Paper No.
C2024-20830

AMPP ANNUAL CONFERENCE + EXPO
MARCH 3-7, 2024 | NEW ORLEANS, LOUISIANA

Mitigating Stray Currents in 5G-Connected Metallic Structures: A Comprehensive Solution

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ABSTRACT

As the telecommunication industry transitions to the fifth-generation mobile network, commonly known as 5G, the adaptation of this technology presents certain challenges that require careful consideration. While existing wireless communication infrastructures can be utilized for implementing 5G, one notable concern involves the potential for stray currents resulting from the installation of 5G equipment on pre-existing structures, particularly those made of metal. These unintentional stray currents have the potential to cause equipment damage, necessitating the development of a comprehensive solution to mitigate their occurrence.

This paper focuses on addressing the issue of stray currents in 5G-connected metallic structures through the proposal of a comprehensive solution. The objective is to provide a preventive measure that ensures reliable and safe operation of 5G equipment without the risk of equipment damage caused by stray currents. The proposed solution aims to be universally applicable to all 5G equipment connections, providing a standardized approach to addressing this concern and facilitating the widespread adoption of 5G technology.

Keywords: Telecommunication industry, fifth-generation mobile network, 5G technology, and stray currents.

INTRODUCTION

The telecommunications sector is transitioning towards the fifth-generation mobile network, frequently labeled as 5G or 5G tech. While current wireless communication systems can support this advancement, specific issues must be resolved for a dependable transition. A particular challenge is the unintended currents which may arise when 5G apparatuses are affixed to legacy structures predating 5G, notably when metal constructs are involved. Ideally, when a power unit is linked to an antenna via a supply and return conduit, no major currents should register on the antenna. Yet, in many scenarios, unwanted currents deviate into the foundational frame of 5G antennas. This unintended deviation can harm devices, indicating an imperative to tackle these currents with a holistic approach. Such a method should inhibit the emergence of these stray currents in metal structures associated with 5G. This methodology should cater to all 5G device integrations.

Many existing infrastructures are embedded in the ground, primarily focused on stability without specific designs to insulate against stray currents. Consequently, parts of these structures come into direct contact with the earth, allowing currents to flow into the soil instead of designated grounding conductors, leading to heightened corrosion at the discharge points. With the introduction of 5G technology, equipment requires adaptations or entirely new designs to handle stray currents, which have risen dramatically from rarely surpassing 0.1mA in earlier generations to potentially exceeding 100 mA in 5G. This surge poses increased safety and corrosion threats, necessitating a specialized corrosion prevention system for 5G. As wireless tech progresses, it's anticipated that stray currents will intensify, emphasizing the need for adaptable corrosion control systems for future demands.

CASE HISTORIES

INTRODUCTION

The dedicated team specializing in corrosion assessment carried out a comprehensive evaluation to determine the presence or lack thereof of stray currents. These currents were potentially induced by 5G equipment and were present on various structures, specifically the monopoles and self-standing towers. The inspected monopoles had a distinct tapered design, while the self-supporting tower was characterized by its three tubular legs. The examined monopoles are of identical design and dimensions, sourced from the same supplier. The sole variation lies in their location, as each monopole is situated at a distinct site.

FIELD VISIT

In undertaking the assessment of stray currents, a range of non-destructive techniques was systematically applied. The evaluation not only checked for the presence of stray currents on the tower's ground conductors but also gauged the ground resistance at these conductors. Additionally, the resistance was measured for other grounding conductors that were positioned above the ground level at each respective site.

The methodology for assessing stray currents was meticulously structured. It was more than just a routine check; the process involved a systematic approach to thoroughly probe all potential sources of stray currents. This method ensured a holistic collection of field data, paving the way for conclusions that were both informed and firmly rooted in scientific rationale.

Current Measurements using Clamp-ON Ammeter and or Swain Meter

Either a clamp-on ammeter or a swain meter was positioned around the tower grounding conductor, cabinet grounding conductor, pole grounding conductor, and hybrid cables to measure and note the detected current values. Before these devices were used, their operational accuracy was confirmed. A test setup was established, and a known current (2A) was introduced using a power source. The clamp-on ammeter (referenced as Figure 1) and the swain meter (referenced as Figure 2) were fitted around the test cables. Observations revealed that both meters displayed a current matching the introduced 2A, confirming the accurate functioning of both the clamp-on ammeter and the swain meter.

