-133
# DIGITAL TESLAMETER
# with serial communications

USER'S MANUAL

For units supplied with software DTM133 V1.0

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Thank you for purchasing and using a Group3 digital teslameter. We hope you will join the many hundreds of users worldwide who are enthusiastic about our products.

Group3 has been designing and building magnetic field measuring equipment since 1983. We are constantly upgrading our products and support documentation. We welcome input from our customers, so if there are aspects of the instrument which you particularly like, or which you would like to see improved, please contact your Group3 supplier (see back page for a complete list) or Group3 directly with your suggestions to **info@group3technology.com**.

The Group3 website, **www.group3technology.com** contains details of all our products. This site is regularly updated, so check it from time to time to learn about recent developments.

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# CONTENTS

## LIST OF FIGURES



## LIST OF TABLES

# 1 GENERAL DESCRIPTION

The DTM-133 Digital Teslameter offers accurate measurement of magnetic flux density, with direct digital readout in tesla or gauss. The instruments are light and compact, and the probes are easy to use. The DTM-133 has been engineered to withstand the severe electrical interference produced by high voltage discharge.

Options provide serial communications (RS-232C and fiber optic) or IEEE-488 interfacing for system applications.

**FEATURES**

Measures magnetic fields over four ranges up to 3 tesla with polarity indication; resolution up to 1 part in 6,000.

Range selection is manual or by selectable auto-ranging.

Used with special miniature Hall probe - easy to attach to magnet pole or other hardware. Probe holders are available as optional accessories.

Accuracy and temperature specifications include total system performance, probe and instrument. This is the only meaningful indication of measurement accuracy.

Probe is calibrated, with field characteristics stored in memory chip contained in cable plug.

Accuracy is better than ±0.03% for the complete system, probe and instrument.

Temperature coefficient is better than 100ppm/°C for the overall system.

Accuracy is verified against nuclear magnetic resonance (NMR) standard.

Probe calibration is verified at many field points on every probe, and a printed calibration table is supplied with every probe.

Front panel keys select the desired field range, and invoke the peak hold function to read the peak field value. The keys are also used to reset the peak hold, to zero the system, and to switch on auto-ranging. Peak hold is implemented digitally, has zero sag.

Digital filtering of the displayed field reading suppresses short-term fluctuations. The filtering characteristic is non-linear; small field variations within a narrow window centered on the currently displayed value are filtered; large field changes are displayed immediately. Filter window and time-constant may be changed by remote command when serial or IEEE-488 option is fitted. Filtering is switched internally.

With digital communications, the DTM-133 can deliver 30 readings per second.

Two digital communication options: serial (RS-232C and fiber optic) and IEEE-488 General Purpose Interface Bus.

With the serial option, a single teslameter may be connected to standard RS-232C equipment, or up to 31 units may be interconnected on the Group3 Communication Loop (G3CL) and driven from computer or terminal.

Fiber optic ports duplicate functions of RS-232C signals, for electrical noise immunity and voltage isolation. Fiber optic links may be up to 60 meters in length, using Hewlett-Packard HFBR-3500 series improved fiber optic cables.

The IEEE-488 option fully supports all relevant GPIB functions and commands, including full talker-listener capability, serial and parallel polling, service request, and talker-only.

ASCII control commands are accepted to modify the output data format, to change the rate of data transmission or to request transmission of a single field reading. Other commands select the field range, select and peak hold functions, turn on and off digital filtering and modify the filter characteristics. System status may be determined remotely.

The system can be operated in triggered mode where field measurements by one or more teslameters are triggered in synchronism with each other by external command.

Internal switches select serial data format and baud rate, device address, string terminators, filtering, field units in gauss or tesla, data format, service request action, EOI action, and perform system reset.

An analog output gives instantaneous field value (0 to 9 kHz), not corrected for probe non-linearity.

Model variations are available without display and keys for true 'black box' magnetic-field-to-computer interfacing.

A panel mount model with display is available.

# 2 SPECIFICATIONS OF DTM-133 SYSTEM

**Specifications of DTM-133 with LPT-130 or MPT-132 Hall Probe.**

| | |
|---|---|
| Measurements | magnetic field density in tesla or gauss |
| Field ranges | 0.3 0.6 1.2 3.0 tesla full-scale,<br>3 6 12 30 kilogauss full-scale,<br>with polarity indication and selectable autoranging<br>maximum calibrated field ±2.2 tesla, ±22 kilogauss |
| Resolution | 1 in 12,000 of bipolar span with digital filtering on |

| **range** | **resolution** | |
|---|---|---|
| | **gauss** | **tesla** |
| 0.3 tesla | 0.5 | 0.00005 |
| 0.6 tesla | 1 | 0.0001 |
| 1.2 tesla | 2 | 0.0002 |
| 3.0 tesla | 5 | 0.0005 |

| | |
|---|---|
| Accuracy | DTM-133 with LPT-130 or MPT-132 probe:<br>±(0.03% of reading + 0.03% of full-scale) max. at 25°C |
| Temperature stability | DTM-133 with LPT-130 probe:<br>calibration: -100 ppm of reading/°C max.<br>add -3ppm/°C for each meter of probe cable<br>zero drift: ±(8 microtesla + 0.0015% of full-scale)/°C max. |
| Temperature stability | DTM-133 with MPT-132 probe:<br>calibration: -100 ppm of reading/°C typical<br>-140 ppm of reading/°C max.<br>add -3ppm/°C for each meter of probe cable<br>zero drift: ±(15 microtesla + 0.0010% of full-scale)/°C typical<br>±(40 microtesla + 0.0015% of full-scale)/°C max. |
| Time stability | ±0.1% max. over 1 year |
| Measurement rate | 30 fully corrected measurements per second |
| Display rate | 10 display updates per second |
| Response time | full-scale change of field reading settles to within resolution in less than 0.2 second (filtering off - see below) |
| Peak hold mode | displays maximum field since mode entered or reset -<br>peak hold is implemented digitally with zero sag or decay |

| | |
|---|---|
| Display | 7-character 7-segment alphanumeric display |
| Indicators | 8 back-lit legends for:<br>0.3, 0.6, 1.2, or 3.0 tesla range selected,<br>peak hold mode on, digital filtering on, tesla/gauss units |
| Display modes | field, peak hold field |
| Digital filtering | field value filtering smoothes out small fluctuations in the reading; large, rapid field changes are not filtered; internally switch selected. |
| Keys | 2 keys select range, access peak hold display, load defaults<br>zero field display, reset peak hold, select auto-ranging, |
| Analog output | instantaneous field analog:<br>full-scale output: ±3V nominal<br>source impedance: 1000Ω<br>accuracy: ±10%<br>bandwidth: 9kHz at -3dB, rolloff 3-pole 60dB/decade |
| On-board switches | digital filtering on/off, units (tesla or gauss) |
| Memory backup | user-entered data stored indefinitely in non-volatile memory |

Power source

| | | | **DTM-133** | **DTM-133-_S** | **DTM-133-_G** | |
|---|---|---|---|---|---|---|
| ac: | min | 8V | 0.65 | 0.75 | 1.1 | A rms |
| | max | 15V | 0.3 | 0.35 | 0.5 | A rms |
| dc: | min | 10V | 0.45 | 0.5 | 0.75 | A dc |
| | max | 19V | 0.17 | 0.2 | 0.3 | A dc |

(because a switchmode regulator is used, input current falls as the voltage rises)
ac line input plugpack supplied.
Power fuse on processor board: 1 amp anti-surge 5 x 20mm
To obtain maximum spark protection, use PS12D7 power supply and ferrite kit 11000036. See section 3.8.
L option: 115/208/230 V ac power input.

| | |
|---|---|
| Enclosure | aluminum, 217 x 125 x 50 mm, textured finish,<br>light tan color, tilt stand fitted to bench models |
| Ambient field | Maximum operating field for electronics package:<br>10 millitesla with single-range probe,<br>0.5 millitesla with multi-range probe. |
| Temperature range | 0 to 50°C operating, absolute maximum temperature of probe 60°C |
| Instrument weight | 1.2 kg, shipping weight: 2.5 kg |

| | |
|---|---|
| Probes | standard sensitivity transverse types: LPT-130, MPT-132<br>high sensitivity transverse types: LPT-230, MPT-230 |

**Additional specifications with communication options**

| | |
|---|---|
| Digital interfacing | serial option: RS-232C and fiber optic;<br>parallel option: IEEE-488 General Purpose Interface Bus |
| System orientation | Group3 Communication Loop (G3CL) using serial ports, simple loop for 31 devices, no multiplexer required;<br>GPIB with IEEE-488 option. |
| Digital data format | ASCII input commands and output responses |
| Commands | requests for field values; setting and inspection of display and control modes; field measurement triggering; entry of numerical values; setting units, output data format, and filter characteristics; test commands. |
| Output responses | field value in tesla or gauss followed by optional T or G and carriage return/line feed; numerical and system status; data requested by commands; messages. |
| Serial bit rate | 16 standard rates, switch selected, 50, 110, 134.5, 150, 200, 300, 600, 900, 1050, 1200, 1800, 2000, 2400, 4800, 9600, 19200 baud. |
| Fiber optic cable | Hewlett-Packard HFBR-3500, 60 meters max. |
| IEEE-488 functions | SH1 source handshake capability<br>AH1 acceptor handshake capability<br>T5 talker (basic talker, serial poll, talk-only mode, unaddressed to talk if addressed to listen)<br>TE0 no address extension talker capability<br>L4 listener (basic listener, unaddressed to listen if addressed to talk)<br>LE0 no address extension listener capability<br>SR1 service request capability<br>RL0 no remote local capability<br>PP1 parallel poll capability (configured by controller)<br>DC1 device clear capability<br>DT1 device clear capability<br>C0 no controller capability |
| GPIB connector | standard Amphenol 57-20240 with metric standoffs |

## ORDER CODES

Basic teslameters,
capable of four measurement ranges 0.3, 0.6, 1.2, 3.0 tesla full scale,
0.03, 0.06, 0.12, 0.3 tesla full scale for high sensitivity probes
support all LPT and MPT series probes, plugpack supplied except for option -L.

