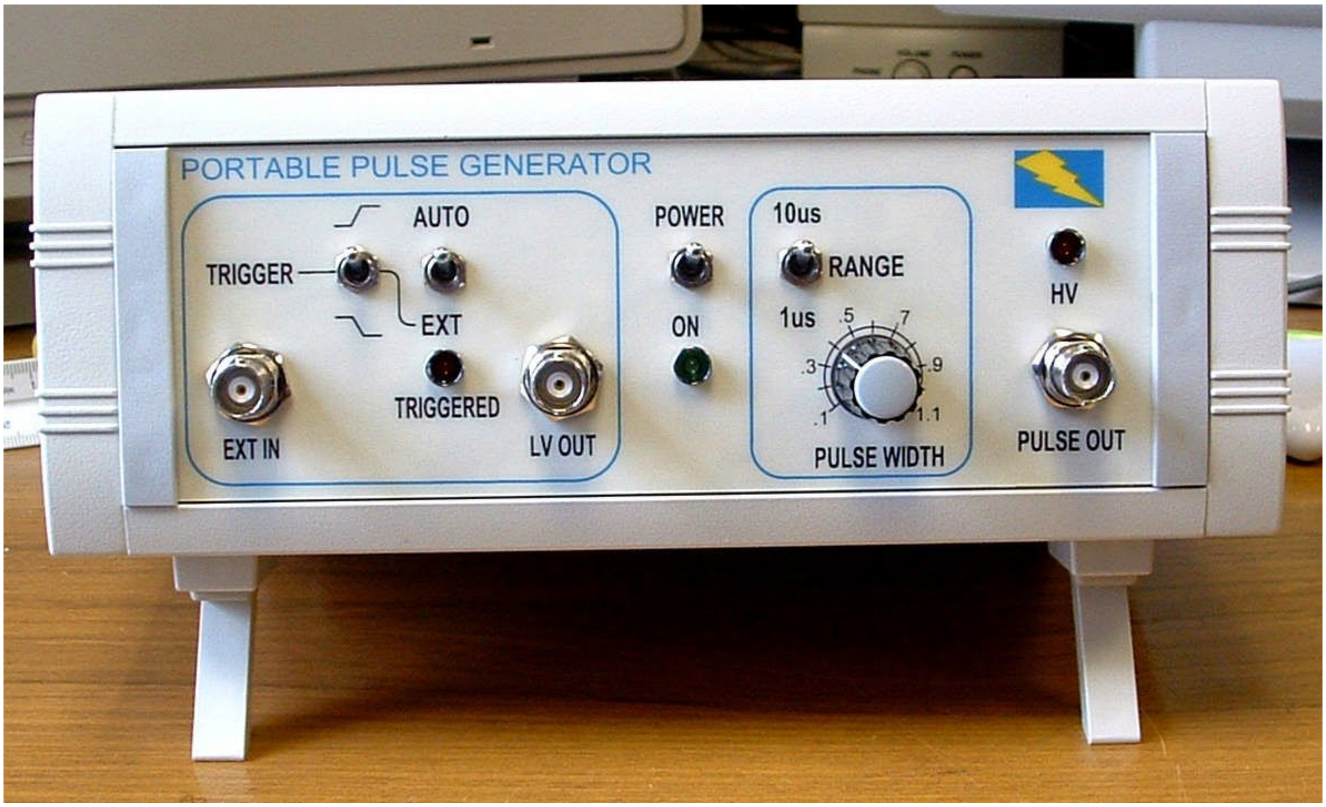
M&B Systems Power Test Equipment



Transponder Unit Type HVS 2000-CT/B

For use in Partial Discharge Mapping of HV cable systems

Advanced Technology for Industry

Cable Mapping Transponder Unit (optional)

The Cable Mapping Transponder Unit is used for PD location on installed cables. For PD location, the reflected pulse which has bounced from the far end of the cable is required for the location. For some simple cable circuits, and for all more complicated circuits, the waveforms of PD events can not be easily interpreted, and the reflected pulse is difficult to distinguish. Hence if the pulse arriving at the end of the cable is used to trigger a device which can apply a larger pulse to the cable, then this pulse can be used to carry out the location instead of the small unclear pulse which is naturally present in the cable
The transponder provides an output pulse height of 200v nominal peak into a high impedance, or 100V nominal peak into 50 ohms.