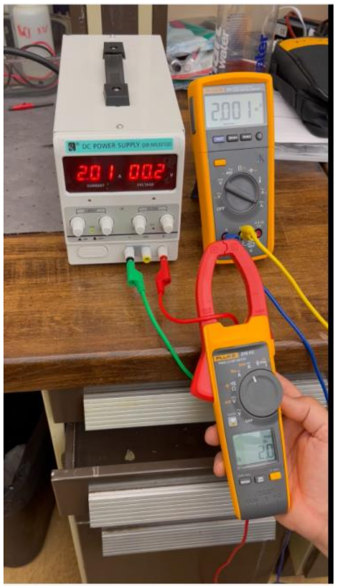

Figure 1: Photograph taken during the verification of clamp-on ammeter.

Figure 2: Photograph taken during the verification of swain meter.

The results from the current measurements taken across hybrid cables, as well as the ground conductor linked to the base plate or pole shaft of the monopole or those attached to the legs of the self-standing towers, are detailed in table 1 below. The designations "unit 1," "unit 2," and "unit 3" in the accompanying table represent 5G apparatuses provided by various customers. The currents that have been measured and documented are of the direct current (DC) type.

Table 1
Current (Amperage) data

Structures	**5G Unit**	**Delta (Δ) Current detected across the Coax Hybrid Cable, Amps**			**Current detected across tower ground conductor, Amps**			
		1	**2**	**3**	**1**	**2**	**3**	**4**
Monopole 1	Unit 1	92.8	--	--	88.0	Not present	Not present	Not present
Monopole 2	Unit 2	0.003	--	--	0.0	0.0	Not present	Not present
Self-Supporting Tower	Unit 1 (1) Unit 2 (2) Unit 3 (3)	92.4	4.373	0.613	4.6 (Leg A)	14.2 (Leg B)	60.1 (Leg C)	Not Applicable

Note: In the table above, Delta (Δ) Current measured across the 3-phase hybrid cable is the difference in the current flowing in the supply line and the current flowing in the return line.

Images of the monopole and the self-standing tower equipped with 5G units can be viewed in Figures 3 and 4.As observed from Table 1, monopole 1 has only one ground conductor, while monopole 2 possesses two, falling short of the recommended minimum of at least one ground conductor for each leg of the tower or four ground conductors for monopole as outlined in TIA(1) -607-B.[1] It seems that the missing ground conductors may have been severed and potentially stolen. On monopole 1, which is equipped with 5G unit 1, a total delta current value of 92.8A was detected across its two hybrid cables. Meanwhile, a current of 88.0A was registered across the lone ground conductor connected to

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monopole 1's base plate. This suggests that the majority of the delta current identified in the hybrid cable flows through the structure, proceeding to the ground ring via the monopole's ground conductor, and ultimately reaches the cabinet via the cabinet grounding conductor (Figure 5).

The data from the tests indicate that the 5G unit 2, mounted on monopole 2, isn't transmitting any currents onto the structure. Self-standing tower had three 5G units and it can be clearly seen that unit 1 is pumping more current onto the self-standing tower. Though unit 2 on the tower is pumping current on to the tower the current value is very low when compared to current pumped by unit 1 on to the tower.

Figure 3: Photograph showing a monopole and the 5G unit connected to it.

Figure 4: Photograph showing a self-standing tower and the 5G unit connected to it.