**DTM-133** (recommended probes are LPT-130, LPT-230, MPT-132, MPT-230)

### Options

Bench style instrument with display: add suffix **-D** |
Panel-mount version: add suffix **-P** | one of these options
Without display, plugpack powered: add suffix **-N** | must be specified
Without display, line voltage power: add suffix **-L** |
Serial data input/output, RS-232C & fiber optic: add suffix **S** | must select
IEEE-488 GPIB capability: add suffix **G** | one option

Example: DTM-133-DS

### Probes

Four ranges, standard 2 meter cable

| | | | |
|---|---|---|---|
| **LPT-130** | standard sensitivity | **LPT-230** | high sensitivity |
| **MPT-132** | probes | **MPT-230** | probes |

Single range probes: add range suffix **-03, -06, -12, -30**.
Special probe cable lengths: add length suffix **-Xm** or **-Xs**,
for **X** substitute cable length in meters, 30 max.
**m** denotes unshielded cable, **s** denotes shielded cable.
Example: LPT-130-2m

### Accessories

fiber optic cable fitted with connectors, 60 meter length maximum
probe holders
fiber optic repeater, bidirectional, model **FOR-2PP**
fiber optic to RS-232C adaptor, model **FTR**
serial/GPIB adaptor, model **COM-488**
digital display for remote control & readout of field values, model **DPM**
rack panels, 3.5 inches high (2U), for rack mounting 1, 2, or 3 DTMs or DPMs
ferrite kit 11000036 for spark protection
power supply PS12D7 for spark protection

# 3 SETTING UP

## 3.1 INTRODUCTION

This chapter provides instructions for the basic operation of all members of the Group3 DTM-133 family of digital teslameters and their companion LPT-130, LPT-230, MPT-132, and MPT-230 Hall probes. If your teslameter is a DTM-133-_S (serial communications option) or DTM-133-_G (IEEE-488 option), a later chapter will describe the use of the relevant digital communications features. For a summary of all current members of the product family, see page 2-4.

These instructions are written for a teslameter with front panel display and keys. Users of teslameters without display and keys should ignore sections of this manual referring to these features. All other aspects of operation are identical.

Before using your teslameter for the first time, please read through sections 3.2, 3.3, 4.1, 4.2, and 4.3 of this manual. This will give a quick introduction to basic operation of the instrument.

## 3.2 INSTALLING THE PANEL MOUNT OPTION

Model DTM-133-P_ is supplied fitted with a special front bezel which has threaded studs to allow panel mounting. A panel mount support bracket (part 17000058) is included to help support the teslameter. Group3 can supply 19-inch wide, 2U (3.5") high rack panels to hold one, two, or three teslameters (parts 17000025, 17000026, and 17000027, respectively). Alternatively, the user can mount the teslameter in any panel of thickness up to 3/16" (4.76mm). Dimensions for the cutout and drilled holes are shown in Fig. 1.

Bezel Outline

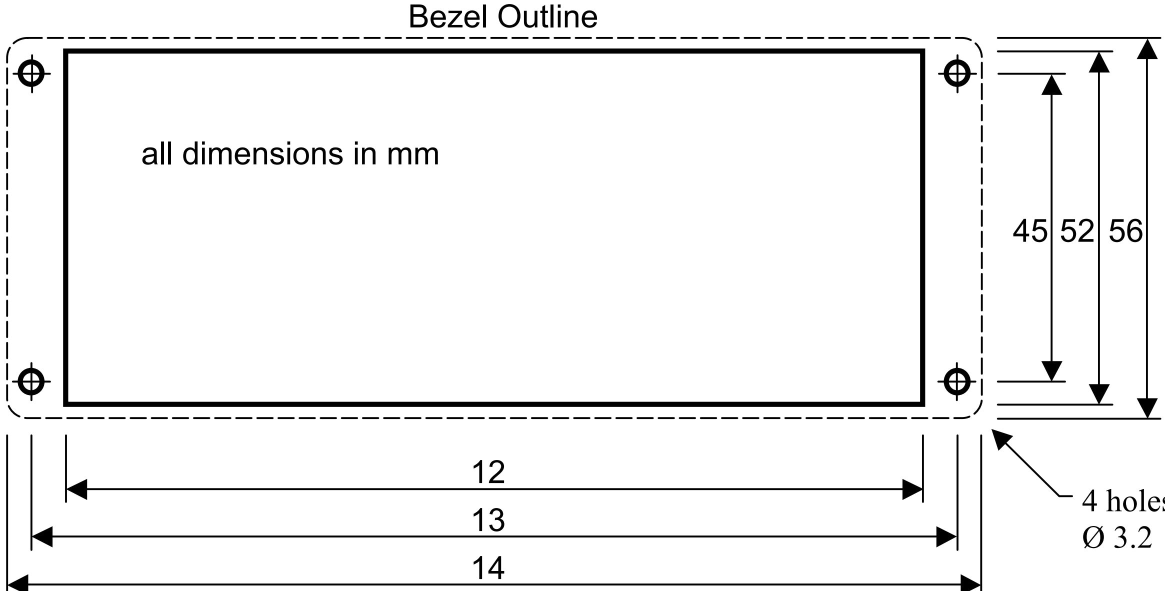



Fig. 1. Panel Cutout Dimensions

To fit the teslameter to the panel, first remove the nuts and washers from the bezel studs. Push the teslameter through the panel from the front, making sure all the studs fit through the small holes. While holding the teslameter in place, place the support bracket under the teslameter from the rear, pushing it up to the panel with the studs through the holes in the bracket. Put the flat washers on the studs, then the lock-washers, and finally screw on the nuts. Make sure the teslameter is resting on the bracket, then tighten the nuts, preferably using a long-stemmed nut driver.

## 3.3 CONNECTING THE HALL PROBE

**Before handling the probe, please read the following:**

Group3 Hall probes are built to be as robust as possible for a small, precision device. However, it is most important that certain precautions be taken when handling and installing probes so that they are not damaged or destroyed, and to preserve their accurate calibration.

Mount the probe head so there is no pressure which will tend to bend or depress its ceramic rear surface. If the probe head is clamped, make sure the surface in contact with the ceramic is flat and covers the whole of the ceramic surface. Do not apply more force than is required to hold the probe in place. Any strain on the ceramic will alter the probe's calibration, and excessive force will destroy the Hall element inside.

When the probe head is mounted, the cable should be clamped firmly nearby so it cannot be torn away from the probe head if accidentally pulled. The flexible section adjacent to the probe head can be carefully folded to allow the cable to come away in any direction, but avoid repeated flexing of this section.

Keep the cable out of the way of foot traffic. Do not pinch the cable, or drop sharp or heavy objects on it. A severed cable cannot be re-joined without altering the probe's performance, and requires factory repair and re-calibration.

The DTM-133 must be used with a Group3 Hall probe. Probe models LPT-130, LPT-230, MPT-132, or MPT-230 are the most suitable for use with the DTM-133. The probe may be one supplied with your teslameter, or it may have been obtained separately. In any case, calibration is preserved when probes are exchanged between instruments.

The standard probe cable length is 2 meters. Probes with non-standard cable lengths up to 30 meters may be ordered from your Group3 supplier. The cable used for Group3 probes is shielded to reduce pickup of induced noise from external sources. Such noise may reduce the accuracy of the instrument, cause malfunctioning, or in extreme circumstances even result in damage to the internal circuitry. See section 3.8.

With the DTM unpowered, plug the probe connector into the instrument. The pin side of the plug is inserted into the large opening in the rear of the DTM, with the plug's label uppermost when the instrument is standing right way up. It is easy to find the correct mating position for the plug, and then push it fully home, but if any difficulty is experienced at first, remove the DTM's top cover by loosening the central screw and lifting the cover off. Now it is possible to see when the plug is centrally located and its overhang slides over the card-edge receptacle, ensuring that its pins engage correctly. Tighten the connector retaining screws finger tight. Do not leave these screws loose as they form part of the shielding system around the teslameter. The teslameter should always be used with both covers attached.

Always disconnect power from the teslameter before connecting or disconnecting the probe. If the probe connector is inserted or withdrawn with power on, data stored in memory may be corrupted, leading to erroneous field readings. If this happens, the instrument should be powered down, and then repowered while both keys are held down. This will restore default operating conditions.

When no probe is connected to the DTM, the display reads **noProbE**.

## 3.4 CONNECTING THE POWER SOURCE

All teslameter versions, except for the L option, are supplied with a plug-pack. Connect the plug-pack to a convenient ac power source, first checking the voltage marked on the plug-pack, and insert the cable connector into the power receptacle on the DTM rear panel.

Instead of the plug-pack, the unit can be powered by any convenient source of ac or dc (either polarity) which meets the specification on page 2-2. The cable connector required for power connection to the DTM is a standard coaxial plugpack connector with 2.1mm centre hole and is generally available from electronics suppliers.

For extra immunity to damage and operational disturbance caused by serious high voltage sparking near the teslameter, the use of the Group3 model PS12D7 off-line switch-mode power supply and the Group3 ferrite kit part no. 11000036 is recommended. These accessories will greatly reduce the amount of electrical transient energy entering the teslameter. The ferrite kit includes a suppressor which fits to the probe cable near the point of entry to the teslameter to reduce the effects of transients picked up on the probe cable. For a full discussion of techniques to promote trouble free operation in electrically noisy environments, see section 3.8 of this manual.

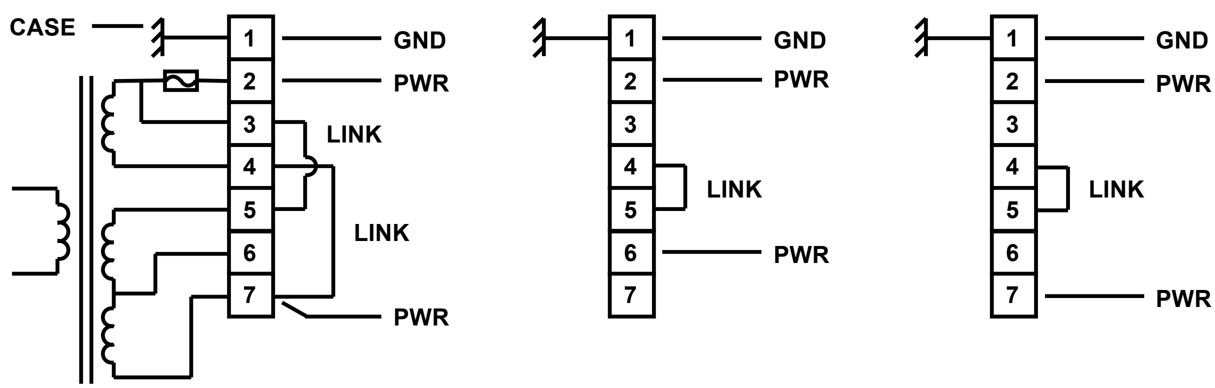
**Powering the L option teslameter -**

The L option will accept power input from the ac power line.

Access to the power input terminals of the L option is obtained by taking off the orange cover; remove the 3 fixing screws to release the cover.

Use 3-conductor power cord. For safety from electrical shock it is essential to provide a reliable ground connection to the DTM case. Make sure the ground wire is connected as shown in Fig. 2. Strip about 60 mm (2.5 in) of outer jacket from the cord, and strip 5 mm (3/16 inch) of insulation from the 3 wires. Pass the cord through the grommetted hole in the cover. Loosen the screw securing the cable clamp and pass the cord through the clamp. Tighten the clamp on the outer jacket. Terminate the wires and fit links according to the supply voltage as set out in Fig. 2 below. Replace the orange cover, making sure that wires are not pinched in the process. For safety reasons, do not operate the unit with the cover off.