Operation using the manual transponder unit

When using PD location methods on high voltage cables, the mapping methods can be made more difficult if the cables are long or other circuit constraints apply. The transponder is designed for use in PD location in the the following cases

- Attenuation too large for long cables
- Waveforms too tricky to interpret
- Teed or jointed cables
- Cables with many ring main units
- Cables with no change in impedance at the far end

The idea behind the transponder operation, is to allow a signal from the end of the cable (strictly the position of the transponder) to be boosted and hence seen as a return pulse for the PD location system to use. Hence the essence of the equipment is a trigger system coupled to a large output pulse generator. When a pulse is received by the transponder which exceeds the trigger level, then the transponder outputs a large pulse which is sent back down the cable. This essentially makes a single ended location system into a double ended location system.

The huge advantage which the double ended location system has over the single ended, is that no waveform interpretation is required for the double ended case. The single ended location system works as shown in figures 1 and 2.

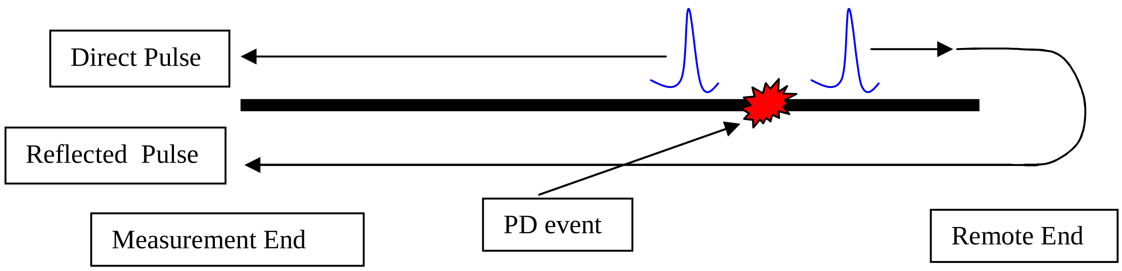


Figure 1 Single ended PD location method

When a PD event occurs, the pulses travel outwards in both direction from the originating site. The first pulse to arrive at the measurement end is the pulse which has travelled directly to the end. The pulse which allows the PD site to be located is the pulse which set off in the opposite direction, and has been reflected from the far end. If both of these pulses are identifiable, then location of the site of the PD event is easy. Results would look like:-

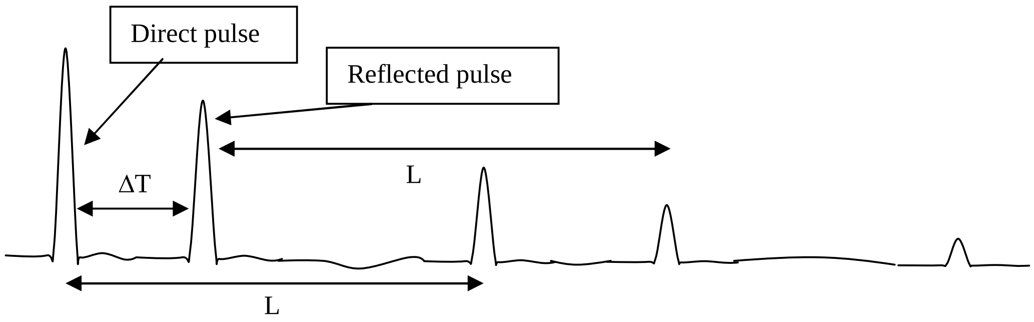


Figure 2 PD pulse trains as seen from the measurement end

The time difference between the first two pulses (the direct pulse and the reflected pulse) i.e. ΔT, locates the site of the PD event. Notice that the two pulses will continue to travel up and down the cable until they become too small to be seen above the noise level.. During this time, they will be reflected at exactly a cable return time away from the previous arrival at the measurement end. This gives rise to sets of pulses spaced at the cable return time.   If L is the return time of the cable length, and this can be easily measured, then the location of the PD event is

Location from measurement end (in %) = 100*(1-ΔT/L)