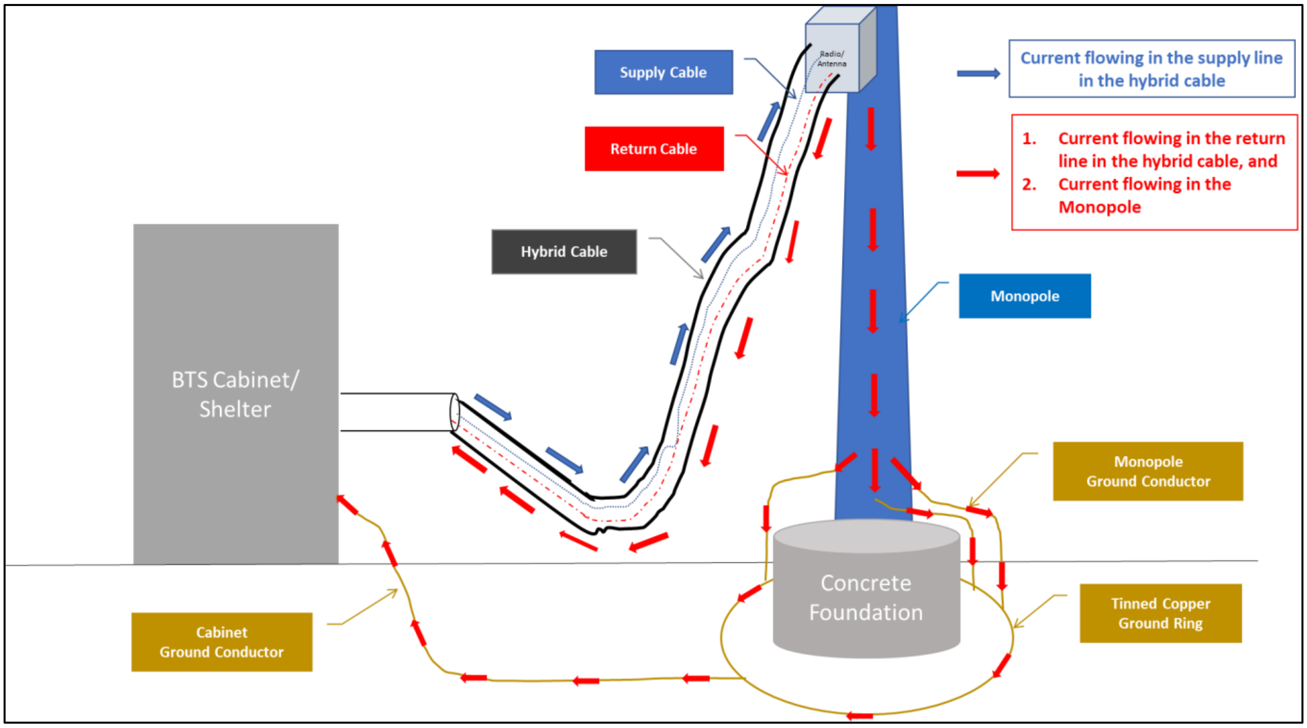

Figure 5: The photograph above provides a general depiction of the current flow.

To gain a deeper insight into potential stray currents emanating from the 5G units and how they might affect the supporting metallic structures, monopole 3 was chosen for study. This pole was unique in that it housed three distinct units, and it was possible to temporarily interrupt the 5G signal. This allowed for a more detailed examination of the stray currents and their origins, providing a comprehensive understanding of their impact on the infrastructure.

Initial current measurements were conducted with all three units actively running. Following this, each unit was systematically powered down, and at each stage, current readings were captured. This methodical approach provided clarity on the extent of stray current generation from each individual unit. Detailed amperage data reflecting these findings can be referenced in Table 2 provided below.

Table 2
Current across monopole 3 grounding conductors

	All units are ON	**Unit 3 is OFF** UNIT 2 is ON Unit 1 is ON	**Unit 3 is OFF** **UNIT 2 is OFF** Unit 1 is ON	**Unit 3 is OFF** **UNIT 2 is OFF** **Unit 1 is OFF**
Current Detected across Ground Conductor 1, A	10.2	10	9.6	0.2
Current Detected across Ground Conductor 2, A	5.3	5.1	5.5	0.2
Current Detected across Ground Conductor 3, A	5.3	4.8	5.1	0
Current Detected across Ground Conductor 4, A	11.1	11.8	10.4	0.4
Total Current, A	**31.9**	**31.7**	**30.6**	**0.8**

Findings of the current measurements across monopole 3 grounding conductors are as follows:

1. Monopole 3 has four grounding conductors.
   - DC current through the monopole 3 grounding conductor 1 is 10.2 Amps, 5.3 Amps through grounding conductor 2, 5.3 Amps through grounding conductor 3, and 11.1 Amps through grounding conductor 4. A total current of 31.9 Amps is passing through the grounding conductors.