Note that input power protection is provided by a thermal fuse wound into the power transformer. This fuse will open in the event of transformer overheating rather than on excess current. The power input must be connected as shown to include the thermal fuse in the circuit correctly. If a fault causes transformer overheating and subsequently the fuse opens, the transformer must be replaced with the genuine Group3 part.




| | | | | | |
|---|---|---|---|---|---|
| 115V | link 4 and 7<br>link 3 and 5<br>power 2 and 7<br>ground 1 | 208V | link 4 and 5<br>power 2 and 6<br>ground 1 | 230V | link 4 and 5<br>power 2 and 7<br>ground 1 |

Fig. 2. Power Input Connections of the -L option

If desired, the wiring may be protected by installing an external fuse in the ac power feed. Suggested fuse ratings are 200 mA for 115 volts, or 100 mA for 208 and 230 volt operation.

When the unit is first powered up, the display shows **Group 3** for 2 seconds before field measurements appear. If the Hall probe is not plugged in, the field reading display is replaced with **noProbE**.

## 3.5 INTERNAL DIP SWITCHES

The main circuit board, under the top cover of the DTM-133, has a set of two DIP switches. The switch functions are listed in Table 1 below. For access to the switches, loosen the central screw and lift the cover off.

| **switch** | **function** | **OFF** | **ON** |
|---|---|---|---|
| 1 | digital filtering | disabled | enabled |
| 2 | field units | tesla | gauss |

Table 1. Internal DIP Switch Functions

The functions of switches 1 and 2 are described in full in section 4. The switches are scanned once a second, so the effects of changed settings can be observed immediately.

## 3.6 ANALOG OUTPUT

An analog output signal is available at the rear of the teslameter. This output is the Hall probe signal amplified to 3 volts full-scale, and gives an indication of the instantaneous field value from dc to 9kHz (-3dB), with a roll-off of 60dB/decade above 9 kHz. Field direction is indicated by the output voltage polarity. There is a small zero offset (10 millivolts maximum), arising from the probe zero-field output and amplifier offsets. The output impedance is 1000 ohm with a 1nF capacitor to common for noise filtering.

The cable connector required is a Molex receptacle type M5051-2 fitted with M2759 terminals. Pin assignments are given below.

The analog output is not corrected for linearity errors.

| **pin** | **signal** |
|---|---|
| 1 | ground |
| 2 | dc output |

Table 2. Analog Output Connector Pin Assignments

## 3.7 GROUNDING

All parts of the teslameter's metal case are connected together to form an integral electric shield around the circuitry inside. When the probe connector is plugged into the teslameter and the retaining screws are tightened, the probe connector case and the teslameter case are connected together and form an integral shield around the circuitry inside. The cable shield is added to the case shield and extends protection from electrical interference almost up to the probe head.

Because there is an internal connection between teslameter circuit common and the probe connector case, when the probe connector is engaged and the retaining screws tightened the teslameter circuit common will be connected to the case. Do **not** make an additional connection between circuit common and the case at any point, including at the RS-232C connector or at the G3CL connectors on serial teslameters, or at the GPIB connector on teslameters with the IEEE-488 option. Such additional connection will form a ground loop and may introduce errors in the measured field value.

The shielding provided with the above arrangement should be sufficient protection against EMI in most cases, especially when the probe cable is shielded. Sometimes it may be found helpful to ground the teslameter case to a good electrical ground point. Connection can be made to the case by inserting an appropriate lug or terminal under the head of one of the rear panel fixing screws.

Further protection from transient interference can be obtained by using model PS12D7 power supply in place of the usual plugpack supplied with the teslameter, and by installing the Group3 ferrite kit part no. 11000036. See section 3.8 of this manual.

For electrical safety, the case of the L version must be grounded through the third wire of the power input cord.

## 3.8 INSTALLATION TECHNIQUES FOR ELECTRICALLY NOISY ENVIRONMENTS

The DTM-133 is a precision electronic measuring device. Because of the nature of the measurements it is asked to do, it is frequently exposed to conditions that are considerably worse than are normally encountered by precision instruments. Therefore, the teslameter has been carefully engineered to be as immune as possible to sparks and other forms of interference through the use of several kinds of power input filtering and a special high-isolation switchmode power module built into its circuitry. The design has been verified by extensive testing, using high energy sparking in close proximity to both the teslameter instrument case and the probe. Nevertheless, due care should always be taken when installing the teslameter system.

The teslameter and its probe must be protected from any chance of receiving a direct hit by a high voltage discharge. The probe should have shielded cable if the meter is to be used in an electrically noisy environment. The cable shield is an RFI screen, not a high current path, so if there is any possibility of an arcing discharge hitting the probe area, then the probe head and part or all of the cable must be enclosed in a metal tube (non-magnetic near the probe head), or shielded in some other way.

The probe cable should be routed away from any power, high current or high voltage wiring. It should be shielded from any capacitively coupled noise effects. If the cable runs close to any section of the apparatus that could be subjected to a very rapid change of potential when a spark discharge occurs, then the probe cable may need additional shielding to prevent capacitive coupling of the noise.

The retaining jack screws designed to hold the probe connector onto the teslameter must be screwed up finger tight, as they form part of the electrical connection of the shield system. The woven braid of the probe cable is terminated to the probe connector case. The retaining screws then connect the probe connector case to the teslameter case.

The teslameter itself should be sited in a sheltered location, where it will not be exposed to spark discharges or radiated or capacitively coupled noise. The teslameter case is made of metal for shielding reasons. However, of necessity it is less than perfect, as apertures have to be left in the case for the display and various connectors etc. The unit is a precision measuring device, and should be treated with care, not subjected to adverse environmental conditions.

The plugpacks supplied with each teslameter should be plugged in to a clean mains power supply. Noise on the mains will work its way through the transformers and disturb the teslameter. Simple mains filters are readily available if there is only one mains supply for the whole machine. Route the low voltage lead away from high current or high voltage wiring. Ideally cut the low voltage lead to the minimum length required for the installation, and re-connect the plug to it.

If you are using the serial communication features of the teslameter, take advantage of the noise immunity of the fiber optic facilities available, rather than using the wired RS-232C connection. Fiber optics were included in the DTM-133 for the express purpose of providing noise free communication in hostile applications. The fiber optic cables used with the DTM-133 are economical and convenient to use - simpler in fact than wiring. To interface the fiber optic cables to your computer or other data acquisition system, use a Group3 model FTR fiber optic adaptor.

### Grounding The Teslameter Case

The probe shield is terminated to the probe connector case, which is then connected by the retaining screws to the teslameter chassis. At this point the entire shield system is floating. In some installations it is beneficial to have the system floating, but most frequently it is sensible to have the shields grounded.

If the teslameter is panel mounted, then the case is almost certainly electrically connected to the control rack, and grounded that way. However if the teslameter is a bench unit, then the rubber and plastic feet on it will isolate the case. If the case does need to be grounded then loosen one of the screws on the back panel and put a grounding lug under the head of the screw. It is most convenient to use a 1/4inch (6.35mm) quick connect tab. The grounding wire can then be easily disconnected if the teslameter has to be moved. Use a heavy gauge, short wire to ground the unit to a substantial grounding point nearby. If the teslameter is sitting on metalwork, then it should really be grounded to that metalwork so it is at the same potential.

**Further Preventative Measures**

If problems are still encountered, despite following the precautions detailed above, then there are some further things to try.

Tests have shown that, in an electrically noisy environment, the main path of noise entry to the teslameter is through the low voltage power supply input. The trouble could come from mains borne transients working their way through the plugpack transformer, or from interference picked up on the low voltage lead itself. The quickest and simplest fix for this problem is to wind the power lead several times through a ferrite core. Use a thick walled ferrite tube of substantial size - a simple small torroid is not nearly as effective. A suggested ferrite is the TDK part number HF70RH26x29x13. This is a tubular ferrite, 29 mm long, 26mm outside diameter, and 13mm inside diameter. Winding the power lead four times through this core, really close to the teslameter, significantly reduces noise upsets.

If the analog outputs are wired up, then shielded twisted pair should be used for all wiring, routed away from any high current or high voltage cabling. In a really noisy environment it can be beneficial to put this analog cabling through a ferrite tube for a few turns to suppress induced noise.

The probe cable itself can be passed through a ferrite core. The internal diameter will need to be sufficient to pass the probe head through. An MPT (miniature) probe head is nearly the same size as shielded cable (6.5mm diameter), but an LPT probe head needs an internal ferrite diameter of 14mm or more. Alternatively a split core ferrite variety can be used, such as TDK part HF70RU16x28x9. The core should be placed where the probe cable enters the probe connector, and optionally a second ferrite can be placed where the cable shield layer ends, approximately 300mm back from the probe head.

Group3 can supply an alternative power supply to be used instead of the usual plugpack. The alternative power supply is model PS12D7. It is a universal voltage (85 - 270V 50/60Hz) input, 12Vdc 7W output unit with excellent input-output isolation for noise and transients. The PS12D7 is DIN rail mounted. In conjunction with the PS12D7 we recommend the use of our ferrite kit, part no. 11000036 which implements the ferrite filtering measures described above. The kit consists of a 1.2 meter length of twin cord with a ferrite tube fitted. This cord is intended to connect between the PS12D7 and the teslameter. The kit also contains a split ferrite tube and housing for fitting to the probe cable.

# 4 OPERATING INSTRUCTIONS

## 4.1 ZEROING

The DTM-133 digital teslameter has a very stable zero field reading. Nevertheless, it is good practice to zero the instrument on all ranges immediately prior to making critical field measurements. The zeroing process takes out residual zero errors in the Hall probe and the instrument's preamplifier "front-end".

Zeroing is mandatory if a different probe is to be used since the instrument was last zeroed. You should also zero the instrument when using it for the first time.

Before zeroing the system, connect the probe and apply power as described in sections 3.3 and 3.4. Allow 30 minutes for the instrument and probe to stabilise.

For absolute zeroing, place the probe in a zero-field region, either in a zero field chamber or inside a suitable magnetic shield, so that the probe is shielded from the earth's magnetic field and other stray fields.

If desired, a relative zero setting may be done; the instrument is zeroed after the probe is placed in its measurement position. Thus any ambient field is automatically subtracted from subsequent measurements. The probe should not be moved once zeroing is complete. About 5% of full-scale may be zeroed out without reducing full-scale span below specification.

The zero field reading is affected slightly by the presence of metal against the probe's back surface. If the probe is to be used clamped to a metal surface, or in a probe holder, it should be zeroed in the same situation. Allow the probe to stabilise thermally for a minute or two before zeroing.

Ambient temperature also has a slight effect on the probe zero. The probe should be zeroed at a temperature as close as possible to the temperature during service.

