International Journal of Engineering Research and Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 22, Issue 7 (July 2026), PP 116-121

Design of Dual-Mode Control System for an EOT Crane

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ABSTRACT:
This paper focuses on the detailed electrical system design of a 40/10 Ton Double Girder Electric Overhead Travelling (EOT) Crane with integration of Radio Remote Control (RRC) in cabin operation. The main aim of this work is to enhance operational flexibility, improve safety conditions, and achieve efficient material handling within industrial setups.
The design has been carried out in accordance with the guidelines of IS 3177:2020, taking into account important electrical parameters such as selection of motors, sizing of cables, selection of DSL (Down Shop Lead) system, calculation of voltage drop, and coordination of protection systems. A 110 V AC control circuit has been developed with proper interlocking between pendant control and RRC operation to prevent simultaneous functioning and to ensure safe switching between both control modes.

Date of Submission: 09-07-2026 Date of acceptance: 20-07-2026

I. INTRODUCTION

Electric Overhead Travelling (EOT) cranes are among the most widely used material handling systems in manufacturing plants, steel industries, warehouses, power stations, and heavy engineering facilities. Their ability to transport heavy loads efficiently, accurately, and safely makes them an indispensable component of modern industrial operations. With the increasing demand for higher productivity, improved workplace safety, and operational flexibility, the electrical design of EOT cranes has become a critical aspect of crane performance and reliability. The electrical system of an EOT crane comprises several essential components, including motors, control circuits, power distribution systems, protective devices, and current collection systems. Proper selection and coordination of these components ensure smooth operation, energy efficiency, reduced maintenance, and compliance with applicable safety standards. Electrical system design must consider factors such as motor capacity, cable sizing, voltage drop, short-circuit protection, control voltage, and reliable power transmission to achieve safe and dependable crane operation.

Recent advancements in industrial automation have encouraged the adoption of wireless control technologies, particularly Radio Remote Control (RRC) systems, in overhead cranes. Radio remote operation allows operators to control crane movements from a safe location while maintaining a clear view of the load, thereby improving operational efficiency and reducing the risks associated with cabin or pendant operation. However, the integration of RRC into conventional crane control systems requires careful design of interlocking mechanisms to prevent simultaneous operation through multiple control modes and to ensure fail-safe performance.

This paper presents the detailed electrical system design of a 40/10 Ton Double Girder Electric Overhead Travelling (EOT) Crane with the integration of a Radio Remote Control system for cabin operation. The design is developed in accordance with the requirements of IS 3177:2020 and includes the selection of motors, cable sizing, Down Shop Lead (DSL) system selection, voltage drop analysis, and protection coordination. A 110 V AC control circuit with appropriate electrical interlocking between pendant control and radio remote control has been designed to ensure safe and reliable operation. The proposed design aims to enhance operational flexibility, improve operator safety, and provide an efficient and standards-compliant electrical solution for modern industrial crane applications.

II. SYSTEM OVERVIEW AND PROBLEM IDENTIFICATION

Fig 1. EoT Crane

Above figure shows a crane having a capacity of 40/10 Ton with a span of 12.5 meters and is used for lifting and shifting heavy loads inside the plant. At present, the crane is operated only through a cabin control system, where the operator controls the crane from a fixed cabin position. The crane is controlled through a control panel installed inside the operator cabin. All crane motions such as hoisting, cross travel and long travel are operated by switches and controllers provided in the cabin. The electrical control system is designed only for cabin-based operation and does not support remote control at present. The operator must remain inside the cabin to perform all lifting and shifting operations. In many situations, the operator does not get a clear view of the load and working area from the cabin. Communication between the operator and ground workers is mainly done through hand signals or voice, which is not always effective. The operator has to stay inside the cabin even when better visibility is required near the load. Due to limited visibility, accurate positioning of the load becomes difficult in some areas. Handling heavy loads of 40/10 Ton increases safety risk for the operator and nearby workers. In congested or hazardous working zones, cabin operation becomes uncomfortable and unsafe. Only one operating mode (cabin control) is available, which reduces flexibility during different types of operations. In case of emergency, the operator is not always close to the load to react quickly.

To address these challenges, the integration of a Radio Remote Control (RRC) system was proposed. The main objective of the project is to enable wireless crane operation while maintaining the conventional pendant station as a backup control method. The integration requires proper electrical interlocking to ensure that both control systems cannot operate simultaneously.