2. When unit 3 was turned off. There was a total current of 31.7 Amps current passing through the pole grounding conductors.
   - This finding suggests that unit 3 was pumping only 0.2 Amps current on to the pole.

3. Unit 3 was already in turned OFF condition, then unit 2 was turned OFF. There was a total current of 30.6 Amps current passing through the pole grounding conductors.
   - This finding suggests that unit 2 was pumping 1.1 Amps current on to the pole.

4. Units 2 and 3 were already in turned OFF condition, then unit 1 was turned OFF. There was a total current of 0.8 Amps current passing through the pole grounding conductors.
   - This finding suggests that unit 1 was pumping 29.8 Amps current on to the pole.

Based on the results from the current measurements, it's clear that the 5G unit 1 on the monopole 1, 5G unit 1 on the monopole 3, and 5G unit 1 on the self-standing tower are transferring currents in excess of 1 A to the examined monopoles, as well as the self-standing tower. Ideally, the concrete foundation of the poles or towers must not be covered with soil (Figure 6). For poles or towers that are directly embedded in the soil, or in situations where the concrete foundation is submerged within the soil (Figure 7), there's a deviation in the current's pathway. Instead of the current traveling through the ground conductors to the ground ring and subsequently to the cabinet, it takes a more direct route, discharging straight from the structure into the soil. This altered flow results in specific areas on the structures from which the current discharges to the soil. These points of discharge are at a heightened risk of rapid corrosion, as depicted in Figure 8.

Figure 6: Photograph of the tower where the concrete foundation is open to atmosphere.

Figure 7: Photograph of the tower where concrete foundation is submerged within the soil

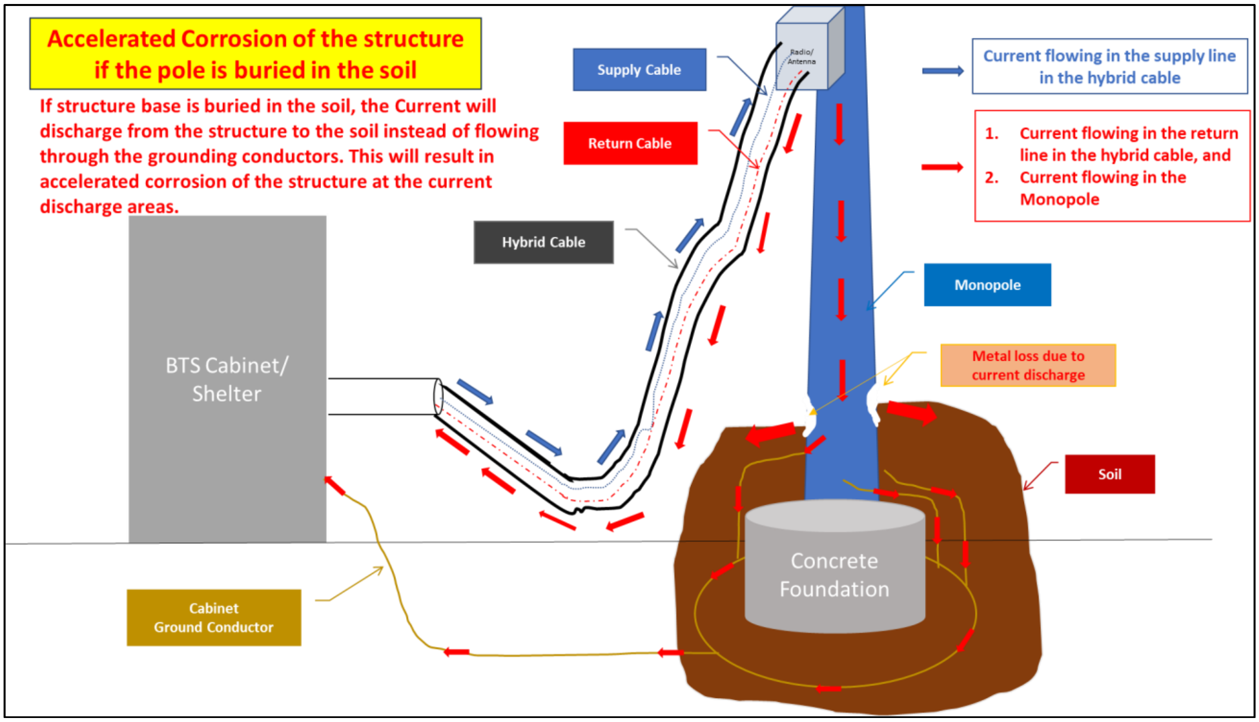

Figure 8: The photograph above provides a general depiction of accelerated corrosion of the structure if the pole is buried in the soil.

