

Section 6

Tone Generators & Operation

6.1	Introduction	6.2
6.2	Theory of Operation	6.2
6.3	Practical Operation	6.3
6.4	The TG-10 UK Tone Generator	6.6
6.4.1	Description	6.6
6.4.2	Operation	6.6
6.4.3	Scematic Diagrams	6.7



6.2 INTRODUCTION

AC Tone tracking of underwater cables is the most reliable and accurate method of determining their position, and this section examines methods of tone injection and operational techniques required. Signal injection always requires the approval of the cable owner and/or operator, and may require significant interaction between the parties.

6.2 THEORY OF OPERATION

The Innovatum cable tracking systems can detect the magnetic signals produced by the injection of an AC tone in a cable or wire. Theoretical considerations of this method are given in **Section 4-1, para 4-1.4**. Cables which may be tracked by this method include submarine electrical communications cables, submarine fibre optical cables (only if a suitable electrical current path exists), submarine power cables and oilfield umbilical cables.

6.2.1 In order to detect the signals produced by a tone in a cable the following considerations apply:

- a) The current flow must be “unidirectional”, meaning that the current feed and current return must be physically separated by a significant distance. The usual method of achieving this requirement is by utilising the seawater as a return path
- b) The current must be of sufficient magnitude to produce an acceptable signal to noise ratio at the sensors. This implies sufficient drive voltage to overcome the resistance of the conductor and return paths.

6.2.2 An AC current injected into a cable will decay as it passes along the cable due to several factors. Two of these are of significance in underwater cable location and tracking operations:



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- a) The capacitance of the cable will allow leakage of the signal to the return path. This capacitance will vary according to the physical characteristics of the cable. Practical field operations have shown signals may be tracked for distances of up to 300 Km on fibre optic communications cables. The rate of signal decay will depend on the “reactance” of the system, which is dependent on the frequency in use, the cable resistance and the cable capacitance.
 - b) The presence of “Repeater amplifiers” in long cables may inhibit the transmission of signals. Repeaters are normally powered via a constant DC current flow in the cable, and may have filter circuits built in to prevent the transmission of electrical noise (and thus tone signals) along the cable

Both of the above factors will determine the maximum distance a signal may be passed along an individual cable.

6.3 PRACTICAL OPERATION

6.3.1 Tone injection into cables requires:

- a) A suitable tone generator, ideally with an isolated output (for safety reasons), a stable frequency, variable frequency control, output current limiting, and operable off of either local AC mains supply, external batteries or internal batteries. Innovatum manufactures a range of suitable devices.
- b) Electrical continuity throughout the cable, via a suitable conductor
- c) A current return path separate and remote from the feed. This current return path will not be critical on long cables, due to the signal leakage to earth described in 5-3.2(a) above.



- 6.3.2** A suitable conducting path in the cable is necessary. Some cables may have spare conductors which may be used. The “Electrostatic Screen” of fibre optic cables may be used, and this is frequently used to carry DC repeater drive current (however, if the repeater stations may filter much of the AC signal, and it is worth locating an alternative conductor if possible). It may also be possible to use the cable armour to carry current when it is isolated from the seawater.
- 6.3.4** The tone will normally be injected at a shore station, or in the case of oilfield umbilicals from a “Platform”. It is also possible to inject a tone from a vessel at sea if access to a cable end is possible on the ship and a suitable return path is available.
- 6.3.5** The choice of a suitable return path is critical to the success of the operation. **The return path MUST be physically well separated from the feed.** It is thus not possible to track a cable where the signal feed and return are together, as in co-axial or twisted pair cables. The ideal return is via the sea or a ground, although in the case of oilfield umbilicals or electrical power cables it may be possible to arrange a return path along a suitable separate cable. **“Well separated” means at least 200 to 300 metres from the injected current path. Less separation will result in errors in measurement.**
- 6.3.6** The return current will flow along the path of least resistance, in accordance with “Kirchhoff’s Laws”. This may cause problems with signal return paths where a cable is armoured with the armour in contact with the seawater, which in many cases may be true. In the case of signal injection via cable armour care must be taken to ensure that:
- a) The armour is isolated at the feed end, and
 - b) the armour is connected to the return path at the remote end

- c) the return path is not via the armour of adjacent cables or pipes.

If the signal return is via multiple paths, the tracking system will only “see” the NET current in the cable.

6.3.7 The choice of frequency will depend on the following considerations:

- a) The noise characteristics of the vehicle carrying the tracking system. The noise “Spectrum” can be measured by using the cable tracking system, and a quiet frequency thus chosen
- b) The characteristics of the cable and any repeaters. A lower frequency will generally have smaller capacitive losses and signal rejection through repeater amplifiers than a higher frequency
- c) In many cases of telecom cable tracking the cable operating company will have signal injection equipment built in to the shore stations, and they will determine the frequency to be used.

It is advisable to use frequencies which are not harmonics of power generation frequencies of 50hz and 60hz, although the standard telecom cable tracking frequencies are 25 and 16.7 hertz.

6.3.8 Tracking of “live” telecom cables may not be possible if they have repeater stations, as the tone signal may cause noise via the amplifiers in the repeaters. It will thus often be necessary to request the cables are placed off line during tracking operations.

6.4 THE TG-10 UK TONE GENERATOR



6.4.1 DESCRIPTION

Innovatum manufacture a portable, multi input power tone generator in the United Kingdom. This unit, known as the “TG10 - UK”, will operate from internal batteries, external 18 - 36 volts d.c., and mains supplies from 85 to 285 volts a.c. 50 to 400 hertz. Nominal battery capacity is 7 ampere hours, and the internal circuitry dissipates very little power. This gives a theoretical operational time of 70 hours at 100 mA output, assuming fully charged batteries.

The tone output is switch selectable from 10 to 1000 hertz, with 4 preset output levels. Maximum output is approximately 1.25 amperes into a short circuit.

Internal batteries are recharged via either the mains supply or the external d.c. supply, and recharging continues during tone output operation.

The unit is enclosed into an orange high visibility weatherproof case, making the unit extremely portable. All controls and connectors are protected by the case lid.



Two LCD meters on the front panel give indications of input DC voltage, output current and output AC voltage.

6.4.2 OPERATION

The TG10-UK is simple to operate, and the following sequence should be used:

1. Connect the output yellow terminal to the cable conductor(s) the tone is to be applied to. Connect the blue output terminal to the return path conductor.
2. Determine the input power to be utilised and connect it. The options are:
 - a) External mains supply, connected via the IEC socket at the lower left of the unit. This power is switched via the rocker switch at the connector. A neon indicator shows when power is applied and switched on.
 - b) External d.c supply, 18 to 36 volts, connected to the red (+) and blue (-) terminals at the lower left of the front panel.
 - c) Internal battery supply, permanently connected.
3. Select the desired power system to the relevant position at the left hand rotary switch. If the mains is connected it will charge the batteries irrespective of the left rotary switch position. When the power is selected on the upper LCD will show the approximate d.c. input voltage.
4. Select the required frequency using the thumbwheel switches. **Note the switches select to 0.1 hertz.**
5. Select the right rotary switch to an output position. Switch the output switch, at the lower right of the panel, to the "ON" position. The lower



LCD should now show the approximate output current, in milliamperes.

6. Adjust the output level switch to give the desired output current.