If the teslameter is set for autoranging (see section 4.4.1), zeroing is implemented simply by momentarily pressing both keys together. The display will flash **ZEro** while the teslameter cycles through all four ranges in turn, waiting for each range to stabilise before zeroing it. The whole process takes about 10 seconds. The range indicators show which range is selected. If a single-range probe is connected, only the one range will be selected and zeroed.

If autoranging is disabled, each range must be manually selected and zeroed. A range is selected by pressing the RANGE key. The four range indicators show the selected range. The RANGE key selects the ranges in turn in the sequence 0.3, 0.6, 1.2, and 3.0 tesla. If a single-range probe is in use, the RANGE key will have no effect.

The zeroing process is implemented by pressing and releasing both keys together. The display will read **ZEro** for a moment, indicating that zeroing has occurred.

The zeroing process should now be repeated for all the remaining ranges. Press the RANGE key to select another range, and zero this range by pressing both keys together, as above. After changing ranges, wait 1 or 2 seconds before zeroing. Continue until all the ranges have been zeroed.

Once the zeroing process has been completed, the internal processor will apply the appropriate correction to whichever range is selected.

Zero offsets calculated during the zeroing process are stored in non-volatile memory, and are retained while the power is off. Therefore the teslameter does not need re-zeroing simply because it has been powered down

## 4.2 INSTALLING THE PROBE

Group3 Hall probes are built to be as robust as possible for a small, precision device. However, it is most important that certain precautions be taken when handling and installing probes so that they are not damaged or destroyed, and to preserve their accurate calibration.

Mount the probe head so there is no pressure which will tend to bend or depress its ceramic rear surface. If the probe head is clamped, make sure the surface in contact with the ceramic is flat and covers the whole of the ceramic surface. Do not apply more force than is required to hold the probe in place. Any strain on the ceramic will alter the probe's calibration, and excessive force will destroy the Hall element inside.

When the probe head is mounted, the cable should be clamped firmly nearby so it cannot be torn away from the probe head if accidentally pulled. The flexible section adjacent to the probe head can be carefully folded to allow the cable to come away in any direction, but avoid repeated flexing of this section.

Keep the cable out of the way of foot traffic. Do not pinch the cable, or drop sharp or heavy objects on it. A severed cable cannot be re-joined without altering the probe's performance, and requires factory repair and re-calibration.

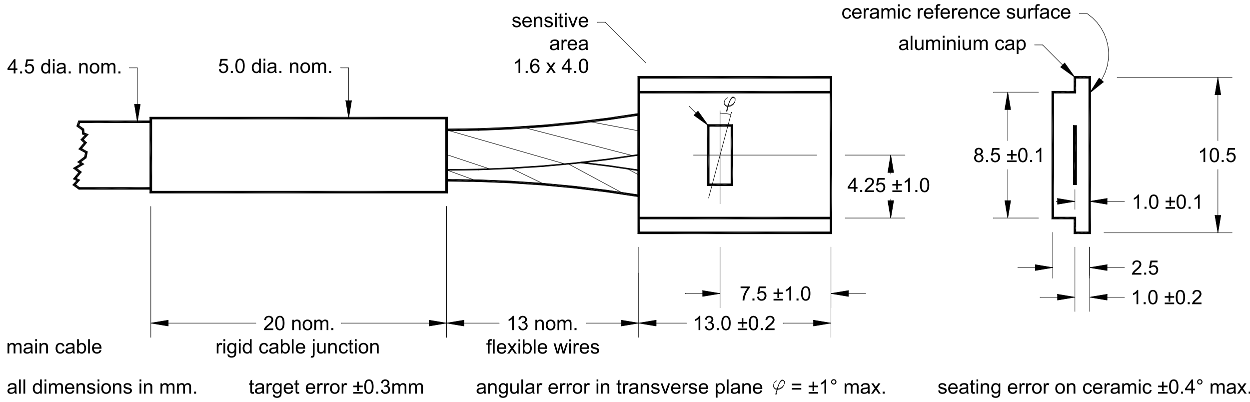
The LPT-130 and LPT-230 probes can be fitted to a Group3 probe holder part number 17000049. MPT-132 and MPT-230 probes fit probe holder part number 17000081. The holder protects the probe and provides additional cable strain relief.

The probe will measure the component of the field which is normal to the flat surface of the probe case. The point of maximum sensitivity is marked by a target printed on the top of the probe case. A positive indication will be obtained when the magnetic field vector enters this side of the probe. The target represents the tail of the vector arrow.

Magnetic field convention is that field lines are directed from an N pole to an S pole. Fig. 3 gives the dimensions of the two styles of probe, and shows the position of the most sensitive point.

If the exact direction of the magnetic field is unknown, its magnitude can be measured by putting the DTM in the peak hold mode, and slowly rotating the probe. As the probe turns and the measured field rises and falls, its maximum value is held on the display. See section 4.4.2b.

**LPT-130 and LPT-230**




**MPT-132 and MPT-230**

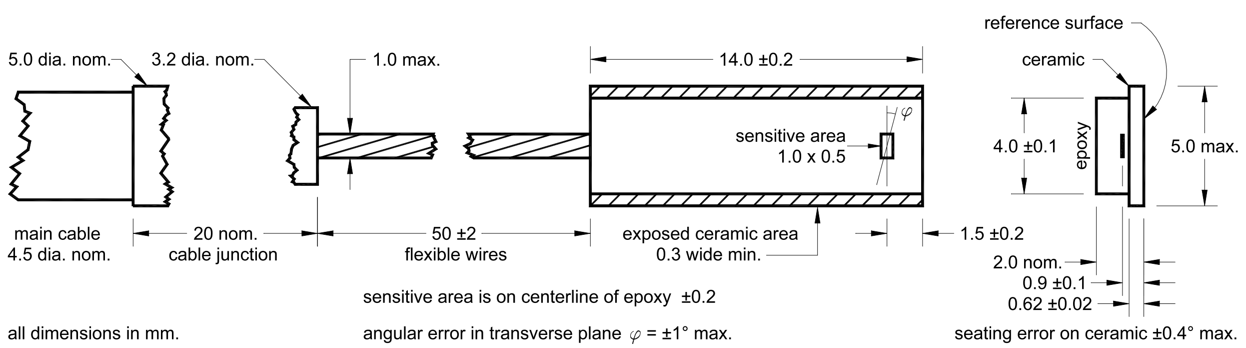



Fig. 3. Probe Dimensions

## 4.3 READING THE FIELD VALUE

The field value is read directly off the display. A negative sign indicates that the field direction is opposite to that described in section 4.2.

The DTM-133 has autoranging capability, and powers up in this mode. Autoranging can be enabled or disabled using the front panel MODE key. See section 4.4 below.

If autoranging is enabled, the teslameter will change to the next range up when the displayed reading reaches 105% of full scale on the current range. The next range down will be selected when the reading drops to 95% of full scale on the next lower range.

If autoranging is disabled, the operator must select the most appropriate range. For maximum resolution, select the lowest range which will display the field value. See sections 4.1 and 4.4 for range selection instructions. If the field exceeds about 106% of full-scale, the message **o'rAnGE** will be displayed. Change to a higher range by pressing the RANGE key until the message clears.

The field may be displayed in tesla or gauss, with the appropriate indicator showing the units in use. To change the units, remove the top cover and operate switch 2. See section 3.5.

## 4.4 DISPLAY MODES, USING THE FRONT PANEL KEYS

### 4.4.1 The Keys

Two front panel keys are used to control the teslameter.

The MODE key, used on its own, switches the instrument between its operating modes, field and peak hold field, and auto-ranging. Pressing the MODE key brings up the operating modes in the following sequence:

field display auto-ranging (power-up default mode)
peak hold field manual range change
peak hold field auto-ranging
field display manual range change

Auto-ranging is indicated by a flashing decimal.
Hold mode is indicated by the HOLD indicator.

The RANGE key selects the range without changing the display mode. If a single-range probe is in use or if auto-ranging is enabled then the range cannot be changed.

The RANGE key is also used to reload system defaults, as follows:

remove power from the teslameter
press and hold the RANGE key
apply power to the teslameter
after the display lights, release the key
the display message **rESEt** confirms defaults reloaded.

Reloading defaults performs the following functions:

clears the zero offset on each range
returns the digital filter parameters to default values
returns the sampling rate to the default value

To zero the display, press the two keys together. The keys must be pressed close to simultaneously for zeroing to take place.

In the peak hold mode, pressing the keys together will reset the peak field reading.

### 4.4.2 Operating Modes

a. Field display.

The teslameter powers up in auto-range, indicated by a flashing decimal.
Four ranges, 0.3, 0.6, 1.2, and 3.0 tesla full-scale, are selected automatically in auto-range, or manually in sequence by pressing the RANGE key when auto-ranging is off.
Four range indicators show the range in use.
With 230 probes, divide the full-scale range indicator by 10.
With all probes, the display shows the true field value. A minus sign is added to indicate reverse polarity fields.
Press the keys together to zero the display. The display shows **ZEro**.
In auto-range, all ranges are zeroed in turn, taking 10 seconds.
Field reading is filtered if selected by the internal switch - see section 3.5.
The FILTER indicator shows when filtering is enabled.

b. Peak hold display, ranges as above.

Displays maximum field measurement taken, either polarity,
since entering the mode, or since last reset.
HOLD indicator shows peak hold mode is operating.
If filtering is on, the filtered field value is held.
Reset is performed by pressing both keys together.
The peak value is also reset if the field polarity changes.

### 4.4.3 Display Messages

**Power up message**
The message **GrouP 3** appears in the display for 2 seconds when the teslameter is first powered. This message is followed by **SErIAL** if the serial communications option is fitted, or **GPIb** if the GPIB IEEE-488 option is fitted.

**Zero**
The message **ZEro** appears when the teslameter is zeroed. See section 4.1.

**No Probe**
The message **noProbE** is displayed if the Hall probe is disconnected from the instrument. While the message is visible, all key functions are disabled.

**Over-range**
The message **o'rAnGE** appears if the field to be measured exceeds the instrument's input capacity.

To clear the over-range message, select a higher range or reduce the magnetic field at the probe, or both if necessary.

During over-range, all key operations are locked out, except for range selection.

If autoranging is selected, steady over-ranging will occur only when full-scale of the highest range is exceeded.

If a single-range probe is in use, no range changing can occur.

**Overflow**
The message **o'FLo** is displayed if the computed value of the field reading exceeds the capacity of the display.

In overflow, the instrument is not over-ranged, but rather the computed reading is too large to be displayed. However, if over-ranging occurs at the same time as overflow, then the over-range message is displayed preferentially.

If the overflow message appears on a DTM-133, it can usually be cleared by reloading defaults (see section 4.4.1). Otherwise, please contact the supplier of the teslameter.

**Reset**
The message **rESEt** appears for 1 second when default settings are reloaded, as described in section 4.4.1.

**Error 1**
This indicates that the main circuit board has no calibration eeprom chip and cannot be used with this software version.

