

# Earthing and Lightning Protection

## Design Considerations for Large, Utility Scale PV Plant

Date : 26 – 27 Nov 2019

Venue: Misty Hills Country Hotel, Muldersdrift, Johannesburg, South Africa

### EARTHING AND LIGHTNING PROTECTION – Design Considerations for Large Utility Scale PV Plant –

A two-day course to be presented on 26 & 27 November 2019 at the Misty Hills Country Hotel in Muldersdrift, Johannesburg, South Africa

#### WHY THIS COURSE ?

**Learner Perspective:** The objective with this course is to increase awareness of and emphasize earthing & lightning protection system design considerations to ensure safety of personnel, plant structures and equipment. At the same time, to be aware of the codes that govern the designs and installations of earthing and lightning protection systems and why a “cook-book-approach” should be avoided. This course addresses the relevant issues from a theory and practical perspective that will enable you to reduce down time of your plant and equipment through correct application of these principles.

**African Perspective:** The UK announced \$126 million of funding for renewable energy in Africa with a program currently backing several renewable energy projects in countries, such as, Tanzania, Burundi, Nigeria and Kenya. According to the International Renewable Energy Agency (IRENA), growth over the past year was primarily driven by five specific countries: Egypt, South Africa, Kenya, Namibia and Ghana. From TERRATECH's experience with some existing plant in Southern Africa, there are lessons to be learned with the objective to ensure that new projects can be commissioned without serious earthing and lightning protection issues. This course is another initiative by TERRATECH and is launched under the *Earthing Africa*<sup>TM</sup> brand in support of the noted objectives.

**Course-Specific Perspective:** There are many courses on earthing and lightning protection. Unlike other courses, this course is specific to PV plant. It offers specific outcomes and offers many nuggets of wisdom, in-line with TERRATECH's motto: *Optimised solutions beyond the ordinary*. In addition, the course material was compiled to offer a deeper understanding of the aspects considered, linking theory with practise and to provide answers to typical *Why on Earth*<sup>TM</sup> questions raised. Overall, the course objective is to promote a better understanding of earthing, electromagnetic compatibility (EMC) and lightning protection based on sound engineering practise.

#### WHAT DOES THE COURSE COVER ?

Probably the best place to learn about earthing, electromagnetic compatibility (EMC) and lightning protection is a large free field photovoltaic (PV) plant. Not only because equipment and human safety and protection are covered but because various philosophies in the context of DC through high frequency electromagnetic phenomena, are covered.

This two-day course covers the following topics:

**Earthing:** The objectives with earthing together with the importance of soil resistivity in electrode design are covered, pointing out the importance of low and high frequency aspects as design considerations. The performance of large integrated electrodes under high frequency conditions are covered, demonstrating the importance of loss of equipotential under lightning earth potential rise (EPR) and how this may affect the selection of technology applied.

The philosophy and reasoning behind specific earthing techniques are covered. Examples include the earthing of PV panels, floating and earthed DC systems, all in the context of personnel and equipment safety.

**EMC:** The objectives and fundamentals are covered, important in the selection of correct mitigation techniques, applicable to design. Coupling modes and vulnerable areas in the plant are addressed. In addition, EM Zones relevant and important to the specification of communication equipment in the field are covered.

Earthing for EMC, as important as earthing for safety, has to integrate with earthing associated with lightning protection and is addressed.

**Lightning:** Lightning is addressed from the risk perspective, including aspects related to external and internal lightning protection. Considerations related to air termination rods are but one example.

**Soil:** The combination of high soil resistivity & lightning

activity, with sensitive electronic monitoring and communication equipment, is a recipe for equipment damage if not addressed properly. This is covered together with mitigation considerations.

**Standards:** Standards are a major aspect to PV Plant design and offer the basis for departure for the design engineer. Here, reference is made to applicable international standards with specific focus on IEC standards; Specific limitations of current international standards and their implications, in the context of large PV plant, particularly related to risk assessment, are covered and link with contractual aspects important to EPC contractors;

**Specific Considerations:** Attention is parted to specific design considerations that are outlined in context with specific topics, such as:

- Low voltage surge protective devices and their correct bonding;
- Air terminations – can you design without them?