<u>Ground Resistance Measurements using Clamp-ON Ground Resistance Tester</u>

The clamp-on ground resistance tester was used to measure the resistance of the grounding conductors of the monopole/tower, cabinet, and pole, and the resulting resistance values were documented. Before its field deployment, the tester was checked to ensure it was functioning correctly. For verification, it was clamped around a standard test ring with a nominal value of 5.1Ω. A reading between 5.0 – 5.2Ω would confirm the device's accuracy. The test yielded a result of 5.2Ω, verifying that the instrument was in proper working condition.

The results from the resistance measurements taken on the ground conductor linked to the monopole's base plate or those attached to the self-standing towers' legs are outlined in the table 3 below.

Table 3
Ground Resistance data

Structures	**Ground Resistance detected across ground conductor, Ω**			
	1	**2**	**3**	**4**
Monopole 1	The values are fluctuating	Not present	Not present	Not present
Monopole 2	0.061	0.062	Not present	Not present
Monopole 3	1.4	0.026	The values are fluctuating	0.027
Self-Supporting Tower	The values are fluctuating	The values are fluctuating	The values are fluctuating	Not Applicable

The ground resistance values measured using clamp-on meter across the monopole 2 grounding conductors are well below 25Ω as per the project requirements. However, ground resistance values cannot be recorded at the ground conductors of the monopoles 1 and 3, and self-standing tower as the resistance values were fluctuating; and this could be due to high currents flowing through the monopole/tower ground conductors.

- During the ground resistance measurements, it was observed that it was very difficult to unclamp the clamp-on meter after the test was complete at monopoles 1 and 3, and self-standing tower. This could be due to modification of the magnetic circuit of the tester due to flow of higher currents through the grounding conductors.
- It is strongly advised not to disconnect the grounding conductors when measuring ground resistance due to the high currents present in the metallic structures. Overlooking this precaution may result in severe consequences, including the risk of electric shock that could be fatal.

CONCLUSIONS

The current detected when clamp-on ammeter was placed across the tower and monopoles grounding conductors is not a stray current but in fact a DC induced current.

- Stray current refers to the current that flows elsewhere rather than along the intended current path. Assessment of monopoles and self-standing tower suggest that this is not the case of stray currents, in fact some of the applied DC current, in addition to along the return line in the hybrid cable, is returning from the antenna/radio through monopoles/tower legs to the actual power source.
- In this case the applied DC current has multiple paths to return to power source, and monopole/tower is one of the paths. This suggests that monopole/tower was part of the current return loop from the initial design stage itself.

RECOMMENDATIONS

Recommendations for corrosion control in metallic structures with potential stray currents from 5G equipment:

- Ensure structures are anchored with concrete foundations and avoid direct burial.
- Utilize separate grounding cables running from the 5G equipment to the ground ring.
- Apply an isolating coating at the top of the structures to separate the 5G equipment from the metallic structures.
- When equipping monopoles and towers with 5G units, it's crucial to consider the installation of a cathodic protection system to counteract potential accelerated corrosion challenges. Cathodic protection controls metal surface corrosion by converting that surface into the cathode of an electrochemical cell, either by using sacrificial anodes, commonly made of zinc or magnesium, or applying an external electrical direct current. Sacrificial anodes, strategically placed near corrosion-prone areas, corrode preferentially, redirecting the potentially harmful current from the 5G unit away from the primary structure. On the other hand, when employing external electrical currents, the structure is polarized cathodically, staving off the oxidation process leading to corrosion. This is particularly advantageous for larger structures or those in aggressive soil conditions. Regardless of the method, the overarching objective remains the same: to combat the adverse effects of stray currents and ensure the durability and structural integrity of 5G installations.

REFERENCES

1. ANSI[(2)] /TIA-607-B, Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.

[(2)]American National Standards Institute, 25 W 43rd Street, 4th floor, New York, NY 10036, USA