## 4.5 DIGITAL FILTERING

The teslameter software includes a digital filtering algorithm which may be enabled by turning on internal DIP switch 1. See section 3.5. Filtering is useful for smoothing out small fluctuations in the field reading. When filtering is enabled, the FILTER indicator is lit.

In order to speed up the response to large field changes when filtering is on, a window is set to define a band about the current displayed field value. Filtering will only occur while the unfiltered field value remains within the window. If the field value changes rapidly enough, the filtered field reading will not be able to follow fast enough to keep the unfiltered value within the window, and filtering is temporarily disabled. This allows the field reading to follow large rapid field changes, while providing good filtering of constant or slowly varying fields.

The default window width is 20 resolution increments on each side of the displayed field reading, for a total window width of 40 increments.

The digital filter performs the following computation:

$$F(new) = F(old) + \frac{F - F(old)}{J}$$

where F(old) is the previous field reading display
F(new) is the updated field reading display
F is the most recent unfiltered field reading
J is the filter factor.

The effective time constant of the filter is dependent upon both the rate at which field measurements are made and the value of J, according to the formula:

$$T = P/\ln[J/(J-1)]$$

where T is the filter time constant
P is the period between field measurements.

Field measurements are made at a fixed rate of 30 per second, so P = 0.033. With the default value of J = 8, the filter time constant is 0.25 seconds. This gives a cut-off frequency in the displayed field reading of 0.64Hz.

# 5 SERIAL COMMUNICATIONS OPTION

## 5.1 FIBER OPTIC CONNECTIONS

The DTM-133-_S has facilities for communicating with external devices, such as computers or terminals, using its serial ports. The teslameter may also be set up to relay communications through other compatible Group3 devices, using the Group3 Communication Loop. See section 5.5.

There are three bi-directional ports, two using standard RS-232C signals, the third employing fiber optics. In electrically noisy environments, or where ground loops could be troublesome, or if a voltage gradient must be traversed, it is advisable to use fiber optics for the serial data link. The teslameter's fiber optic ports accept Hewlett-Packard HFBR-3500 series fiber optic cables up to 60 meters in length.

Fiber optic cables are fitted with a blue connector at one end and a gray connector at the other. Although functionally identical, the colors make it easier to keep track of cable routing when connecting up a system. The convention is to use gray at send ports and blue at receive ports.

To connect the cables, simply push the connector in through the appropriately labeled hole in the teslameter's rear panel. The connector will snap into place. To disconnect, give the cable a gentle tug. Loose cable ends should be protected from dirt and scratching.

## 5.2 ELECTRICAL SERIAL DATA INPUT/OUTPUT CONNECTIONS

Serial data connections to the teslameter can be made electrically in two ways, as alternatives to the fiber optic method described in the previous section:

### 5.2.1 The G3CL Ports

The two 4-way Group3 Communication Loop connectors, one each for send and receive, provide an electrical alternative to the fiber optic ports, and handle the same data. Signal levels are equivalent to RS-232C levels. RS-232C handshake signals are not present at these ports.

The G3CL ports allow serial connections to be made using a simple twisted pair or coaxial cable for each data direction, and avoid consideration of handshake signals if these are not required in the application.

Connection to the G3CL ports requires two Molex receptacles type M5051-4 with M2759 crimp terminals. Pin assignments are given in Table 3 below. The RS-232C standard allows cable lengths of up to 50 ft, but in practice longer cables will work reliably, particularly at the lower bit rates. Connection is made through the labeled opening in the

teslameter's rear panel.
In the device at the send port, pin 2 (common) is connected to circuit common. However, at the receive port the signal drives an optical coupler without any direct connection to the circuitry. This arrangement avoids ground loops which can inject noise into the link and give rise to transmission errors.

| **pin** | **use** |
|---|---|
| 1 | signal active |
| 2 | signal common |
| 3 | cable shield (optional) |
| 4 | not used |

Table 3. G3CL Connector Pin Assignments

### 5.2.2 The RS-232C Connector

The RS-232C connector is a 26-pin field which can be used to connect the teslameter to a computer, terminal, printer, or other external equipment which can send and receive RS-232C signals. The pin field will connect with a standard 26-way flat cable socket connector, for example 3M type 3399-6000. The pin assignments follow those of the standard 25-way RS-232C connector, starting at pin 1 and omitting pin 26. If desired, an adaptor cable may be used to allow cables with 25D connectors to be plugged in to the teslameter.

In order to avoid the conflicts and confusion which often arise when RS-232C is used to interconnect equipment which cannot be classified strictly as either communications or terminal equipment, the teslameter has been provided with a number of user options in the form of moveable jumpers and wire-wrap posts on the serial board. Thus pins 2 and 3 may be connected to send and receive signals, respectively, or vice versa.

Similarly, a number of the most-used RS-232C handshake signals are provided on the board, and these may be routed to appropriate pins on the connector if desired. But their use is optional. In most cases no active handshaking need be used. Some external equipment may require certain signal lines to be held high for correct operation. These options are provided for (see below).

The teslameter can provide one output handshake signal, RTS, which is asserted high when the unit has data it wishes to transmit.

The teslameter can also accept up to two input handshake signals, CTS and DCD. If CTS is held low by the external equipment, then no data will be transmitted. When low, DCD inhibits and initializes the receive input of the teslameter. DCD must be high to allow the unit to accept incoming data. If these inputs are not connected to the RS-232C pin field, the relevant pins must be tied to +5 volts on the serial board, using the jumpers provided.

The handshake signals can be used only when the teslameter is connected directly through its RS-232C connector to an RS-232C compatible device. When several

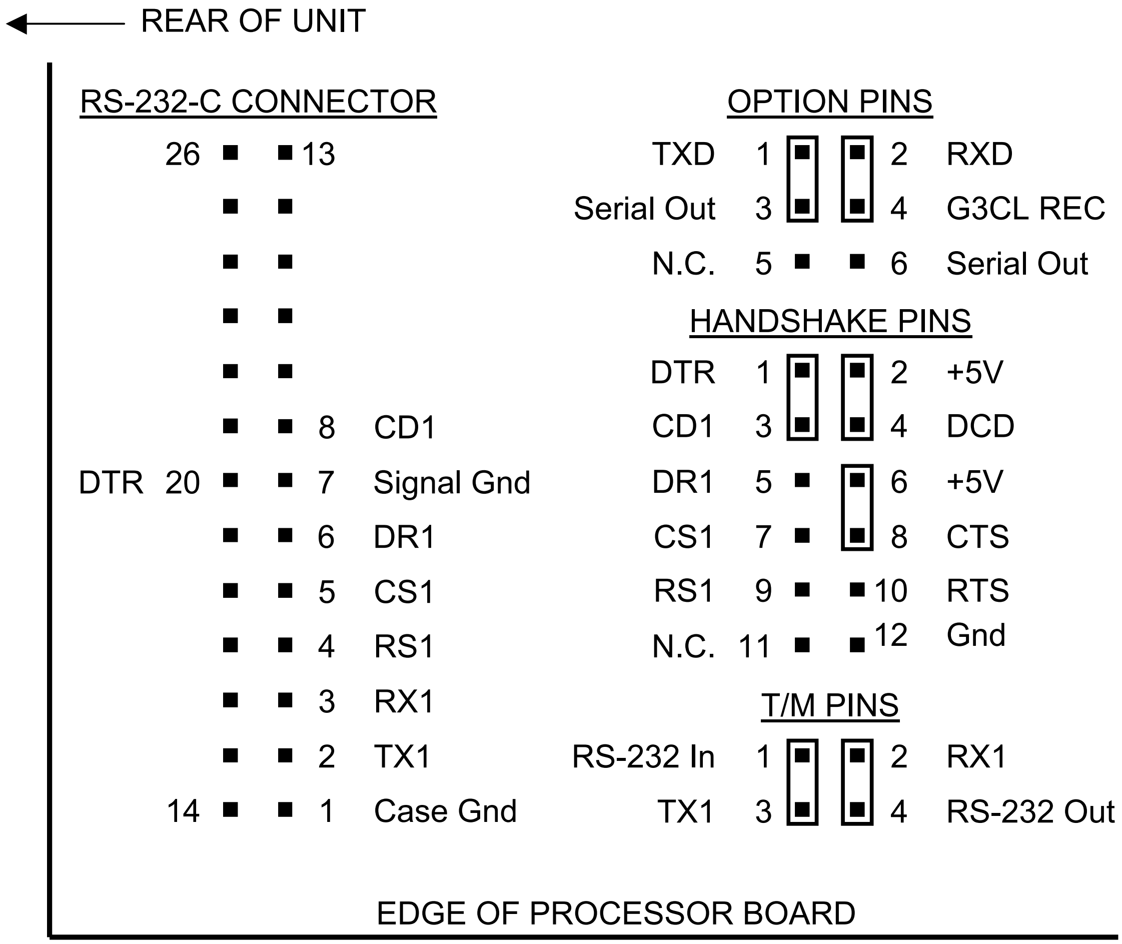



Fig. 4. RS-232C Connector and Jumper Locations

| pin | RS-232C signal name | signal direction | connection in DTM |
|---|---|---|---|
| 1 | protective ground | | instrument case |
| 2 | transmit data | output | TX |
| 3 | receive data | input | RX |
| 4 | request to send | output | *RTS or +5V |
| 5 | clear to send | input | *CTS or open |
| 6 | data set ready | input | *DCD or open |
| 7 | common | | circuit common |
| 8 | carrier detect | input | *DCD or open |
| 20 | data terminal ready | output | *+5V |

* option according to requirements of external equipment.
Note: connect CTS and DCD to +5 volts if not otherwise used.

Table 4. RS-232C Connector Pin Assignments, Terminal Mode

Group3 devices are arranged in a loop using the Group3 Communication Loop ports, RS-232C handshaking cannot be used. CTS and DCD must be tied high in this case. Table 4 below gives the pin assignments and signal names when the teslameter is configured as a Data Terminal Equipment (DTE). This will be referred to as terminal mode.

| pin | RS-232C signal name | signal direction | connection in DTM |
|---|---|---|---|
| 1 | protective ground | | instrument case |
| 2 | transmit data | input | RX |
| 3 | receive data | output | TX |
| 4 | request to send | input | *DCD or open |
| 5 | clear to send | output | *+5v or pin 4 |
| 6 | data set ready | output | *RTS or +5V |
| 7 | common | | circuit common |
| 8 | carrier detect | output | *RTS or +5V |
| 20 | data terminal ready | input | *CTS or open |

* option according to requirements of external equipment.
Note: connect CTS and DCD to +5 volts if not otherwise used.

Table 5. RS-232C Connector Pin Assignments, Modem Mode

The unit can also be set up to behave like a Data Communications Equipment (DCE), for example a modem. The instrument is then said to be in modem mode. See the RS-232C connector pin assignments for modem mode below in Table 5.

Fig. 4 shows the location of the RS-232C pin field, moveable jumpers and wire-wrap posts on the serial board.