Throughout the course, relevant aspects in the broader context are addressed. Examples include:

- Water-based, floating PV systems;
- Single point bonding in contrast to required multi-point bonding of cable shields.

Time is also allowed to look at where new developments are taking place and what is offered. Examples are covered and comparisons are made between better options.

The course concludes with aspects important to the EPC contractor:

- When should earthing, EMC and lightning protection be considered in the design process?
- The importance of a user requirement specification and typical content.

**Practical Session:** A practical session will cover specifics about soil resistivity measurement and electrode resistance testing, not only pointing out potential pitfalls but also explaining *Why on Earth™* it is done in a specific manner.

Even though the focus is on large utility scale photovoltaic plant, the principles covered can well be extended to large wind farm projects and other industrial sites.

## WHO SHOULD ATTEND THIS COURSE ?

This course was designed to benefit technical personnel from Utilities, Engineers, Managers, Technical Specialists, Site Supervisors, Operators, Lightning Protection Specialists, Earthing and Lightning Protection System Designers and other personnel involved in the procurement of equipment, planning, design and construction of large free field PV plant / industrial plant.

In addition, any person interested in the topic with solid knowledge and background in electrical engineering.

## WHY ATTEND THIS COURSE ?

Many times, earthing is incorrectly referred to as a “black art”. This course is intended to steer away from and to clarify this misconception by providing the course participant with material to better understand the philosophy behind the technical application, to further better and improve design, clarifying what should / can be done and why it should be done.

The course does not promote a “cook-book” approach to design but supports the necessary foundation for the course participant to arrive at the better solution through proper engineering, design consideration and thinking.

More responsibility together with accountability, particularly in South Africa, have recently shifted towards the design engineer and the EPC contractor to ensure lightning protection in large free field PV plant is adequately covered. This course will assist the design engineer and the EPC contractor through awareness of aspects, not so obvious, that can go wrong.

Many an existing PV plant, across the world, speak of specific challenges experienced in earthing, EMC and / or lightning protection. The value in attending this course, in essence, falls with awareness of the host of relevant and not-so-obvious considerations, demanding attention from the design engineer, to arrive at a workable solution and to ensure a reliable plant and savings in cost.

Learning outcomes: On completing this course, the learner will be able to:

- List and discuss the coupling modes and anticipated damage mechanisms associated with lightning activity;
- Identify pitfalls in earthing and lightning protection design of large utility scale PV plant;
- Identify limitations of current international lightning protection standards in terms of its application to large PV plant and how to work around the limitations;
- Consider and select technology options for improved earthing and lightning protection design.
- Explain and motivate the application of specific earthing, EMC & lightning protection considerations;
- Employ specific concepts from and covered in the course in the earthing and LPS design of a large utility scale PV plant.

The value added from attending this course include:

- Building your skills and extending your knowledge in earthing, EMC & lightning protection of large PV plant.
- Demonstrating your new-built skills improves your success in bidding for projects and offer higher confidence to your client in your optimised designs.
- Save time in searching for answers by learning from a recognized expert with academic, industry and field experience;
- Receive comprehensive course material;
- Receive a course completion certificate and collect your (SAIEE) CPD points.

## WHAT COURSE MATERIAL IS AVAILABLE ?

Comprehensive course notes will be provided in electronic format (pdf) that covers the aspects outlined in the programme. **PLEASE NOTE:** In view of environmental care and to align with e-technology, no hard paper copies of the course material will be issued. Course material will only be made available in electronic format. The course material will be made available to course participants one week before the start of the course and only if full payment has been received. It is advisable to allow for sufficient time, typically one week before the start of the course, to prepare your own hard copies of the course material if course participants so desire. Alternatively, course participants are welcome to bring their own laptops along to the course to display the course material.

## WHAT IS THE PRESENTATION STYLE ?

The course presentation style is based on class room instruction led by the course presenter but is interactive in that questions and points of discussion can be raised by course participants at any time during the presentation. In addition, a practical session to be held at the venue site, forms part of the course. The course language is English. Discussions & presentations will be conducted in English.

## WHO RECEIVES DISCOUNT ?

In support of learning and training efforts in South Africa, discount is offered to South African citizens. The discount amounts to about 30 % based on exchange rates at the time of preparing this material.