III. TECHNICAL SPECIFICATIONS AND DESIGN PARAMETERS

A. Rating and size of DSL / Runway Conductor

The total ampere load of the crane system is calculated by considering the full load currents of allmotors andreducingthem using the load diversityfactor(fD)and dutycycle factor (fED) as specified in Table 1 and Table 2. After identifying the motors with the highestoutput(ID),theircurrentsalongwithauxiliaryloads (IG)aresummedtoobtainthe total demand current(IDA = ΣID + ΣIG). The final current rating of the runway conductor (DSL) is then determined by multiplying the total load current with the duty cycle factor and diversity factor, i.e., CurrentRating=Total LoadCurrent×fED ×fD

TABLE 1: Load Diversity Factor

Sl No.	Duty Class	Diversity Factor for 1 Crane	Diversity Factor for 2 Cranes	Diversity Factor for 3 Cranes	Diversity Factor for 4 Cranes	Drive Diversity Factor for 5 Cranes	Drive Diversity Factor for 6 Cranes	Drive Diversity Factor for 7 Cranes and More
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	M6, M7, M8	1.0	0.95	0.91	0.87	0.84	0.81	0.78
ii)	M5	0.7	0.8	0.65	0.5	0.5	0.5	0.5
iii)	M1 to M4	0.5	0.7	0.5	0.4	0.4	0.4	0.4
	NOTE — In case the cranes are of different duty classes, then diversity factor of higher duty class shall be considered.							

TABLE 2: Duty Cycle Factor

	Duty Cycle Factor (f_{ED})						
Running period ED	20 percent	30 percent	40 percent	50 percent	60 percent	80 percent	100 percent
Reduction Factor f_{ED}	0.45	0.54	0.63	0.71	0.78	0.89	1

DSL calculation and voltage drop calculation for 40/10T DG EOT Crane

Bay length	86	Mtr
Effective Bay length	77	Mtr
Crane Quantity	1	Nos.
feeding Arrangement	centre feed	
Ambient Tempaeratur	50	C

SR.	MOTION	CONDITION	Mech Kw	Qty	FLC	Total current	Rate KW	Rated Amp	Rate KW	Rated Amp
1	M.H	Running	81.49	1	149.33	149.33	85	IA1=157	85	157
2	A.H	idle	20.01	1	41.07	41.07	23	IA2=46	23	46
3	C.T	idle	2.57	1	6.39	6.39	3.2	IA3=7.4	3.2	7.4
4	L.T	Running	3.92	2	7.72	15.44	5	IA4=11.1	5	11.1
5	Aux.Load	ON			5	5				

DSL selection

IA6= Running current of 2 MOTIONS (MH+LT) and Aux . Load of crane	169.8	Amps.(ia1+ia4+ia5)
D.F= Diversity factor for one crane running	1	
Itotaldf= Total current after appling D.F	169.8	amps.(Itotal/DF)
J= Current Density of Mild Steel	0.42	amps./mm2
AREA= are a	404	sq.mm

Selected angle size	50*50*6	mm	50*50*6	568
Area of selected ms angle	568	sqmm	65*65*6	744
			65*65*8	976

Fig 3. DSL and Voltage drop calculations

B. Cables and Conductors

Cables used in crane wiring shall comply with relevant Indian Standards. Copper or aluminum cables are used for power wiring, while only copper cables are used for control wiring. Single strand cables are not used for sizes above 6 mm². For cranes with AC VFD, festoon or rubber cables with low capacitance are recommended. Cable selection considers factors like ambient temperature, grouping, and voltage drop, and must follow standards such as IS 694, IS 1554, IS 9968, and IS 7098. Minimum conductor sizes are: 2.5 mm² (power) and 1.5 mm² (control) for up to M5 class,4.0 mm² (power) and 2.5 mm² (control) for M6 and above.

C. Current Rating of Cables

Cable current ratings given in Indian Standards or by manufacturers are based on continuous duty. Since cranes operate on intermittent duty, the cable rating is up-rated using an intermittent duty factor. The effective (operative) cable rating is calculated by consideringambienttemperature,cablegrouping,cabledisposition,andintermittentduty factor.

Therequiredcurrentisgivenby:

Irequired=Iequipment/(C1×C2×C3)where

C1=Ambienttemperaturecorrectionfactor, C2 = Group rating factor, C3=Intermittentdutyfactor(10/√CDF),typically1.7for30minratedmotorand1.4for1 hour rated motor.