For terminal mode, the send and receive (T/M) jumpers should be pushed onto the square posts lined up parallel with the long side of the circuit board. In modem mode, the jumpers are set at right-angles to the above. See Fig. 5.

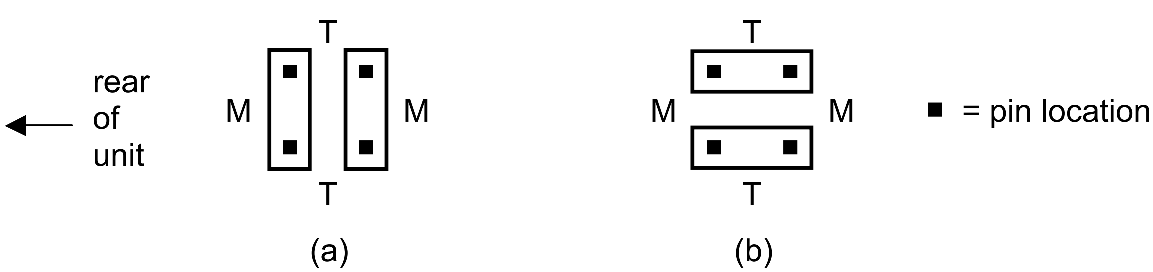



Fig. 5. Send and Receive Jumpers (a) Modem Mode, (b) Terminal Mode

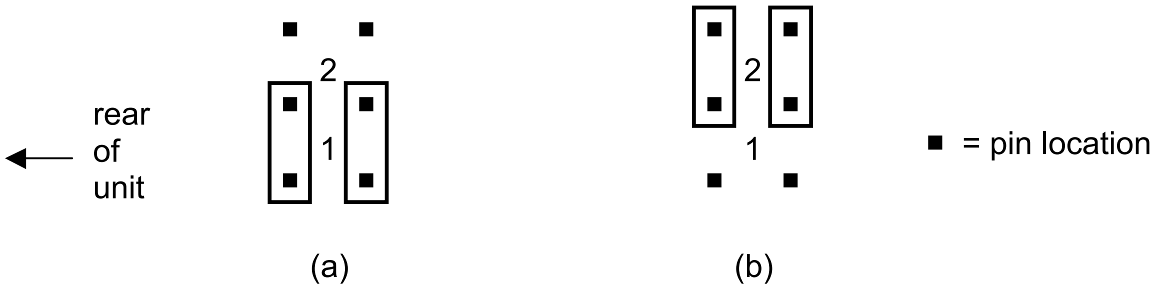



Fig. 6. Option Jumpers (a) Option 1 (b) Option 2

The option 1 and 2 jumpers configure the relationship between the RS-232C connector and the G3CL ports. For single device systems, option 2 should be selected. Refer to Fig. 6 below. Section 5.5 describes the use of the option jumpers in setting up the alternative G3CL arrangements.

Fig. 4 also indicates the positions of the wire-wrap posts on which appear the RTS, CTS, and DCD signals, +5 volts and ground, and posts which connect to RS-232C connector pins 4, 5, 6, 8, and 20. These pins may be wire-wrapped according to the options set out in Tables 4 and 5. When pins are adjacent they may more easily be connected with push-on jumpers.

## 5.3 SERIAL BOARD DIP SWITCH SETTINGS

The Serial Board in the teslameter is provided with two sets of DIP switches, allowing the user to set up operation and communications according to system requirements. To obtain access to the switches, turn the teslameter over and take off the bottom cover by loosening the single central screw. Refer to Fig. 7 for switch locations. Switch functions are as follows:

S1 8-way DIP switch - sets device address; sets serial data format:
number of data bits, parity, and number of stop bits.

S2 8-way DIP switch - selects operation mode and communication mode.

Detailed DIP switch settings are given in Tables 6 and 7 below.

The switches are read by the processor once per second, so the effects of changed settings can be observed in real time.

| switch | function | switch OFF | switch ON |
|---|---|---|---|
| S1-1 | set device address | adds 0 to address | adds 1 to address |
| S1-2 | set device address | adds 0 to address | adds 2 to address |
| S1-3 | set device address | adds 0 to address | adds 4 to address |
| S1-4 | set device address | adds 0 to address | adds 8 to address |
| S1-5 | set device address | adds 0 to address | adds 16 to address |
| S1-6 | ) | | **maximum valid address = 30** |
| S1-7 | ) serial data format | see Table 7 for encoding format | |
| S1-8 | ) | | |
| S2-1 | transmission mode | on demand only | every reading sent |
| S2-2 | select terminator | line feed | carriage return |
| S2-3 | double terminator | disabled | enabled |
| S2-4 | echo commands | echo OFF | echo ON |
| S2-5 | field units | tesla | gauss |
| S2-6 | units symbol | no symbol | symbol after data |
| S2-7 | digital filtering | filtering OFF | filtering ON |
| S2-8 | defaults | no action | defaults loaded |

Table 6. DIP Switch Functions

| S1-8 | S1-7 | S1-6 | data bits | parity | stop bits |
|---|---|---|---|---|---|
| * OFF | * OFF | * OFF | 7 | even | 2 |
| OFF | OFF | ON | 7 | odd | 2 |
| OFF | ON | OFF | 7 | even | 1 |
| OFF | ON | ON | 7 | odd | 1 |
| ON | OFF | OFF | 8 | none | 2 |
| ON | OFF | ON | 8 | none | 1 |
| ON | ON | OFF | 8 | even | 1 |
| ON | ON | ON | 8 | odd | 1 |

Table 7. Serial Data Format Switch Settings

If the system contains only one device, it is recommended that its address be set at 0 (S1-1 through S1-5 OFF). Then the external control device does not need to initiate commands with a device address command. Also in a single device system, S2-1 can be set ON so the teslameter will transmit field readings continuously at the maximum rate of 30 per second. S2-1 sets continuous transmission only if the device address is 0.

S2-2 selects the character sent as string terminator. S2-3 when ON introduces a pre-terminator character before the final string terminator. The pre-terminator is the character not selected by S2-2. The terminator sequence as selected by S2-2,3 is as follows:

| | | S2-2 | |
|---|---|---|---|
| | | OFF | ON |
| S2-3 | OFF | lf | cr |
| | ON | cr, lf | lf, cr |

Table 8.  String Terminator Switch Settings

S2-4 controls the echoing of input commands by the teslameter. If echoing is selected, every command from the external control device is echoed before the response to the command is transmitted. Usually echo is set ON if the 26-way RS-232C port is used, and OFF when using either pair of G3CL ports. If echo is ON in the latter case, the teslameter will transmit each input command twice, first the original command rippling through, then the echoed command. When echo is OFF when the RS-232C port is used, the input command will not be returned to the external control device.

S2-6 when ON adds the field units characters T or G to the transmitted string after the numerical values.

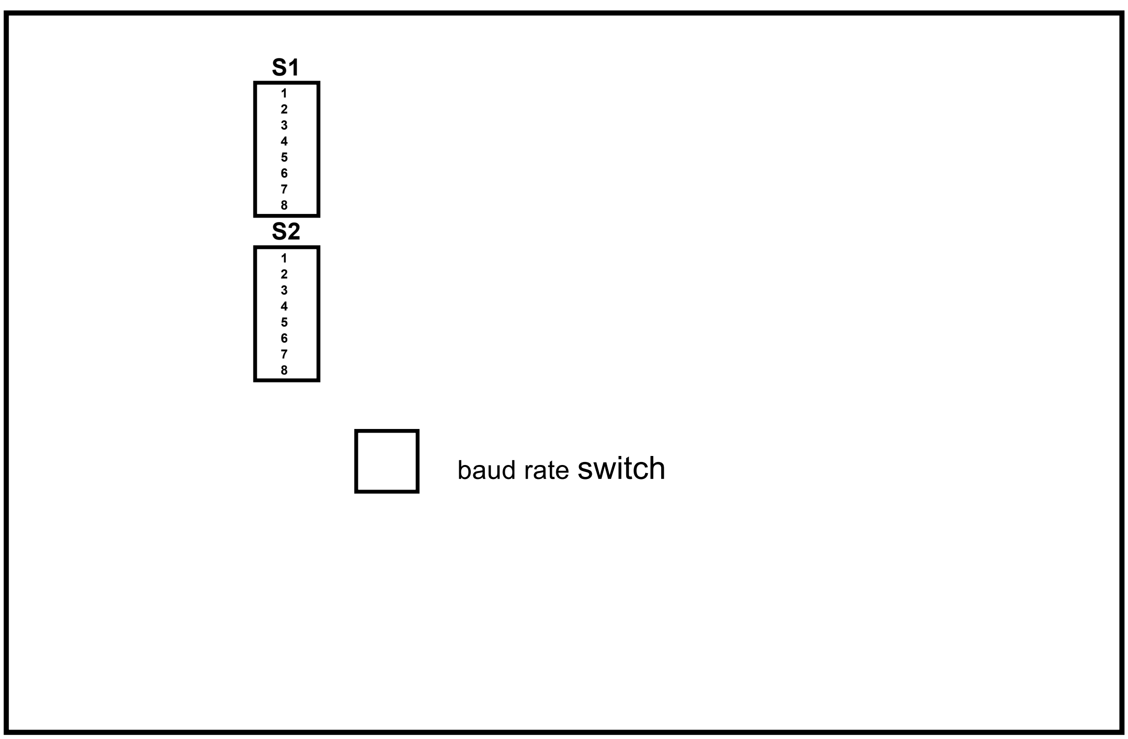



Fig. 7.  Location of Serial Board Switches

## 5.4 BIT RATE SELECTION

A 16-position switch is provided on the Serial Board for setting the serial data bit rate (baud). See Table 9 for switch position versus bit rate, and Fig. 7 for the location of the switch. The baud rate must be set to match that of the communicating device.

| switch position | baud bits/sec |
|---|---|
| 0 | 50 |
| 1 | 110 |
| 2 | 134.5 |
| 3 | 150 |
| 4 | 200 |
| 5 | 300 |
| 6 | 600 |
| 7 | 900 |
| 8 | 1050 |
| 9 | 1200 |
| A | 1800 |
| B | 2000 |
| C | 2400 |
| D | 4800 |
| E | 9600 |
| F | 19200 |

Table 9. Bit Rate Switch Settings

## 5.5 USING THE SERIAL DATA INPUTS AND OUTPUTS

### 5.5.1 Serial Data Connections

The three bi-directional serial input/output ports at the rear of the teslameter can be used in various ways to connect the device to external equipment for data logging and systems applications. Sections 5.1 and 5.2 give information on making connection to the ports and configuring the signal flow.

In systems containing more than one teslameter or other compatible Group3 device, the serial data path can be configured in an arrangement called the Group3 Communication Loop (G3CL). This allows convenient communication of up to 31 devices with a single computer or terminal without the need for a multiplexer.