## WHERE TO GET MORE INFORMATION FROM ?

Kindly contact TERRATECH for more and specific information at: [office@terratechnology.co.za](mailto:office@terratechnology.co.za)  
The course registration form is also available at: [www.terratechnology.co.za](http://www.terratechnology.co.za)

## WHAT THIS COURSE IS NOT

This course does not offer a specific detailed design for any large utility scale PV plant. This course is not a consultation on the design of any large utility scale PV plant.

## EARTHING AND LIGHTNING PROTECTION – Design Considerations for Large Utility Scale PV Plant –

A two-day course to be presented on  
26 & 27 November 2019 at the  
Misty Hills Country Hotel in Muldersdrift,  
Johannesburg, South Africa

## WHO IS THE COURSE PRESENTER ?

The course presenter is  
Dr Pieter H Pretorius, Principal  
Consultant of TERRATECH, a  
Johannesburg-based enterprise in  
South Africa.  
([www.terratechnology.co.za](http://www.terratechnology.co.za))



Pieter H Pretorius received a B.Eng (Electrical and Electronics) degree from the Potchefstroom University in 1985, an M.Eng (Bio-Engineering) degree from the University of Pretoria in 1990 and a PhD from the University of the Witwatersrand in 2000. His career in earthing, electromagnetic compatibility (EMC) and lightning protection is founded on his interest in electromagnetics.

He joined Eskom, the major utility in South Africa, in 1988 where he enjoyed career growth over a seventeen-year period to the level of Corporate Consultant. Boundary conditions drew him to independent consultancy in 2005. He also engaged as a Senior Lecturer at the University of the Witwatersrand for a short period.

He has authored / co-authored more than 100 papers, has registered four patents and has contributed chapters and parts of chapters to the Eskom Power Series and a book for CEATI International in Canada.

He developed an Earthing, EMC and Lightning Protection philosophy document and user requirement specifications for an International Engineering Group focusing on Large PV Plant and has been involved in design reviews and the investigation of earthing and lightning protection problems in several PV plant in South Africa and neighbouring countries.

He is registered as a Professional Engineer with the Engineering Council of South Africa, is a participating member in several CIGRE Working Groups and is an ELPA accredited Lightning Protection System Designer.

His detailed CV is available: [www.terratechnology.co.za](http://www.terratechnology.co.za)



## OVERVIEW OF PROGRAMME

### Day 1:

#### Introduction

- Components and systems of a typical PV plant in the context of earthing & LP
- Typical reported field problems
- Contractual considerations
  - Lightning risk as driver
  - The Design Engineer and accountability
  - User requirement specifications (URS)
  - Standards – A primer

#### Fundamental Considerations

- A fresh look at voltage, current and impedance
- Linking to electric and magnetic fields
- Models in soil and air
- Coupling modes
- Lightning damage mechanisms
- A fresh look at some fundamental concepts
- Mitigation and methods of improvement

#### Earthing Considerations

- Introduction and objectives
- Soil parameters
- Measurement and interpretation
- Electrode behaviour – low frequency and high frequency
- Mitigation and methods of improvement

#### Personnel Safety Considerations (LF)

- Introduction and objectives
- Faults in the plant
- Personnel safety
- Mitigation methods
- Specific challenges and considerations related to numerical modelling

#### Practical Session

- Measurements highlighting challenges
- Interpretation and discussion of measurement data from practical session (during next session)

### Day 2:

#### Equipment Safety Considerations (HF)

- Introduction and objectives
- Electrode behaviour - loss of equipotential

#### Lightning Protection System Considerations

- Introduction and objectives
- External Lightning Protection
  - Air termination rods
  - Earth electrode design considerations
- Internal Lightning Protection
  - LV SPDs and Equipotential Bonding
- Lightning protection zones (LPZ)
- Risk assessment considerations

#### Standards

- Outline of typical applicable standards
- Limitations of standards and what to do

#### Electromagnetic Compatibility (EMC) Considerations

- Introduction and objectives
- Fundamental concepts
- Earthing and bonding considerations
- Signal cable considerations
- Earthing – an integrated approach
- Electromagnetic (EM) zones
- Typical applicable standards