W.O : BECL-3466

CAP:40/10T D/G EOT CRANE

CABLE SELECTION CALCULATION

Factors				
	X	Rating Factor for temperatue	50 degree	0.9
	Y	rating factor for grouping laying	2 cables	0.84
	Z	Rtaing Factor for CDF in %	40	1.6
B=X*Y*Z		Combine Rating Factor		1.2

SR. No	Description	Rating KW	FLC of motors	combine rating factor	Cable current required	Sq.mm	Core	Conductor	Type	Insulation	Current Rating in Amps
1	M.H	85	157	1.2	130.83	35	3	CU	armoured/flexible	XLPE,EPR	151
2	A.H	23	46	1.2	38.33	4	3	CU	armoured/flexible	XLPE,EPR	40
3	C.T	3.2	7.4	1.2	6.16	1.5	3	CU	armoured/flexible	XLPE,EPR	22
4	L.T	5	11.1	1.2	9.25	1.5	3	CU	armoured/flexible	XLPE	22

Ambient Temperature Derating factor for 50C 0.9

Fig 3. Cable Selection calculations

D. Protection and Limit Switch Logic Matrix

TofulfilthesafetyrequirementsofIS3177:2020,amatrixoflimitswitchesandprotection deviceswasdeveloped. Thesedevicesactasthephysical"ExecutionLayer" forthecontrol logic.

ROTARY GEAR LIMIT SWITCH			
MAKE-KAKKU			
Main Hoist		**Aux.Hoist**	
RATIO FOR ROTARY GEARED LIMIT SWITCH	**32**	RATIO FOR ROTARY GEARED LIMIT SWITCH	**27**
HEIGHT OF LIFT IN Mtr.	16.5	HEIGHT OF LIFT IN Mtrs.	17.5
NOS. OF FALLS	8	NOS. OF FALLS	4
DIA.OF ROPE DRUM IN Mtr.	0.657	DIA. OF ROPE DRUM IN Mtr.	0.407

Fig 4. Limit Switch Selection calculations

E. Control Transformer Selection and Capacity Calculation

As per the safety guidelines in IS 3177, the control circuitry of the 35/5T EOT crane must be electrically isolated from the main power circuit. This is achieved by installing a Control Transformerthatstepsdowntheprimarysupplyof415VACtoasecondarycontrolvoltage of 240V AC. The selection of the transformer KVA rating is not based on a simple power sum, but on the dynamic current demands of the contactor coils and the RRC receiver unit. The Excel calculation focuses on two critical states: 1. Pick-up (Inrush) Current: When a motion is initiated (e.g., Main Hoist start), the contactor coil requires a high "Pick-up" current to overcome the mechanical spring tension and close the contacts. This is often 6 to 10 times higher than the steady-state current. The transformer must be sized to handle this momentary peak without a voltage dip that would cause the RRC receiver to reset.

2. Hold-on (Sealed) Current: Once the contactors are closed, they require a much lower "Hold-on" current to stay energized. The transformer must be capable of providing this current continuously across multiple simultaneous motions (e.g., Hoisting and Long Travel operating together) without overheating.

Fig 5. Control Transformer Selection and Capacity Calculations

ROTARY GEAR LIMIT SWITCH			
MAKE-KAKKU			
Main Hoist		**Aux.Hoist**	
RATIO FOR ROTARY GEARED LIMIT SWITCH	**32**	RATIO FOR ROTARY GEARED LIMIT SWITCH	**27**
HEIGHT OF LIFT IN Mtr.	16.5	HEIGHT OF LIFT IN Mtrs.	17.5
NOS. OF FALLS	8	NOS. OF FALLS	4
DIA.OF ROPE DRUM IN Mtr.	0.657	DIA. OF ROPE DRUM IN Mtr.	0.407

F. Lighting Transformer Selection and Capacity Calculation

The lighting transformer (TR2) is designed to supply power to various lighting and utility loads such as panel lights, cabin light, bell, UBL (under bridge lights), walkway lights, cabinfan, plug & socket, and cabin exhaust fan. The total connected load is first calculated by summing all individual wattages, which comes to 1414 W.To account for power factor (assumed 0.8), the effective load is calculated as:

Total Load = 1414 / 0.8 = 1767.5 VA

The corresponding current at 240 V supply is:I = 1767.5 / 240 = 11.05 A

Further, a 20% safety margin is added to ensure reliable operation and future load consideration:

Adjusted Load = 1767.5 × 1.2 = 2121 VA

Based on this calculated value, the nearest standard rating is selected, hence the lighting transformer rating is chosen as 2000 VA. For protection and proper operation, MCB ratings are selected as follows:

- Incomer MCB: Calculated using transformer rating → (2000 / 415) × 1.25 ≈ 6 A, hence 10 A MCB selected
- Outgoing MCB (240 V): (2000 / 240) × 1.25 ≈ 10.4 A, hence 16 A MCB selected
- Outgoing MCB (24 V): (2000 / 24) × 1.25 ≈ 13 A, hence 16 A MCB selected

Thus, the selected transformer and protection scheme ensure safe, efficient, and reliable operation of all lighting and auxiliary loads in the crane system.

