# Monitoring Australian Utility Poles

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**Abstract:** Utility power poles span the Australian landscape and are particularly important for ensuring power to remote communities. A feasibility assessment for using fibre Bragg gratings to assess telecommunication utility poles is presented.

## 1. Introduction

The internet-of-things (IoT) is reaching into society across many areas, a consequence of a gradual expansion form transmitting communications data to transmission diagnostics data pretty much from anywhere. Within cities, smart metering and so on is being adopted worldwide, reflecting the power industry as an earlier adopter of IoT related technologies in power. Much of this technology is RF based, typically wireless – within high density relatively small areas with the consumer base to justify scaling, the technology already adds value monitoring power in the home. More recently, questions have been raised about the availability of wireless to sustain the IoT once diagnostics reaches critical numbers that exceed anything known today. This is especially of concern as a vast new array of diagnostic technologies comes on line that is data intensive – a forerunner of this has been the issue of latency already impacting the gaming community and the issue of vast volume transmission associated with 4K imaging in hospitals, presently dealt with by LiFi. From the power industry perspective, these issues may not appear so critical but given the rise of photonics within the IoT, there are strong incentives for moving towards photonic based sensing for diagnostics – in remote regions, optical fibre is superior to cable, and photonics offers hardware encoding of data rather than within the software, potentially reducing the looking data crunch where much consumption is directed towards coding and identification than actual content. Arguably, much more critical applications might be the monitoring of critical infrastructure


Figure 1. (a) An old, abandoned, timber, utility pole no longer in use at the University of Sydney; (b) A packaged FBG is placed approximately 1.3 of the way up the pole.

particularly that in remote regions where daily visitations are not feasible. Here, we suggest optical fibre sensing technology offers a potential diagnostic for monitoring power utility poles.

## 2. Power Utility Poles

The delivery of electricity to areas relies on continual unimpeded transfer through cables. Much of this can be very energy inefficient over large areas using traditional cables. Nevertheless, these cables are supported by posts that span across territories of varying vastness. Australia has some of the longest stretches in the world, often through landscapes that raise enormous challenges for their maintenance. The interior populations in country towns are often small raising the cost of maintenance logistics and challenging the management of routine monitoring and replacement.

The majority of poles in Australia are timber [1], typically a local hardwood such as an ironbark. They are about 30 cm in diameter, and up to 10 meters tall. Smaller versions of similar thickness a few meters typically occur near the transmission box they feed into – Figure 1 shows an example near a utility box at the University of Sydney in Australia. To reduce in-ground decay, mostly by fungi, the base of these posts are often sealed in a concrete mix in an attempt to reduce moisture, oxygen and temperature build-up. However, over time this too can break down and become exposed. For this reason, the timber is often dosed with poison. To enhance resistance against termites, a significant problem in Australia, they are coated with various compounds. In Sydney this can be K55 Creosote, which has repeatedly been shown to have minimal toxic effects beyond the purpose of reducing termites [2].

## 3. Characterising Poles

Poles can be inspected by attendance and carrying out direct visual inspections, boroscopic probing at the base, and sample drilling. Without even considering remote locations, there remains some debate as to whether current methods are generally satisfactory, and a series of advanced techniques are being explored. It has been suggested that an ideal method of pole assessment would be able to indicate a pole's remaining strength, serviceability an remaining life with reliability [3].

More advanced methods of diagnosing tree properties involve stress testing, experimental modal analysis and resistance drilling [1]. Stress testing is an interesting one because it essentially measures a direct acoustic ore mechanical impedance. This approach has been used to detect the presence of decay in timber bridges since it affects the stress wave propagation velocity [4].

The mechanical or acoustic impedance, $Z$, is related to the density of the pole material, $\rho$, the propagation velocity of a stress wave, $c$, imparted to the pole and the cross-sectional area of the pole, $A$: $Z = \rho c A$. Plotting the velocity per unit force applied as a function of time produces a frequency plot that characterises the inverse impedance, or motility [1]. Thus, the measured frequency will be directly impacted by changes in the wood properties.

The question we want to ask is how we might use such an approach to achieve remote diagnostics, particularly in remote fields where regular inspections or maintenance will not occur. Such diagnostics could in the first instance be sufficient to monitor earth subsidence, the occasional earth quakes that occur across Australia and so on. With a standardised force being applied regularly, perhaps powered by the cables themselves, the quality of the timber over time can be monitored. Here, we show preliminary results of the simple effectiveness of an FBG to directly monitor in time the imposition of a force onto a pole. The spectral shift is a direct measure of the changes in density and displacement that also affect the velocity so the wavelength deviation a function of time is essentially the same graph. It can be used to directly gauge the frequency response, a combination of frequency itself and decay time ultimately determine by local changes in net density. The material response is therefore a reflection of the material elastic properties at that point in time.

Figure 1(b) shows the packaged, conventional type I fibre Bragg grating (1 cm, R ~ 20%), produced with an ArF exciplex laser. The package itself was designed to keep the rain off the element and fabricated using 3D printing. The grating, under the 3D printed protection, is first epoxied to the centre of a 15 mm ×100 mm aluminium patch of thickness 0.5 mm (for ease of handling and attachment to the telegraph pole in the field). This patch is then epoxied directly to the timber pole using Araldite epoxy.

A second FBG is also present on the patch but has one end unfixed and is therefore insensitive to strain; this grating is for temperature measurement only and used to subtract the $D\lambda$ component of FBG1 that is due to temperature changes. The force imparted was by the sudden placement of the weight of one of the researchers (Dr/ Kevin Cook) against the pole. Although the pole itself moved considerably in its concrete base, which was showing signs of deterioration, the imparted forced was measured as a frequency amplitude variation, accompanied by a resonant decay of 1/e ~ (8-10)s. Despite the different impartations, both risetimes and decay times were similar and showed no obvious nonlinear deviations, indicating the mechanical quality of the timber remains largely intact. Visual inspection also failed to find any obvious decay other than some splitting at various points associated with long term exposure to harsh weather. However, this did not appear to impact the elasticity of the pole in any detectable way; simultaneously it indicated no problems with the FBG coupling to the timber. The free FBG showed no response as expected. The results are summarised in Figure 2.

## 5. Conclusions

A single FBG sensor suffices to detect and measure the elastic timber properties of utility poles, making it an ideal IoT compatible sensor. It can be operated remotely and at long distance, perhaps embedded within the utility cables themselves or within telecommunication cables nearby.

## 6. References


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