#### Integration Considerations (Bringing it all together)

- An integrated system – earthing, EMC and lightning protection
- Installation considerations – what can go wrong?
- Concluding remarks

## COURSE REGISTRATION ORDER AND BOOKING FORM

<b>Course:</b>	Earthing and Lightning Protection - Design Considerations for Large Utility Scale PV Plant				
<b>Venue:</b>	Misty Hills Country Hotel, Muldersdrift, Johannesburg, South Africa				
<b>Date:</b>	26 & 27 November 2019		<b>Course Code:</b>	19-011	
<b>Price:</b>	(Please indicate your participation status here ↓ with a tick (☑) mark)				
<b>\$ 1,240-00 (USD)</b>	Non-Citizen of SA				
<b>R 12,750-00 (ZAR) Including VAT</b>	South-African Citizen			<b>Discounted for SA Citizens</b>	
<b>Details of Course Participant:</b>					
<b>First Name:</b>				<b>Initials:</b>	
<b>Surname:</b>				<b>Title:</b>	Mr / Mrs / Ms /
<b>Job Title:</b>			<b>Organization:</b>		
<b>Address 1:</b>				<b>City:</b>	
<b>Address 2:</b>		<b>Postal Code:</b>		<b>Country:</b>	
<b>ID No (South African Citizens only)</b>				<b>ECSA No:</b>	
<b>Passport No (Non-Citizens of SA)</b>				<b>SAIEE No:</b>	
<b>E-mail:</b>			<b>Mobile No:</b>		
<b>No special dietary requirements:</b>		<input type="checkbox"/>	<b>Halaal:</b>	<input type="checkbox"/>	<b>Vegetarian:</b> <input type="checkbox"/>
					<b>Please tick (☑) one.</b>
<b>Signature:</b>					
By signing, I confirm that I understand and accept the booking terms and conditions (Please ensure that you have read through the terms & conditions.)					
<b>Authorisation Details (This part to be completed by the approving authority):</b>					
<b>First Name:</b>				<b>Initials:</b>	
<b>Surname:</b>				<b>Title:</b>	Mr / Mrs / Ms /
<b>Job Title:</b>			<b>Organization:</b>		
<b>Billing</b>				<b>City:</b>	
<b>Address:</b>		<b>Postal Code:</b>		<b>Country:</b>	
<b>E-mail:</b>			<b>Mobile No:</b>		
<b>VAT No:</b>			<b>Signature:</b>		
<b>Please Note:</b> This booking is invalid without a signature. By signing, the Signatory agrees to and accept the terms of conditions attached to this document (Please ensure that you have read through the terms & conditions.)					
<b>Completed Registration Forms:</b> Please return your completed registration form by e-mail to: office@terratechnology.co.za					

## TERMS AND CONDITIONS OF SALE:

### 1. Registration:

- One course registration order and booking form per course participant needs to be completed and submitted for registration.
- All registrations will be confirmed by e-mail.
- Please do not make any payments before you have received an official invoice.
- Payments for the course are payable on presentation of the invoice.
- In the event of unforeseen circumstances or circumstances beyond our control, TERRATECH reserves the right to postpone, cancel, and change the programme content, the presenter/s, the venue, or the date at any time deemed necessary.
- In the event of TERRATECH cancelling an event, TERRATECH will issue a 100 % credit for the amount paid for that event, to be used towards any future TERRATECH event.
- Once you have been invoiced, you will be liable for payment. Cancellation by the course participant does not waiver payment should you wish to cancel before payment was made.
- Due to limited venue space, **we advise early registration** to avoid disappointment.
- The client / course participant agrees and allows TERRATECH to retain the client / course participant information on a database to be used by TERRATECH to assist in communicating information related to this course and other courses, products or services offered by TERRATECH which may be of interest to the client by letter, phone, email or other electronic means. If the client / course participant wishes to stop receiving such information please inform the TERRATEHC office by e-mail: [office@terratechnology.co.za](mailto:office@terratechnology.co.za).