Or alternatively,

Location from remote end (in %) = 100*ΔT/L

However, it is often difficult to carry out the locations using this simple single ended method for the reasons mentioned above at the start of this section. Mainly the reflected pulse is either too small or it is confused with a lot of other pulses which may be present due to other reflections, noise, or some other 'distortion' of the waveform. Hence if the second pulse could be made to stand out, then location would be simple. This is the task of the transponder, which simply boosts the size of the reflected pulse so that it can easily be distinguished. A typical waveform would then look like:-

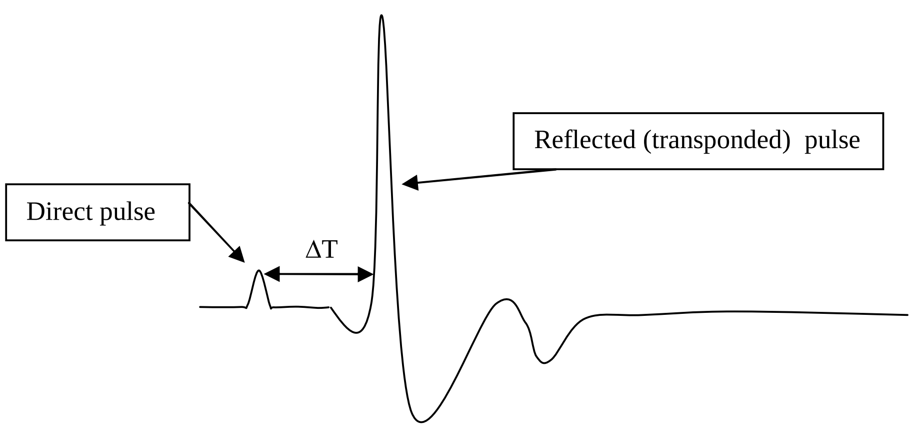


Figure 3 Example of waveform with transponded pulse

In most cases the digitizer would be set to see the size of the direct pulse, so that the transponded pulse would be heavily off scale in normal circumstances. Under these conditions, the amplifiers would be overloaded, and so the waveform following the transponded pulse probably is not representative of the cable reflections which might exist in the absence of the transponded pulse. The location of the PD site is calculated in exactly the same way as the standard single ended method, using the times ΔT and L.

The transponded pulse can be delayed, so that the waveform can be measured in the conventional single ended way, but still be triggered using the tranponded pulse. This requires the digitizers to have enough memory to able to allow this function. The digitizers need to run at the same saple rate as would be used in the single ended method, and have a memory depth which will allow either 20μSec, 50μSec or 100μSec in addition to the cable time L. In this case the whole of the original waveform can be preserved, but triggered with the delayed transponded pulse.

It can be seen from figure 4 that the original waveform can be preserved with this method. This allows the single ended method to be used, and in addition, a confirmation of the position of the reflected pulse using the known delay of the transponded pulse.

A typical waveform would look like:-

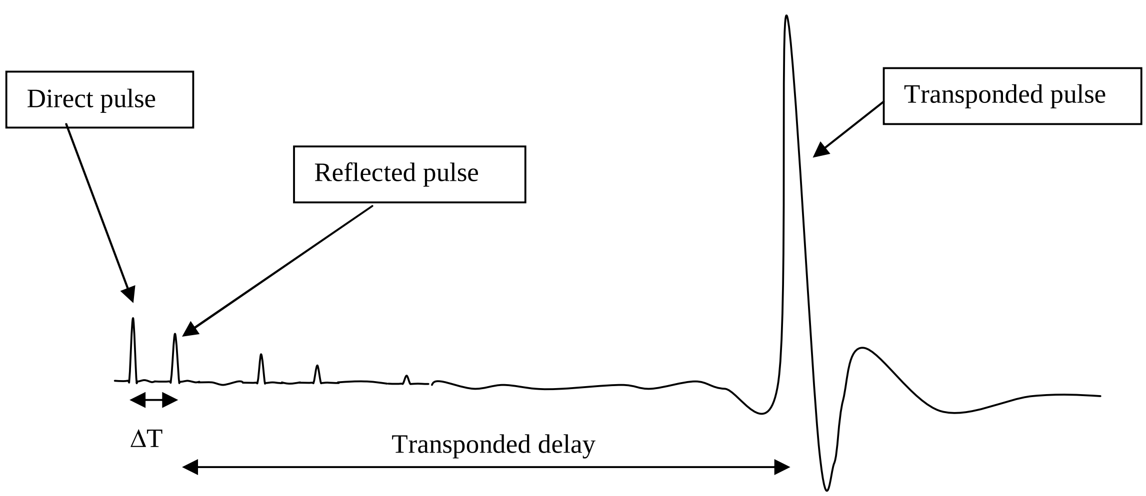


Figure 4   Using the transponder with transponded delay

Software for PD mapping which knows about transponders, should allow for the entry of a variable transponder delay to be able to show and calculate the PD locations.

