

## Differences between the BTB series and an electric field mill

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*The Biral BTB series thunderstorm detectors use changes in the atmospheric electric field to detect and range lightning, as well as to warn of potential overhead thunderstorm development. Changes in the electric field between 1-45 Hz are used, which is a considerably lower frequency than signals produced by electromagnetic (radio) waves used for wireless communication or emitted by electronic equipment. Whilst signals in 1-45 Hz are produced by the relatively slow changes in electrostatic fields, the 1 Hz high pass filtering used by all BTB sensors prevent direct measurement of the atmosphere's background (DC) electrostatic field. The BTB series measurement technique is therefore referred to as "quasi-electrostatic". This technique has the distinct advantage of removing noise from slow changes in the electric field below 1 Hz, which are not associated with lightning.*

The background electric field of the atmosphere typically varies on timescales of minutes and is measured using a device called an electric field mill. Also used in thunderstorm warning applications, this instrument typically incorporates a metal blade rapidly rotated by a motor, which is alternately exposed then shielded from the atmosphere. The current induced on the blade electrode by this movement is proportional to the atmosphere's electric field. These instruments are designed to measure the DC and slow-varying component of the atmospheric electric field, and typically output every second. The main purpose of a field mill is to accurately measure the steady-state electric field directly above the sensor. The ability to quantify the magnitude and polarity of the electric field, including during fair weather conditions away from thunderstorm activity, makes them well suited for atmospheric electrical research.

Field mills can detect the increased field strength associated with strongly charged clouds within a few kilometres from the sensor. Clouds which generate strong electric fields are more likely to

produce lightning, so these measurements can be used to warn of potential overhead lightning activity. Typically, a warning is produced if the electric field magnitude exceeds a pre-defined threshold. Given this relies on an absolute value, the field mill must be correctly sited and calibrated in order to be effective (close proximity to buildings and trees will significantly lower the values and reduce the probability of thunderstorm detection, for example). Since not all clouds which produce a strong electric field generate lightning, one of the main limitations of a field strength value used in isolation is the high false alarm rate. Setting a higher threshold can reduce this, but usually at the expense of lead time for the storm's arrival or increased failure to warn, given the very limited range where a strong electric field exists around a storm cloud (typically less than 5 km). It is therefore advisable to use strong electric field warnings in combination with lightning detection. To address this, some field mill-based warning systems also detect nearby lightning by the sharp change in electric field it produces. Whilst the difference in background electric field measured by a field mill before and after a flash can be used to

broadly estimate its proximity up to ~30 km away, determination that the sharp change in field was generated by a lightning flash can be challenging to do, especially during heavy precipitation where background noise increases substantially.

The BTD series is designed to monitor conditions where a thunderstorm may develop overhead, as well as detecting lightning from active thunderstorms in the local area. For this, it does not need to measure the background field strength directly, only its rapid changes. Therefore, it cannot be used to quantify the background electric field, which is the main purpose of a field mill. However, the BTD does infer the existence of strong field magnitudes by sampling the charge on precipitation falling on the antennas, which is proportional to the atmospheric electric field. A strong electric field also generates clouds of ions near the surface, resulting from corona discharge from the tops of nearby grounded, tall structures and vegetation. These wind-blown ion clouds, referred to as space charge, are also detected by the BTD. Like a field mill, the BTD can therefore warn of the strong electric fields associated with overhead thunderstorm development.

In addition to warning of strong electric fields, the BTD also locates all forms of lightning over a comparatively large area. For example, the BTD-3XX sensors have a range of 83 km, which is 2-3 times the maximum range of a typical field mill. The neutralisation of charge in a thunderstorm by a lightning flash usually takes approximately 0.2 seconds, with ~95% of flashes lasting less than 0.9 seconds. The 100 Hz sampling rate of the BTD series is substantially higher than the one second sampling typical of a field mill, meaning that these signals are captured in appropriate detail for reliable detection and range calculation.

To summarise, field mills are ideally suited for long-term monitoring of the slow-varying, background atmospheric electric field, where absolute values and polarities are required, during both fair and disturbed weather. The BTD series is designed specifically for use as a complete thunderstorm warning system, with an emphasis more on aiding operational decisions on lightning critical activities than quantification of the atmospheric electric field at the site.



## Advantages of the BTD series compared to an electric field mill:

- Field mills normally use high DC electric field thresholds to warn of potential thunderstorm activity, which tend to give a high false alarm rate (~90%), since most shower clouds will activate it. The BTD series use specific signals such as strongly charged precipitation or strong E-field variability (not absolute strength), which lowers the false alarm rate.
- Some field mills report nearby lightning, but typically within 30 km and with poor resolution. The BTD-3XX produces lightning warnings up to 83 km and reports range to the nearest 0.01 km.
- Unlike the BTD series, field mills do not have the ability to provide lightning direction, so cannot provide lightning location, only broad proximity.
- Field mills can produce lightning false alarms, since unlike the BTD series they cannot distinguish between other sources of rapid electric field change, e.g. nearby movement, birds flying over, heavy rain etc. which increases their false alarm rate.
- Field mill sensitivity (and therefore lightning range estimation) is highly dependent on site conditions and is difficult to calibrate without expert knowledge and equipment.
- Field mills have moving parts, so are liable to mechanical failure, jamming, wear etc. The BTD series have no moving parts and operate under harsh weather conditions and environments.
- Field mills need their top (aperture) to have a clear view of the sky at all times. This means that they will not work if there is any obstruction on them, e.g. bird sitting on the top or snow cover (field mills are not normally heated). Our BTD series are resistant to this, and will work with snow or birds on the antennas.

### About the Author

*Dr Bennett is the Meteorological Products Manager for Biral, UK. He has a PhD in Atmospheric Electricity and over 10 years' experience in research and development of lightning detection systems, including working at the UK Met Office and is a visiting Research Fellow at the University of Bath. He has written over 30 papers in atmospheric electricity, published in peer-reviewed international journals.*