The G3CL is a communication protocol defining hardware, electrical and fiber optic signal parameters, and a command structure based on the ASCII code. All the commands applicable to the teslameter are defined in Tables 10 & 11 below.

In the G3CL a message from external equipment (computer, terminal, modem etc.) is sent to the first device in the loop. This device retransmits the message to the second, and so on around the loop, until finally the last device sends the message back to the external unit. Thus the system verifies that all devices are active and have listened to the message. See Fig. 8.

Each device is assigned a unique address in the range 0 to 30, as set on the internal switches (see section 5.3). When connected in a loop containing more than one device, the devices must be set by means of an internal switch not to initiate communications themselves. They may only respond to commands from the host unit. In the teslameter, switch S2-1 must be OFF.

All Group3 devices with serial communication are fitted with fiber optic transmitters and receivers as a standard feature. Fiber optic cabling is particularly valuable when the loop runs in the vicinity of electrically noisy equipment, or when voltage isolation is required. The system uses the Hewlett-Packard HFBR-3500 series fiber optic cables. Individual cable sections between devices may be up to 25 metres in length.

Use a Group3 model FTR fiber optic to RS-232C adaptor to connect the fiber optic cables to a standard 25-way D-type RS-232C receptacle on your computer or terminal.
Electrical serial data connections to the RS-232C standard are provided on Group3 serial devices. There are two possible configurations of the loop using electrical signals, as shown in Fig. 8.

One arrangement uses the RS-232 connection between the host equipment and one of the devices on the loop. The rest of the loop is connected via the G3CL ports, either electrical or fiber optic, or a mixture.

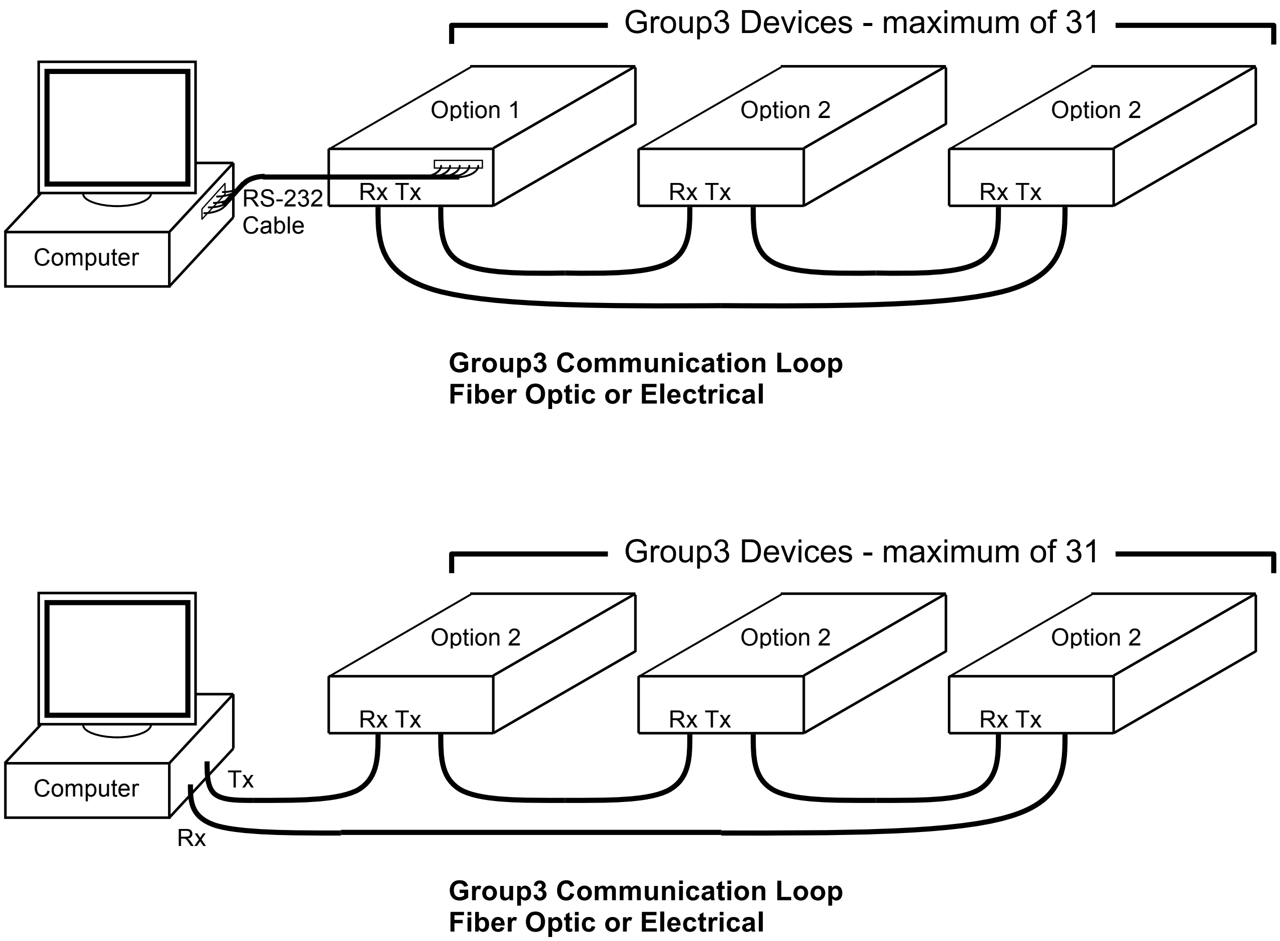



Fig. 8.  G3CL - Alternative Configurations

The second arrangement uses the G3CL ports on every device. Observe the option jumper settings required as shown in Fig. 6. Note that the fiber optic and electrical G3CL ports are functionally identical and are completely interchangeable in use.

### 5.5.2  DTM-133_S Serial Input Commands

The commands which can be used with the teslameter, either as a single unit or in a G3CL of various Group3 devices, are set out in Tables 10 & 11 below. Table 10 lists the commands in alphabetical order, while Table 11 groups the commands according to function. In order to gain familiarity with the commands, it is recommended that you connect the DTM to a terminal. The commands can then be typed in from the keyboard, and the responses observed on the terminal's screen.

The commands are in the form of one to three ASCII alphabetical characters, in some cases followed by a decimal number represented by n in the table.

All commands expecting a number longer than 1 digit must be followed by a carriage return <cr> character. If no number is entered where one is expected, zero will be entered automatically. A decimal point is not required in whole number entries.

Numerical values entered by commands are retained in non-volatile memory when power is off.

Default values shown below apply after load defaults command CTRL X.

Switch-selectable defaults are loaded on power-up, reset, and when a switch setting is changed. See sections 3.5 and 5.3.

All teslameter responses start with a space character. Decimal numbers include a decimal point. Some are in exponential format.

If an error message is returned, the complete command must be re-entered.

### TABLE 10. DTM-133-_S COMMANDS - ALPHABETIC LISTING

| command | description |
|---|---|
| An | Address device n - all following commands are acted on only by the unit of address n (n = 0 though 30) as set on internal switches. |
| B<text><cr> | ASCII text (7 characters maximum) appears on teslameter display. |
| B<cr> | Cancel text mode, return to normal display. |
| D0 | Turns OFF digital filtering. |
| D1 | Turns ON digital filtering. |
| EP | Erase (reset) peak hold field value. |
| EZ | Erase zero - cancels zero correction on current range. |
| F | Field reading - requests a field reading from the teslameter. |
| GC | General function Continuous - teslameter measures continuously at 30 readings per second. This is the power-up default mode. |
| GV | General function Triggered - field is measured only on V command. |
| IA | Inspect auto ranging status - returns 0 for OFF, 1 for ON. |
| ID | Inspect Digital filtering status - returns 0 for OFF, 1 for ON. |
| IG | Inspect General function - returns C for continuous, V for triggered |
| IJ | Inspect filter factor - returns filter factor. |
| IK | Inspect sampling interval - returns interval in seconds between transmitted field values. 0 implies readings sent at maximum rate. |
| IN | Inspect display mode - returns H for hold display, N for normal. |
| IR | Inspect Range - returns 0 for the lowest range to 3 for the highest range. |
| IY | Inspect window - returns value of window within which filtering occurs. |
| IZ | Inspect zero - returns zero correction of selected range. |

| | |
|---|---|
| Jn | Filter factor - enters filter factor n. Default n = 8. Allowed n = 1, 2, 4, 8, 16, 32, 64, 128. Entered values from 2 to 128 are rounded to nearest allowed value. Filtering becomes more severe as n increases. |
| Kn | Sampling interval - enters interval between output field values. Default n = 0, every reading sent, rate is 30 per second; n = any positive number with 1 decimal place up to 6553.4, time in seconds between transmitted field values. |
| NH | Display mode: Hold - teslameter display shows peak field value. |
| NN | Display mode: Normal - teslameter displays instantaneous field value |
| P | Peak hold field - teslameter returns peak field value. Peak value is always available irrespective of display mode. |
| Q | Test teslameter front panel display. |
| Rn | Range selection: n = 0 through 3. R3 selects highest range. Default is least sensitive range, or range of single-range probe. Ignored if teslameter is in auto range mode. Returns error message if single-range probe is in use. |
| SB0 | Autoranging OFF. |
| SB1 | Autoranging ON. Default is autoranging ON. |
| SE0 | Echo OFF - teslameter does not echo characters received. |
| SE1 | Echo ON - every character received is echoed by teslameter. |
| SM0 | Send mode: field readings sent when requested by F command only. |
| SM1 | Send mode: field readings sent at intervals defined by Kn command. Default for unit on address 0 is set by S2-1. |
| SU0 | Turns OFF units symbol sent after field readings. |
| SU1 | Turns On units symbol sent after field readings. |
| SZn | Set zero - enters zero offset n for the selected range; useful when the teslameter must be zeroed but using Z command is inconvenient; the correct zero offset must be known; can be obtained after Z command by using IZ, and should be noted for future use with SZ. |
| UFG | Units: field values displayed and transmitted in gauss. Default set by S2. |
| UFT | Units: field values displayed and transmitted in tesla. Default set by S2. |
| V | Triggers field measurement after triggered mode selected by GV. |
| WA | Returns uncalibrated raw field reading immediately after digitizing. |
| WE | Like WA except field reading has teslameter's internal calibration applied, but not corrected for probe errors. |
| WZ | Like WE except field reading is modified by user-entered zero. |
| Yn | Window - enters n = window within which digital filtering occurs. Maximum n = 255. Default ±20 resolution increments on current range. |
| Z | Zero - defines present field value as zero for selected range only. |
| CTRL B | Returns single hex character 0 through F indicating the position of the baud rate selection switch; once the command has been given, changing the switch position does not alter the baud rate until some other command is sent. |

| | |
|---|---|
| CTRL D | Returns an 18-bit binary number representing the states of the two DIP switches on the main board and the 16 DIP switches on the communications board. 0 = OFF, 1 = ON; once the command has been given, changing the switch position does not alter the baud rate until some other command is sent. |
| CTRL U | Restarts operating software as if DTM had been freshly powered up. |
| CTRL X | Load system defaults - all default values & modes reinstated. The message RESET is transmitted. |

End of Table 10

### 5.5.3 Serial Output Error Messages

The following error messages are transmitted as a result of error conditions:

BAD OR MISSING EEPROM indicates that the main board has no calibration eeprom chip and cannot be used with this software version.