Tips for using the transponders for PD location.

1. When setting up the transponder locations at the remote end, use an oscilloscope to set up the transponder trigger level. This helps to show that PD pulses and not noise or some other pulse type are actually triggering the transponder.
2. Try to ensure that the same signals of the PD events are being seen by both ends of the cable. This will guarantee that the transponder will trigger on pulses which will reach the far end of the cable. For example, if the cable is very long, (e.g. greater than 3km say) and the pulses on the cable are very small (e.g. around 50pC say), then it is unlikely that these PD pulses will be seen at both ends of the cable. Hence transponded pulses will not be related to any signal which can be seen from the measurement end of the cable. This would be another reason to use a delayed transponded pulse, and then the original pulse train is visible. In such a case, it will be obvious that the transponded pulse is not related to any signals at the measurement end.
3. If time permits, carrying out the measurments at both ends of the cable can provide confirmation that locations have been made correctly. This doubles times for measurements, but this can sometimes be worth it in cases where there is doubt or confusion as to the correct locations on line.

4. For most on-line measurments, there will be only a few sites which are responsible for PD events. Use the transponder so that it triggers on these events, and not on any other pulses which may be related to noise or interference. In other words, take advantage of the fact that larger PD events do can make measurements much easier. This must be balanced with the fact that PD sites often have a characteristic magnitude, especially whilst they are developing. Hence try to ensure that PD events as small as possible can be recorded, as these may be from PD sites which will grow into more active sites in the future. Try to take advantage of good PD signals, but ensure that as good a dynamic range of events as possible, can be captured.
5. Often the PD activity can change during measurements. These will vary with load, voltage and time etc. It is often useful to have staff at the remote end during on-line PD testing, to arrange for adjustment of the transponders during the tests. Mobile communications are very important in this case, as is accuracy of instructions.
6. The cable length L can be measured using the transponders on-line. Set up a pulse generator (a transponder is ideal for this) at the measurement end, and allow the transponder at the remote end to be triggered on the pulse generated at the measurement end. The time difference between the launched pulse and the received transponded pulse, is the cable return travel time. Check that this measured time seems sensible for the length of cable being tested. Check also that the measurement is repeatable, and not a trigger from noise at the transponder end. This is best carried out with two transponders, as the signal levels will be large enough to ensure noise is not a problem in triggering the remote transponder.
7. Transponders can be put in cable circuits at ring main units. They do not have to be put at the ends of cables. However, make sure that the transponder is well coupled to the circuit. Use the cable length method to ensure that the system responds to pulses on the cable, and that the coupling of the transponded pulse back onto the cable is adequate. Often in on-line cases, the through coupling of CT's on earth straps is poor. In these cases, signal levels may not be the same as at the ends. Check this if you intend to use this method.
8. The transponders can be used off-line if required. In the off-line case, use another cable core as the return path for the transponded signal. In this case, the transponded pulse will never appear on the main signal path, so use a different channel on the digitizer/oscilloscope for this application. It is generally easy to do this method off-line, as no coupling difficulties arise. The signal level of 50V may actually be too big in this case, and divide by 10 probes may have to be used to detect the transponded pulse

Manual Transponder Specification

Output Pulse magnitude	100V into 50Ohms
Output Pulse width	Variable between 100nSecand 10µSec
Output Pulse trigger	Internal 10 Hz generator or External from rising or falling edge of external signal at TTL level
Input Bandwidth	10MHz
External Trigger pulse for oscilloscope	2V nominal
Input / Output protection	All protected by gas discharge tubes
Input / Output connections	BNC type
Power	Rechargeable lead acid. Capacity 6 hours between charges
Charging unit for battery	110-220V,50/60Hz
Weight	4 Kg

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