### 2. Price:

- The price is inclusive of course materials, lunches and refreshments during the two days of the course presentation as outlined in the programme. The price is inclusive of the relevant taxes.
- TERRATECH is not responsible for covering any travel costs, accommodation costs or any other costs incurred by course participants. Course participants will be responsible for their own travel and accommodation arrangements.
- An invoice will be sent to candidates upon receipt of the candidate's fully completed registration form.
- Payment must be received in full before the course material will be released to a course participant. Course material will only be issued in electronic format. It is advisable to allow for sufficient time, typically one week before the start of the course, to prepare your own hard copies of the course material if course participants so desire. **PLEASE NOTE:** No hard copies of course material will be issued at the course and course material will be made available to course participants, in electronic format, one week before the start of the course and only if full payment has been received.

### 3. Payment Terms:

- Following completion and return of the course registration order and booking form, full payment is required on receipt of the invoice by the course participant.
- Payment must be made by the course participant and must be received by TERRATEHC prior to the commencement date of the course. The full course fee is payable and is non-refundable.
- A receipt will be issued once payment has been received.
- Kindly note that TERRATECH reserves the right to refuse admission to and participation in the course if proof of payment has not been received prior to the start of the course and as outlined in this Section 3 of the terms and conditions.
- A cancellation fee will be charged under the terms outlined in Section 5 below.
- Unless otherwise stated on the invoice, payment must be made in South African Rand (ZAR).
- Once payment has been made please e-mail proof of payment to [office@terratechnology.co.za](mailto:office@terratechnology.co.za)
- The course fee includes relevant taxes, namely, Value Added Tax (VAT).
- Please use the Invoice Number as reference to your payment.

### 4. Payment Method:

- Only electronic Bank Transfer or Bank Cash Deposits are accepted. No cash or cheques offered directly to TERRATECH are accepted.
- Bank details will be displayed on the proforma invoice to be issued for each delegate registering following receipt of the course registration order and booking form by TERRATECH.

### 5. Cancellation / Substitution:

- **Cancellations:** will be charged under the terms set out below.
- In case the course participant cancels his / her course reservation, he / she shall pay TERRATECH the following cancellation fees:
  - Cancellations received in writing more than 14 days prior to the commencement date of the course carry a cancellation fee equal to 50 % of the full price of the course. Should cancellations be received less or equal to 7 days prior to the commencement date of the course, the full course fee is payable and is non-refundable. Non-payment or non-attendance does not constitute cancellation.
- Cancellations must be forwarded in writing by e-mail to TERRATECH.
- **No shows:** will be charged at the full registration fees. Cash alternatives will not be offered, however, substitutions at no extra charge are welcome.
- **Postponement:** No charge.
- **Substitution:** If a course participant cannot attend the course, he / she can send a substitute. There are no charges for substitutes provided that substitutes are from the same country as the course participant.
- Course participants may substitute delegates at any time. TERRATECH must be informed of substitutes in writing by e-mail. All terms and conditions equally apply to substitutes and automatically transfer and apply to the substitute once TERRATECH is informed in writing about the substitute.
- Provided the total fee has been paid, substitutions are allowed up to 7 days prior to the commencement of the course, at no extra charge.

- Substitutions made within 7 days of the commencement date of the course will be allowed subject to an administration fee equal to 10 % of the total course price.
- If, for any reason, TERRATECH decides to cancel or postpone this training, TERRATECH is not responsible for covering airfare, hotel, or other travel costs incurred by clients. The course fee will not be refunded, but can be credited to a future training.
- The course programme content is subject to change without notice.
- While every reasonable effort will be made to adhere to the advertised package, TERRATECH reserves the right to change event dates, sites, venues or location or omit event features, or merge the event with another event, as it deems necessary without penalty and in such situations no refunds, part refunds or alternative offers shall be made.
- In the event that TERRATECH permanently cancels the event for any reason whatsoever, (including, but not limited to any force majeure occurrence) and provided that the event is not postponed to a later date nor is merged with another event, the client / course participant shall receive a credit note for the amount that the client / course participant has paid to such permanently cancelled event, valid for up to one year to be used at another event. No refunds, part refunds or alternative offers shall be made.
- By completing and signing the course registration order and booking form you agree to adhere to and comply with the cancellation and payment terms.