INVALID COMMAND ENTRY indicates that the command entered was illegal.

NUMBER TOO BIG indicates that the number entered in a command was too big.

POSITIVE NUMBER REQUIRED indicates erroneous entry of minus sign.

FRAMING ERROR indicates the wrong number of bits were sent in one or more characters of the last command.

OVERRUN ERROR indicates characters were sent too quickly for the DTM to process. The teslameter contains a fifo buffer which can accept more than 30 command characters in an unbroken stream.

PARITY ERROR indicates a mismatch in parity in one or more characters of the next command to be executed.

If framing, overrun, or parity errors are detected, the command is ignored.

FIXED RANGE PROBE and AUTORANGING indicate an illegal attempt to change range.

The messages NO PROBE, OVERFLOW, and OVER RANGE duplicate the functions of these messages on the DTM display.

### 5.5.4 Some Examples Using the Commands

With the teslameter connected to a source of serial data as described in sections 5.1 and 5.2, send the character Z to the DTM. This will zero the range currently selected. To check which range is current, send IR to the DTM. The response will be 0 for the 0.3 tesla range, 1 for 0.6T, 2 for 1.2T, and 3 for the 3.0T range. In order to change the range, send R followed by a single numeral as defined above, e.g. R2 will select the 1.2T range, and IR will return 2 to confirm the range selection. Always wait a second or two after a range change before zeroing.

To check which mode the DTM is in, send IG. This will return C for continuous mode or V for triggered mode.

Zero all ranges: R0/ZR1/ZR2/ZR3/Z , where / indicates a 1 to 2 second pause.

If a single range probe is in use, attempts to select another range will return the message FIXED RANGE PROBE.

The command F will return the field value as measured by the selected range.

**TABLE 11. DTM-133-_S COMMANDS - LISTING BY FUNCTION**

**COMMUNICATIONS**

| | |
|---|---|
| An | Address - all following commands are acted on only by the unit of address n (n = 0 though 30) as set on internal switches. |
| Kn | Sampling interval - enters interval between output field values. Default n = 0, every reading sent, rate is 30 per second; n = any positive number with 1 decimal place up to 6553.4, time in seconds between transmitted field values. |
| IK | Inspect sampling interval - returns interval in seconds between transmitted field values. 0 implies readings sent at maximum rate. |
| SE0 | Echo OFF - teslameter does not echo characters received. |
| SE1 | Echo ON - every character received is echoed by teslameter. |
| SM0 | Send mode: field readings sent when requested by F command only. |
| SM1 | Send mode: field readings sent at intervals defined by Kn command. Default for unit on address 0 is set by S2-1. |
| SU0 | Turns OFF units symbol sent after field readings. |
| SU1 | Turns On units symbol sent after field readings. |
| UFG | Units: field values displayed and transmitted in gauss. Default set by S2. |
| UFT | Units: field values displayed and transmitted in tesla. Default set by S2. |

**FIELD VALUES**

| | |
|---|---|
| F | Field - teslameter returns a field value. |
| P | Peak hold field - teslameter returns peak field value.<br>Peak value is always available irrespective of display mode. |
| WA | Returns uncalibrated raw field reading immediately after digitizing. |
| WE | Like WA except field reading has teslameter's internal calibration applied, but not corrected for probe errors. |
| WZ | Like WE except field reading is modified by user entered zero. |

**RANGE SELECTION**

*See the note on range changing at the end of this chapter about changing ranges.*

| | |
|---|---|
| Rn | Range selection: n = 0 through 3. R3 selects highest range.<br>Default is highest range, or range of single-range probe.<br>Ignored if teslameter is in auto range mode.<br>Returns error message if single-range probe is in use. |
| SB0 | Autoranging OFF. |
| SB1 | Autoranging ON. Default is autoranging ON. |
| IA | Inspect auto ranging status - returns 0 for OFF, 1 for ON. |
| IR | Inspect Range - returns 0 for lowest range through to 3 for highest range. |

**ZEROING**

| | |
|---|---|
| Z | Zero - defines present field value as zero for selected range only. |
| IZ | Inspect zero - returns zero correction of selected range. |
| EZ | Erase zero - cancels zero correction on current range. |
| SZn | Set zero - enters zero offset n for the selected range;<br>useful when the teslameter must be zeroed but using Z command<br>is inconvenient; the correct zero offset must be known;<br>can be obtained after Z command by using IZ,<br>and should be noted for future use with SZ. |

**FILTERING**

| | |
|---|---|
| D0 | Turns OFF digital filtering. |
| D1 | Turns ON digital filtering. |
| ID | Inspect Digital filtering status - returns 0 for OFF, 1 for ON. |
| Jn | Filter factor - enters filter factor n. Default n = 8.<br>Allowed n = 1, 2, 4, 8, 16, 32, 64, 128. Entered values<br>from 2 to 128 are rounded to nearest allowed value.<br>Filtering becomes more severe as n increases. |
| IJ | Inspect filter factor - returns filter factor. |
| Yn | Window - enters n = window within which digital filtering occurs.<br>Maximum n = 255. Default ±20 resolution increments on current range. |
| IY | Inspect window - returns value of window within which filtering operates. |

**PEAK HOLD MODE**

| | |
|---|---|
| P | Peak hold field - teslameter returns peak field value.<br>Peak value is always available irrespective of display mode. |
| EP | Erase (reset) peak hold field value. |
| NH | Display mode: Hold - teslameter display shows peak field value.<br>NN returns to normal mode. |

**TRIGGERING**

| | |
|---|---|
| GV | General function Triggered - field is measured only on V command.<br>GC returns to normal mode. |
| V | Triggers field measurement after triggered mode selected by GV. |
| IG | Inspect General function - returns C for continuous, V for triggered |

**DISPLAY**

| | |
|---|---|
| UFG | Units: field values displayed and transmitted in gauss. Default set by S2. |
| UFT | Units: field values displayed and transmitted in tesla. Default set by S2. |
| NH | Display mode: Hold - teslameter display shows peak field value. |
| NN | Display mode: Normal - teslameter displays instantaneous field value |
| IN | Inspect display mode - returns H for hold display, N for normal. |
| B<text><cr> | ASCII text (7 characters maximum) appears on teslameter display. |
| B<cr> | Cancel text mode, return to normal display. |
| Q | Test teslameter front panel display. |

**SYSTEM & TESTNG**

| | |
|---|---|
| Q | Test teslameter front panel display. |
| CTRL B | returns single hex character 0 through F indicating the position of the baud rate selection switch; once the command has been given, changing the switch position does not alter the baud rate until some other command is sent. |
| CTRL D | returns an 18-bit binary number representing the states of the two DIP switches on the main board and the 16 DIP switches on the communications board. 0 = OFF, 1 = ON; once the command has been given, changing the switch position does not alter the baud rate until some other command is sent. |
| CTRL U | Restarts operating software as if DTM had been freshly powered up. |
| CTRL X | Load system defaults - all default values & modes reinstated.<br>The message RESET is transmitted. |

End of Table 11

## 5.6 TRIGGERED OPERATION

Triggering allows one or more teslameters to make synchronized field measurements on demand. The teslameter is set for triggered operation by entering the command GV. This stops continuous sampling of the field value.

To initialize a measurement, enter the command V. This is the only command which is simultaneously obeyed by more than one device on the loop; the V is not to be preceded by an address command; all devices which have been set for triggered operation by the GV command will respond to the V. The new measurement will immediately appear on the teslameter display, and can be read on the serial output by entering the F command.

As a useful diagnostic aid while a system is being set up, the effects of the GV and V commands on the teslameter can be observed directly by removing its top cover and watching the LED nearer the front panel on the analog board. During normal continuous operation the LED will seem to be on continuously but in fact it is flashing 30 times per second in accordance with the field measurement rate. After the GV command the LED will stop flashing. Then each time the V command is given, the LED will flash once. Continuous operation is restored using the GC command.

The following sections describe details of triggered operation.

### 5.6.1 Automatic transmission of new measurement

When a teslameter is used on its own as the only device in a G3CL, the field measurement triggered by V will then be transmitted immediately if the device has been set for continuous transmission by the SM1 command or if S2-1 is ON with the address set to zero.

If the teslameter has been initialized by the SM0 command, or if S2-1 is OFF, or if the device address is not zero, the new measurement will not be transmitted until the F command is entered.

In multi-device systems, each teslameter should be set NOT to send the new reading automatically; each device must be read out individually by addressing it (An) then requesting a field value using F.

### 5.6.2 Digital filtering with triggered operation

If filtering is ON, then each time a measurement is triggered the filtering algorithm will calculate a new field value for display and transmission, as described in section 4.5.

The effective time-constant will depend on the timing of the V commands.
If the field values obtained on triggering are required to reflect only the field at the time of triggering and not contain any history, then filtering should be turned OFF.

### 5.6.3 Triggered operation timing

The teslameter starts sampling the field within 1.5ms after the V trigger command has been received. The field is sampled for a period of 8.3ms. After sampling, the value is digitized and computations are done.

The new field value is ready no later than 60ms after the V command is received. Do not request transmission of the field value (using F) sooner than 60ms after the V command, or the previous field value may be transmitted. Transmission of the field value starts 8ms after the F command.

If the teslameter is set for automatic transmission of the new value (S2-1 is ON or command SM1 entered), transmission will start 34ms to 60ms after the V command, depending on the field value.

### 5.6.4 When the V command is ignored

The V command is ignored by teslameters which have not been initialized for triggering by the GV command.

The V command is ignored by teslameters which have been initialized for triggering, if the command is received while the device is still in the process of making a measurement in response to a previous V command.

### 5.6.5 Zeroing while in triggered mode

If the teslameter is zeroed, either with the keys or by remote command, while in the triggered mode, a new zero offset will be calculated and stored, using the last field measurement made. The effect of the zero operation will be reflected in the next field measurement, when the V command is given.

To ensure the most accurate zero, it is best to place the teslameter in continuous mode with filtering on, allow time for the display to settle, then give the zero command. The unit will zero correctly in triggered mode if first the V command is given while the probe is in zero field with filtering off; then the Z command (or pressing both keys together) will zero the instrument.

---

**Note - Readings After a Range Change**

After a range change – manual or autoranging – it takes the circuitry and calculation path some time to settle with the new values.

**Disregard any readings for 2 seconds following a range change.**

If continuous readings are required, it is suggested that autoranging be **disabled**.

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