Fig 6. Lightening Transformer Selection and Capacity Calculations

Lighting Transformer (TR2) Calculation

No.		Qty.	Watt	Total(Wat	W/0.8	V	A	Selected MCB(A)
1	Panel Light	4	11	44	55	240	0.34	6
2	Cabin Light	1	40	40	50	240	0.31	6
3	Bell	1	70	70	87.5	240	0.55	6
4	UBL	4	250	1000	1250	240	7.81	6
5	Walkway Lights	2	60	120	150	240	0.94	6
6	Cabin Fan	1	40	40	50	240	0.31	6
7	Plug & Socket 240V	4	20	80	100	240	0.63	6
8	Cabin Exhaust Fan	1	20	20	25	240	0.16	6
				1414	1767.5		11.05	
				2121				
	Lighting Transformer(TR2)			2000 VA				

	V	A	SEL.MCB(A)
Incomer MCB	415	6	10
Out Going MCB	240	10.4	16
Out Going MCB	24	13	16

G. Motor Selection and Efficiency Standards (IS 325 & IS 12615)

Theoverallperformanceanddependabilityofan EOTcranelargelydependontheproper selection of its three-phase induction motors. In this project, motors for the Main Hoist (35T), Auxiliary Hoist (5T), and travel mechanisms have been selected by following the guidelines of IS 325 and IS 12615:2018 to ensure safe, efficient, and reliable operation.

As per IS 325, crane-duty motors are required to operate under intermittent conditions, typically S3 or S4 duty. For the Main Hoist, the motor is selected to deliver adequate starting torque so that it can lift the full 35-ton load smoothly from rest without any risk of stalling. Considering the harsh industrial environment, motors are designed with Class F insulation, which allows them to withstand higher temperature rise during continuous and heavy-duty operations.

Additionally, to ensure durability and protection in dusty and humid conditions commonly found in industrial plants, motors are provided with an IP55 enclosure. This protects internal components from dust ingress and moisture, thereby improving operational life and reliability.

IV. RESULTS AND DISCUSSIONS

A complete electrical design and development of an EOT crane system was carried out, with a key focus on the integration of Radio Remote Control (RRC) along with conventional cabin operation. The objective was to enhance operational flexibility, safety, and efficiency without compromising the reliability of the existing system.

The system was designed, implemented, and analyzed through:

- Preparation of basic and detailed electrical schematics
- Selection and integration of protective devices, transformers, and control components
- Implementation of dual-mode operation (Cabin + RRC)
- Testing and validation through inspection and commissioning stages.

The integration of the RRC system was achieved by incorporating it into the control circuit architecture of the crane.

The control supply (110V AC) derived from the control transformer (TR2) was used to power both Cabin control circuits and RRC receiver unit.

The RRC receiver outputs were interfaced with:

- Contactor coils
- Control relays
- Directional and motion control circuits (hoist, cross travel, long travel).

V. CONCLUSION

This paper successfully demonstrates the integration of a Radio Remote Control (RRC) system with conventional cabin operation in an EOT crane. The developed electrical system ensures reliable performance, enhanced safety, and improved operational flexibility.

The dual-mode control system allows the operator to switch between manual cabin operation and wireless remote operation, depending on the application requirement. Proper electrical interlocking was implemented to prevent simultaneous activation of both modes, ensuring safe and conflict-free operation.

The use of transformers for control, lighting, and braking circuits ensured stable voltage levels and safe operation of sensitive components. Additionally, the incorporation of protection devices such as MCCB, MCBs, and isolators enhanced system reliability by safeguarding against faults.

Testing and validation confirmed that:

• The RRC system responds accurately to control commands

•Smooth coordination exists between different crane motions

•The system maintains stable performance under varying load conditions

Overall, the integration resulted in a robust, efficient, and operator-friendly control system, meeting industrial standards and improving productivity.

Future Scope:

Although the current system performs efficiently, several enhancements can be implemented to further improve performance and adaptability:

1. PLC-Based Advanced Control

• Replace conventional relay logic with PLC-based control systems

• Enables better automation, diagnostics, and flexibility

2. IoT and Remote Monitoring

• Integration of IoT-based monitoring systems

• Real-time tracking of Crane performance, Fault conditions, Energy consumption

3. Enhanced Safety Features

• Addition of Anti-collision systems, Load monitoring sensors, Smart limit switches

• Improves safety in complex industrial environments.

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