#### **6. Course Material:**

- Course material: Comprehensive course notes will be provided in electronic format (pdf) that covers the aspects outlined in the course programme.
- **PLEASE NOTE:** No hard copies of course material will be issued at or before the course and course material will be made available to course participants, in electronic format, one week before the start of the course and only if full payment has been received. It is advisable that you allow for sufficient time, typically one week before the start of the course, to prepare hard copies of the course material for your own use, if you so desire. Alternatively, you are welcome to bring your own laptop along to the course to display the course material. No laptops will be provided by TERRATECH.

#### **7. Copyright:**

- Copyright of Course Material: All intellectual property rights in all materials produced or distributed by TERRATECH in connection with this course are expressly reserved and any unauthorized duplication, publication or distribution is prohibited.
- Please note that TERRATECH reserves all rights in connection with and relating to the course material. This document will remain as proof of the legal status of the course material that it pertains to.
- All course material, comprising of the course material in MS Word Format, in Paper Document Format (pdf), printed hard copy and in any other format or any parts thereof as presented for and during the course, remains the property of TERRATECH and is expressly intended for educational use only by the course participant, as listed on the signed course registration order and booking form, and on one computer at a time only.
- The course material or any part thereof may not be ceded, lent, sold, distributed, transferred, uploaded to a server, to a cloud, public domain or any other data storage facility in any format or given to any other person, except the course participant, without the express, written consent of TERRATECH.
- The said course material covers and is related to the course described in this document which includes the course registration order and booking form, a description of the course and the terms of conditions.

#### **8. Alterations:**

- Alterations to the advertised package: TERRATECH reserves the right to alter this programme without notice or penalty and in such situations no refunds or part-refunds or alternative offers will be made. Should TERRATECH permanently cancel an event, for any reason whatsoever, the client shall be provided with a credit of the equivalent amount towards the cancelled event. In case of a postponed or cancelled event, TERRATECH will not be responsible for covering airfare, accommodation, or other travel costs incurred by client / course participant.
- TERRATECH reserves the right to change or cancel any part of the programme due to unforeseen circumstances.

#### **9. Disclaimer:**

- The author / contractor / course presenter has exercised great care to ensure that the course material covered is accurate and complete. Despite this effort, the information may be incomplete. In addition, the examples presented and the materials are used to convey specific concepts to assist understanding of the course topic. The author / contractor / course presenter does not assume responsibility for the consequential effects of any errors or omissions nor the misinterpretation or wrongful application of the material covered in this course. The user / designer is and remains completely responsible for his / her own work regarding the fitness of any design and adherence to applicable laws, standards and codes. In the same manner, the user / designer is responsible for following the design and for the installation thereof in a workmanlike and professional manner.
- Whilst this course material has been prepared with care, TERRATECH can give no warranty regarding the applicability of the contents in a specific context and shall not be liable for any direct, indirect, indirect or consequential loss or damage arising out of its use.
- The information contained in the course programme was accurate and complete at the time of production. However, factors beyond TERRATECH's control (such as environmental, regulatory or technical changes) may cause the content of this course announcement form or of the program to change. In the event of such change, TERRATECH will formally notify current registered course participants. All possible measures will be taken to minimise inconvenience to course participants and learners.

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**10. Indemnity:**

- With regard to any Practical Session/s: The organisers / hosts / presenters of the course and the equipment demonstrators, that are not official agents of the equipment being demonstrated, specifically disclaim any implied warranties of merchantability and fitness for a particular purpose of the measurement equipment that will be demonstrated. It is recommended that course participants interested in more details about the equipment, follow up on such interest by approaching the official agents for more information and for application details.
- Learners participating in the practical session/s agree to sign the relevant indemnity form before the practical session at the course.

**11. Authorisation:**

- Bookings are invalid without an authorisation signature.
- The person completing and submitting this course registration order and booking form hereby certifies that he / she is duly authorised to place this order on behalf of the contracting course delegate / company / organisation, who will be invoiced accordingly and will be responsible for settling the account as per the TERRATECH Terms and Conditions of Sale outlined in this document.

**12. Governing Law:**

- This Agreement shall be governed and construed in accordance with the law of South Africa and the parties submit to the exclusive jurisdiction of the court/s in South Africa.